High Performance Buildings
2. The Process of Delivery for Universities and Colleges

March 2008

"Increasing uncertainty and insecurity of energy supplies, and challenging Government targets to reduce carbon emissions, make it essential that new build and refurbishments in universities and colleges are more sustainable. This guide shows how this might be achieved, and in ways that enhance rather than jeopardise their total performance for staff and students. It is required reading for anyone making decisions about the academic estate."

Peter Kerr, Director of Estates, Heriot-Watt University, and Chair, AUDE

Prepared by:

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Thirdwave The Business Case for Sustainability

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Publisher's Note

The content of this guide is broadly applicable to the design, construction, demolition and refurbishment of any building type found within the further and higher education sector. It provides general background advice and does not prescribe specific construction forms, materials or procurement routes. It does not substitute for professional advice on these and other building development issues.

The guide has been prepared jointly by the Higher Education Environmental Performance Improvement (HEEPI) project, SUST - The Lighthouse on Sustainability, and Thirdwave Ltd. It has benefited from input from a number of senior academic and estates colleagues who have commented on development drafts - for which we are most grateful.

This guide discusses how the business and environmental benefits of high performance buildings can be achieved in practice within universities and colleges. A companion guide, *High Performance Buildings - 1. The Business Case for Universities and Colleges* discusses their financial, performance and other benefits. There is also an Overview which introduces the concepts for senior managers. All of these publications are available electronically from the partner's web sites - **www.heepi.org.uk**, **www.sust.org**, and **www.thirdwave.org.uk**.

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Foreword

Sustainable development is increasingly at the heart of economies worldwide and is therefore having great influence on buildings. They are significant contributors to global environmental problems such as greenhouse gas emissions and the depletion of natural resources. Better design, construction and refurbishment can minimise these impacts through, for example, responsible selection of energy, material and water efficient solutions.

There are now many policies and initiatives to achieve this, by influencing planning, building form, materials and services issues, and the inter-relationships between these and the surrounding environment. The majority of public buildings also have design briefs that call for better environmental performance and greater social responsibility.

Despite this, the number of sustainable buildings actually being delivered - in further and higher education and elsewhere - is still relatively low. Even when a project appears to have a 'green' design, the final environmental performance, and social impact, is often disappointing. The main reasons for this include omission of specific features or equipment during the detailed design phase, last minute substitutions of materials or equipment on site, poor workmanship or a failure to commission properly.

This is especially disappointing in universities and colleges. They have an enormous new build and refurbishment programme, which will have major impacts on future energy and other operating costs. They are also in a unique position to influence many of tomorrow's decision-makers and opinion formers, because they will be studying in the built environment which is created. It is therefore vital that further and higher education does more to achieve sustainable buildings.

In fact, it will be eventually be forced to do so - by impending legislation, rising energy costs, tightening of building regulations and changing stakeholder expectations. There is growing evidence that those who anticipate the trend can avoid associated additional fuel bills, expensive retrofitting measures, and other costs which will impact upon their less proactive peers. They will also benefit from enhanced reputation, and from improved well being and productivity of building users.

Experience shows that these benefits can be achieved without, or with minimal, increases in capital costs if sustainability requirements are:

- built in from the start, and backed by clear internal commitment;
- seen as part of a 'high performance' design process which recognises the synergies between sustainability and other building objectives such as long-term adaptability and lowest 'whole life cost';
- embedded into the construction process through robust and unambiguously worded tenders and contracts, and other means; and
- maintained through the inevitable pressures to compromise on key aspects of the design.

Doing this is not easy, but we hope that this guide will provide some assistance to the decision-makers in universities and colleges who must make it happen - and therefore help to achieve long-life, loose fit, and low energy buildings which are truly fit for their purpose.

1. Introduction

This guide is primarily aimed at non-specialist decision-makers who are involved in the procurement of buildings. It provides background information, examples of good and bad practice and, in particular, four sets of questions which can be used as 'meeting agenda items' in each of the main stages of:

- inception
- design
- build, and
- handover and use.

Experience shows that delivering, and achieving the benefits of, a high performance building is the same as delivering any 'excellent building', i.e. one which meets all of the client's expectations. The key mechanisms for both are:

- a careful selection process which ensures that each member of the professional design team has demonstrated experience of achieving very low energy buildings with acknowledged environmental credentials;
- a thorough pre-design process which rigorously analyses the requirements of a building, defines clear, measurable, performance objectives (including energy and environmental objectives) to guide subsequent implementation, and which builds good relationships both within the design team and between the team, and customers and key contractors;
- a holistic design and development process which iteratively considers all the key building elements and features in relation to one another, and which incorporates the views of key stakeholders such as users and maintenance staff, as well as contractors. This approach results in better functionality and avoidance of expensive errors (such as over-sizing of equipment and resultant wasteful energy consumption), effective project management which balances all the performance objectives (including the energy and environmental issues), and ensures that key design features are not lost because of time pressures, contractor resistance, or other factors;
- sensible value-engineering based on whole life costing, thereby avoiding the frequent practice of eliminating relatively small amounts of capital cost only to incur much higher operating costs through increased consumption of utilities, more expensive maintenance, and other unanticipated outcomes; and
- effective quality control and commissioning throughout the process so that the performance objectives are delivered in practice.

The following pages elaborate on how these can be achieved.

- High performance buildings require the integration of sustainability concerns from their earliest stages

How to Achieve High Performance Buildings

ESTATES STRATEGY

- Ambitious, unambiguous, sustainability vision, targets and specifications
- Continuing relationships with experienced contractors so that skills and knowledge can be transferred between projects (whilst respecting procurement rules)
- Internal capacity to set and implement high performance building objectives
- Standard procedures to assess energy efficiency and other sustainability features in design, at handover, and in use
- Whole life costing approach to decisions, including those of value engineering

INCEPTION & FEASIBILITY

- Option Appraisal
- Strategic Brief
- Procurement Strategy

- A high level sustainability champion
- Ring fenced budgets for commissioning, POE and sustainability appraisal
- Location, orientation, form and lay out remain flexible into design stage
- Full consideration of alternatives to new build/refurbishment

DESIGN

- Outline Proposals
- Detailed Proposals
- Production Information

- Iterative process of modelling and reappraisal to achieve integrated and optimal design
- Maximum use of passive features such as natural lighting, materials and ventilation
- Incorporation of facility and user perspectives
- User friendly and synergistic controls
- 'Right sizing' of space and equipment based on good understanding of likely occupancy and use

BUILD

- Tender
- Construction

- Inclusion of specific sustainability requirements (including targets) in tenders and contract documentation
- Project management aware of importance of sustainability features and ensuring that they are achieved in practice

HANDOVER & USE

- Commissioning
- Post Occupancy

- Effective commissioning done independently of main contractors
- Full documentation of all building components and systems
- Thorough evaluation to optimise performance, and feed lessons back to future building design

2. A Strategic Approach

Many universities and colleges face the prospect of developing or upgrading a series of buildings at the same time. It is therefore important that they implement high performance building approaches and standards from the start. Such a strategy should:

- inform, involve, and build support amongst senior managers, and academics, students and other key internal stakeholders;
- send clear messages to both internal decision-makers (e.g. senior academics who see a new / refurbished building as their 'baby') and design teams about the requirement for high performance buildings;
- avoid duplication of work between building projects (e.g. setting of environmental performance standards, detailed design guidance);
- create a 'learning cycle' which enables new developments to learn lessons from past developments; and
- build - within the constraint of procurement rules - long-term relationships with suppliers who can deliver sustainable, and cost-effective, solutions in practice.

Developing a Policy

The foundation of a strategic approach is a policy, with defined and measurable objectives. Whether expressed in general statements of intent, or detailed guidance, this must spell out the client's expectations of:

- excellent environmental and sustainability performance, beyond building regulations;
- an integrated design process;
- use of whole life costing; and
- rigorous commissioning and post occupancy evaluation.

It is also essential that the key aspects of high performance building policies are embedded in Estates Strategies, Master Plans and other strategic documents, as well as contract documentation.

