Delivering the future, today

Project manager’s guide
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1. Introduction

This guide is designed to assist project managers to deliver sustainable low carbon buildings. It details a five-step process that, if followed, will markedly improve the quality of the internal environment of the building, assist in assuring that it achieves best value and result in significant carbon savings throughout the lifetime of the building.

It is designed to be read in conjunction with the other guides in the Carbon Trust Delivering the future, today pack. The Delivering the future, today pack contains the following documents and tools:

**Documents**

**Executive summary**
A summary of the suite of documents and tools.

**Setting the scene**
This document demonstrates the benefits that can be achieved and the problems that can be avoided by following a robust process in the procurement of low carbon new build and refurbished buildings.

**The project owner’s guide**
This brief guide is designed to be read by the senior project owner. It introduces the requirement to change the way we procure new build and refurbished buildings and summarises the Carbon Trust five-step process to achieving that aim.

**The project manager’s guide**
This more detailed guide should be read by project managers and members of the design team. It lays out a detailed process that if followed should ensure that a sustainable low carbon building, be it a new build or refurbishment, representing Best Value with minimum whole-life costs should be delivered.

**Tools**

- **Client value preparation tool**
- **Skills, knowledge and experience tool**
- **Low carbon tracker**

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The following chapter details the step-by-step process that should be followed to ensure that the resulting new build or refurbishment provides an exemplar result.

Throughout this chapter green boxes indicate good practice and red boxes indicate risks. The following figure outlines each of the five steps and summarises the processes required for that step.

The process will vary slightly depending on the chosen procurement route. With an in-house design team, the bidding team selection in the preparation step will not be required but the selection of the in-house team during organisation preparation will need to be more rigorous.

At the beginning of each step there is a table showing the main processes involved, who would normally be responsible for them and what their deliverables are. The green circle represents the main responsible person and the amber circle represents the individuals supporting the processes.

Again this will vary slightly depending on the procurement route taken. The project manager role may differ depending on whether they are a member of the client organisation, part of the design team, or an independent resource.

The tools described in this guide are available on the Carbon Trust website at www.carbontrust.co.uk/scotland and may be downloaded for use on any project. The principles within this guide and in the tools apply to the private sector as well as the public sector so their use need not be restricted to public sector organisations.
Step 1. Preparation

The first step allows an organisation to assess its readiness to produce a low carbon new build or refurbishment and to identify any gaps in knowledge or skills that need to be filled. It also brings the organisation to the stage when an outline business case can be produced, an operational carbon target is set, a site chosen and a design team or delivery partner chosen.

This step contains a number of the most important processes in the methodology. As was shown in the “Setting the scene” document many projects take the wrong path from the start either by having an internal or external team responsible for delivering the building with some key skill gaps, failing to set rigorous targets for the building to meet in operation or undervaluing the low carbon measures at the business case stage.

This step consists of a number of processes some of which need to run concurrently. These processes are shown in the following table along with the responsible person and the deliverables from the process:
A number of the processes need to be run concurrently:

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<tr>
<th>Process</th>
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<th>Deliverables</th>
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<td>Project owner</td>
<td>Finance director</td>
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<td>Setting client values</td>
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<td>In-house team</td>
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### Organisation preparation

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<td>Project owner</td>
<td>Low carbon adviser appointment</td>
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<td>In-house team selection</td>
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<td>Low carbon adviser appointment</td>
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### Site selection

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### Bidding team selection

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- **main driver**
- **additional driver**
A. Project owner

In most projects, be it a new build or a refurbishment, a senior knowledgeable responsible person is likely to be appointed (the “project owner” under Scottish Construction Procurement Manual terminology or the “Senior Responsible Owner (SRO)” under Office of Government and Commerce terminology).

This is normally defined as an individual with the “status and authority to provide the necessary leadership” (1). If the intention of the project is to deliver a low carbon building this individual will need to be prepared to champion the low carbon aspects of the building. This will require a broad level of knowledge covering the requirements for a productive workplace, the synergies with a low carbon building, the design hierarchy required to minimise energy demand, the gap between traditional building procurement strategies and those required to deliver a low carbon building and the importance of using a robust whole-life costing methodology. Some training may need to be provided to the project owner to ensure that they have the skills required.

Good practice
A senior knowledgeable responsible person needs to be appointed to champion the project. This must be an individual with regular access to senior decision makers and they must have a good knowledge of sustainability issues.

B. Setting the values and overarching targets

The responsibility for delivering a low carbon building rests with the client. It is up to the client to establish its low carbon objectives for the design team and to provide them with targets for the building performance. This process needs to be led by the senior management of the client and progress is to be reported back on a regular basis.

(1) Client values

Once the project owner has been appointed, the first stage of any project should be determining the client values. Typical client values include goals such as:

- A good working environment
- Low whole-life costs
- Iconic appearance and how much this can exceed basic cost
- Flexibility of space.

These values can then be prioritised. This ensures that when differences of opinion on design strategies occur there is no doubt as to what the client’s objectives for the project are.

Good practice
The first step of any project is to hold a value charrette to determine the main client design values and to prioritise those values.

(2) Value charrette

A method of identifying the client values is to hold a value charrette. This is a short meeting of the key decision-making individuals involved in the process. These will normally include a senior representative of the users such as a head of department or the head teacher in the case of a school; the finance director; the head of the estates department and the sustainability representative.

The aim of the charrette normally includes the following elements:

- Clarifies the client’s aspirations
- Provides a viability framework for client’s aspirations – the values are attached to the early stage project objectives
- Confirms commitment to carry out assessment of:
  - Minimum space requirements
  - Options for providing required space i.e. new build, refurbishment or lease
  - Requirements for site if new build is an option
- Identifies strategic issues
- Identifies contributions to the project from the various professional groups
- Confirms commitment to carry out skills, knowledge and experience assessment on all individuals working on the project including those involved in the initial business case
- Identifies the key integrated design issues
- Identifies the person to be the low carbon auditer.
(2) Value charrette

- Sets payback period for any energy saving projects, typical 10 year payback for building fabric costs
- Confirms the requirement to use full whole-life costing
- Defines the basis for cost cutting measures on completion of design.

A short presentation at the beginning of the meeting on the duty to reduce emissions, the financial benefits of a sustainable approach and the importance of a productive workplace helps to set the stage and place the analysis in context. The agenda of a value charrette is given in Appendix 1.

The results of the charrette are summarised in a brief report, that is circulated to all team members and to the Chief Executive. A recommended format for this report is shown in Appendix 1.

The values determined during the value charrette can then be used as a basis to develop a number of overarching design and operational targets.

(3) Client value preparation tool

Prior to holding the charrette, it is useful to gain an understanding of the organisation's ability to deliver a low carbon building with its existing policies and resources. This will help identify any major barriers that need to be addressed prior to commencing the project. The client value and preparation assessment tool has been developed to assist in this process.

Organisations rank themselves from 0 to 4 on a range of subjects related to the delivery of a low carbon building. This is grouped into five areas:

- Organisational management
- Client values at project inception
- Process and finance
- Investment and whole-life costs
- Contractual arrangements.

Good practice
The organisation's values and preparation to deliver a low carbon building should be assessed prior to commencing the project.

The output from the tool is in the form of detailed analysis of each area and a spider chart summarising the results. This is circulated to all value charrette participants prior to the meeting.

Figure 1. Summary of client values and preparation.

(4) Overarching design and operational targets

Setting targets for design and operational aspects of the building at the earliest stage of the project ensures that the correct design philosophy is pursued. These are normally detailed in an Overarching Technical Brief.

Good practice
Overarching design and operational targets need to be set for the project prior to the site being chosen and the design team being appointed.
A target must be achievable, measurable and responsibility for reaching it must be able to be clearly assigned.

Typical overarching design and operational targets are shown in Appendix 3 along with recommended minimum levels and best practice values and options for measuring the required parameters.

Where refurbishment is identified as one of the options, information will need to be gathered about the existing building to assess its potential for improvement prior to moving on to setting some high level targets.

**Good practice**

In the case of a refurbishment, the existing building should have a condition survey, be thermographically surveyed to identify heat leakage points and pressure tested for air leakage points.

### (5) Whole-life costing

Whole-life costing is a legislative requirement and ensures that decisions are made on the total cost of the building and its component parts over the building lifetime and not only on the initial capital cost. Detail on the regulatory requirement is provided in the "Setting the scene" document.

If whole-life costing is correctly carried out, it will normally result in a low carbon building, provided that the design intent is reflected in the delivered building.

Any whole-life costing methodology must have the following elements:

- All aspects of procurement, construction, operation, maintenance and decommissioning to be included
- Realistic forecasts of energy and carbon prices must be used
- The assessment should last for the expected lifetime of the building or 100 years, whichever is shorter.

Appendix 4 provides the detail of a robust methodology for applying whole-life costing. Within the appendix is an energy price forecast that can be used as the basis for the energy price inflation of the model. The forecast shows energy prices doubling by 2020, which is generally a well-accepted expectation. The following graph shows how this level of energy price inflation would affect a current electricity price of 12p/kWh.

![Electricity cost forecast](Figure 3. Electricity cost forecast)

At this stage of the project a whole-life costing methodology will need to be agreed.

**Good practice**

Whole-life costing should be used for all projects. It includes all aspects of project design, construction, commissioning, operation, decommissioning and disposal.

### (6) Outline business case strategy

A second report will be required at this stage: a summary of the Outline Business Case Strategy. This includes all of the options that need to be considered and the methodology to be used in the outline business case.

The methodology should ensure that all options for the building are evaluated including looking at refurbishment of the existing building, refurbishing a building at a different location, a new build on the existing site or a new build on a new site. It should ensure that the business case financial model uses whole-life costing and also specify what individuals are to be consulted as part of the process.

A design professional needs to be consulted to discuss the options.

A recommended format for this report is shown in Appendix 5.
C. Organisation preparation

Once the initial design aim has been determined, an in-house team can be selected to deliver the project. The roles and responsibilities of the team members will be dependent on the procurement route used and the required balance between in-house expertise and external advisers. To fulfil the low carbon and sustainability objectives of the project specific expertise and skills will be required.

