High Performance Buildings

1. The Business Case for Universities and Colleges

March 2008

"Finance directors are increasingly aware - and concerned - of the rising costs of energy, water, and waste management. We are also a key target of the many Government measures to provide greater financial incentives for environmental improvement. Hence, this document's key message - that many environmental benefits can be achieved cost-effectively if the right things are done in building design and construction - is one that everybody connected with financial issues in further and higher education should heed."

Philip Harding, Director of Finance, University of Westminster, and Chair, BUFDG

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Higher Education Environmental Performance Improvement (HEEPI)

SUST. The Lighthouse on Sustainability

Thirdwave – The Business Case for Sustainability

In association with:

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Ailtearachd is Dealbhadh na h-Alba

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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, or 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 highlights the strong business case for more sustainable buildings in universities and colleges. A companion guide, *High Performance Buildings - 2. The Process of Delivery for Universities and Colleges* discusses how the business and environmental benefits can be achieved in practice. 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**.

Foreword

Buildings represent major investments in the future delivery of further and higher education. We dedicate money, time, creativity and many natural resources to their construction and ongoing maintenance.

Buildings provide shelter for human activities so that society can prosper; and good buildings represent the best that a generation can achieve in terms of skill and beauty.

Buildings can also be significant contributors to global problems such as polluting emissions, climate change and the depletion of natural resources. It is in this arena that we must focus our greatest skill, knowledge and creativity when making the longer term investment decisions that buildings demand.

The sustainable design and construction of both new and refurbished buildings can minimise negative impacts through, for example, more efficient use of energy and water, or the utilisation of renewable energy and materials. All universities and colleges will eventually do this - driven by a mix of rising energy costs, tightening regulations and changing stakeholder expectations.

Those who anticipate the trend can avoid additional fuel bills, expensive retrofitting measures, and other costs which will hit their less pro-active peers. They can benefit from demonstrating leadership in an arena where expectations are rapidly rising, and comparisons are increasingly being made. As many institutions operating sustainable buildings have already found, enhanced reputation, coupled with the improved well being and productivity of building users, frequently offers the greatest financial reward of all.

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

- sustainable construction processes and practices are embraced from the start as a key performance requirement; and
- the design and procurement process is managed effectively - with clear responsibility for, and timely decision-making to meet, all the institution's long-term requirements, including sustainability.

Some universities and colleges are already doing this, and would do more with encouragement. However, the majority need to change in order to catch up. Instead of focusing primarily on the immediate concerns of capital cost or design and assessing the standard and value of buildings against today's norms, senior decision-makers should evaluate options against the scenarios that are likely to apply in 20-30 years time, and their impact on whole life costs. They should also pay greater attention to the implementation of designs so that benefits are actually achieved in practice.

We hope that you will find this guide to the Business Case, and the companion guide: *The Process of Delivery*, valuable in developing your estate to meet the challenges of the coming century.

1. Introduction

Decisions about new, or major refurbishment of existing, buildings are some of the biggest to be made within the further and higher education sector. Their capital impact is obvious, but of even greater significance is the stream of operating costs they create and, above all, their impact on people. Good physical environments can facilitate high quality learning experiences and research, and improve productivity and attendance. They can also be attractive to prospective employees and students, who increasingly seek out universities and colleges whose values reflect their own, and in whom they can take pride.

The following pages demonstrate that getting these decisions right today requires much greater attention to sustainable development, and especially environmental performance, than in the past. They outline the multiple dimensions of benefit from this - in Finance, Risk, Performance and Reputation. And they make the business case for a more coherent, and better informed, engagement with the issues by all those involved in new building projects, from their earliest stages.

Good Environmental Performance = Good Building Performance

Many of the features of high performance buildings which reduce environmental impacts are complementary, rather than conflicting, with other building requirements. For example:

- Optimised use of daylight, in bright, airy, buildings with views of the outside, has positive psychological effects on most users; creates a sense of connection with the natural world and the diurnal cycle that has measurable effects on learning outcomes in teaching rooms and libraries; reduces eyestrain and other adverse effects of artificial lighting; and has low electricity consumption for illumination.
- Use of natural ventilation, rather than mechanical ventilation or air conditioning, reduces the costs and environmental impacts of energy consumption; and the maintenance burden associated with complex equipment.
- Maximum use of natural, sustainably produced, materials reduces environmental impacts; has positive psychological effects on most users; and avoids the harmful emissions associated with some man-made building materials, finishes and cleaning materials (e.g. in adhesives, solvents and plastics).
- A high level of metering and monitoring highlights opportunities to reduce energy and water consumption; identifies problems in building operation; and can provide rich information for use as a teaching resource in undergraduate and specialised postgraduate courses.
- High levels of flexibility - if uses can be more easily changed over time there is an environmental benefit of longer lives for existing buildings, and less need for new ones; and a financial benefit of avoiding high costs for renewal or replacement.
- Designing and sizing building systems and equipment on the basis of well-understood needs, and careful modelling of their interaction, rather than 'rule of thumb' assumptions, can result in reduced capital and operating cost, easier maintenance, and lower energy consumption.