Capacity is Vital

Many universities and colleges under-estimate the complexity, time requirements, and potential difficulties and frustrations associated with developing even a single building, let alone multiple buildings. As a result, decision-makers often struggle to remain abreast of essential parameters, with the result that sustainable design issues can be seen as dispensable 'extras'. A breakdown in communication between decision-makers, or between stages in the process, often compounds the difficulty. Whilst, as the next section discusses, reliable suppliers who have 'got' sustainability can help to overcome these challenges, internal capacity is also important, especially in larger institutions which are dealing with many buildings. Some ways of achieving this are:

- Developing more internal expertise. (In the US Harvard University employs a central team of experts to achieve this - see companion guide for further details - whilst in the UK Sheffield Hallam University has trained several staff in environmental building assessment).
- Developing routine procedures which operate independently of individuals such as standardised sustainability assessments at the main 'gateway' reviews of a project.
- Hiring some specialists, independently of design teams, who report directly to the institution, e.g. project managers, or strategic sustainability advisors, to provide vital early stage inputs. This can appear expensive, but the costs can be offset by more effective management not just of individual developments, but a series. However, it is important that out-sourcing of this kind does not impede internal capacity building.

■ The aspiration for high performance buildings must be embedded in Estates Strategies, Master Plans and building-specific documentation

A Strategic Approach To A High Flying Campus

The University of Hertfordshire's £120 million de Havilland campus consolidated the activities of two older campuses onto a single brown-field site (the former British Aerospace Aerodrome and factory) in Hatfield. This now hosts the Business School and Schools of Humanities and Education, a 460 seat conference and events centre, a sports village and 1,600 residences. The academic buildings were a Private Finance Initiative project, whilst the sports village and residences were privately funded.

The lead contractor, Carillion, was partly selected because of its willingness to support the University's environmental aims (as evidenced by recycling 65% of construction waste). Notable features of the campus include:

- buildings with high thermal mass, natural ventilation, solar control and shading, and sustainably produced timber;
- residences which are 60% more energy efficient than typical examples;
- 50% of electricity sourced from renewable energy;
- planting of 250 native trees and almost 30,000 other plants to maximise biodiversity; and
- community involvement, e.g. through sports coaching for schools and student volunteer programmes.

The energy efficient design of the new campus will save approximately £3 million on energy bills over 25 years. This involved £109,000 of additional capital expenditure which should be paid back in under three years.

Nicola Corrigan, the University's then Environmental Coordinator, attributed the good environmental performance to a strategic approach which "used the 'Natural Step' framework for general guidance, and a BREEAM 'excellent' target and whole life costing calculations for design details."

3. Inception - Case, Options and Brief

Inception has three main stages - business case and option appraisal; developing a strategic brief; and establishing a procurement strategy. It usually involves only a relatively small number of senior people within universities and colleges, and a few people from actual or potential suppliers, such as architects. Often, none of those involved will have detailed knowledge of sustainability and environmental issues.

It is vital that sustainability issues are on the agenda from the very beginning. Key features of a building can become 'embedded' in people's thinking at an early stage. This will influence the development of the brief, and will then be carried on into the design stage unchallenged. Subsequent changes, which might be desirable for sustainability reasons, may then become difficult, as implementation would mean changing the collective mindset and / or 'unpicking' other features of the design. The opportunities for action at later stages can also be constrained by the choice of procurement method.

Business Case and Option Appraisal

This stage establishes that there is a need for the project and determines where it fits into the strategic plan for the institution as a whole, including responding to changes in educational practices, funding availability, branding and expansion plans. Since reuse of existing buildings avoids the environmental impacts of constructing new ones, it is vital that options for reorganisation, acquisition or refurbishment are considered creatively before the case for new build is accepted.

If a capital project is definitely required, the business case for it - or for alternative options - must explicitly take sustainability issues into account. In some cases this may require a full assessment of environmental and transport impacts, both for the building itself, and for its interactions with the rest of the campus, and the surrounding area. For example, are there opportunities to develop a brownfield site, or to use existing infrastructures, or to establish new capacity which could be shared with future buildings?

Developing a Strategic Brief

A good brief sends both a general message of intent, and specific instructions, to the design team and, ultimately, contractors. It covers issues from the commissioning body's strategic position, through to high level details of specification and performance. It should also include requirements for thorough commissioning and post occupancy evaluation of the building. Clear and emphatic highlighting of environment and sustainability in the brief ensures that everyone involved knows from the start that these are important, and are required criteria in tender and planning documentation. It should make it more difficult to exclude desirable high performance and sustainable approaches on cost grounds, or to argue that certain requests are not deliverable.

It is essential to set clear, measurable and stretching output specifications as part of the project brief. This is especially important for procurement routes where the design team does not report directly to the client. Requiring defined levels of performance for key performance indicators is the only means by which influence can be exerted. External assessment tools such as BREEAM (see Appendix 1) can help with this but are best seen as a complement to, rather than a substitute for, organisations setting their own standards.

▪ A new building is an environmental luxury - couldn't refurbishment or reorganisation make it unnecessary?

Key Questions for the Inception Stage

1. Is the Project Sponsor (person or small group responsible for delivering the project on the client side) aware of the importance of environmental and sustainability issues, and of the need to insert requirements into the brief and contract documents?
2. Has someone been appointed with a responsibility to champion environmental and sustainable issues, and with sufficient authority and knowledge to ensure that their recommendations are taken seriously?
3. Do the proposed consultants have a proven track record on delivering best practice, high performance, and low carbon buildings, both as individuals and as part of an integrated team? And do they have adequate incentives to design to the standards set, particularly where these may require additional work?
4. Have clear and measurable performance standards been set and communicated? Is it evident to suppliers that these are 'expected' and 'required', rather than simply something to be 'investigated' or 'considered'?
5. Has a systematic attempt been made to learn from the experience of similar buildings, both within and outside the sector? And how will the experience of this building process be recorded so that the learning cycle can continue?
6. Have the implications of different procurement routes for environmental and sustainability issues been considered, and - when a route has been chosen - have actions been taken to overcome any problems?
7. Has the Office of Government Commerce guidance on sustainable building procurement been followed?
8. Have possible alternatives to a new building, such as better use of existing space, been properly considered in the light of different assumptions about the future (e.g. that planned revenues will not be achieved)?
9. Has the interaction of the new building with surrounding ones, and other planned developments on campus, been considered and any synergies exploited (e.g. possibilities of shared building services)?
10. Have alternative sites been considered to improve sustainability (e.g. using brownfield land), and does the analysis of that chosen (e.g. sun-path, wind speed and direction, renewable energy potential, traffic routes, biodiversity and landscape impacts, planning context etc.) validate the choice of location and contribute to achieving the performance standards?
11. Is there budgetary provision for additional expenditure on the design (e.g. BREEAM certification), thorough commissioning, Post Occupancy Evaluation, and - for complex buildings, or groups of buildings - a dedicated building manager?
12. Have the financial projections for the building taken a whole life costing approach so that the revenue implications of any decisions are clear?
13. Have the views of key stakeholders, such as users, and facilities and environmental managers, been sought and fully considered?

4. Inception - Procurement and Design Team

Procurement Strategy

There are several procurement routes available to universities and colleges (see Appendix 2 for descriptions and discussion), and they have different implications for how sustainability is approached. Briefly:

- client-led approaches allow the client to influence the design and key decisions throughout the process so - whilst it is important to have a strategic consideration of sustainability from the earliest stages - there is the opportunity to track progress and revise where necessary, and to consider tactical issues at a later stage;
- the other approaches involve supplier responsibility for some or all of the design, so all of the issues described in this guide have to be considered in advance, and translated into outcome specifications, targets and bonuses / penalties that will effectively guide their activities, and allow success or failure to be unambiguously assessed before handover.

The remainder of the guide is based on the client-led approach, which is still the most common in the sector.

Selecting the Design Team

The traditional approach to building design - as set out in the RIBA Plan of Work - was relatively hierarchical and compartmentalised.[1] The architect was the leader, and other members (e.g. structural, civil and building services engineers and quantity surveyors) were there as supportive specialists, working independently of each other. The result was usually 'best-fit' engineered solutions rather than fully integrated developments.

The Egan report identified this system as a major cause of construction problems such as cost over-runs and poorly performing buildings.[2] It recommended a more collaborative, partnership based, approach both within design teams, and between them, clients, and contractors. This is becoming more common, which is good for high performance buildings because their sustainability features also require such an approach. However, they also have the additional requirements of a good awareness of sustainability awareness amongst all design team members, and, more importantly, a track record of achieving them in practice.