There are three main elements to this process:

- Assessing the skills, knowledge and experience of your in-house team
- Setting up a low carbon tracker to ensure that all environmental elements of the project are implemented and the targets met
- Engaging with the future users of the building.

(1) Skills, knowledge and experience tool

The Carbon Trust has created a skills, knowledge and experience tool to assist in the evaluation of the organisation and to identify gaps and training needs. It is in the form of a simple spreadsheet. The organisation marks itself from 0 to 4 on its knowledge and experience of a wide range of aspects of a building project. On some of the aspects, they give themselves two marks, one for their knowledge of the aspect and the second for their actual experience in delivering a building with that aspect.

The spreadsheet collates the scores and portrays them in two different formats. The first is a table showing the scores for each aspect and the second is two spider diagrams summarising the results.

In this example the organisation has a good level of general knowledge with a high level of expertise in Passive Design and Site Selection and Planning. Where no individuals are available with the required level of experience in a particular area then training should be arranged or an external adviser appointed.

Once the internal team has been selected and their skills and experience assessed, a number of external advisers are likely to be required. The skills and experience tool can be used to assess possible candidates for the role.

These may include:

- A low carbon adviser
- An acoustics specialist
- A commissioning adviser.

Figure 4. Example output from skills, knowledge and experience tool.
(2) Low carbon adviser

It is recommended to use a low carbon adviser on every project, either an appropriately qualified and trained in-house resource or a specialist consultant. They should be able to monitor the low carbon and sustainable aspects of the project. They may also carry out the BREEAM assessment if it is required. Some low carbon advisers are competent to monitor the dynamic simulation of the project. A detailed role description is required.

- Reporting on low carbon and sustainability aspects of the project to project owner on a monthly basis
- Supporting the skills, knowledge and experience assessment process
- Maintaining the low carbon tracker
- Assessing the assumptions and results from the dynamic simulation
- Assessing and reporting any impacts on carbon emissions and whole-life costs of value engineering decisions
- Reporting any impacts on carbon emissions from changes in building materials or equipment by the construction company
- Provide support on whole-life costing to ensure that energy and carbon costs are properly accounted for.

They may also provide advice on:
- Embedded carbon
- Waste and recycling
- Water use and recycling
- Transport planning.

The emergent design and energy models need to be regularly monitored under the control and advice of the low carbon adviser, using other specialists as required to:
- Make sure the design is on track to meet targets
- Monitor models and compare with initial assumptions
- Undertake a review of “commissionability”
- Review the controls strategy
- Review locations of control devices
- Make sure future maintenance is easy, low cost and suited to available skills
- The building is performing as intended and required.

Whilst the low carbon adviser may not possess all the skills required for the above, they need to be able to advise on the reviews that are required and track that the reviews have been undertaken in time.

(3) Low carbon design tracker

To ensure that low carbon measures are recorded and monitored throughout the procurement process a low carbon design tracker has been produced. A team member, normally the low carbon adviser, takes responsibility for maintaining the tracker.

It allows each low carbon design issue to be recorded along with the individual responsible for the issue; the evidence or action required; the date or design stage by which the issue needs to be resolved; the outcome; completion date and references to documents involving the issue. There is an added benefit that the tracker provides an additional level of monitoring that assists in ensuring that a project does not exceed its initial purpose.

The tracker is pre-populated with recommended issues for tracking; however, it should be tailored as appropriate to the project.

Good practice

The use of a low carbon design tracker can be adopted at project commencement. It must be maintained throughout the project and reviewed regularly by the design team.
(4) Engagement with the users

One of the most important elements of the procurement process is obtaining a detailed understanding of the users’ requirements. This is a particularly difficult process to manage as it needs to be ensured that it remains a positive process and does not present an opportunity for user pressure groups to be formed.

The user engagement should be comprehensive and wide ranging and is a dual process of consultation and information. The first stage of the consultation should always include an education session covering:

- The values identified at the preparation step
- The elements of the productive workplace
- Adaptive comfort
- The importance of the consultation process as a means for the users to influence the design of the building.

This education session also introduces the opportunity to begin the process of setting the user expectations for the new building.

The objectives of the user engagement should include:

- Defining high level requirements
- Determining the room functions and sizes
- Confirming occupancy numbers and patterns
- Determining any specific temperature requirements

- Equipment requirements
- Server room requirements
- Specialised room requirements (e.g. labs, storage rooms)
- Level of user control required for lighting and heating
- Need for whiteboards or AV equipment
- Possible changes required in the future.

It is usual to have a representative of the users on the design team to ensure that their requirements continue to be given consideration.

It is important that user requests are carefully considered and where deemed that they will not be possible to accommodate the reasons for this should be explained to the users in a reasoned manner.

**Good practice**

A detailed user engagement process should be carried out at project commencement and their views should continue to be canvassed throughout the project whenever any major design changes are proposed.
A full options appraisal for a new building needs to be carried out prior to finalising the site and the position of the building within the site including the following elements:

- Orientation options
- Urban horizon angle
- Access to enable delivery of biofuels
- Planning restrictions
- Available space
- Prevailing weather direction
- Zoning of adjacent areas.

To ensure that the options appraisal is comprehensive it may be necessary to carry out some high level dynamic simulation of a building on the potential sites to determine the likely effect of shading, prevailing weather and orientation.

An example building of the required floor area should be used. Different floor plans and building heights can also be explored at this stage. This would normally include looking at a number of iterations of the façade to optimise its external layout.

Achieving a low carbon design is easier when a north-south orientation for the main façades is used as opposed to an east-west orientation, which has low angled sun at the beginning and end of the day. The south facing façade can have brise soleil to minimise direct sunlight into the building, whilst the north façade provides the majority of the quality daylight.

Clients seeking to relocate should consider the inherent sustainability and potential for energy efficient operation of the building they are seeking to purchase or lease.

A pre-acquisition audit by a low carbon adviser is recommended. This should look at inherent features that cannot be easily changed such as insulation, good transport links and day-lighting to displace artificial lighting. In addition, the audit should consider the cost and practicality of retrofit and refurbishment features such as efficient boilers, good zoning and control of heating and lighting controls.

**Good practice**

A full options appraisal should be carried out prior to finalising the site. This includes investigating options to refurbish or lease a building. Dynamic simulation including façade modelling should be included in the analysis.

Finally the whole-life costing implication of the site should be considered. A high level analysis can be used to compare different sites and different building locations within a single site.
E. External adviser and bidding team selection

When appointing an external adviser, design team or other external contracting partner, understanding their depth of knowledge of low carbon practicalities and sustainability issues is of paramount importance.

The Carbon Trust has developed a tool to assist in this process. It works in the same manner as the skills, knowledge and experience tool in Section C of Step 1. It will allow each tendering party or prospective adviser to be assessed on their ability to deliver a building that is fit for purpose. Completing the tool should be one of the requirements of the invitation to tender.

This can be used as a basis for identifying areas for further investigation during interviews. Where respondents mark themselves with a 4 for an item in the grid, investigating their rationale for this mark and asking for examples of how they have achieved the outcome in other projects would provide a means of assessing their suitability for the project. Where organisations have lower marks of 0 or 1 it would be possible to explore how they intend improving these elements.

Good practice

The design team’s skills, knowledge and experience should be evaluated during the selection process using the skills, knowledge and experience tool.

For all forms of procurement, the low carbon adviser should be an integral part of the evaluation process. Clients should be aware of the risks of diluting sustainability requirements in the later legal processes leading to contract signing and consult with the adviser during this process.

The bidding teams should be made aware that detailed technical questions concerning low carbon will be asked at the interview and that the individuals who will be responsible for the day-to-day design must be present at the interview.

Scoring of teams and tenders should be made transparent and issued with the Invitation to Tender (ITT) documents. It is worthwhile indicating that ambiguity in the responses will attract a lower score than clear, explicit and detailed commitments. The score for the sustainability and low carbon design aspects should be significant and related to measurable or verifiable information where possible e.g. energy model returned with tender, insulation and airtightness values, past performance of buildings.

The process will depend on the form of procurement, a number of examples are given below:

- Traditional procurement and frameworks – the outcome is wholly dependent on the skills of the design team and the tool provides a rigorous assessment of skills. Appointment terms are important – see below.

- Design and build forms of contract including NEC, various other partnering arrangements, any private finance or public partnership type contracts – the skills of the design team should be established ideally at Pre Qualifying Questionnaire (PQQ) stage, but certainly at ITT stage and a process put in place to score the PQQ/tender in both quality terms as well as cost.

- Appointment of technical advisers, property managers, and facilities manager (FM) providers – all these appointments should include performance clauses related to energy and sustainability. Examples of this could include:
  - Requirements for technical advisers to research, set and manage the progress towards an operational energy target
  - Property managers to have an active energy management role with reporting and benchmarking
  - FM providers’ contracts to include specific performance targets in terms of energy use and plant operation. An example of this could be to maintain boilers within +/- 5% of rated efficiency.
Appointment terms whether in a contract or professional appointments should incentivise integrated design and passive demand reduction. The means of achieving this are dependent on the form of procurement but may include:

- Requirements to demonstrate that the project is on course to meet energy target at a specific design stage before sign off and permission is given to proceed to the next stage. Fees/payments may be withheld as a penalty
- Fee structures based on a combination of performance and capital cost, avoiding traditional percentage fees for engineering services that incentivise higher capital spend
- Gain/pain share mechanisms for operational energy performance – for example as used in health Private Finance Initiative (PFI).

Good practice
Wherever possible design team fees should incentivise integrated design and passive demand reduction.

The additional duties beyond current standard contract clauses must include:

- A statement that the design team or delivery partner is contracted to design a low carbon building
- A requirement to carry out full dynamic thermal and visual modelling to optimise the low carbon design including at least six iterations of the façade simulation
- Adherence to the commissioning metering and monitoring requirements
- An acceptance that additional time must be included to permit the Architect and the Services engineer to carry out the additional liaison necessary to deliver a low carbon building and that this is covered by the agreed fees.

