Building for the Future -
Sustainable Construction for Professionals

How to Commission Sustainable Construction in Further Education Colleges

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How to use the guide

This report provides guidance on sustainability issues while commissioning construction of new buildings or refurbishments within further education (FE) colleges in the UK.

The guidance is primarily meant to be used by senior management teams who are involved in decision-making when a building construction project is to be commissioned. A summary section at the beginning of each chapter in this guidance report provides an overview of the main points discussed in the chapter.

Although the guide outlines the process for commissioning sustainable construction in FE colleges, it should be used in conjunction with the sources of further information provided.

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Other Titles in the Series

This guide is one of a series of 5. The others in the series are on:

- ***How to Conserve Energy in Further Education Colleges***
- ***How to Conserve Water in Further Education Colleges***
- ***A case study of an Academy building: City of London Academy***
- ***A case study of a FE building: Merton College, London***

The partnership would like to acknowledge the feedback received from GVA Grimley and King Sturge in preparing this report.

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Foreword

This guide is a product of Building for the Future - an inter-regional collaboration, part-funded by the GROW EU Interreg3C joint programme, which aims to achieve balanced and sustainable economic growth.

The purpose of this guide is to assist and advise colleges in the commissioning of new buildings.

By reviewing some of the issues involved in commissioning a building, we hope to strengthen the client-designer partnership, and so aid the construction of high quality, sustainable developments.

The built environment with which we choose to surround ourselves comes at a cost. As clients buying new buildings, we keep an eye on the bottom line, and rightly so. But we also want to reduce the environmental burden of our buildings that will impact, not just the present occupiers, but also future generations.

AOSEC is very grateful to the partners that have been such an essential support to this project, and so it is with real appreciation that I thank the Environment Agency, the LSC and SEEDA.

Dr Anne Murdoch
Chair of Board of AOSEC
Principal & Chief Executive of Newbury College

Executive Summary

The overall objective of this guide is to enable colleges to become informed construction clients who know how to ask the right questions when commissioning sustainable construction in colleges.

The report first discusses the implications of government policies and the drivers for sustainable construction in the built environment, and then suggests an approach for commissioning sustainable construction, from the initial briefing stage to completion and operation.

The report then lists key sustainability measures and strategies with their associated capital costs, which need to be considered when commissioning sustainable buildings for colleges. It also includes a short section on the advantages and disadvantages of using modern methods of construction.

Finally, the key barriers which hinder sustainable construction are raised, and methods to overcome them are discussed. In particular, the barrier of availability of additional capital costs to fund sustainable construction measures could be addressed by the LSC's sustainable construction policy, which requires FE Colleges to include green proposals in their designs if they are to draw down funding.

Contents

1. INTRODUCTION
why commission sustainable construction

This section describes the context for sustainable construction, the key factors that drive it and the business case for considering sustainability in the FE sector. The key benefits of commissioning sustainable construction are:

- Cost savings due to lower fuel consumption
- Less CO_2 emission which drives climate change.
- Meeting the social responsibility of the FE institution
- Health and comfort with naturally lit spaces
- Enhanced institution image by being exemplar developments
- Higher productivity amongst staff and students

To achieve these benefits, sustainable construction should:

- Minimise energy in construction & use
- Design for minimum waste
- Preserve & enhance biodiversity
- Conserve water resources
- Respect people & local environment
- Monitor & report, (i.e. use benchmarks)

The LSC's enhanced capital contribution is now available to support these measures.

1.1 Context for sustainable construction

In recent years, there has been a widespread interest in the sustainable design and construction of buildings, driven by the following key factors:

- Depletion of fossil fuels and the consequent rise in energy costs
- Environmental concerns about climate change due to increased emissions of green house gases, primarily CO_2
- Water scarcity due to change in global patterns of rainfall and increased consumption rates.

Sustainable construction lies at the heart of any plans for a sustainable community.

1.2 Impact of buildings

Globally, buildings are responsible for consuming the following resources (Edwards and Turrent, 2000):

- Materials: 50% of all resources go into construction
- Energy: 45% of energy generated is used to heat, light and ventilate buildings and 5% to construct them
- Water: 40% of water used is for sanitation and other uses in buildings
- Land: 60% of prime agricultural land lost to farming is used for building purposes
- Timber: 70% of timber products are used in building construction

Incorporating sustainable construction practices while commissioning new buildings and refurbishments has the potential to reduce these consumption patterns and the environmental impacts associated with them.

1.3 Further Education (FE) Sector

The sustainable development education panel in its third annual report, 2001, recognised sustainable development as a mainstream issue for further and higher education sectors.

The sector, in England alone, annually, consumes 5.2 billion kWh of energy and is responsible for releasing 3 million tonnes of CO_2 annually in the atmosphere (DEFRA, 2006).

"It has been estimated that a 25% saving could be made across the sector by energy efficiency measures alone. In new buildings, this saving can be as high as 30% to 50%. On an average, this would result in savings of operational cost of about £50,000 to £450,000 per college". (BRECSU, 1997 a & b)

Typical figures for a 5000m^2 academic building (Action energy, 2002)

Construction cost @ £2000/m^2 = £10,000,000

Energy cost over 20 years = £ 925,000 (@ £5.60/m^2/year, with fuel prices inflating at 5% per annum)

Energy costs amount to 10% of the construction cost!