In practice, it is very difficult to assemble design teams from scratch to meet these criteria. Larger institutions seeking high performance buildings will usually need - commensurate with procurement rules - to build and maintain relationships with a core group of suppliers who have 'got' sustainability.

Setting Environmental Targets

Constructing Excellence defines many environmental and other KPIs for buildings.[3] Possible indicators include:

Energy in use - a percentage reduction in carbon emissions relative to current Building Regulations. The UK Government has suggested a minimum of 10% reduction on current Building Regulations, and BREEAM 2006 for Offices (see Appendix 1) requires a 30% reduction to achieve Excellent status. In 'cost in use' terms it is important to also require actual reduction in design heat loss / electrical power consumption too.

On-site energy generation - a requirement that 10% or 20% of electricity and / or heat is derived from renewables, CHP or other Low / Zero Carbon Technologies, which are being encouraged by Government. These can benefit the institution by contributing to carbon targets, provide protection against supply disruptions and price increases, and enhance reputation by supporting innovation and an important nascent industry.

Water use - a consumption target expressed in m^3 per occupant per year (and that is set at a level such as 1 m^3 per occupant per year so that it makes water efficient fixtures and fittings mandatory).

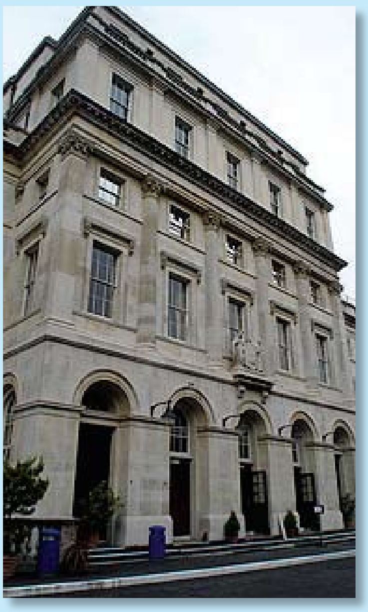
Timber - use of certified sustainable timber, e.g. 100% certified by the Forest Stewardship Council (FSC).

Recycled content of building materials - a percentage target, ideally informed by the latest research from the Waste Resources Action Programme (WRAP), which suggests that a recycled building material value of 25% or higher can be achieved at little or no additional cost.

Construction - percentage of on-site waste arisings by weight or volume which is diverted from landfill and reused or recycled.

Local sourcing - a percentage of materials (by weight or value, or both) sourced from within a set radius such as 30 miles, so as to reduce the embodied energy / transport related impacts of the materials in the building.

Checking Occupancy Levels



Many briefs will be risk averse and assume very high occupancy even on the hottest summer days. This creates an enormous cooling requirement (as the effects of solar gain and high ambient temperatures will be exacerbated by high internal heat gain from people and equipment). Very expensive plant - both to buy and run - may be specified for just a few hours of operation a year as a result.

Detailed occupancy profiling of the building can change this scenario by making clear, for example, that many students and some staff will be on holiday during July and August. This was the case at King's College, where the design of a naturally ventilated refurbishment (pictured) accepted that temperatures would rise to uncomfortable levels - above 28°C - on up to five days a year. Profiling suggested that these generally would fall in quiet vacation periods. This has proved to be the case and no major problems have resulted. (See the companion guide for details of the refurbishment).

5. Design - Overview

Sustainability may appear to be a costly and time consuming distraction. Changing this perception requires its embedding in the design process through:

- clear client specifications for key aspects of performance, such as energy consumption or daylighting levels, and the underlying factors which help to achieve them (e.g. selection of materials based on low toxicity and recycled content, air-tightness);
- a design team that adopts sustainability as a priority, and manifests this not just in rhetoric but in the day to day thinking and actions of its members, and in the details of the orientation, layout, fabric, energy, resources, location, and landscape interaction, of the new and refurbished buildings they plan;
- a process that reduces traditional design team-construction-contractor-user barriers by adopting a less confrontational and more holistic 'team-based' approach, which maximises participation and consultation by all relevant stakeholders from the outset, and throughout delivery, including post occupancy.

A common sense approach that avoids an excessive emphasis on 'green jewellery' - e.g. flashy technologies which may not make a great difference in practice, or are difficult to make work properly - is also important. In most cases, the greatest environmental, as well as business, benefits are likely to be achieved through low cost, generally passive, and proven technologies; through control systems that work; and through buildings that are heavily utilised and have the flexibility to remain so for many years to come.

The Traditional Approach

Building design is complex, involving many different elements (e.g. fabric, heating, power supply, integration and transport connections) which interact with each other. To progress, there has to be a cascading process of 'fixing' key features of the overall design and its elements, so that more detailed design can take place within known objectives and parameters. As the process continues, the costs of 'unfixing' these features becomes ever greater because any subsequent decisions which have been based upon them must be unravelled.

The typical building process involves a small design team fixing building parameters in ever greater detail - and with ever greater reliance on drawings and models - at three main stages:

1. 'Outline' or 'sketch' design stage - this fleshes out the strategic brief with a more detailed specification of building structure and layout and key features of the building elements (e.g. required temperature parameters and assumed occupancy levels for cooling systems);
2. Detailed proposals stage - these contain near-final specifications for all aspects of the building and its elements (e.g. size, positioning and engineering requirements of plant and distribution facilities); and
3. Production information stage - this fleshes out the detailed proposals for tender documents and subsequent contracts (e.g. specifying a particular model or manufacturer).

Typically, the design team begins with a small 'core' group of architects and consulting engineers and adds other key contractors - such as main building services/plant providers and project management consultancies - during the detailed proposals stage. For most building elements, the design team's main role is to ensure conformance with overall objectives, but detailed design will be left to sub-contractors.

Key Questions for the Design Stage

1. Has sufficient time been allowed for design iteration during key stages so that integration of sustainability objectives, and optimisation of environmental and related performance, can be achieved?
2. Has a whole life costing approach been taken in key financial decisions, including value engineering?
3. Does the building maximise the passive potential of orientation, layout and construction?
4. Are controllable natural ventilation systems used wherever possible?
5. Are environmental and sustainability performance standards on course to be met, and is a systematic process of review in operation?
6. Has there been consultation at appropriate stages of design development with users (including people with disability), facility, energy and environmental managers, maintenance and cleaning staff, and other key internal stakeholders? And have they been involved, together with other internal customers and the main suppliers, in a design charette to develop an integrated and inclusive approach to the design?
7. Is the design team working in an integrated fashion, and is communication between the client and the design team sufficient to ensure the continued smooth running of the project?
8. Are building services reduced to the minimum necessary, and are these as efficient as possible? Is there an opportunity to replace or displace existing inefficient systems in neighbouring buildings?
9. How do predicted construction costs, energy costs and maintenance costs compare with both current costs and best practice, and is there scope to improve them in a win-win manner?
10. Have the consultants made use of relevant guidance, e.g. on Green Specification?
11. Has proper attention been given to the location and user friendliness of controls, meters and sensors, and has this been translated into precise specifications for contractors?
12. Is there a quality control process to ensure that detailed designs conform to the design intent, especially with regard to sustainability?
13. Have interactions with local drainage, electricity, gas, sewerage and water supply infrastructures been fully considered, and optimised?
14. Have opportunities for inclusion of the 'Key Environmental Features' (p.14) been fully explored, and have appropriate Options Appraisals been conducted on possible financial and other benefits of them?

6. Design - Barriers and Integration

Barriers to Sustainable Design

The traditional design approach (usually) ensures reasonably speedy progress, contractual simplicity, and high standards in specialist areas. However, there are often several big difficulties, including:

- 'locking in' key features of the outline design (e.g. assumptions about the location, orientation and appearance of the building) without understanding their operational implications for energy consumption, capital and running costs, and other areas - so that, by the time these become apparent, they have to be accepted because changing the (by then) detailed design involves significant delays and expense;
- interactions between elements can be ignored, resulting in either expensive problems in operation (e.g. high solar gain from large windows in areas which need to be cool), or failure to identify possible synergies between them (e.g. using water storage tanks intended for emergency use as thermal storage devices);
- practical issues of construction and usability - which design sub-contractors often have greatest expertise in, or need to be guided on - are not highlighted until a late stage, when it can be difficult to find better alternatives (e.g. because of ordering lead times for sustainable materials); and
- detailed element design may be at variance with overall sustainability objectives (e.g. by specifying well proven but energy inefficient plant rather than more efficient alternatives).