- The environmental features of high performance buildings can support other building objectives, often at no additional cost

Doing Up the Strand - Sustainable Refurbishment at King's College, London

Since its opening in the 1830s, the listed King's Building has seen many modifications. Refurbishment of an 8,800m^2 wing - much of it unoccupied because of poor condition, and relocation of previous users - became a priority in 2002. The conventional solution, according to Director of Estates, Ian Caldwell, "would have been to accept the modified structure, and to modernise its services, including installation of a central air conditioning system. However we wanted a sustainable solution to make the building more attractive to users and the community, and also to reduce or contain energy and other operating costs."

The solution was removal of accretions such as mezzanine floors, book lifts, and partitions, and consolidation of services into 'micro-risers' in the main corridors. This allowed restoration of the more open spaces, higher room volumes, and greater window area of the original design, and enabled high use of natural lighting and ventilation. Re-establishing a visual relationship between circulation spaces and staircases also reduced lift requirements.

Other measures to restrict air conditioning to a few specialist areas include opening windows and ceiling fans, purpose-designed internal shutters to control solar gain (and provide better light control for presentations), and renewal - with insulation - of the double-storey slate roof to reduce summer solar gain (as well as heat loss in winter). Integral rooflights also bring natural light into the heart of the building.

Additional features include an 80% recycling of demolished materials, 100% use of sustainably produced timber, occupancy sensing control of lighting and urinals, and an advanced building energy management system.

Feedback on the building has been very positive, especially after training about its features. According to Energy Manager, Keith McIntyre, the "energy benefits are enormous. Even with more usable space, annual electricity consumption is down 18%, and gas by 11%. This has saved £96,790 a year, with little if any additional capital expenditure needed to achieve it."

2. What Are High Performance Buildings?

High performance, well-designed, buildings should synthesise all aspects of how a building functions, including aspects usually associated with 'green issues' and 'sustainability'. They are achieved by using:

- structures and layouts that deliver highly productive and adaptable working conditions;
- practices and materials that are designed to safeguard occupants' health and well being;
- very low energy solutions and low carbon resource inputs;
- low water consumption systems; and
- effective use of scarce material resources.

The term 'green' building can be interpreted in many ways, and can be mistakenly associated with buildings that are more expensive to build, or buildings which emphasise environmental aspects of design at the expense of other, equally important, issues such as functionality and aesthetic. To avoid such confusion, for the purposes of this guide, the alternative term 'high performance building' is used in order to emphasise a more holistic attitude to design that incorporates sustainability at an intrinsic level; and to focus attention on the following key features:

- firstly, the importance of adopting a holistic design process that optimises the performance of all the key features of the building with the result that any environmental or 'green' features are fully integrated and do not conflict with other design aims, such as capital and operating costs, comfort, high utilisation and flexibility;
- secondly, avoiding the risk of delivering a 'low performance building' with the associated risk of dissatisfied staff and students, high energy and water costs, lack of attention to 'future proofing' in terms of adaptability and flexibility, and high maintenance costs; and
- thirdly, redressing the perception that energy and environmental issues are technical issues that can be addressed at a late stage in the design process.

Experience shows that the cost of dealing with sustainability issues effectively rises with time. By considering them strategically, and as key design requirements, costs can be minimised and opportunities for associated benefit maximised. This approach also firmly places sustainability at the centre of a design process that focuses on high performance over the whole life of a building. Over this period, the salaries of occupants, and other operating costs, will significantly outweigh the initial capital expenditure. Improved sustainability therefore creates very large whole life benefits from:

- lower rises in utility costs; and
- lower sickness and absence rates, improved occupant productivity and performance (arising from natural lighting and ventilation, and higher indoor air quality through use of toxin-free materials).

A 'whole life cost' perspective of this kind avoids the common trap of missing large opportunities for long-term financial and environmental benefit because of a short-term focus on relatively small amounts of capital spend.

■ If whole life costs are calculated accurately, energy and environmental investments often have very short payback periods

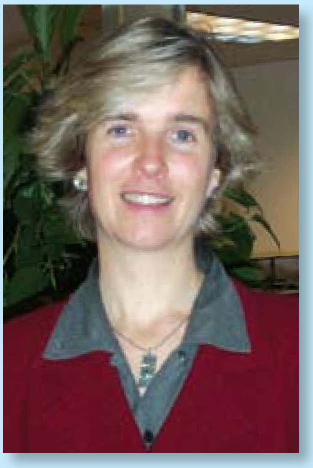
High Performance Building at Harvard

In 2000 Harvard University established a Harvard Green Campus Initiative (HGCI), with the aims of stimulating environmental improvement across the institution, and providing specialised support to individual Schools.

In early 2006 the Initiative had 13 full-time staff - 5 of whom specialised in high performance buildings - and an annual expenditure of $1.1 million. A third of this was provided by the University, with the remainder coming from 'fee for service' internal consultancy activities.