It may also be necessary to amend the stages at which certain services are performed.

Under all contracting structures, including those where the design team is not appointed by the client, these duties must be adhered to and included in the contracting arrangements.
Step 2. Design

The design step of the methodology assists in providing a holistic approach to design of the new build or refurbished building. It ensures that there is opportunity for innovative design approaches, that the design team is given sufficient information about the required internal environment of the building, that a commissioning strategy is planned as part of the design process and that regular reviews ensure that the design will meet the values set out by the client.

This step is usually design team led with support and monitoring provided by the low carbon adviser and in-house team.

A high level of interaction with the users may be required to ensure that the detailed targets are appropriate for the intended use.
A. Design charrette

Once the detailed room requirements and user specifications such as output specifications and functional relationships have been set, the detailed design process can be commenced.

A design charrette provides a forum for design concepts to be discussed. The aim of the charrette is to achieve the following:

- Setting quantifiable metrics to verify compliance with client objectives (if not already set)
- Helps all design team members understand the implications of agreed project objectives
- Sets project strategies for consideration of potential design solutions
- Reviews grants and aid available
- Identifies outline solutions for key design issues
- Identifies decision phasing (e.g. heat sources when demand defined)
- Identifies need and budgets for specialist input – e.g. simulation.

Good practice
A design charrette should be held with the entire procurement team to explore design concepts and to enable the client values to be disseminated to the team.

All members of the procurement team must attend the charrette. The results of the skills, knowledge and experience assessment should be available to inform the discussion on the need for specialist input. The charrette can be started by a short presentation of the elements required for a productive workplace and a reminder of the design hierarchy for successful low carbon buildings.
The design charrette also provides a good opportunity to discuss issues such as the amount of future proofing that can be included.

Buildings can be partially future proofed by a number of simple measures:

- Ensure that the building is designed for the forecast temperature increases due to climate change
- Ensure that there is sufficient space for additional service ducts to be installed
- Locate plant room on perimeter of building at ground floor level to allow for future expansion.

Technological advances in building materials and equipment are occurring constantly. The design charrette allows the discussion of new technologies, the benefits that they can provide and the potential risks of implementation.

Some of the newer low carbon technological advances include:

- Phase change materials: materials that utilise the change from solid to liquid to absorb excess heat. They enable thermal mass to be introduced to a building without extensive use of concrete, stone and other materials with high thermal capacity
- Dynamic insulation: ventilation air is drawn into a building through the insulation tempering the air and recovering heat from the insulation
- Direct ground source cooling: water is drawn into a building through a borehole beneath the building providing cooling water at around 14°C.

The Carbon Trust recommends using no more than one LZCT (Low and zero carbon technologies) for heating in a building following the experience of the Low Carbon Buildings Accelerator Programme (Power Play - CTG050).

A discussion of IT requirements and server rooms also needs to be included, as these are substantial energy requirements. Server rooms need only be cooled to 27°C within the racks according to the ASHRAE guidance, which can be done with filtered high volume outside air when placed on a north or east wall. The new Class D equipment is rated to 40°C. The ultimate is of course to be able to use this heated air closeby in the building during the heating season.

Risks

- Integration of multiple cutting edge technologies can cause issues
- Complex control, operation and maintenance requirements may cause problems for the building operators and users.
B. Establishing detailed targets

Detailed requirements will need to be established for the building as a whole and for each room in the building. This is a time consuming process involving a combination of design team participants and representatives of the users. The user representatives will include final users of the building, those that will be operating and maintaining the building and service providers to the building such as IT.

At a minimum, the detailed targets should cover the following elements:

- Design compliance
  - Artificial lighting efficiency and high level control
- Performance in use
  - Daylight requirements to displace artificial lighting
  - Temperature limits
  - HVAC controls
  - CO₂ limits and ventilation rates
  - Design heat gain from equipment
  - Artificial lighting quantity, quality
  - Detailed lighting control
  - Acoustic parameters
  - Surface reflectances
  - Solar gains during heating and non-heating seasons.

These will normally be set out in a combination of a detailed environmental brief, schedules and room datasheets. Appendix 7 shows an example of the detailed environmental brief, Appendix 9 shows an example of the environmental schedules and Appendix 10 shows an example of the environmental elements of the room data sheet.

The advantage of setting performance in use targets is that the designers have far greater design freedoms. It is important to strike a balance between rigid targets and common sense that a small percentage of the building will not meet the specification.

C. Commissioning strategy

Commissioning is vital to the efficient operation of a building. It is normally specified on a system-by-system basis, which can lead to poor interfaces and conflicting operation – for example a heating system operating simultaneously with a local cooling system.

A commissioning strategy needs to be set at an early stage in the project. This allows the necessary monitoring to be incorporated into the design and will also assist in ensuring that sufficient consideration is taken of how the different elements of the building will work together.

Traditional commissioning requires that all systems are tested by manufacturers for correct and safe function, are wired correctly, connected as specified and that flow rates meet the design parameters. Results are reported to the M&E manager or consultant who may witness a sample of the results.

This process needs to be expanded to ensure that all of the separate elements of the building work together and are properly controlled. When the project is in the commissioning stage, it is important to determine that the design intent has been met, that the systems have all been commissioned and that satisfactory internal conditions are achieved.

Commissioning of individual systems in isolation may achieve this but are unlikely to optimise energy performance. For this, the interaction of systems, the building and its users needs to be considered. It is at this point that many buildings fail to achieve the expected performance.
The following processes need to be included:

- Manage the interface between systems
- Decide on a control strategy that takes into account the characteristics of the systems controlled and the building (For example is it lightweight? heavyweight? intermittent? What is the furniture layout? Have any changes occurred during construction which may affect the strategy)
- Ensure it is tested in practice that the strategy works, and minimises energy use.

The client, backed up by the contract documents, should make it clear that a building will only be accepted as practically complete once it is proved to be operating efficiently.

The strategy needs to detail the roles and responsibilities of the individuals involved in commissioning and detail the checks and reviews that are required.

To achieve a comprehensive commissioning process the following roles and reviews are required:

(1) Overview role

An overview role is performed by a commissioning adviser. This may be the low carbon adviser or a member of the design team if they have a suitable skillset. Otherwise, a specialist commissioning adviser should be appointed.

The adviser will be responsible for monitoring the commissioning and ensure that a sufficiently robust process is followed. They also need to ensure that the commissioning follows an iterative rather than linear process extending into occupation and seasonal operation to allow the building to be fine-tuned.

Where BREEAM is required, it is mandatory to have a commissioning adviser. However, the BREEAM specification for the role is insufficient to meet the requirements recommended in this guide.

(2) Other roles

The main contractor has an important role in the management and coordination of trades and in allowing adequate time in the programme.

The client and project manager must coordinate with users/occupier to determine how they will use the building and communicate this to the commissioning team.

A controls expert may also be required for buildings that are more complex.

(3) Reviews

Into detail design phase, when working drawings are being prepared, it is recommended that the design is reviewed by the commissioning adviser, or a commissioning agent who can be an external consultant or a member of the contractor’s team. The aim would be to ensure that the systems can be commissioned accurately, that all measurement devices can be accessed and are likely to record and measure sufficient parameters to demonstrate that the system is operating to the design conditions.

At this stage, a controls review should also be undertaken. The designer may need to work with a controls specialist to make sure that the design intent is understood and that sufficient inputs and outputs to the control system have been allowed. Even on the simplest scheme, a review to make sure for example, that temperature detectors are not near sources of heat gain is worthwhile.

A controls specialist can provide valuable input to the design in terms of the practicality and robustness of the design intent and a balance between over complexity and maximum efficiency reached.

The building documentation and logbook should also be reviewed as part of the commissioning process along with the proposed training for the facilities manager or janitor who will be responsible for the building.

Good practice

A commissioning adviser should be appointed at commencement of stage D and should attend design and progress meetings at least every 2 months.

Where a commissioning manager is used, they should be experienced in energy issues OR work under the direction of an energy specialist.

The main contractor coordinates and programmes the activities and allows sufficient time for fine-tuning.

The client accepts the building when proven to work efficiently.
D. Design evaluation

Once a contract is awarded or a traditional design is underway, there needs to be a number of key reviews to establish that the energy and sustainability objectives are being met.

There needs to be a role of monitoring and evaluating the emergent design, measuring against the sustainability and low carbon objectives set in the brief. Where BREEAM is used, the audit role to assess whether the BREEAM rating will be achieved will be undertaken by the assessor.

There is another vital role to be undertaken by the low carbon adviser where operational energy targets have been set. The building blocks of the design that will make the target achievable will gradually emerge through energy modelling, building and system design, and procurement of plant and equipment. These need to be monitored and compared to baseline assumptions to ensure the development is on track to meet the targets. This needs to be undertaken early enough so that remedial action can take place before procurement decisions are made.

Depending on the scale and complexity of the project, the low carbon adviser, or energy specialist should review reports such as façade studies, the energy model, a sample of building and building engineering drawings and specifications to test the probability of the design achieving the targets set. This should be reported and tracked and the client needs to ensure action is taken where necessary.

Other specialists can make a valuable contribution in terms of the commissioning, controls and FM.

Good practice

The design must be continually monitored to ensure that the required targets will be met. Any deviations must be highlighted and remedial actions taken.

E. Financial, contractual and risk arrangements

During the design process it is essential that the financial and contractual arrangements required to deliver the building be considered.

(1) Financial arrangements

Many modern, low carbon buildings use multiple innovative technologies to achieve their low carbon credentials. This is especially true of some renewable technologies. If any such technologies are planned, the financiers of the project should be contacted early in the decision making process to ensure that the technology’s use will not cause an issue with funding.

It is also essential that funders understand how whole-life costing will be applied to the project and will form the basis of decisions. This may require a shift of funding from an operating cost budget to a capital budget.