Integrated Design

The outline or sketch stage is when barriers are lowest, and sustainable design features can be introduced most easily, without additional capital cost. This requires:

- adopting clear sustainability targets and ensuring that they reach all people involved in the design process, e.g. through constant restatement by the project manager at key meetings;
- retaining continuity by re-appointing design teams and contractors who have shown that they can deliver cost-effective sustainability (as far as this is compatible with achieving good value);
- involving key consultants and contractors, e.g. through a design charette;
- allowing time for iteration of outline and detailed designs in response to feedback; modelling of mass, orientation, glazing and shading to reduce energy costs; and the results of analytical techniques such as dynamic thermal modelling, daylight analysis and computational fluid dynamics; and
- ensuring that key features and assumptions which influence sustainability outcomes, such as orientation and layout of buildings, are based on accurate information, and proper assessment of alternatives.

Integrated design is also aided by effective communication, both amongst the design team and between its members and the increasing number of experts, suppliers and other parties (e.g. local authority planners) who become involved over time. Two aspects in particular are vital in optimising sustainability:

- ensuring that relevant experts and specialists are aware that key decisions which could affect later environmental options are being made; and
- ensuring that decisions which have been made, e.g. about environmental performance, reach all the key players in the design process, and that they are aware of their importance.

■ Users and stakeholders should be involved as much as possible, at all stages

Key Environmental Features of High Performance Buildings

Sustainable siting - firstly, try very hard to reuse, rehabilitate, extend or share services with existing buildings. If impossible, then choose locations which have lowest adverse ecological impact, minimise summer heat gain and winter heat loss, and allow most users to avoid car travel.

Optimal siting and layout - orientate the building to minimise heating and cooling needs, and avoid glare, solar gain or noise; establish layouts that group activities and minimise energy consumption.

Minimise use of fossil fuels - high insulation to cut heat loss; reduce unwanted air infiltration; reduce mechanical services loads by optimum use of passive cooling and heating, and other methods; increase the efficiency of energy supply by using methods such as combined heat and power (CHP); and maximise use of renewable energy resources, e.g. with biomass boilers for space heating.

Minimise use of water - reduce consumption and leakage, and maximise use of grey water.

Sustainable drainage - delay rainwater runoff to help reduce flood risks by use of attenuation in ponds or tanks below ground, and ensure that runoff is not polluted.

Sustainable products and materials - use materials, finishes etc., that have low (or no) toxicity either when in use or *in situ*, e.g. products that eliminate gases such as formaldehyde or volatile organic compounds (VOCs), and ensure minimal lifecycle environmental impacts compared to conventional ones.

Minimise waste - use recycled materials and minimise site wastage (during construction, occupation and at end-of-life) through easy deconstruction and 'demountability', and make provision for adequate recycling and waste handling facilities for the building users.

Maximise natural lighting - to minimise energy consumption, and have positive effects on occupant health, comfort, and productivity by optimising daylight use through effective design of window area, window head height, orientation, solar shading, and internal decoration and fit-out.

Natural ventilation - optimised through 'chimneys' and other means.

Hygroscopic building materials - these absorb or release water depending on moisture levels, (to provide an alternative to impermeable moisture barriers, which trap moisture and pollutants within the building and require high levels of ventilation).

Ecological benefits - enhance biodiversity and create pleasing natural environments through use of native species, imaginative landscaping and interior use of plants and water features.

Saving on a Rainy Day at the University of Brighton

In 2003 one of the sector's first rainwater recovery systems was installed in the University's Watts Building. The system collects water from the roof, and then filters it into a collection tank for use in toilets and urinals. In periods of low rainfall the system switches automatically to mains supply. The scheme has reduced the building's water consumption by 31%, and water costs by £2,446, giving a payback of 4.4 years. An additional benefit is reducing the load on an over burdened storm drainage system in the locality.

Energy Manager, David Anderson believes that "rainwater recovery should be feasible in most new buildings. It's a low cost, low maintenance, way of conserving water, as well as saving money."

7. Design - Flexibility and Maintenance

High performance buildings have five distinctive design principles:

1. very low carbon emissions;
2. good environmental performance;
3. flexibility;
4. reliability and ease of maintenance; and
5. effective local control of lighting, heating and ventilation.

The first two have been discussed in previous pages, so this section focuses on the other three.

Design for Flexibility

The benefits of building flexibility are described in the companion guide. To achieve a 'loose fit and long life' the design team will need to consider any possible changes in use and maximise the ability of the building to accommodate these. The measures to achieve this can include:

- use of power supply systems which can adjust to building occupation patterns;
- incorporation of cabling and wiring layouts which allow quick and low-cost reconfiguration;
- use of control systems which allow zonal management and monitoring, and maximise local control by occupants;
- use of modular equipment and fixtures wherever possible; and
- incorporation of allowances for future extension or alteration, e.g. through built-in spare service connections.

Design for Reliability and Ease of Maintenance

All too often, the views of the maintenance staff who will eventually be required to operate a building are not taken into account in its design. Failure to consult with these people results in expensive mistakes, e.g. purchasing low capital cost equipment which is very expensive to maintain, or the positioning of meters or sensors in the wrong places.

The sustainability aspects of high performance buildings have two main impacts on reliability and maintenance. The first is that simple, passive features are highlighted as alternatives to conventional solutions to typical issues. For example, the use of thermal mass as a feature to reduce cooling or heating loads (rather than simply accepting such loads as a technical requirement to be met) allows ventilation plant to be downsized, which in turn reduces operating and maintenance costs.

The second impact high performance buildings have on reliability and maintenance is the introduction of new, active technologies that also meet environmental objectives - e.g. the use of sophisticated mechanical devices to provide shading of windows, or the mechanical circulation of ambient air to enhance natural ventilation approaches. Whilst these active technologies can be effective, care is needed that high profile but potentially risky technologies are not allowed to dominate the proposed design. Less glamorous approaches might deliver better long-term performance in terms of both energy consumption and maintenance cost.

Simple, passive, energy efficiency features are the cheapest and most reliable

Creating Sustainable Laboratories

The increasing prevalence and high energy intensity - up to five times that of offices per square metre - of laboratories means they account for a significant proportion of energy consumption at research-led universities. The US-based Labs21 initiative - which is now being adapted to European experience by the authors of this guide - has shown that this consumption can be reduced or avoided through optimal design.[4]

Amongst other buildings, the Labs21 initiative has influenced:

- the Whitehead Biomedical Research Building at Emory University, Atlanta, which achieved a LEED Silver rating (see Appendix 1), and saves 3.4 million kWh of electricity per year (worth over £250,000 in the UK) when compared to a hypothetical building designed to meet only relevant building standards;[5] and
- the US Environmental Protection Agency's Robert Kerr Environmental Research Centre at Ada, Oklahoma, which is aiming to be the world's first laboratory to be 'carbon neutral' in its (non-transport) operations.[6]

Although some detailed Labs21 recommendations are laboratory-specific (such as use of variable or low air flow fume cupboards), many others are applicable to all highly serviced buildings, such as data centres and libraries. They also mirror many of the points made in this guide. The Labs21 recommendations include:

- great emphasis on achieving an inclusive design process to create greater dialogue between suppliers, and between suppliers and users;
- careful profiling of occupancy, loads and other aspects of building operation so that services and equipment can be 'right sized' (rather than being designed on the basis of rules of thumb, or high safety margins set to take account of uncertainty);
- maximum use of daylighting to reduce energy consumption and to provide congenial working conditions;
- use of interstitial floors, or 'walk in' ceilings, to provide independent access to ventilation and other equipment or ductwork for monitoring, maintenance and modification - these service spaces can be built to end before the perimeter, allowing the main ceilings to arch upwards toward double height windowed walls (5.4m) that maximise daylight;
- maximum use of modular elements and equipment to make right sizing easier and provide the high level of flexibility which is important in buildings housing fast changing activities; and
- a strong focus on commissioning, which Labs21 sees as a quality control process managed independently of the main contractor (and beginning at inception, rather than being the final activity before handover).[7]

8. Design - Controls and Materials

Design for Effective Control

Energy consumption can be greatly reduced - often with improved occupant comfort - through better control of heating, ventilation and air conditioning (HVAC), and lighting systems. However, achieving this requires controls which:

- are easily understood and can be adjusted by users;
- are installed and commissioned and operated correctly;
- use proven adaptable technologies (e.g. local lighting controls with daylight sensors and presence detection systems);
- correspond with building zones as occupied in use (e.g. departments); and
- operate in a way that is comprehensible to a lay building manager / administrator.