The Initiative supports the development of high performance buildings through:

- a $3 million Fund providing interest free loans for up to five years to finance any additional capital costs created by a choice of environmentally superior alternatives in the design of new and refurbished buildings (with another $3 million Fund available for initiatives in existing buildings or activities);
- provision of specialist inputs to all stages of building design (including writing tenders and contracts);
- preparation of proposals for environmental investments on behalf of School facilities departments;
- organising and running design charettes (which bring together clients, suppliers and stakeholders to achieve better integration and understanding);
- organising and running training courses;
- providing expertise in, and preparing submissions for, environmental certification of buildings.



The Initiative estimates that annual savings arising from its activities are more than four times greater than running costs, and that the average return on the investments financed by its Loan Funds is around 28%. The Initiative's Director, Leith Sharp, believes that "multinational companies have learnt the hard way that their environmental and social performance - and the way in which this is embodied in activities and buildings - have a big influence on corporate and brand reputations. Universities - especially those who want to be global players - must learn the same lesson, for tomorrow's students, faculty and opinion-formers will pay great attention to this criteria when judging the institutions they will respect and support. Higher performance buildings are therefore vital - but can only be achieved through strategic commitment, and attention to detail in design and implementation."

3. The Financial Case - Capital Costs

Well designed and constructed high performance buildings can create significant lifetime benefits in operating costs, with modest or no increase in capital cost.

Capital Premia

Some features of high performance buildings, such as active renewable energy systems, external solar shading, higher specification lighting controls, or rainwater harvesting, can involve additional capital expenditure. But other features have the opposite effect. These can include:

- reduced need for mechanical ventilation and cooling equipment in buildings designed to be naturally ventilated;
- reduced size (and therefore cost) of boilers, radiators, pipes, air handling units and other equipment as a result of better understanding of need and / or reduced heat gains or losses; and
- creation of additional usable space (or reduced overall size of the building) by a smaller plant footprint.

Recent research suggests that, although many high performance buildings to date have incurred a capital premium, this partially reflects a lack of familiarity with new techniques and technologies and / or the institution's desire to make a statement with no great regard to cost considerations. High performance buildings need not result in increased costs, provided the design and delivery teams are well briefed and understand the design objectives from the outset. The evidence for these statements includes:

- A report by the California Sustainable Building Task Force (a collaboration of all the major state agencies to examine the case for high performance buildings) which found that, in a sample of 20 high performance buildings, the average capital premium dropped from 3.25% in 1996, to 2.01% in 2004.[1]
- An examination by Davis Langdon, Quantity Surveyors, of 138 US high performance buildings - many in further and higher education use - which had achieved accreditation under LEED (the US Green Building Council's Leadership in Energy and Environmental Design scheme - see Appendix 1 of the companion guide for details).[2] The study concluded that, whilst there was variation in the costs of the different projects, there was no correlation between LEED rating and cost. In broad terms, for each LEED-rated building that cost more than average, there was another one with the same rating that cost less than average.
- A study for the US General Services Administration - which has responsibility for Federal buildings - found that: "when projects take advantage of many "no cost" or "low cost" credit opportunities, the overall construction cost premium can be surprisingly limited, even at the higher rating levels. Under certain conditions, it is even possible for projects to show a slight cost decrease." [3]
- An equivalent UK study for the Building Research Establishment (BRE) on the costs of achieving accreditation to the BRE Environmental Assessment Method (BREEAM - see Appendix 1 of the companion guide for details), in which cost consultants Cyril Sweett concluded that: "improving building sustainability performance can be achieved without significantly increasing the capital cost." [4]

- High performance buildings can cut capital costs through 'rightsizing' of plant, and less, or no, need for cooling and mechanical ventilation equipment

Dundee's Green Tribute Saves Money and Attracts Students and Staff

The University of Dundee's Queen Mother Building has enabled the consolidation of the previously separated activities of the Department of Applied Computing. The design consists of clusters of circular 'pods', grouped around a central services spine. The computer and research labs, plus offices, are in pods embedded into the building structure. The teaching rooms and other public spaces are free-standing within a triple height atrium. The simplicity of this pod design facilitates natural ventilation, makes maintenance straightforward (as does the use of simple interior finishes), and enhances flexibility, especially in the public areas. The building has also been designed for expansion - by adding an additional storey - without the need for major additional construction.

Other sustainable features of the building design include optimisation of:

- orientation - smaller windows on the south side minimise solar gain and glare on computer screens, and glazed screens on the north side take advantage of good natural light and the views;
- thermal mass - load bearing brick walls increase the ability of the internal spaces to buffer internal and external heat gain and loss;
- internal layout - the shape of the pods allows cross ventilation and enables a cellular form which gives most building users access to windows that can be opened; and
- high levels of insulation - the building has U-values of 0.18W/m^2 for the roof, 0.23W/m^2 for the walls (which are clad with an insulated render system) and 0.25W/m^2 for the floor, while the windows are double-glazed with low-E glass.

The University's Combined Heat and Power (CHP) station provides the building's electricity and heat. This generates financial savings and reduces carbon emissions. The result of these features is that, even when taking into account a relevant proportion of the fuel used to run the CHP plant, the building's services create only a quarter of the carbon dioxide (CO_2) emissions of a conventional, air conditioned, computer laboratory.