(2) Contractual arrangements

It is possible to set a wide variety of targets for a building but it must be remembered that any targets used must be measurable and responsibility for their achievement must be clearly defined. This will enable the target to be successfully combined into the relevant contract. Failure to consider these two factors will render a target useless.

(3) Risk arrangements

A number of aspects of this guide require minor deviations from traditional contracting practises. It must be ensured that any legal advisers and insurers are aware of these changes so that their services can be adjusted accordingly.

Risks

- Care should be taken when specifying new technologies as financiers may be unwilling to accept their use
- It may be more challenging to insure performance in use contracting
- Inadequate capital budgets has been behind many failures to achieve low carbon buildings.
**Step 3. Pre-construction**

Steps 1 and 2 of this guide will have ensured that an appropriately skilled team has developed a low carbon design with optimal environmental conditions. All of these benefits can be lost if they are not translated into robust contractual terms and delivered by a construction team with the necessary understanding and skills.

---

### Preparation
- In-house team selection
- Setting the values and overarching targets
- Organisation preparation
- Site selection
- Bidding teams selection

### Design
- Design charrette
- Establishing detailed targets
- Commissioning strategy
- Design evaluation
- Finance, contractual and risk arrangements

### Pre-construction
- Bid evaluation
- Financial close

### Construction
- Commissioning

### Use
- Monitoring and reporting
- Verifying of performance in operation
- Post occupancy evaluation

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Evaluating the tenders and ensuring that key design features are not lost without the implications being understood is a key task of both the in-house team and the low carbon adviser.

<table>
<thead>
<tr>
<th>Process</th>
<th>Responsible person</th>
<th>Deliverables</th>
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<td>Project owner</td>
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<td>Bid evaluation</td>
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<td>Review of tenders</td>
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<td>Financial close</td>
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<tr>
<td>Review of value engineering decisions</td>
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- ○ main driver
- ○ additional driver

Report on low carbon aspects of tender

Report on impact of decisions
A. Bid evaluation

The key to good bid evaluation is to be explicit and detailed in what needs to be returned with tenders.

The extent of return information needs to be proportionate to the size of scheme, but the principles are the same for any scheme:

• The nature of the information required from the tenderers should be verifiable and consistent
• The requirements for bid returns should be a team effort to avoid overlap and confusion (this is also true of the output documents)
• The low carbon adviser should provide guidance to the evaluation and dialogue process and should provide a review of the dynamic thermal simulation model
• The quality scoring should be made available to the tenderers
• All bids must be comparable and the scoring must be performed on the same basis
• Any areas where the specification brief could not be fully met for low carbon or ease of use/maintenance reasons must be highlighted. Some Clients allow a non-conformity of a certain percentage and it is up to each design team to balance capital cost against ease of use and operational cost.

As far as possible require the tenderer to use proformas such as the skills, knowledge and experience tool, forms and schedules to be filled in as this makes comparison between tenders easier.

Allow time or have a mechanism such as competitive dialogue to seek clarification to reduce any uncertainty on the intent of the contractor. This dialogue is also a good opportunity to get to know the bidders team and assess their abilities and attitude.

During dialogue and/or once tenders are returned, analysis will determine that:

• The bid information requested is complete and robust – commercial skills can be needed here to detect ambiguity
• Any commitments made are consistent with other information – for example, if a general commitment to good insulation has been made in the sustainability section, that this is confirmed by good U values in the architectural specification.
• The commitments made are then embedded in the formal contract and are not lost as aspirations at tender stage
• The commitments in terms of energy and sustainability are realisable in practice.

The tender stage for larger projects requires method statements relating to the design process and an energy model based on the design. The methodology for the model should be explicit in the ITT documents to enable like for like comparison between tenders. This needs to be evaluated in detail. The attitude and willingness of the contractor to adopt the ways of working outlined in this guide must be established.

Past performance, references relevant to sustainable design and unambiguous statements can all form part of a quality score which when combined with the cost leads to a “most economically advantageous tender” evaluation.

B. Financial close

Many low carbon and sustainable features are lost at financial close due to value engineering.

This can be avoided by ensuring that the effect of any options proposed for reducing capital costs or risks are properly evaluated by assessing the impact using the thermal dynamic model and evaluating the whole-life cost impact to ensure that it still meets the best value criteria.

Care needs to be taken that targets are not watered down by other commitments made to reduce capital costs. For example, a commitment to comply with the lighting elements of the building regulations instead of meeting the lighting targets will have implications for the productive workplace and may result in increased internal gains contributing to an overheating problem. One common problem encountered is automatic lighting controls being removed at the value engineering stage. If proper whole-life costing is used this type of decision is not possible.

Good practice

Any value engineering that takes place must have its implications on the whole building performance fully assessed.
Step 4. Construction

At the construction stage the emphasis is on close monitoring of the build and a robust commissioning procedure.

The low carbon adviser and the commissioning agent will perform the main roles at this stage, reporting regularly to the project owner on progress.

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<th>Process</th>
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<td>Project owner</td>
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<td>Construction</td>
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<td>Contractual issues</td>
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<tr>
<td>Commissioning Review</td>
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</table>

○ main driver ○ additional driver
A. Construction contractual issues
Ensuring a well-designed building is delivered is reliant on effectively structured contracts.

The contractual structures and drafting must ensure that the contractor is legally obliged to deliver a building that meets the required performance in use standards. This will require them to allow monitoring of the build by suitable individuals from the client team, which will include the low carbon adviser and the commissioning agent. It may also include a Clerk of Works if one is used. The low carbon adviser will be maintaining the carbon tracker during the build process and it should be a requirement of handover that all items on the tracker are completed. This will require additional clauses to be added to the standard construction contracts.

**Good practice**
The contractor must be legally obligated to provide sufficient access to the necessary client team members to ensure that the building to be delivered meets its design intent.

In many contracts the contractors are allowed to substitute similar material and equipment to those initially specified. This can be avoided by specifying negotiable and non-negotiable requirements in the contractual obligations.

Where substitutions are permitted it must be ensured that the item’s low carbon performance is equivalent or better than that which it replaced. It must also not increase the project’s whole-life costs. This will require running the dynamic thermal simulation to determine its impact on the building performance. For example, changing an element of the building fabric for another with a similar u-value may have an impact on thermal mass of the building. Only by modelling the change will the multiple benefits of a single element of the building be understood.

**Good practice**
Material of equipment substitutions should only be allowed if the impacts on the building performance and operating costs are fully modelled.

Build quality must also be tightly monitored. Regular checks should be made on all relevant parts of the build to ensure that quality levels are maintained. For example, the integrity of the insulation installation should be frequently tested.

**Risks**
Problems in construction can occur due to a number of issues:
- Complexity of buildings
- New building techniques
- New materials
- Air tightness requirements
- Thermal bridging.

B. Commissioning
As was discussed in the “Setting the scene” document a robust commissioning process will play an important role in identifying defects, ensuring controls are correctly set and that the building meets its design intent. This strategy will have been set at the design stage.

The timing of the commissioning checks will be key. It should consist of an iterative process starting with simple checking of a piece of equipment under test conditions but then moving on to further checks to ensure that the control strategy is acceptable and that it interacts correctly with other equipment and building fabric. Final checks are to occur once users have occupied the building to ensure that the systems and controls are appropriate for the way the building is used.

For example,
- Time settings may not have been checked with the users;
- Daylight sensors may not be adjusted to the reflectances once the furniture and flooring are in place and;
- The physical checks that the temperatures being read by the Building Management System (BMS) are accurate and representative of the space may not have been undertaken.

Responsibility needs to be allocated to an appropriate person. The building is not to be accepted for practical completion until it can be reasonably demonstrated that it is performing as required and intended.

Finally, the future FM provider or FM contract manager needs to review the building to make sure that maintenance will be easy and low cost. This review looks at ease of access; minimising the number and cost of spares and consumables; and planning for the skills needed to maintain the building in optimum condition.
Step 5. Use

The period between practical completion and the end of the defects period allows for detailed monitoring of the building to ensure that it meets its design intent and to identify and rectify any issues found.

The on-going monitoring of a building once construction has been completed is often neglected. Ensuring that this does not occur requires responsibility to be allocated to an appropriate individual. This may be a member of the in-house team, the low carbon adviser or the commissioning agent.

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<thead>
<tr>
<th>Process</th>
<th>Responsible person</th>
<th>Deliverables</th>
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<tr>
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<tr>
<td>Continuous and spot monitoring</td>
<td>Project owner</td>
<td>Monthly reports</td>
</tr>
<tr>
<td>Verifying of performance in operation</td>
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<tr>
<td>Review</td>
<td>Finance director</td>
<td></td>
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<tr>
<td>Post occupancy evaluation</td>
<td>In-house team</td>
<td></td>
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<tr>
<td>Evaluation</td>
<td>Project manager</td>
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<td>Low carbon adviser</td>
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<td></td>
<td>Commissioning adviser</td>
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<td></td>
<td>Design team</td>
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</table>

- main driver
- additional driver
A. Monitoring and reporting

A monitoring and reporting strategy will have been considered early in the design process to allow the necessary monitoring equipment to be installed.

The strategy should have two aspects. The first is that it must enable all of the targets specified in the overarching technical brief and the room data sheets to be monitored during the commissioning period. The second aspect is that it must allow on-going monitoring of the building ensuring that any equipment issues are quickly identified and unwanted user behaviour recognised and addressed and therefore avoidable waste minimised.

The strategy is likely to consist of a combination of continuous monitoring and spot checks. The continuous monitoring is normally carried out by automated meter readers, sub metering and building management systems. Thermometers, humidity meters, light meters and CO₂ meters can be used to carry out spot checks.

Where an energy target has been set, operational use needs to be compared to the assumptions modelled during the design phase. This will include hours of use, the floor area occupied, and the weather conditions compared to the model, density of small power installed and characteristics of usage. Where equipment power is likely to be a major source of carbon emissions, lighting and power metering need to be separate to enable trends in each to be identified.