If these controls are not used, the risk of merely repeating old experience in a new building is enhanced - for example, in a survey 57% of UK facilities managers stated that their heating and cooling plant ran simultaneously.[8] The respondents to this survey also requested three key changes in control specification:

- that control systems should be kept simple and the industry should adopt a standard configuration;
- that controls should be capable of manual override for short periods of time, or within a range of set points; and
- that control systems should be less complicated and more intuitive to use.

Materials

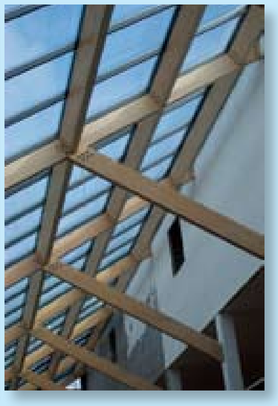
It is important for the design team to understand the physical properties of each individual material or component, how they are assembled, how they interact when in place, and how they can be disassembled to allow maintenance and, ultimately, demolition. The widespread use of applied finishes, composite materials and finishes and materials with highly synthesized chemical structures imposes a considerable embodied energy and toxic load on a building, as well as militating against recycling and biodegradability. The building design process must systematically assess finishes and materials specifications for their contribution to the following objectives:

- the reuse of materials that are robust, natural, local or even found on site (e.g. demolition materials);
- the use of recycled aggregate/pulverised fuel ash in concrete and lime based mortars (because Portland cement production generates 8% of world CO_2 emissions);
- the use of independently certified timber supplies;
- the avoidance of applied finishes, or finishes that require harsh cleaning regimes;
- easy deconstruction of the building for reuse and recycling; and
- the minimisation of unwanted air infiltration through the building fabric.

■ **Effective controls are critical for low energy buildings - but often don't work well in practice**

How to Source Sustainable Timber

Supplies of sustainably produced hardwoods and plywood - with credible documentation to guarantee it - have been limited, so planning has to begin at an early stage. Architects must not only specify the need, but must also identify at least one reliable supplier who can meet the requirement to time and budget. In the case of Scottish Natural Heritage's new headquarters in Inverness (pictured), this involved identifying and felling 350 tonnes of larch trees in local forests while the project was still on the drawing board. This meant the wood was available for harvesting and processing by the time it was needed in the build phase.



Anticipating and Influencing Occupant Behaviour

Individuals not only have different preferences for the temperature, ventilation and lighting of their workspaces, but their reactions to buildings can be adversely affected if they do not feel in control of these parameters. Providing appropriate control - such as opening windows, blinds, and local thermostatic controls - is very important. Clearly, this can conflict with achieving energy efficiency goals if people use localised controls wrongly, e.g. by opening windows instead of turning the thermostat down.

It is almost impossible to completely mesh the human desire for instant feedback with the slow response offered by high thermal mass buildings. However, experience shows that user education can make a difference to behaviour. There are also many opportunities to achieve energy efficiency in other ways (such as reducing heating and lighting in low, or no, occupancy periods) which, when taken together, would counterbalance any additional energy consumption and cost arising from control misuse. Indeed, it is a price worth paying to ensure support for the whole building's sustainable objectives and high performance levels of users.

How to Protect Sustainable Designs from Value Engineering and Cost Cutting

A holistic sustainability strategy avoids heavy reliance on single elements that might be deleted from the specification when the budget gets tight. Begin by ensuring core elements all contribute directly to project standards, e.g., limit solar gain through building form, fabric and orientation before considering solar shading with brise soleil.

For elements at risk from value engineering, prepare in advance a reasoned, modelled, and cost-based argument for retaining them.

9. Build - Tendering

This section is written with reference to the client-led procurement routes identified in Appendix 2. Achieving successful high performance buildings using this approach requires the selection of design teams and contractors who fully appreciate the importance of the environmental and sustainability objectives and who are capable of delivering them with 'value for money'.[9]

Project Tendering

It is important that high performance and sustainability objectives feature prominently in all the main stages, which are:

Invite interest - any invitation must highlight the client's expectations for a high performance building incorporating sustainable construction principles. There may also be value in specifically alerting contractors with good track records in such buildings, but who haven't worked with the institution before.

Pre-Qualification Questionnaire (PQQ) - this aims to produce a shortlist of 4-8 potential Tenderers by asking probing questions and scoring answers according to a publicly disclosed method. It is vital that evidence of key environmental and sustainability capabilities are highlighted in this PQQ.

Invitation to Tender (ITT) - this comprises many documents detailing contract requirements. These form the reference point for any subsequent disputes. In a traditional contract these documents will include a set of detailed design drawings, specification and Bill of Quantities. In a single stage tender, all of this information will be provided simultaneously by bidders. In a two stage tender, a short list of contractors is asked to submit costs for preliminaries and overheads (the cost of managing a project), plus rates for individual trades. The winning tenderer is subsequently asked to apply those rates to a Bill of Quantities that will be independently checked and assessed.

Tender evaluation and checking - final tenders are assessed to ensure that they meet the requirements of the brief and do not alter the form of the contract. The main variable between bids has traditionally been price; but it is vital to undertake a quality analysis with sustainability factors forming part of the quality criteria. (This is even more important, of course, for tenders for Design and Build, or Partnership contracts).

Post tender - in some cases, the client may negotiate changes to the design with one or more of the contractors, either because - in a desire to reduce their financial risk - their bids contain significant caveats about it, or because they are above the target price. It is sometimes environmental features which trigger these discussions, e.g. high pricing of 'unusual' features such as hygroscopic materials, or unwillingness to offer absolute guarantees that sustainable materials will be sourced. Many of the original aspirations can be lost at this stage if key sustainability stakeholders have no inputs, and if alternatives to changing the specifications are not fully explored.

- **The commitment to high performance buildings has to reiterated at all stages of tendering, and embedded in contract documentation**

Key Questions for the Tendering and Construction Stage

Are all of the following points in this list covered effectively in relevant documentation, e.g. Pre-Qualification Questionnaire (PQQ), tender documents and contracts?

Do the contractors have:

1. A good understanding of the importance of, and the ability to deliver, the high performance, low carbon, features of the building?
2. Recent, successful, experience of constructing - and productively working with design teams on - high performance buildings? If so, will the individuals who have achieved this have a leading role in the current project?
3. A management structure which clearly defines both the roles and responsibilities of individuals for environmental and sustainability issues, and establishes a single point of contact on these for the client?
4. Documented experience of participation in relevant Government and trade initiatives on sustainable construction and related areas?
5. Adequate internal policies and systems (e.g. an Environmental Management System, a Biodiversity Management Plan, a Site Waste Management Plan), training programmes, and other initiatives to ensure that sub-contractors and site workers are aware of, and have the capacity to implement, the high performance building objectives?
6. Adequate internal policies and systems to ensure compliance with component and material requirements such as local purchase policies, requirements for FSC certified timber, and setting a percentage target for the use of recycled and recyclable materials?
7. A practical understanding of the importance of local issues (and of any relevant local authority guidance or conditions), and the need to maximise local employment?
8. Clear guidance about, and supervision of, the fitting of controls, meters, sensors, insulation and other important contributors to low energy buildings?
9. Good health and safety, and working, conditions?

10. Build - Construction

Agreements

Once a tender has been accepted, the ensuing agreement should:

- reiterate the environmental and sustainability goals and performance targets;
- identify milestones and potential pressure points and at what point they should be explicitly considered; and
- ensure that that there is sufficient time included within schedules to respond properly to any sustainability-related problems identified.