According to Michael Sinclair, the building's Project Manager, the University "achieved these benefits with a cost of £1,670 per m^2, which is fairly low for a computer facility, and comparable with industry norms. The building's airy feel and pleasant working spaces have also made it hugely popular with users. Perhaps too much so, as both staff and students prefer to work and study in it rather than use some of the other facilities on the campus. But we've certainly achieved our objective of an iconic building, which enhances networking, and allows us to attract some of the best staff and students in a very competitive field."

4. The Financial Case - Revenue Costs

Operating Costs

The most obvious revenue benefits from high performance buildings, compared with conventional alternatives, are:

- lower energy costs - with savings rising as energy prices increase;
- lower waste disposal and water costs - which are also likely to increase more quickly than inflation; and
- lower maintenance costs - due to reduced scale equipment and/or less complex building services.

The scope for energy savings is demonstrated by the difference in energy consumption between the best and the worst buildings, for example:

- An office designed to UK Good Practice standards (as defined by ECG19) will consume up to 225 kWh/m^2/yr of energy for heating, ventilation / air conditioning, light and small power, at an annual cost in 2006 energy prices of around £12 per m^2 - equivalent to £250,000 per year for a 20,000 m^2 building.[5] For an equivalent building with 'typical' performance, this cost would be significantly higher at around £430,000 per year.
- A HEEPI benchmarking study of UK laboratories found that the annual energy cost differential between a 'best practice' and a 'typical' laboratory of 3,000 m^2 (using 2006 prices) was around £163,000 for a medical / biosciences lab, £141,000 for a chemistry lab and £83,000 for a physical / engineering lab.[6]

A study by the financial research company Innovest for the US Environment Protection Agency also examined property companies whose office buildings conformed to the EPA's Energy Star labelling scheme for energy efficiency.[7] It found operating costs per square metre for these buildings were up to 40% less than for conventional offices, and, in many cases, a gain of higher rental income. It attributed these 'win-win' outcomes to integrated planning, site orientation, energy saving technologies, on-site renewable energy systems, light-reflective materials, natural daylight and ventilation, and downsized equipment.

Future Costs

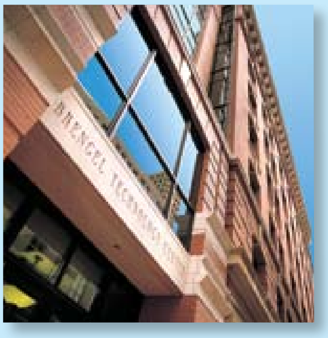
Experience suggests that the level of additional capital costs associated with high performance buildings will continue to fall in future as:

- the construction sector gains experience in delivering against this new agenda; and
- greater price competition and economies of scale are achieved for sustainable products, technologies and materials.

Conversely, it is likely that rising (albeit fluctuating) energy prices and labour costs, and greater need for building flexibility in a much more uncertain world for higher education, will increase the operating benefits of high performance buildings.

- The benefit-cost ratio of high performance buildings will grow as resource prices rise, regulations become more stringent and experience of their construction and operation increases

High Performance Buildings Needn't Cost More



A research study undertaken by the US Green Building Council concluded that: "Many green buildings cost no more to build - or may even cost less - than conventional alternatives because resource-efficient strategies and integrated design often allow downsizing of more costly mechanical, electrical, and structural systems. For instance, the cost of building Johnson Control's Brengel Technology Center in Milwaukee (pictured) was on a par with prevailing construction rates, despite numerous high-tech features like personal comfort control systems, multi-media systems, and information tracking systems." [8]

The study also found that "SC Johnson's Headquarters in Racine, Wisconsin, incorporated elements such as personal environmental systems, a restored natural site, and extensive daylighting at a cost 10-15 percent below the U.S. average for comparable office and laboratory space."

"Minimal increases in upfront costs of about 2% to support green design would, on average, result in life cycle savings of 20% of total construction costs - more than ten times the initial investment"

- Report of the California Sustainable Building Task Force.[9]

Whole Life Costing

The biggest barrier to specification and delivery of high performance buildings is the perceived lack of connection between capital and revenue budgets. Usually the building's 'prospective occupiers' (e.g. a university department) are focused on getting the most, and best, accommodation available for a given capital sum. Running cost responsibilities fall to another budget, which is usually the responsibility of the Estates Department, and these are therefore often less 'visible'. This explains why environmental measures with reasonable payback periods are often not implemented. The long-term cost burden of this can be considerable, particularly given that the Government assumes a minimum 120 year life for major public buildings.[10]

One solution to this issue is a 'whole life costing' approach to procurement, which quantifies the total capital and operating costs of a building over its lifetime so that a 'net present value' can be calculated.[11] It is important when doing this not to underestimate benefits by:

- using too high a discount rate (for instance, a cost of £100 in 20 years time is equivalent to a current cost of £37 now if a 5% rate is used; but only £15 if a 10% rate is used);
- making overly optimistic assumptions about future trends in utility, materials, and labour costs (e.g. that they will only rise in line with inflation - which most forecasts suggest is unlikely);
- over-estimating the durability, and under-estimating the maintenance costs, of building elements; and
- ignoring possible future expenditure, such as retrofitting air conditioning because of a warmer climate.