Regular reports will be required detailing the results of the monitoring. The following reports are recommended.

- Monthly detailed report to design team and building operators on results of monitoring, overall efficiencies, building balance temperature, boiler condensing, how much day-lighting is replacing artificial lighting.
- Monthly report to senior management during commissioning and defects period on deviations from targets showing who “owns” the problem, how much it is costing and the recommended action to rectify it. A breakdown into different areas and ranking them according to over spend with an associated cost makes the exercise more meaningful.

One-off reports will also be required. After one year of operation a comparison between actual costs and those forecasted in the whole-life costing model should be provided.

B. Verifying performance in operation

As part of the preparation and design steps both overarching and detailed targets will have been set and will have been given contractual weight. These will require verifying.

Where an operational energy target has been set and particularly where there are contractual implications on failure to meet the target, a formal programme of review is recommended. This will set the intervals of review, define the extent of the review and record the usage and weather factors affecting energy use.

For more complex schemes where there is a contractual requirement to meet a target, it is recommended that during the two or three year “proving” period, the contractor is required to allocate a suitably skilled energy manager to provide active energy management and to provide a detailed report on actions undertaken.

C. Post occupancy evaluation

Post occupancy evaluation is a valuable tool to identify the success of the building in achieving its low carbon objectives without compromising the internal environment.

The timing of the review is key. A survey that takes place three to six months after a building has been occupied will probably be biased by the inevitable teething problems. This can be very useful for identifying these issues but will not give an overall view of whether the building has met its low carbon objectives.

Once these issues have been rectified a more balanced opinion should result from the evaluation. This will normally occur after the end of the first year of occupation has been completed.

The method of performing the post occupancy evaluation to ensure that it captures sufficient information on the low carbon aspects needs consideration. Typical techniques include:

- Evaluation of monitoring data
- Walk through and observation
- Interviews
- Questionnaires
- Focus groups
- Workshops.

The choice of which of these to use will depend on the building use and the particular aspects requiring investigation.
4. Bibliography

1. Scottish Government.  

2. Feist, Dr. Wolfgang.  

3. BSI.  

4. HM Treasury.  

5. Ofgem.  

## 5. Definitions and acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ACH</td>
<td>Air changes per hour.</td>
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<tr>
<td>BMS</td>
<td>Building Management System – a computer based system to control building services. Sometimes also called BEMS, with an energy inserted.</td>
</tr>
<tr>
<td>BREEAM</td>
<td>Building Research Establishment Environment Assessment Method.</td>
</tr>
<tr>
<td>Cd/m²</td>
<td>Candela per metre squared. This is a measure of brightness of light reflecting back from a surface.</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide. 1)Related to emissions leading to climate change. 2) emissions from breathing out giving a stuffy environment in a room.</td>
</tr>
<tr>
<td>EPC</td>
<td>Energy Performance Certificate.</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating Ventilation and Air Conditioning. Generally referring to mechanical ventilation through ducting that can be heated or cooled according to requirement.</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology, normally referring to computers.</td>
</tr>
<tr>
<td>ITT</td>
<td>Invitation To Tender – A document by a Client that stipulates the Employer’s requirements inviting a response from the market that will be used to decide who to engage.</td>
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<tr>
<td>Lux</td>
<td>The light output from a lamp is illumination and its level is measured in lux.</td>
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<tr>
<td>LZCT</td>
<td>Low and zero carbon technologies.</td>
</tr>
<tr>
<td>NEC</td>
<td>‘New Engineering Contract’ from 1993, that are used as a standard contract for building and design contractors.</td>
</tr>
<tr>
<td>PFI</td>
<td>Private Finance Initiative – a means of private money being invested into public buildings that is paid back during the operation of the building.</td>
</tr>
<tr>
<td>Design charrette</td>
<td>A design charrette looks at the different options of the design that could be used for the building taking into consideration the values.</td>
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<td>------------------</td>
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</tr>
<tr>
<td>Overarching brief/targets</td>
<td>Overarching targets that set out what a building has to conform to overall, and take precedence over room data sheets.</td>
</tr>
<tr>
<td>Passive demand reduction</td>
<td>Reduction in energy requirements through location of windows to reduce electricity for lights; location of windows to gain from solar heat during the winter but avoid it in summer; orientation of a building to reduce air leakage rates through entrance doors and ventilation; heavyweight structure of a building to allow night time cooling in summer avoiding chilling requirements.</td>
</tr>
<tr>
<td>Reflectance</td>
<td>The amount of light that is reflected from a surface. A glossy surface is 100, a matt surface is 0.</td>
</tr>
<tr>
<td>Room data sheets (RDS) – environmental schedule</td>
<td>Room data sheets give information to designers what is required in different room types for the users. An environmental schedule will detail the temperature and lighting requirements in a table format. The overarching targets are for the whole building, and supersede any information in conflict with RDS.</td>
</tr>
<tr>
<td>Thermographic survey</td>
<td>A survey using an infrared camera that has different colours according to temperature. Generally you do it in winter, and heat the building extra high, so that areas of high heat loss show up.</td>
</tr>
<tr>
<td>Value engineering</td>
<td>The cost cutting exercise after a design has been put together to ensure it can be funded.</td>
</tr>
<tr>
<td>Visual comfort</td>
<td>The comfort that our eyes like. The eye regards 30-200 cd/m² as perfect, but 30-700 cd/m² very workable. If a range of 1:100 is in view then this gives eye strain.</td>
</tr>
<tr>
<td>Whole-life costing</td>
<td>A means of costing investment to see what it is worth over its life, including increase in costs above inflation, replacement cost during its life, etc. The standard investment criteria looks at simple payback and takes only account of capital and annual running cost at today’s value.</td>
</tr>
</tbody>
</table>

| ppm | Parts per million – a measure of CO₂ concentrations. Background CO₂ causing Climate Change is now at 380 ppm. The World Health Organisation (WHO) proclaims that no one should be in a room of over 2500 ppm. |
| PQQ | Pre Qualifying Questionnaire. |
| sBEM | Simplified Building Energy Model – a simple model (not dynamic) used by Building Standards to model energy to be used by a notional building for regulatory compliance. |
Appendix 1. Value charrette agenda

Introduction

Introductions
Management and team member introductions.

Introductory presentation
Presentation on the duty to reduce emissions according to the Climate Change Act Scotland (2009), the financial benefits of a sustainable approach and the importance of a productive workplace.

The project

Project aim
Discussion of the aim of the project e.g. “to provide a good working environment at as low a cost as possible”.

Project values
Selection of at least five values that the project must meet such as “good internal working environment” or “low whole-life costs”. These need to be ranked in order of importance.

Identification of the key integrated design issues
Identification of the key integrated design features such as no air conditioning, no cooling below 26 °C etc.

Overarching targets
Agreeing the use of overarching targets and specifying which ones to use.

Organisational issues

Review of project value and preparation tool output
Discussion of the strengths and weaknesses of the organisation and how these will impact on the delivery of a low carbon building.

Budget availability and payback criteria
Confirmation of the capital and operating budgets available for the building and confirmation that whole-life costing will be used to evaluate options.

Confirmation of the payback periods permissible for low carbon measures, this is typically 10 years for building fabric measures.

Basis for cost cutting measures on completion of design
Agreement of any areas that will be ring-fenced if a project cost cutting basis takes place and agreement that whole-life costing will be used to assess the impact of the measure.

People issues

Key stakeholders
Discussion of key stakeholders who will need to be consulted about the project including the users, facilities management, the IT department, etc. This must include all parties who will be involved in the specification of furniture and equipment for the building and anyone involved in operation of the building.

Skills, knowledge and experience assessment
Discussion of and commitment to use the Skill, Knowledges and Experience tool to assess the in-house expertise and identify the areas where additional training or external assistance may be required.

Identification of the individual to be appointed as the low carbon adviser
Identification of a suitably skilled individual to monitor and report on the low carbon credentials of the project and maintain the low carbon tracker.
Appendix 2. Value charrette report template

Project:  
Date:  
Present at meeting:  

<table>
<thead>
<tr>
<th>Project aim</th>
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<td>Project values</td>
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<td>Main design issues</td>
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<td>3.</td>
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<tr>
<td>Budget availability</td>
<td>Capital:</td>
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<td></td>
<td>Operational:</td>
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<tr>
<td>Payback criteria for low carbon measures</td>
<td>e.g. 10 Years</td>
</tr>
<tr>
<td>Commitment to using full whole-life costing</td>
<td>Statement such as: “We commit to use whole-life costing to evaluate the project in accordance with the Carbon Trust publication: Delivering the future, today”</td>
</tr>
<tr>
<td>Cost cutting measures methodology and red lines</td>
<td>Statement such as: “We commit to use whole-life costing when determining measures for cost cutting.”</td>
</tr>
<tr>
<td>Key stakeholders</td>
<td></td>
</tr>
<tr>
<td>Skills, knowledge and experience issues identified</td>
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<tr>
<td>Low carbon adviser</td>
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## Appendix 3. Overarching targets