Construction Phase

Construction requires a vast array of materials, labour and equipment to come together at the right time. This involves co-ordination of many trades, sub-contractors and suppliers. Unfortunately, it is also the stage when many environmental and sustainability features are watered down or lost, for reasons such as:

- unexpected problems due to inadequate attention to what were perceived as lower priority issues;
- sub-contractors who do not understand, or are not experienced in, what is required;
- inadequate monitoring of the work of subcontractors, e.g. attention to detail during fitting of insulation;
- ordering of materials on a 'just in time basis', so that the additional lead times which are sometimes required for sustainable materials have not been factored in, resulting in last minute substitutions;
- the desire of most contractors to complete the works as quickly, and at as small a cost to themselves, as possible;
- optimistic bidding, with the hope that time pressures will create flexibility in some of the deliverables so that costs can be reduced; and
- poor specification by the client / design team, e.g. not requiring specific models of, or key functionality in, electricity meters.

Avoiding these problems requires:

- careful consideration - with regard to both sustainability and other areas - of the experience, reliability and project management skills of the main contractor and sub-contractors;
- very clear specifications about sustainability requirements in tender documents, and assurance that there is clear and unambiguous communication of these by main contractor to their sub-contractors;
- ensuring adequate ordering lead times are laid down for unusual materials and specialist equipment;
- making sure that sustainability-related expertise which is drawn upon to win the contract is also involved in the key stages of construction; and
- choosing contractors who are members of relevant industry organisations and schemes, e.g. the Association for Environment Conscious Building (AECB), the Considerate Constructors Scheme, or who implement relevant guidance, e.g. from Constructing Excellence or on Site Waste Management Plans.[10]

- **Detailed specification and checks are essential if energy efficiency features are to work effectively**

The Importance of Checking Construction Quality

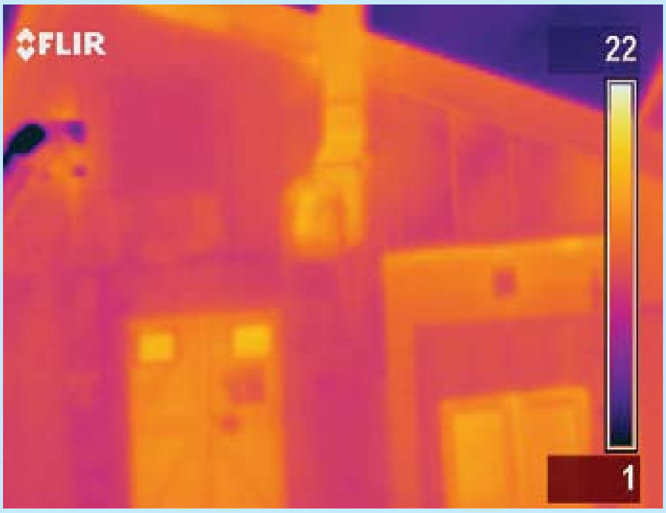
"Investigations commissioned by Aberdeen Council, and carried out by BRE, to determine why a modern housing development supposedly compliant with Building Regulations suffered heat losses normally associated with Victorian housing, found that in most of the houses the insulation, though notionally compliant with recommended levels, was very poorly fitted. Poor workmanship and a lack of post-completion checks ensured that any potential benefits from increased energy efficiency set out in the Regulations were completely lost. BRE's work to investigate compliance of new housing with air permeability standards, highlighted similar problems. It tested 33 homes to determine if they met Building Regulation standards in this respect. Over 60% of these properties failed."

House of Commons Environmental Audit Committee - First Report, January 2005 [11]

Techniques for Checking On-site Quality

Pressure testing and thermal imaging are two valuable techniques for assessing the quality of a completed building. But they are most useful when contractors know in advance that they are to be used, and that they will be held responsible for defects uncovered.

Pressure testing is used to test the overall air-tightness (i.e. the background air infiltration rate) of a building. A powerful fan is sealed over one of the entrances to the building, and the air flow rate at various pressure differences is measured. Part L of the Building Regulations in England and Wales requires that a given air flow rate is achieved at a pressure difference of 50 Pascals (roughly equivalent to pressure differences around a building caused by strong wind).



Thermal imaging offers a more focused, but complementary, service as it can be used to identify the leaks that are causing any pressure losses, as well as locating other faults in the building envelope - such as cold bridges, missing insulation, and water ingress behind cladding panels. Areas of high heat loss show up as red or white - as in this thermal image of a house.

Thermal image of a house
Picture credit: Steve Goodhew, University of Plymouth.

11. Handover and Use - Commissioning

Despite the best design team and client intentions, research shows that many buildings have a worse energy performance in use than was predicted at the design stage. Some common reasons are:

- poor analysis during design;
- inadequate site supervision leading to cutting corners in construction;
- surprises with regard to building uses and occupancy levels;
- equipment malfunctioning due to incorrect installation or lack of knowledge by facilities staff; and
- overly complex control systems which are either not used at all, used incorrectly, or result in heating and cooling systems 'fighting' each other.

With proper quality assurance procedures and a formal Post Occupancy Evaluation (POE), these problems can be solved - and at the expense of suppliers rather than the client. This benefits not only the occupants and managers of the current building but, by creating a precedent, should also have a positive impact on the delivery of subsequent buildings by the same design team and / or contractor.

Commissioning

Commissioning is essentially a building quality assurance process which verifies that the work done, and any plant installed, conforms to the design intent (including any environmental performance criteria) and the detailed design specifications. It can be done as one of many tasks by the design team, main contractor, or the customer, but is generally best accomplished as an independent activity by a specialist commissioning contractor. This is especially important in very complex buildings such as laboratories.

Effective commissioning is vital if environmental benefits are to be achieved as they often rely on correct installation and operation of building features, and / or optimisation of controls to reflect actual (rather than assumed) occupancy and use. Unfortunately, this is often not the outcome in practice. For this reason, the US LEED environmental assessment scheme gives credits for independent commissioning, and BREEAM gives credit for seasonal commissioning - i.e. re-commissioning / tweaking systems every three months during the first year of occupation (see Appendix 1).

Effective commissioning can also guard against any problems arising from the unusual and/or 'one off' features which, in the current emergent stage of green technologies, are sometimes found in sustainable buildings. Although commissioning is relevant to all stages of a building, most activity is in the period just before or at handover. The main environment-related activities which need to be undertaken properly at this stage are:

- thorough testing of system and equipment performance, using techniques such as air pressure testing and thermal imaging, and rectification of any problems which emerge;
- training of operation and maintenance personnel and occupants; and
- assembly and handover of high quality (rather than quantity), user-friendly, and, increasingly, electronically searchable, documentation of what has been built, and how equipment and systems operate.

Relevant documents include a Building Log Book, as-fitted drawings, copies of relevant certificates and receipts (e.g. for FSC timber), technical literature, and comprehensive Operation and Maintenance manuals.[12]

■ Commissioning and Post Occupancy Evaluation can optimise an existing building, and provide invaluable feedback to improve successors

Key Questions for the Handover and Use Stage

1. Is someone of authority clearly responsible for ensuring the effective commissioning of the building and managing its subsequent performance?
2. Have the future costs and risks of potential building problems been fully considered and compared with the costs of independent commissioning?
3. Is there comprehensive, and reproducible, documentation on systems and equipment and controls covering both technical features and intended operation?
4. Have appropriate methods - e.g. by checking air leakage and insulation - been used to establish that energy and environmental performance standards have been met during construction, and is there provision for final testing 12-18 months after handover?
5. Have all relevant stakeholders been involved in commissioning, e.g. building managers and maintenance staff?
6. Have relevant training and awareness programmes been established for facilities staff and occupants?
7. Is there budgetary provision for a thorough Post Occupancy Evaluation study, with a contractual requirement that the design team and main contractors attend a review meeting? And will the outcomes be documented in ways that will help internal decision-makers, suppliers and the wider FHE community improve the design and construction of subsequent buildings?
8. Are measures in place to assess performance on a regular basis, in different seasons, and, where necessary, to allow changes to be made to controls and other parameters?

Commissioning Pays Off

A US study of 224 buildings found that, for new ones, average commissioning costs were 0.6% of total construction costs, and had an average payback time of 4.8 years from energy costs alone.[13] It concluded that, when non-energy benefits were taken into account, "the net cost for new buildings is often zero or even negative." The results were also based on energy prices considerably lower than those prevailing today.