5. The Risk Management Case

The Funding Councils have advised institutions to pay greater attention to identifying and minimising "the threat or possibility that an action or event will adversely or beneficially affect an organisation's ability to achieve its objectives." [12] High performance buildings can help to avoid or mitigate a number of potential financial and other risks.

Risks Related to Energy and Water

Rapidly rising utilities costs are major items of controllable expenditure. Hence, unexpected variances from a projected budget can have significant implications for financial performance and flexibility, especially when budgets are tight. By reducing overall consumption of energy and water, high performance buildings reduce the scale of these risks. They also avoid the risk of future associated difficulties and / or the need for costly retrofitting if new regulations are applied to existing buildings - as is increasingly the case as Governments try to meet their long-term targets for reducing carbon dioxide (CO_2) emissions.

All utility infrastructure has a maximum capacity, and in most cases this is far above predicted actual demand. Hence, incremental increases in demand within a building envelope appear to require very low capital investment, often involving only some extra cabling or pipe work. However, once maximum capacity is approached, further expansion can be very expensive. Additional infrastructure will be needed, such as construction of new electricity sub-stations, and upgrading of transmission cables to provide adequate electricity supply. High performance buildings reduce the risk that a need for additional, and expensive, utility infrastructure will constrain future expansion. This point is especially important for refurbished buildings, which should aim to work within the utility 'footprint' of the existing structure.

Risks of Inflexible Buildings

Universities and colleges face many uncertainties about future funding, student numbers and course delivery mechanisms. Buildings which are not easily adaptable create a business risk. This could be caused by high overheads as a result of having to carry high-cost, under-utilised, facilities, and / or high costs of adaptation (and related business disturbance) to new requirements. The design philosophy of high performance building reduces these risks. It stresses the benefits of building flexibility for both business and the environment (i.e. reduced need for new buildings because existing ones are better utilised). It also protects against any future constraints on building use and adaptation arising from high energy prices or more stringent environmental legislation.

Workplace Health and Safety

Outbreaks of Legionnaires' disease, and occurrences of 'Sick Building Syndrome', have led to several expensive and reputation damaging lawsuits against building owners and developers. The risks to universities and colleges are not just legal costs, but also the associated adverse effects on employee performance and attendance, and the time required to solve problems. High performance buildings with high levels of natural ventilation and daylighting, and natural materials, can help to reduce these risks.

- Better space utilisation from more flexible buildings creates both business and environmental benefits

Buildings That Keep on Giving

In 1995 the University of East Anglia's Elizabeth Fry Building achieved energy consumption half that of a conventional building, while costing a similar amount (£900/m^2) to the cost yardstick of the time. The building avoided high profile green features in favour of a simple but effective, and well implemented, design which includes:

- a narrow plan, allowing high levels of daylight to reach all spaces;
- high insulation, with 200mm of insulating material in wall cavities, and triple-glazed, argon-filled, windows (that open when ventilation is needed);
- detailing which avoids air leakage and cold bridging (and whose successful construction required clear explanation to site workers, and detailed checks before being concealed);
- use of concrete hollow core floor slabs, and a Termodeck heating and cooling system, to stabilise internal temperatures;
- external and integral blinds in the windows to minimise solar gain in the summer; and
- pressure testing for air leakage, prior to occupation.

The building's annual electricity consumption of around 61 kWh/m^2/year of electricity, and 35 kWh/m^2/year for gas (which equates to CO_2 emissions of 44 kg/m^2/year), is still amongst the best in the sector, and means that the University has already achieved cumulative savings of over £350,000 compared to a typical building of the period. It has also achieved one of the highest scores in the occupant satisfaction surveys carried out by the Usable Buildings Trust.[13] One occupant remarked that: "I love it. It combines a sense of tranquillity with aesthetic delight".

Maximising Building Adaptability

An adaptability assessment explores the building elements that affect its future adaptability, and can be done for either new or existing buildings. Key issues include:

- site (possibility of expansion, access for pedestrians, access for public transport and for services);
- interior layout and design (completeness of brief, flexibility of layout, grouping of functions, average main room size, provisions for disabled people);
- structure (strength of columns and walls, column density and span, floor-to-ceiling height, floor loading, floor structure, remove-ability of partitions, thermal mass);
- Heating, ventilating and air conditioning (HVAC) system (plant location, size and space needs, access for people, access for equipment, ducting access), electricity (extra load, wiring space, access for servicing);
- water (supply, capacity), sewage (capacity), drainage (capacity); and
- lifts (capacity, extra space).

6. The Performance and Reputation Case

A review of a financial services building in the City of London published by the Royal Academy of Engineering, *The Long Term Cost of Owning and Using Buildings*, is often quoted in commercial and Government procurement guidance.[14] It developed a '1:5:200' rule of thumb. Simply put:

- the costs of owning and using a building (finance, maintenance and operations) over a 20 year period is 5 times greater than its initial design and construction cost; and
- the cost of staff salaries and business operations in a building over a 20 year period is, on average, 200 times greater than its initial design and construction cost.