<table>
<thead>
<tr>
<th>Target</th>
<th>Description</th>
<th>Good practice</th>
<th>Best practice</th>
<th>How measured (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 EPC rating</td>
<td>EPC Rating without use of renewable technologies</td>
<td>B+</td>
<td>A</td>
<td>sBEM or dynamic simulation</td>
</tr>
<tr>
<td>2 Operating target</td>
<td>What the building energy target is once in operation including the time schedules, IT loads, etc.</td>
<td>office</td>
<td>office</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+40kgCO$_2$/m$^2$</td>
<td>school</td>
<td>school</td>
<td></td>
</tr>
<tr>
<td>2 Daylight (design target)</td>
<td>The lighting energy used in the whole building under full occupancy on a bright day (sky illuminance &gt;15,000 lux) shall be at least X% lower than on a dull cloudy day (sky illuminance &lt;2,000 lux). This requirement aggregates lighting energy for all spaces in the building.</td>
<td>40%</td>
<td>55% or better</td>
<td>Lighting energy must be separately metered. Spot readings of outside lux levels taken with a light meter.</td>
</tr>
<tr>
<td>3 Artificial lighting energy</td>
<td>Lighting energy in spaces larger than 20m$^2$, occupied for more than two hours per day shall be not more than $X$ W/m$^2$/100 lux. Luminaire light output ratios must be better than 80%.</td>
<td>2.4 W/m$^2$/100 lux</td>
<td>2.0 W/m$^2$/100 lux</td>
<td>Separate metering of lighting electricity consumption. All lights in rooms greater than 20m$^2$ to be switched on with all other lights off for monitoring period.</td>
</tr>
<tr>
<td>4 Maximum lux levels</td>
<td>Unless otherwise specified, in spaces with an areas greater than 15m$^2$ the maximum light level from indoor artificial lighting shall not exceed the required lighting level by more than the sum of $X$ lux + Y% of the required lighting level at any point in the space.</td>
<td>50 lux + 30%</td>
<td>40 lux + 30%</td>
<td>Spot measurements with a lux meter.</td>
</tr>
<tr>
<td>5 The heating balance temperature of the building for all spaces</td>
<td>The outside air temperature on a bright cloudy (low cloud preferred) day at which internal gains just supply all the heating energy to maintain the specified internal operative temperature, for densely occupied spaces (at least 1 person per 3m$^2$) shall be not more than $X$˚C. Maximum internal gains (metabolic and equipment) during the measurement period must not exceed 50 W/m$^2$.</td>
<td>10˚C</td>
<td>8˚C or lower</td>
<td>Continuous monitoring of inside and outside air temperature preferred but spot measurements acceptable. Continuous or spot monitoring of heating distribution plant operation.</td>
</tr>
</tbody>
</table>

1 All meters used for monitoring to be calibrated to the appropriate standard and have an adequate level of accuracy.
### 6. Summertime overheat

Whenever the outside air temperature is above 23°C, and the diurnal temperature range (lowest temperature from the previous night to the maximum daytime temperature the following day) exceeds 4°C, the internal operative temperature shall not exceed the outside air temperature by more than X°C for the first eight hours of substantive operation each day. This shall apply for internal gains (excluding insolation) up to 80 W/m².

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2°C</td>
<td>-2°C or lower</td>
<td>Continuous monitoring of inside and outside air temperature preferred but spot measurements acceptable.</td>
</tr>
</tbody>
</table>

### 7. Heating load under design conditions (2)

The maximum heating load for the whole building under design conditions, with occupancy gains, but no lighting or solar gains, with internal conditions as defined in the Room Data Sheets, shall be no more than X W/m². Recovery time should be considered with the building temperature able to be increased by at least 0.3°C/hour under design conditions without occupancy.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 W/m²</td>
<td>10 W/m²</td>
<td>Heat metering of the flow to the distribution system or input fuel monitoring, monitoring primary and secondary pump energy use to determine heat gains.</td>
</tr>
</tbody>
</table>

### 8. Hot water service operating efficiency

The overall efficiency (defined as energy contained in the hot water exiting from the tap or shower head, related to the supply side energy used for hot water generation) shall not be less than X% on an annual basis.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>45%</td>
<td>55%</td>
<td>Flow metering of domestic hot water. Annual calculation comparing energy in hot water used compared to fuel input for hot water adjusted for efficiency.</td>
</tr>
</tbody>
</table>

### 9. Heating losses

The boiler standing losses shall not exceed X% of the heat input on an annual basis.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>20%</td>
<td>Flow metering and temperature monitoring of heating distribution inlet and outlet.</td>
</tr>
</tbody>
</table>

### 10. Ventilation during occupied hours

CO₂ shall not exceed X ppm under any conditions for more than 20 minutes in each working day.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500 ppm</td>
<td>1000 ppm</td>
<td>Continuous monitoring of extract air by BMS or spot checks using a CO₂ meter.</td>
</tr>
</tbody>
</table>

### 11. Air tightness

Air-tightness detailing and testing to achieve <X m³/hour.m² façade at 50Pa

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 m³/hour.m²</td>
<td>1 m³/hour.m²</td>
<td>Air pressure testing.</td>
</tr>
</tbody>
</table>

### 12. Heat distribution

All room temperature sensors used to control room temperatures shall at all times measure a temperature that does not deviate from the air temperature by more than X°C

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2°C</td>
<td>1°C</td>
<td>Spot checks with a handheld thermometer</td>
</tr>
</tbody>
</table>

---

2 This is based on a design temperature of -4°C and will require adjustment for different design temperatures.
Appendix 4. Whole-life costing

The Office of Government Commerce gives a definition of whole-life costing in its publication “Whole-life costing and cost management.”

“The whole-life costs of a facility (often referred to as through-life costs) are the costs of acquiring it (including consultancy, design and construction costs, and equipment), the costs of operating it and the costs of maintaining it over its whole-life through to its disposal – that is, the total ownership costs. These costs include internal resources and departmental overheads, where relevant; they also include risk allowances as required; flexibility (predicted alterations for known change in business requirements, for example), refurbishment costs and the costs relating to sustainability and health and safety aspects.”

What it should include

The following table shows what elements should be included in the calculation of whole-life costs for a new build, building refurbishment or leased building. It is based on a combination of BS ISO 15686 Part 5 (3) and advice in the Treasury Green Book (4).

Items in bold are deemed to be essential.

<table>
<thead>
<tr>
<th></th>
<th>Acquisition/Construction</th>
<th>Operation and maintenance</th>
<th>End of life costs and residual value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New build</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site costs (purchase, improvement, infrastructure provision)</td>
<td></td>
<td>The performance over time of each element</td>
<td>Inspection costs</td>
</tr>
<tr>
<td>Design/Engineering costs</td>
<td></td>
<td>Costs associated with degraded performance</td>
<td>Decommissioning costs</td>
</tr>
<tr>
<td>Regulatory/Planning costs</td>
<td></td>
<td>The likely lifetime of each element</td>
<td>Recycling costs</td>
</tr>
<tr>
<td>Construction and earthworks</td>
<td></td>
<td>Maintenance and replacement costs</td>
<td>Disposal costs</td>
</tr>
<tr>
<td>Commissioning costs/fees</td>
<td></td>
<td>Cleaning and minor repairs</td>
<td></td>
</tr>
<tr>
<td>Business use of in-house resources and administration</td>
<td></td>
<td>Costs associated with loss of amenity due to unavailability or failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy, other utility and carbon costs</td>
<td></td>
</tr>
<tr>
<td><strong>Refurbishment</strong></td>
<td>Initial survey costs</td>
<td>The performance over time of each element</td>
<td>Inspection costs</td>
</tr>
<tr>
<td>Design/Engineering costs</td>
<td></td>
<td>Costs associated with degraded performance</td>
<td>Decommissioning costs</td>
</tr>
<tr>
<td>Regulatory/Planning costs</td>
<td></td>
<td>The likely lifetime of each element</td>
<td>Recycling costs</td>
</tr>
<tr>
<td>Decanting costs</td>
<td></td>
<td>Maintenance and replacement costs</td>
<td>Disposal costs</td>
</tr>
<tr>
<td>Decommissioning, recycling and disposal costs of existing equipment and building fabric</td>
<td></td>
<td>Cleaning and minor repairs</td>
<td></td>
</tr>
<tr>
<td>Construction and earthworks</td>
<td></td>
<td>Costs associated with loss of amenity due to unavailability or failure</td>
<td></td>
</tr>
<tr>
<td>Commissioning costs/fees</td>
<td></td>
<td>Energy, other utility and carbon costs</td>
<td></td>
</tr>
<tr>
<td>Business use of in-house resources and administration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lease</strong></td>
<td>Lease administration costs</td>
<td>Lease costs</td>
<td>Removal costs</td>
</tr>
<tr>
<td>Temporary costs/Decanting costs</td>
<td></td>
<td>Costs rechargeable by landlord</td>
<td>Reinstatement costs</td>
</tr>
<tr>
<td>Design/Engineering costs</td>
<td></td>
<td>Maintenance and replacement costs</td>
<td></td>
</tr>
<tr>
<td>Regulatory/Planning costs</td>
<td></td>
<td>Cleaning and minor repairs</td>
<td></td>
</tr>
<tr>
<td>Fit out costs</td>
<td></td>
<td>Costs associated with loss of amenity due to unavailability or failure</td>
<td></td>
</tr>
<tr>
<td>Commissioning costs/fees</td>
<td></td>
<td>Energy, other utility and carbon costs</td>
<td></td>
</tr>
<tr>
<td>Business use of in-house resources and administration</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The decision on which elements to include will depend on the type of building and services.
The process
To produce a robust whole-life costing model is a reasonably simple process of the following four steps:

- **Determine Methodology**
  - Forecast period
  - Real or nominal model to be used
  - Elements to be included
  - Discount rate to be used

- **Agree Forecasts**
  - Inflation (if nominal)
  - Energy prices
  - Carbon price

- **Determine Costs and Timescales**
  - For each major item or group of items
  - Acquisition/construction costs
  - Operating and maintenance costs
  - Expected life
  - End of life costs
  - Residual value

- **Build Model**
  - Build a simple spreadsheet programme or use specialist software to develop your baseline model

If it is intended that the Project Quantity Surveyor carries out the whole-life costing, their credentials and methodologies should be carefully investigated during the design team appointment stage of the project.

Selecting an energy price forecast
Most organisations assume that the energy prices will follow inflation, and use a simple payback period for decision making as a conservative option. However, using no increase beyond inflation is the one scenario that is definitely incorrect. It is possible to purchase forecasts from a number of organisations but these can be expensive. Most organisations choose to base their forecasts on publicly available information. Ofgem has recently been running a project to investigate the UK’s security of supply. As part of this, they have devised four pricing scenarios each with different predictions of growth and legislation. These can be seen in their publication “Energy market scenarios update” published in February 2010 (5). These show an increase in real terms (without accounting for inflation) of between 94% and 115% for electricity costs and between 64% and 139% for gas costs by 2020. This is equivalent to a year on year increase of between 5% and 8%. This is consistent with the price increases trend that has occurred since 2003 as evidenced in the Department of Energy and Climate Change publication “Quarterly Energy Prices” (6).