The study also highlighted the importance of 'continuous commissioning' at regular intervals after handover. At Texas A&M University's Kleberg Building (pictured) one such exercise produced an 84% reduction in hot water, and a 64% reduction in chilled water, consumption.

12. Handover and Use - Occupation

Post Occupancy Evaluation

Even with proper commissioning, buildings seldom, if ever, operate perfectly after handover. The reasons for this include:

- the need to fine-tune individual operational elements - both as stand-alone, and in their interaction with other elements - for a variety of different operating circumstances (e.g. seasonal variation);
- the variability of users, whose behaviour and attitudes are impossible to anticipate completely in advance; and
- many of the other design and construction problems identified in previous sections.

It is therefore vital to systematically review building performance so that any problems - such as higher than expected energy performance - are identified, and solved, post handover. Thorough Post Occupancy Evaluation (POE) can also improve future building processes and outcomes by providing feedback about successes and failures to internal decision-makers, the design team, contractors, and the broader educational community. A study by the Association of University Directors of the Estates (AUDE) has identified three distinct stages:

- short term - conducted within the first few months of handover, with the main aims being to identify and resolve major problems within the defects liability period;
- medium term - conducted after a full year's operation so that seasonal variations are taken into account, all issues are likely to have emerged, and any under- or over-utilisation can be identified;
- long term - conducted several years after handover to ensure that all problems have been resolved, that operation has not 'drifted' away from optimum, and that the building is being effectively utilised and remains 'fit for purpose'.[14]

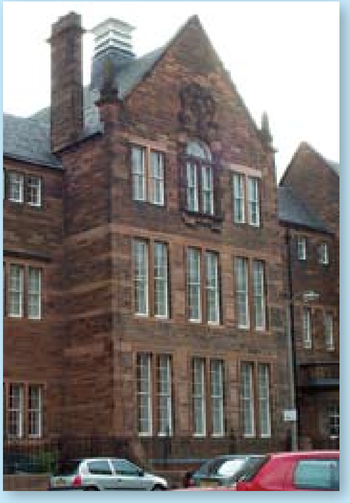
At least one of these reviews should be independently facilitated. And there should be inputs, varying at each stage, from:

- the main contractors who will need to rectify any problems which are their responsibility, and also feed any lessons back into their future work;
- building users such as academic and administrative staff or students (gathered by any or all of questionnaires, interviews and focus groups); and
- facilities staff, including those responsible for energy and environmental issues.

Unfortunately, this ideal approach is a long way from the current reality. Many universities and colleges fail to undertake any kind of systematic POE, and even fewer do more than one. Even when an evaluation is undertaken, there is often no research into user views, or involvement of contractors. The main reasons are time pressures, lack of budget, and the unwillingness of contractors to provide unpaid time and / or risk possible embarrassment. These problems can only be overcome if POE is built into organisational policies, processes and budgets from the start, and made a contractual requirement for suppliers.

■ Very few building initially operate as intended, and many consume more energy than their design suggests

Getting Handover and Use Right - Norton Park, Edinburgh



A Victorian school building was converted in 1999 by the Albion Trust for flexible accommodation for a number of charities. The refurbishment work incorporated the principles of high performance design: including super-insulation, high specification secondary glazing, rainwater harvesting and solar slate technology.

Post commissioning initial results were encouraging, with energy consumption lower than typical new buildings - but not as good as expected. However, with the appointment of a Facilities Manager, trained to optimise the Building Energy management System (BEMS), tune settings and detect faults, a dramatic improvement in performance was achieved to the point where best practice for new build projects has been matched.

Reducing Energy Consumption at Wessex Water HQ, Bath

Emissions from Wessex Water's new, 'low carbon' headquarters were higher than anticipated in the first year after occupation. However, these were reduced by 23% in the next year through a monthly follow up and evaluation by the building consultants. The architect, Rab Bennetts, commented that:

"We learned an enormous amount, and the shocking fact is how much a building can be improved by not walking away after handover." [15]

Findings from Actual Post Occupancy Evaluations in Universities and Colleges

- Blockages in natural ventilation ducts.
- Controls that are very difficult to understand and reach, and therefore go unused.
- Identifying considerable under-utilised space in an apparently over-crowded building.
- Heating and cooling systems on at the same time.
- High use of artificial lighting in daytime because blinds or curtains are frequently drawn to reduce glare and reflection (e.g. so that whiteboards are visible).
- High energy consumption in some naturally ventilated buildings because summer ventilation strategies create high air 'leakiness' in winter.
- Badly functioning building management systems due to 'standard' programming, or use of 'temporary' overrides which become permanent.
- Need to ensure greater privacy and security, e.g. by effective blinds and prickly hedge barriers, for ground floor residences.

Appendix 1 - BREEAM and LEED: Assessing Building Environmental Performance

There are a number of methods for assessing the environmental and other sustainability features of construction in the UK. Many have been developed by consultancies to assist their own work, but two have more general applicability - the Building Research Establishment Environmental Assessment Method (BREEAM) for buildings, and the closely related Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) (developed for the Institution of Civil Engineers) for other aspects of construction.[16]

BREEAM reviews the design and specifications for a building against criteria grouped into eight headings:

1. management
2. energy
3. health and well being
4. pollution
5. transport
6. land use
7. ecology, and
8. materials.

Each criterion is weighted in importance by having a varying number of points attached to it. The completed design is assessed against these criteria, and scored as, Pass, Good, Very Good or Excellent.

For some kinds of buildings, such as offices or schools, there are standard ‘templates’ providing the criteria for assessment. If these do not exist - as is the case for most buildings in further and higher education - an individual ‘bespoke’ template has to be created by BRE, at additional cost. To be certified, the scoring has to be undertaken by BRE-trained and licensed Assessors. Some institutions have avoided the costs of bespoke, independent, BREEAM assessments (but also eschewed the potential value of external scrutiny, and public recognition) by simply using BREEAM internally, as a generic tool to shape the building’s development.

The main advantages for an institution adopting BREEAM are that it provides clear and measurable guidelines for the design team to work to. It also enables clients to make a statement about their commitment to sustainability (although this is only impressive if they aspire to Excellent for new buildings, and Very Good for refurbishments). If the design is independently certified, there can be further reputational benefits from good performance, and from the additional driver for improvement created by designers’ awareness that their plans will be scrutinised more thoroughly than with an internal process.

On the other hand, BREEAM’s points-based nature means that positive performance in some areas can be used to offset poor performance in others - for example, a Good or even Very Good BREEAM rating has been achieved with fairly ordinary energy performance. The schemes also focuses on the initial design of the building, and therefore offer no guarantees that the claimed benefits will be achieved in practice. It should be used as a complement to, rather than a substitute for, an institution setting its own strategic requirements for environmental issues, e.g. targets for energy consumption per m^2, and monitoring their achievement.

BREEAM can be useful but doesn't remove the need for institutions to set their own targets, and to ensure that these are achieved

Making a Research Statement - The Devonshire Building

The University of Newcastle upon Tyne opted for a high performance building to house a new Institute for Research on Environment and Sustainability. The Devonshire Building - which was one of the first laboratories, and one of the first higher education buildings in the UK, to be awarded a BREEAM Excellent rating - has many innovative features. There is extensive natural lighting, with automatic controls to limit heat gain, glare and over-use of artificial lighting. Space is grouped and organised so that environmental conditions in laboratories can be tightly controlled whilst an atrium functions as a climate buffer for adjacent spaces. Other features include heat recovery from exhaust air, photovoltaic cells to convert daylight to electricity, material selection based on lifecycle analysis of environmental impact, and rainwater harvesting to supply water for toilets.

The US Green Building Council and Leadership in Energy and Environmental Design (LEED)

The US LEED scheme is similar to (and was loosely modelled on) BREEAM. It is a points-based system which covers broadly similar topics and also has four rating grades: Certified, Silver, Gold, and Platinum.[17] It differs in detail in having generic criteria (which can be applied to any kind of building), and in being self-assessed (but with external scrutiny of the results). It also differs in philosophy, in that BREEAM is a proprietary consultancy product, whereas LEED is associated with - and owned by - the US Green Building Council, a public interest organisation which brings together multiple stakeholders (including representatives of the construction professions, developers and environmental groups) to support an activist mission of stimulating more sustainable construction.[18] One consequence of this is that the criteria for LEED are published, and any changes are developed through a consensus process. These greater linkages with external stakeholders mean that achieving a LEED-certified building is generally higher profile, and more meaningful to non-experts, in the US than a BREEAM certification is in the UK.