Whilst the ratios will vary for individual buildings, almost all will gain great financial value from even small changes in employee productivity, if these are maintained over time.

These findings are corroborated by the California's Sustainable Building Task Force, whose research found that the annual salary cost of state employees is around ten times greater than the annual costs of providing their workspace.[15] It also noted emerging evidence of improved employee productivity, reduced absenteeism and health problems, and better operating performance, in sustainable buildings. WalMart, for example, has found that sales are much higher in naturally lit stores than in comparable artificially lit ones and now has a policy of all natural lighting in new outlets.

Reputation and Recruitment

A UK study of five new academic buildings and campuses - a number of which had strong sustainability features - by the Commission for Architecture and the Built Environment (CABE) found that:

- 60% of students and staff said that building design quality positively influenced their choice of university;
- more than 70% of staff and students believed that the functions and facilities of the buildings they work in improve the way they feel and behave; and
- 62% of staff said the 'wow factor' was evident on their initial visit to their building or campus.[16]

Some universities, such as the University of Gloucestershire, believe that this is especially true of high performance buildings, and are using them to establish a corporate 'brand' in which sustainability is an integral feature. Staff turnover can be significantly reduced if the quality of facilities, and the working environment, is high.

Additional benefits can be gained if these high performance buildings are incorporated into research and teaching, e.g. through availability of energy consumption data, or by visible 'labelling' of key sustainability features. Curriculum links can range from one topic amongst many on an undergraduate module, to building-based projects in specialist courses, such as architecture, engineering or environmental science.

Planning benefits can also accrue from a good sustainability record and reputation. These include:

- an easier and quicker route to planning permission (or perhaps even getting it at all) because of proactive anticipation of aspects which often cause difficulty (e.g. transport impacts);
- less stringent conditions because the institution is trusted to keep its sustainability promises; and
- less expensive commitments for 'planning gain'.

- High performance buildings can improve the well-being, productivity and attendance of occupant, and foster better learning by students

The Market Values High Performance Buildings

The *Green Value* report - published by the Royal Institute of Chartered Surveyors - stated that: "A clear link is beginning to emerge between the market value of a building and its green features. Not only are green

buildings good for the environment, provide healthier places to live and more productive places to work, they can command higher rents and prices, attract tenants more quickly, reduce tenant turnover and cost less to operate and maintain. But because comparatively few green buildings have been built, further work is needed to quantify more precisely the extent of benefit." [17]

The CK Choi Building (pictured) on the University of British Columbia's Vancouver campus was one of the research case studies. The report found that the facility had a comparable capital cost to conventional ones, but used 49% less energy and - through international publicity - had greatly enhanced the University's reputation. It also made it easier to justify - and provided valuable experience on how to design and implement - subsequent green buildings.

"We can give a rough answer to the question: How important are buildings to workplace productivity? Answer: In the UK, the best buildings have a perceived productivity lift of up to plus 12.5%, the worst a productivity fall of up to minus 17.5% - a difference between the best and the worst of 30%" [18]

- Adrian Leaman, Usable Buildings Trust

Lockheed Building 157

This 60,000m^2 office building in California was completed in 1983, and featured then 'state of the art' use of daylighting, energy efficiency and ambient noise control. A detailed comparison of the same workers in its first year of operation, and in their previous office, found that:

- absenteeism declined 15%, whilst productivity rose by a similar amount
- lighting bills fell by 75%
- energy use fell by 50%, not only because of reduced lighting consumption but also because of a smaller cooling load as a result of lower heat gain.[19]

These gains were maintained over time.

Appendix 1 - The Environmental and Social Benefits of High Performance Buildings

The main ways in which buildings influence the environment are through their:

- use of energy, and related impacts on climate change
- use of materials
- generation of construction (and ultimately demolition) waste
- use of water, and creation of run off and sewerage
- local impacts such as habitat loss, dust or noise.

Energy and Climate Change

Buildings account for around 50% of UK energy consumption, and a broadly similar proportion in other industrialised countries.[20] Historically, the main energy load has been heating, but a warmer climate and rising expectations are resulting in increased demand for comfort and equipment cooling. This has important resource and cost implications, because conventional cooling methods in countries such as the UK (which have primarily fossil fuel-based electricity systems) involve two major forms of energy inefficiency. The initial loss is from converting fossil fuels to electricity (which generally wastes two thirds of the primary energy). The second loss is in converting that electricity into 'coolth'. This route contrasts with on-site fossil fuel heating, which converts the thermal energy directly into the final output of heat. (Of course, both cooling and heating also involve further energy losses in the distribution of chilled / warmed air and water within buildings).

Energy production and use has impacts on communities and landscapes, and creates air and water pollution. Fossil fuels are also a non-renewable resource and will be depleted at some point in the future. (However, market mechanisms, and the technological advances they stimulate, make it more likely that the adverse effects of depletion will be higher prices rather than absence of supply).