It is recommended that three energy price scenarios are used:

- **Low Case**: 5% per annum real increase
- **Base Case**: 6.5% per annum real increase
- **High Case**: 8% per annum real increase

The impacts of these forecasts on a 2010 electricity price of 12 p/kWh are shown in the graph below:
Appendix 5. Project report: Outline business case strategy

Project:
Date:
Present at meeting:

Project summary

e.g. Replacement or refurbishment of existing training centre. Resulting solution to enable increase of number of trainees at any one time to 200. Four new additional ICT suites to be provided. A canteen and showers to be included. etc.

Options to be considered

e.g.
Refurbishment of existing building
Relocating to another existing building
Demolishing existing building and rebuilding
Building on different site.

Outline business case evaluation requirements

E.g.
To take into account reductions in productivity due to building internal environment including visual comfort, acoustics and thermal comfort
Additional design fee requirements
To take into account whole-life costing, an energy and carbon price forecast to be used (state which forecast).
Appendix 6. Design charrette agenda

Project values overview
The results of the value charrette to be disseminated to all participants.

Overarching targets
If no overarching targets have been set, they should be set at this stage. If they are already in place they should be disseminated to the participants.

Strategy discussion
Sets project strategies for consideration of potential design solutions.

Review of grants and aid available
Discussion of any potential sources of funding for low carbon features.

Design issues
Identifies outline solutions for key design issues.

Decision phasing
Identifies decision phasing (e.g. heat sources when demand defined).

Resourcing plan
Identifies need and budgets for specialist input – e.g. simulation.
### Appendix 7. Low carbon tracker

Extract from the low carbon tracker tool:

<table>
<thead>
<tr>
<th>ISSUE/REFERENCE</th>
<th>ISSUE OWNER</th>
<th>EVIDENCE AND/OR ACTION REQUIRED</th>
<th>DATE OR DESIGN STAGE REQUIRED</th>
<th>Status</th>
<th>OUTCOME, DATE COMPLETED, DOC. REF.</th>
<th>Carbon Trust further literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant space and access studies</td>
<td>Plant space and access studies</td>
<td>Space studies to allow options for passive ventilation, renewables and heat recovery</td>
<td>Audits prior to issue of output spec</td>
<td>●</td>
<td>1:500 options drawings with marked up space options</td>
<td></td>
</tr>
<tr>
<td>Systems development</td>
<td>Systems development</td>
<td>Options studies on proposed ventilation and energy supply strategies, integrating supply and demand side</td>
<td>Audits prior to issue of output spec</td>
<td>●</td>
<td>Whole life cost and carbon model</td>
<td></td>
</tr>
<tr>
<td>Site layout</td>
<td>Site layout</td>
<td>Microclimate</td>
<td>Studies looking at effect of heat islands, hard landscaping, trees, over shading, water on proposed building</td>
<td>Audits prior to issue of output spec</td>
<td>●</td>
<td>Input to modelling</td>
</tr>
<tr>
<td>Orientation</td>
<td>Orientation</td>
<td>Option appraisal looking at building orientation and siting of areas on particular orientation</td>
<td>Audits prior to issue of output spec</td>
<td>●</td>
<td>Whole life cost and carbon model</td>
<td></td>
</tr>
<tr>
<td>Massing</td>
<td>Massing</td>
<td>Option appraisal looking at narrow plan options</td>
<td>Audits prior to issue of output spec</td>
<td>●</td>
<td>Whole life cost and carbon model</td>
<td></td>
</tr>
<tr>
<td>Wind studies</td>
<td>Wind studies</td>
<td>Commission studies on wind effects and development of passive ventilation strategy</td>
<td>Detailed design stage</td>
<td>●</td>
<td>Wind effect modelling (will be required for large developments over 4 storeys)</td>
<td></td>
</tr>
<tr>
<td>Pollutants</td>
<td>Pollutants</td>
<td>HLM</td>
<td>Site layout options with respect to access roads, parking and other pollutants and proximity to air intakes and windows</td>
<td>Audits prior to issue of output spec</td>
<td>●</td>
<td>Site layout options 1:500</td>
</tr>
<tr>
<td>Energy model</td>
<td>Energy model</td>
<td>WW</td>
<td>Provide sketch scheme energy models based on options considered</td>
<td>Prior to issue of output spec</td>
<td>●</td>
<td>Energy model and input to whole life cost model</td>
</tr>
</tbody>
</table>
## Appendix 8. Detailed environmental specification

Unless otherwise specified in the room data sheets the environmental conditions in all rooms and circulation areas shall adhere to the following specifications:

<table>
<thead>
<tr>
<th>Lighting and daylighting</th>
<th>Requirements</th>
<th>Example for office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daylighting quantity</td>
<td>Acceptable level detailed in environmental schedule. These levels to be achieved in operation.</td>
<td>4 – 6%</td>
</tr>
<tr>
<td></td>
<td>Daylight to be the prime source of lighting energy to be supplanted when necessary with artificial lighting energy.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows not to be obstructed at all by blinds or curtains when these are opened.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dim-out (to achieve daylight factor less than 0.1%) to be possible.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dim-out means must not restrict ventilation air.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NB. Minimum ceiling height of 3.4m will allow optimum daylight levels to be attained.</td>
<td></td>
</tr>
<tr>
<td>Daylighting quality</td>
<td>Luminance range to have a ratio of 1 to 10 within the normal range of vision. A range of 1 to 100 can cause eyestrain</td>
<td></td>
</tr>
<tr>
<td>Daylighting uniformity</td>
<td>Uniformity ratio specified in Environmental Schedule.</td>
<td>&gt;0.4</td>
</tr>
<tr>
<td></td>
<td>Target of better than 0.4. NB. This will require top-lighting and deep plan day lighting from both sides.</td>
<td></td>
</tr>
<tr>
<td>Surface reflectance</td>
<td>Minimum surface reflectance levels to be as follows:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Walls: 0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ceiling: 0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floor: 0.3</td>
<td></td>
</tr>
<tr>
<td>Gloss factor</td>
<td>Gloss factor of window cills and flooring to be less than 15%.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gloss factor of furniture to be less than 20%.</td>
<td></td>
</tr>
<tr>
<td>Whiteboards/Screens – daylight impingement</td>
<td>The maximum daylight related luminance on a cloudy day without any blinds being drawn or windows obstructed (including clerestory lights and roof-lights), perpendicular to the whiteboard/screen surface, shall not exceed 2% of the sky luminance at 30° above the horizontal.</td>
<td></td>
</tr>
<tr>
<td>Whiteboards/Screens – peak white image brightness</td>
<td>The peak white image brightness (above background luminance) perpendicular to the whiteboard/screen surface shall be at least 100 Cd/m².</td>
<td></td>
</tr>
<tr>
<td>Whiteboards/Screens – artificial lights</td>
<td>No direct light from luminaires onto the whiteboard / screen.</td>
<td></td>
</tr>
<tr>
<td>Artificial lighting lux</td>
<td>Minimum and maximum lux levels specified in Environmental Schedule.</td>
<td>300 – 430 lux</td>
</tr>
<tr>
<td></td>
<td>Where higher levels are needed for more visually demanding tasks such as for office desks, this should be provided by task lighting.</td>
<td>Task: 500 lux</td>
</tr>
<tr>
<td>Artificial lighting uniformity</td>
<td>Specified in Environmental Schedule.</td>
<td>0.8</td>
</tr>
<tr>
<td>Artificial lighting colour rendering</td>
<td>Minimum Ra specified in Environmental Schedule.</td>
<td>80%</td>
</tr>
<tr>
<td>Artificial lighting colour temperature</td>
<td>Range specified in Environmental Schedule.</td>
<td>3500K – 4000K</td>
</tr>
<tr>
<td>Artificial lighting ceiling illuminance</td>
<td>Minimum illuminance and minimum uniformity specified in the Environmental Schedule.</td>
<td>90 lux</td>
</tr>
<tr>
<td>Artificial lighting wall illuminance</td>
<td>Minimum illuminance and minimum uniformity specified in the Environmental Schedule.</td>
<td>90 lux</td>
</tr>
<tr>
<td>Glare Index</td>
<td>Not more than 19 to be calculated by using CIBSE methodology.</td>
<td></td>
</tr>
<tr>
<td>Artificial lighting – required controls</td>
<td>Detailed requirements in room data sheet. Light level sensing – zones must include window area, mid room, and rear of room. Occupancy sensing – maximum area covered by any one sensor not to exceed 50m². Where manual switches are used as a minimum, individual light switches to be installed for window area, mid room, and rear of room. Maximum area per light-switch is 25m². Light switches located adjacent to door from corridor, to be operable by users.</td>
<td>Light level and occupancy</td>
</tr>
<tr>
<td>Maximum lighting energy W/m²</td>
<td>Specified in Environmental Schedule.</td>
<td>9.5 W/m²</td>
</tr>
<tr>
<td>Lighting for cleaning and security</td>
<td>Only in immediate work area plus areas for safe circulation.</td>
<td></td>
</tr>
</tbody>
</table>