The success of the US Green Building Council has spawned sister organisations in other countries, including a UK Green Building Council.[19] This was launched in spring 2007 with a mission to "dramatically improve the sustainability of the built environment by radically transforming the way it is planned, designed, constructed, maintained and operated." As BRE was actively involved in its creation it is unlikely that it will result in LEED being introduced to the UK. More likely is that - in much the same way as the International Standards Organisation's environmental management system standard, ISO 14001, harmonised national approaches in the 1990s - both BREEAM and LEED may be modified over the next decade in response to the development of a new international framework for the assessment of sustainable construction. The vehicle for such activities now exists in the form of a World Green Building Council, which co-ordinates the actions of its national members.[20]

Appendix 2 - Sustainability Aspects of Different Procurement Approaches

	Client Led (Lump sum, Management contract)	**Supplier Led** (Design and Build, PFI and other Partnerships)
Operation	The client controls the process. This includes developing the initial brief, appointing the design team, approving key decisions as they progress through the RIBA work stages, and appointing contractors. There are a number of variants of this approach including: One stage lump sum - the traditional (and still most common) approach where contractors become involved at a late stage of the design, and provide a fixed bid based on a build up of costs against a detailed Bill of Quantities. Two stage lump sum - where one or more contractors have an earlier involvement (allowing them to contribute to the design process) by tendering a Bill of Rates. When the design is completed a price is calculated by applying the costs to the Bill of Quantities. Management contract - a single contractor is appointed early in the process and manages all construction on a fixed fee basis. Specific tasks are then tendered in the same way as single stage lump sum contracts.	The client establishes a set of 'employer's requirements' for a building but contractors have responsibility for the final design, and construction. There are a number of variants on this approach including: One stage design and build - the client establishes a brief and appoints a design team but at some stage (which may be as late as planning consent) invites Contractor's Proposals for a fixed fee to finalise the design and then construct it. Once agreed, the design team may be 'novated' to work for the contractor. Two stage design and build - a main contractor is appointed at an early stage on the basis of a Bill of Rates, and a final price if then agreed based on a detailed design and a Bill of Quantities. Once appointed, the contractor assumes responsibility for the design. Partnership - a contractor or developer bids to design and build the building, typically at zero or reduced cost on the basis of a long-term income stream from involvement in its operation (e.g. ownership for a number of years, with a guaranteed leaseback to the client, often including facilities management). PFI (public finance initiative) and PPP (public private partnership) are the most common schemes of this kind.
Potential sustainability strengths	The client can select a design team and contractors who are committed to, and experienced in, high performance buildings. There is also considerable opportunity for clients to monitor and influence all stages of the process.	The 'employers requirements' provide an opportunity to set clear, specific and legally enforceable sustainability performance criteria. Concentration of design and construction responsibility onto the contractor can reduce co-ordination problems. The developer's responsibility for medium-long operation in partnership contracts provides an opportunity to apply specialised expertise to energy management, although this depends on appropriate incentives in the contract.
Potential sustainability weaknesses	Requires considerable commitment and capacity on the part of the client to ensure good design and implementation. Co-ordination of suppliers can be difficult to achieve.	It is difficult to anticipate all sustainability contingencies in the 'employers requirements'. Time pressures, and the involvement of only a few senior staff, can also mean that key expertise and stakeholders are excluded from discussions about 'employers requirements'. Difficult to write 'cast iron' partnership contracts which provide strong incentives for developers to achieve good sustainability performance.
Key factors for success	A committed client, with capacity for effective engagement throughout the process. An integrated and effective design team, with a commitment to sustainability.	Incorporation of specific, measurable, sustainability goals into 'employers requirements'. Strong incentives for good sustainability performance in operation of partnership contracts. Effective commissioning and post occupancy evaluation to ensure that 'employers requirements' have been met.

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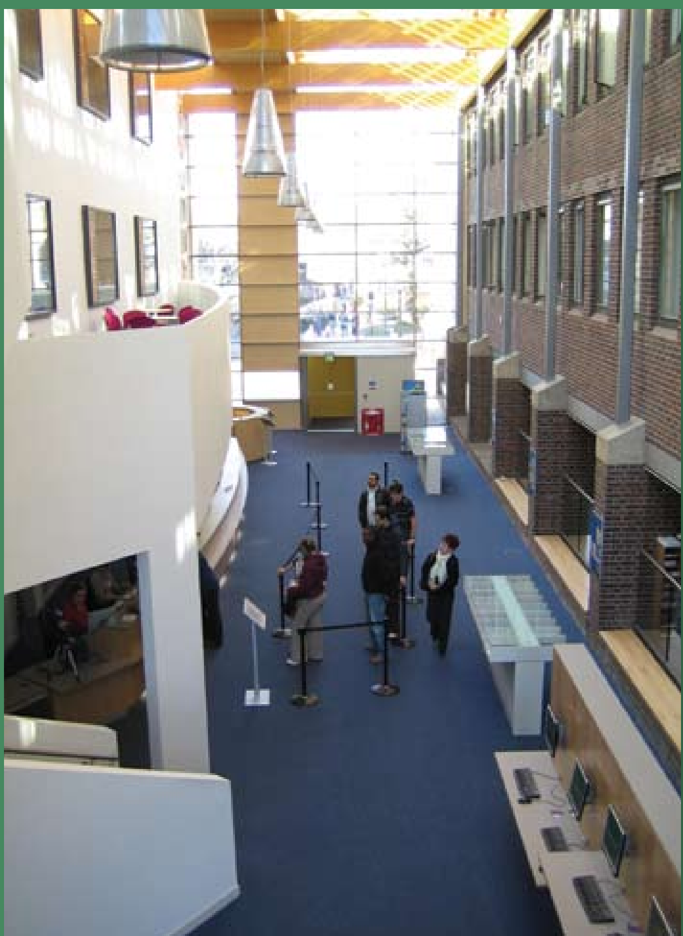
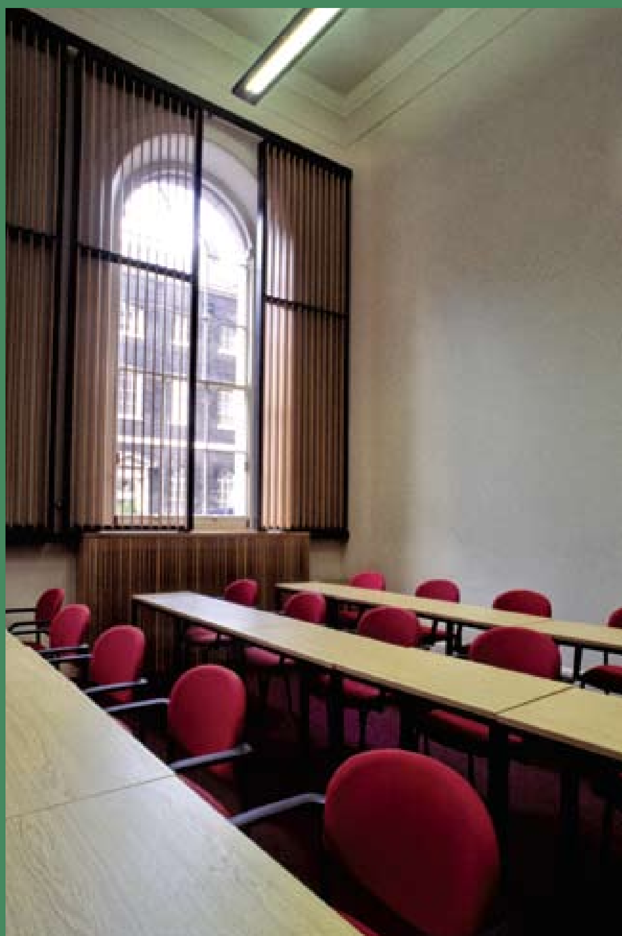
20. See ww.worldgbc.org.

Buildings which have won or been highly commended in the Sustainable Construction category of the Green Gown Awards

Queen Mother Building, University of Dundee



Administration Building, University of Southampton



King's Building, Kings College