The *Intergovernmental Panel on Climate Change* believes that fossil fuel production and combustion is the major causal factor in the warming which is being experienced in the UK and worldwide.[21] This change is being driven by rising man-made emissions of gases - especially CO_2 - which are causing a "greenhouse effect" by trapping heat in the atmosphere. The UK Government therefore has ambitious targets to reduce CO_2 emissions. This will inevitably require further tightening of building codes beyond the changes in 2006 and 2007 respectively to Part L of the Building Regulations for England and Wales, and Section 6 of the Building Standards (Scotland).

To date, actions have focused on emissions related to energy consumption in building use, but the issues of embedded energy in materials, and the energy consumption of transport related to construction and journeys by occupants, will also rise in importance.

High performance buildings can minimise CO_2 emissions by:

- reducing the energy needed to provide heating, cooling, and other services to occupants during the use phase;
- reducing use of road transport by occupants through locations which enable alternative access; and
- using less, and lower carbon, materials, such as lime mortar rather than Portland cement.

Financial and Comfort Benefits from Natural and Controlled Lighting

The University of Glasgow has made good use of daylight, by installing a single lighting control system in three adjacent new buildings, the Wolfson Medical School, the Cardiovascular and Biomedical Research Centre, and the CRUK Beatson Cancer Research Facility. Energy use is minimised by microwave presence detectors in circulation corridors, stairs and toilets, and seminar rooms; daylight controlled dimming; and centralised time control. The system is also very flexible, with all features being capable of remote monitoring and adjustment by University staff or suppliers. The supplier estimated annual savings of £7,000 of electricity just from the first building, the Wolfson, with a simple payback of 8 years. Financial benefits should be greater once all three buildings are in full operation. Users also appreciate the visual delight provided by the natural light.

"The rise of a global market has worked against reducing energy costs relating to the transportation of materials. Whereas slate may have been delivered to site from Wales or Cornwall, it might now come from Spain or China … As operational energy consumption reduces … embodied energy is becoming of greater significance". [22]

Isabel McAllister, Associate Director of Sustainability, Cyril Sweett

High Performance Buildings and Climate Change

The likely impact of global warming in the UK will be hotter, drier, summers with wetter and much stormier conditions during the rest of the year.[23] There is also an unquantifiable risk that climate change will cause the Gulf Stream to weaken, in which case winters could be significantly colder with more snow, and summers could be cooler, than at present.

High performance buildings can help to mitigate the long-term effects of climate change by reducing CO_2 emissions directly, and by raising awareness of environmental issues amongst users - both of which could slow down the rate of change. Their design will also have to take account of increased wear and strain on external building elements and mechanical services (resulting from more extreme winds, wetting and drying cycles, and temperature ranges or durations), and increased risks of flooding from intense storms or rising sea levels.[24]

Appendix 1 - Continued

Materials

One third of all raw materials consumed in the UK and other developed economies are used in buildings. Much of this is brick and concrete, with the attendant impacts of mining, quarrying, cement production and transport on landscapes, communities, air pollution, and CO_2 emissions. Buildings are also a big market for timber, which is often produced in ways which degrade soils, increase run off and use excessive amounts of chemicals.

The creation and transport of building materials consumes large amounts of oil, gas, coal and electricity. The production of this 'embedded energy' has its own environmental impacts such as emissions of CO_2 and air and water pollutants.

High performance buildings minimise these impacts by:

- maximising the capacity and flexibility of individual buildings (and having a design process which questions whether a new building is necessary in the first place) so that fewer are required in the UK as a whole; and
- making maximum use of materials which are renewable or recycled, and produced locally (so that transport impacts are reduced).

There can be one potential resource disadvantage of some high performance buildings - use of greater amounts of concrete than might normally be required in order to provide passive cooling and heating. This can be mitigated by using concrete containing large amounts of lime or pulverised fuel ash (which reduce the energy and CO_2 impacts of its production), and / or alternative forms of thermal mass. In any case, over the building's lifetime, the adverse environmental impacts of any extra mass are usually much less than those of the energy it would consume without such thermal mass.

Waste

Construction waste brings large and increasing costs to business. Disposal charges are rising as landfill tax increases, and as increasingly limited landfill space becomes more expensive. In addition, money is being spent on purchasing, transporting and processing materials which end up being useless.

High performance buildings can reduce the amount (and costs) of waste through:

- integrated planning of demolition and construction programmes, so that uses for demolition materials are found on site before looking elsewhere for markets;
- waste minimisation in construction, e.g. through off-site fabrication, reducing packaging waste by favouring minimally packaged materials and / or removing it prior to site delivery, and choosing building dimensions that suit standard lengths of materials used;
- designing for waste minimisation in operations, through provision of appropriate facilities and space for waste segregation and storage; and
- designing for reuse if possible, and for easy demountability/disassembly and recycling, so that wastes arising from demolition are minimised.

Low Carbon Administration at Southampton

The University of Southampton's new Administration and Student Services Building occupies a brownfield site, and increases the capacity of an older building by linking through a spectacular three-storey glass atrium.