**Temperature**

<p>| Desired inside temperature range during occupied hours in the heating season | Air temperature measured at 1m from floor in the centre of the room shall be within the range specified in Environmental Schedule. Radiant temperatures of at least 90% by area of the opaque fabric (excluding the floor if under-floor heating is the main emitter of heating energy) must be no more than 1°C above the maximum internal air temperature and should not be below the minimum internal air temperature. If under-floor heating is used, floor surface temperatures shall not exceed air temperatures (at 1m from floor in the centre of the room) by more than 3.5°C for more than 2 hours each working day, or by more than 2.5°C for the remainder of the working day. | 19 – 22°C |
| Maximum temperature in heating season to be achieved by paid-for heating energy | As specified in the Environmental Schedule. (Note: if self-regulating under-floor heating is used, deemed compliance will be achieved if the floor surface temperature more than two hours after the start of occupation is less than or equal to 2.5°C above the specified temperature). | 21°C |
| Summertime maximum operative temperature | Whenever the outside air temperature is above 23°C, and the diurnal temperature range (lowest temperature from the previous night to the maximum daytime temperature the following day) exceeds 4°C, the internal operative temperature shall not exceed the outside air temperature by more than 1.5°C for the first eight hours of substantive occupation each day. This shall apply for internal gains (excluding insulation) up to 80W/m². This should be met without air conditioning. | |
| Maximum insolation (solar heat gain) | Specified in the Environmental Schedule. | 25 W/m² |
| Maximum heat gain from non-fixed equipment – design data | As specified in the Environmental Schedule. | Occupied 20 W/m² Unoccupied 5 W/m² |</p>
<table>
<thead>
<tr>
<th>Room temperature optimum start accuracy – heating by radiators and air handling</th>
<th>Except where self-regulating under-floor heating is the main heating source, the desired room temperature is to be achieved within 30 minutes of occupation start on 60% of occupied days in the heating season.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room temperature optimum start accuracy – space heating by self-regulating under-floor heating</td>
<td>Unless a statutory requirement exists, no requirement if self-regulating under-floor heating is the main heating source during occupied hours.</td>
</tr>
<tr>
<td>Pre-heat rate of temperature rise when un-occupied</td>
<td>The minimum rate of rise of room operative temperature under design conditions, with the space un-occupied, must be &gt;0.3˚C per hour.</td>
</tr>
<tr>
<td>Room heating response to internal gains</td>
<td>Heating emitter / controls response time for 63% change in heating output shall be less than 20 minutes for both increase and decrease of output.</td>
</tr>
<tr>
<td>Heating controls location and authority</td>
<td>No room occupant control over heating temperature, start time, finish time, regular day omission, holiday days omit. All these controls to be centrally operable by facilities management.</td>
</tr>
<tr>
<td>Heating zoning</td>
<td>Each room and circulation space will be assigned to a heating zone in the environmental schedule</td>
</tr>
<tr>
<td>Cooling temperature</td>
<td>As specified in the Environmental Schedule. Mechanical cooling must not be used if cooling is possible using external air or zero carbon impact sources such as groundwater or earth tubes.</td>
</tr>
<tr>
<td>ICT Rooms</td>
<td>The only limitation on temperature in the ICT/server room is that it is to be measured above the racks and to be no more than 27˚C. Class D equipment is preferential as this is guaranteed up to 40˚C.</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Ventilation during occupied hours - Sufficient ventilation shall exist to ensure that carbon dioxide level in this space does not exceed the maximum level specified in the Environmental Schedule for more than 20 minutes each day. The operational target is also specified within the Schedule. (1,000ppm approximates to a fresh-air ventilation rate of 8 litres/person per second). The required ventilation shall be maintained during room dim-out / blackout, and shall not be impaired by security or safety requirements. Cold draughts from incoming ventilation air in cold weather shall not cause thermal discomfort to occupants. Maximum 1,500 ppm Target 1,000 ppm</td>
</tr>
<tr>
<td>Ventilation outside occupied hours</td>
<td>Fresh air rate must be within the range specified in the environmental schedule. This may be achieved by passive infiltration means such as by trickle vents in windows. The ventilation heat loss must not exceed fabric heat losses. 0.1 – 0.3 ach</td>
</tr>
<tr>
<td>Natural ventilation</td>
<td>Windows used for a natural ventilation strategy to be opened within 300 mm of the ceiling to assist with avoiding summertime overheating. Curtains and blinds not to obstruct the window openings.</td>
</tr>
<tr>
<td>Volatile organic compounds (VOC)</td>
<td>At no time during occupied hours shall the total indoor VOC exceed the level specified in the Environmental Schedule. 200μg/m³</td>
</tr>
<tr>
<td>Acoustics</td>
<td>Reverberation time Tmf - Max duration for mid-frequencies when un-occupied specified in environmental schedule. &lt;0.8 sec</td>
</tr>
</tbody>
</table>
### STI index

Must be greater than the level specified in the Environmental Schedule.  
>0.65

### Background noise level maximum during heating season

Maximum level specified in Environmental Schedule. This figure excludes the contribution from ICT and office equipment installed by the occupier.  
35 DB LAeq

### Background noise level maximum during hot summer days

Maximum level specified in Environmental Schedule (must be achieved with maximum ventilation rate operational).  
35 DB LAeq

### User comfort

| Visual comfort | Ceiling to be light coloured.  
| Window frames and bars to be light coloured or white.  
| Window reveals to be splayed. |

### Accessibility

| Accessibility | Switches for individual user ICT to be at desk height. |
Appendix 9. Environmental schedule

The environmental schedule is divided into four sections:

1. Lighting and daylighting
2. Temperature
3. Ventilation
4. Acoustics.

Each section outlines the environmental conditions required in each room and circulation area in the building. Any deviations from this schedule must be approved by the Client. The first entry in each table specifies the default conditions required to achieve a low carbon building. Certain rooms may require deviations from these defaults due to required occupancy rates, installed equipment or specialist use, or because not every room is able to have a perfect fit regarding ventilation and daylighting. The Client needs to give flexibility to the designers to adopt the best solution that may require a compromise on a percentage of the floor area. The designers need to identify in the design documentation where the specification will not be met, so that the Client can make the decision.

These are to be read in conjunction with the detailed environmental specification.

Lighting and daylighting

<table>
<thead>
<tr>
<th>Room</th>
<th>Ref</th>
<th>Day-lighting</th>
<th>Artificial lighting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Quantity %</td>
<td>Uniformity</td>
</tr>
<tr>
<td>Default</td>
<td>4 – 6%</td>
<td>&gt;0.4</td>
<td>300</td>
</tr>
</tbody>
</table>
## Temperature

<table>
<thead>
<tr>
<th>Room</th>
<th>Ref</th>
<th>Heating zone</th>
<th>Inside temp. range during occupied hours in heating season</th>
<th>Max. temp. to be provided for by paid for heating</th>
<th>Maximum insolation (solar heat gain)</th>
<th>Min. cooling temperature</th>
<th>Maximum heat gain from non fixed equipment (design data) W/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min °C</td>
<td>Max °C</td>
<td>°C</td>
<td>W/m²</td>
<td>°C</td>
</tr>
<tr>
<td>Default</td>
<td></td>
<td></td>
<td>19</td>
<td>22</td>
<td>21</td>
<td>25</td>
<td>26</td>
</tr>
</tbody>
</table>

## Ventilation

<table>
<thead>
<tr>
<th>Room</th>
<th>Ref</th>
<th>Ventilation Type (mech. or natural)</th>
<th>CO₂ level ppm</th>
<th>Fresh air rate during unoccupied hours ach</th>
<th>Maximum VOCs µg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Maximum</td>
<td>Operational target</td>
<td>Min</td>
</tr>
<tr>
<td>Default</td>
<td></td>
<td></td>
<td>1500</td>
<td>1000</td>
<td>0.1</td>
</tr>
</tbody>
</table>

## Acoustics

<table>
<thead>
<tr>
<th>Room</th>
<th>Ref</th>
<th>Reverberation time Tₚ (sec)</th>
<th>STI index</th>
<th>Maximum background noise dBLAeq, 30min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Heating season</td>
</tr>
<tr>
<td>Default</td>
<td></td>
<td>&lt;0.8</td>
<td>&gt;0.65</td>
<td>35</td>
</tr>
</tbody>
</table>
Appendix 10. Room data sheet

These room data sheets show only the environmental information required and should be incorporated into your standard room data sheets.

<table>
<thead>
<tr>
<th>GENERAL ROOM INFORMATION</th>
<th>INTENDED ROOM ELECTRICAL EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room Name:</td>
<td>e.g. Computers</td>
</tr>
<tr>
<td>Description:</td>
<td>20</td>
</tr>
<tr>
<td>Relationship to other rooms:</td>
<td>70</td>
</tr>
<tr>
<td>Normal no. of room occupants:</td>
<td>Laptop computers in use during office hours only, with 40% of the time on full load and 60% on standby. During non-office hours about 30% will continue to be on standby. It is desirable that users have ability to switch off at the socket overnight so that no power is used for AC adaptor.</td>
</tr>
<tr>
<td>Maximum no of room occupants:</td>
<td></td>
</tr>
<tr>
<td>Normal occupancy times:</td>
<td></td>
</tr>
<tr>
<td>Cleaning times:</td>
<td></td>
</tr>
<tr>
<td>Security check requirement</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENVIRONMENTAL CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAYLIGHTING</td>
</tr>
<tr>
<td>Blinds / Curtains required?</td>
</tr>
<tr>
<td>ARTIFICIAL LIGHTING</td>
</tr>
<tr>
<td>Task lighting requirements</td>
</tr>
<tr>
<td>Control detail</td>
</tr>
<tr>
<td>TEMPERATURE</td>
</tr>
<tr>
<td>Local controls</td>
</tr>
<tr>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>VENTILATION</td>
</tr>
<tr>
<td>Local controls</td>
</tr>
<tr>
<td>ACOUSTICS</td>
</tr>
<tr>
<td>Acoustic treatment</td>
</tr>
</tbody>
</table>
The Carbon Trust is a not-for-profit company with the mission to accelerate the move to a low carbon economy. We provide specialist support to business and the public sector to help cut carbon emissions, save energy and commercialise low carbon technologies. By stimulating low carbon action we contribute to key UK goals of lower carbon emissions, the development of low carbon businesses, increased energy security and associated jobs.

We help to cut carbon emissions now by:

- providing specialist advice and finance to help organisations cut carbon
- setting standards for carbon reduction.

We reduce potential future carbon emissions by:

- opening markets for low carbon technologies
- leading industry collaborations to commercialise technologies
- investing in early-stage low carbon companies.

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