The building's energy and water efficiency features include: cooling intake air during warm months by passing it through underground ducts; a rainwater harvesting system to flush WCs; a high level of air tightness, and use of lime mortar. The latter has a number of advantages compared with Portland cement, including being fired at lower temperatures, absorbing high levels of carbon dioxide during curing, being less likely to crack, and in making it easier to dismantle at the end of its life, thereby enabling recycling of bricks after demolition.

The building also features open plan offices with breakout areas and small meeting rooms, to achieve greater efficiency in the use of space.

Socio-Economic Effects

Buildings have many local impacts, including:

- infrastructure - particularly roads and public transport;
- employment and businesses - both in terms of how the building is used, and how it is constructed (e.g. training and job opportunities in the local construction industry, opportunities for local suppliers).

Clients can work with local authorities and other stakeholders to ensure that a project offers a range of wider benefits and that these are recognised by the community.

The supply chain also connects buildings to other parts of the world. Great reputational and financial damage can be done to any organisation which does not consider issues such as the sustainability of imported materials, and the working conditions of those who produce them, into their procurement choices.

Appendix 1 - continued

Water and Drainage

Mains water and sewerage charges have increased considerably over the last decade. They are likely to become even more expensive because of:

- a growing imbalance between rising demand and constrained supply (as a result of drier conditions and deficiencies in storage and inter-regional transfer capacity)
- rising expectations, and tighter regulations, about the cleanliness of water courses and the sea.

Those planning soft landscaping in drought-prone parts of England must also take into account the possibility of hosepipe bans during extended periods.

Owners and designers of high performance buildings can reduce the amount, and costs, of water consumption and discharges to sewers through:

- specifying and installing water-efficient appliances such as low volume flush WC's, waterless urinals, and spray taps;
- collecting and using rainwater (which can also assist Sustainable Urban Drainage Strategies by attenuating storm water runoff);
- collecting, treating and re-using grey water (discharges from sinks or appliances); and
- using on-site pond and reed-bed systems to purify grey water and / or mitigate storm water runoff.

Local Environment

Impacts on the local environment are most obvious during the construction phase (noise, dust, air pollution, water pollution, and waste to landfill, for instance). However, the sum total of such impacts over the lifetime of the building (especially when end of life is considered) can be just as, or more, significant.

Building designers can help to reduce construction site impacts in a number of ways, e.g. by specifying off-site fabrication. This can reduce waste and transport movements to and from the site, as well as delays to completion.

Managing a construction site in accordance with the international standards of environmental management (e.g. ISO14001) can help to ensure that all opportunities for environmental improvement are taken, and thereby improve potentially difficult relations with neighbours and with stakeholders such as pollution watchdogs.

Designers should also consider pollution from the building during its operation, and take steps to avoid light, noise, air and water pollution. However, more obvious impacts of design are on local biodiversity and the visual impact of the building on its surroundings. These often provide straightforward opportunities for a project to contribute demonstrable improvements to an area.

- New or refurbished building need a 'wow factor' - high performance buildings can simultaneously deliver this *and* sustainability

University of York - Building Tomorrow's Science through Today's Green Technology

The new National Science Learning Centre is located at, and was designed and project managed, by the University of York. It offers development courses for school and further education science teachers and technicians, with the ultimate aim of encouraging more post-16 students to choose science options. The Centre has been established by the White Rose University consortium of Leeds, Sheffield and York Universities, together with Sheffield Hallam University, with Government and Wellcome Trust funding.

Night view of the National Science Learning Centre

The building's features include:

- a geothermal cooling/heating system which saves £11,000 annually compared to conventional alternatives;
- a multi-species sedum or 'living' roof over much of its area;
- low energy lighting with a state of the art control system;
- variable ventilation which responds to space occupancy levels;
- extensive use of natural lighting and ventilation;
- use of rainwater for WC and urinal flush systems;
- use of Greenpeace-approved "Aquatherm" pipework made of recycled material rather than traditional steel or copper; and
- a high level of flexibility as a result of partitioning of laboratories and lecture theatres.

Many of these elements can be used to support teaching, supplementing specific curriculum features such as a public display of data from the Building Management System; a weather station on the roof to help study climatic change; and a science trail and webcams highlighting the biodiversity around the building, particularly moths and owls.

The Centre's Director, Professor John Holman, sees the Centre as "being a place of quality and atmosphere to show teachers of science from primary and secondary schools the importance of the job they do, so that they in turn can inspire a future generation of scientists. That's why we have a striking building, full of light, which is a science teaching aid in its own right - especially through its 'green' features. For example, the geothermal heating and cooling not only reduces our CO_2 impact, but also gives us a fascinating context for the teaching of energy transfer and earth science."

Appendix 2 - How to Manage Delivery to Achieve Business Benefits

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

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See www.heepi.org.uk/hpbguides.htm for details of web links for many of these documents.

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

National Science Learning Centre, University of York

De Havilland Campus, University of Hertfordshire

Wolfson Building, University of Glasgow