As shown in the box on the left hand side, energy costs constitute a substantial part of the life cycle cost of constructing and operating a building if considered over a 20 year period. Since most FE colleges are going to use the buildings for at least 20-25 years, it becomes essential to incorporate energy efficiency measures at the initial stages of designing a building.

The potential for achieving such savings with available technology is maximised in a new building, where sustainable and energy efficient strategies are incorporated in the design stage. The argument against incorporating sustainability in buildings most often relates to the added cost of including such measures. However, studies by BRE show that buildings can achieve very good or even excellent environmental rating at very little additional cost.

For example in a naturally ventilated office, a BREEAM Good rating can be achieved for a saving of between 0.3% and 0.4% of capital cost. A Very Good rating can be achieved for between a cost saving of 0.4% and an additional cost of 2% for a range of locations (BRE and Cyril Sweett, 2005).

Therefore, while commissioning a new building, whole lifecycle costs should be considered, and sustainability measures viewed as a long term investment in the building. A minor increase in capital cost has the potential to significantly reduce running costs over the life cycle of a building.

1.4 Benefits of Sustainable Construction

Sustainable buildings tend to be more desirable to the occupants than an equivalent standard building (Roaf et al., 2004). Also the Government believes that "sustainable construction can cost less, and certainly need not cost more than average." In addition, running costs are reduced in sustainable buildings, as there will be less energy consuming equipment installed, and it will run for fewer hours during a shorter heating season. Reducing the consumption of fossil fuel based energy will in turn result in lower CO_2 emissions and help claw back emission levels, enabling us to mitigate the worst impacts of climate change.

There are also other benefits of sustainable buildings related to health and comfort. Efficiently controlled and environmentally friendly buildings provide healthy living and working conditions. Lighting, internal temperatures and fresh air are all equally important in determining the comfort of people in a space. Studies have shown that people prefer working in naturally lit spaces which are naturally ventilated by openable windows. Similar studies in schools have linked availability of natural light to higher productivity, satisfaction and faster learning.

In summary, the key benefits of commissioning sustainable construction in the FE sector include:
- Cost savings due to lower fuel consumption
- Environmental benefits and less CO_2 emission which drives climate change.
- Meeting the social responsibility of the FE institution to educate future generations about sustainability
- Enhanced institution image by being exemplar developments
- Health and comfort with naturally lit and controlled spaces
- Better living /working environment and higher productivity amongst staff and students

Some of these benefits are expanded upon in the Sustainable Construction Task Force's report, *Reputation Risk and Reward* (Sustainable Construction Task Group, 2005).

1.5 Defining sustainable construction

The DTI's UK strategy for more sustainable construction, Building a Better Quality of Life, suggests key themes for action by the construction industry and these could form a set of client requirements (DETR, 2000):
- Minimise energy in construction & use
- Conserve water resources
- Design for minimum waste
- Lean construction & minimise waste
- Do not pollute
- Preserve & enhance biodiversity
- Respect people & local environment
- Monitor & report, (i.e. use benchmarks)

Since 90% of current buildings are likely to be in use in 30 years time, sustainable refurbishment will be of even greater importance than new build, and it should follow the aforementioned themes.

In particular the use of energy, water and other resources in a sustainable construction is dependant on three factors :

- Building design - built form and building fabric
- Operation and maintenance – building services, lighting, maintenance and controls
- In use - function, occupancy pattern and users' awareness about energy conservation.

A sustainable construction will need to address all three factors. Passive design strategies such as day lighting, natural ventilation and an appropriate building fabric, should be integrated into the design to reduce energy consumption. Efficient building services for space and water heating should be accompanied with effective controls and management. Use of energy-efficient lighting and equipment, water saving fixtures and minimisation of waste during operation, are other important areas of consideration.

For a building to be sustainable and use resources efficiently, it is also important to ensure that it is used as intended. This requires the users i.e. the staff and students to be aware of the features and the controls provided.

2. POLICY DRIVERS: the need for sustainable construction

Sustainability in construction is driven by a number of policy drivers which include legislation, national and international sustainability targets as well as fiscal incentives, making it almost mandatory for all new developments to be sustainable to some degree.

The key international legislation is the Energy Performance of Buildings Directive (EPBD), which requires mandatory energy performance and energy certification of buildings. National requirements are led by the Part L Building Regulations, Planning policy guidance and statements, Secure and Sustainable Buildings Act, and Micro-generation strategy.

Besides legislation, a range of targets have been set nationally, and internationally, to reduce CO_2 emissions and waste: these directly impact sustainability in buildings and construction.

2.1 Legislation

The government's sustainability agenda is represented in various policies and legislations, ranging from international, national and regional laws to local planning frameworks.

2.1.1 **International**

The *Energy Performance of Buildings Directive* (EPBD) is a European Union directive whose key provisions include:

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

Member states, including the UK Government, had to implement the Directive by January 2006, but presently, the UK Government, along with many other EU states, have failed to meet this deadline. It is expected that a strategy will soon be published describing how the UK will implement the Directive.

2.1.2 **National**

Building regulations Part L for conservation of fuel and power deals with the conservation of energy in buildings relating to the building fabric and services, including heating, cooling and hot water. It specifies a target CO_2 emission rate for achieving compliance. Part L applies to new buildings as well as refurbishments. The recent revision to Part L (energy efficiency) has resulted in a 20% improvement on 2001 energy standards in buildings since it became live in mid-2006.

Planning policy guidance and statements (PPG/S): PPG and PPS set out central government policy on a range of planning issues. Some of the PPGs and PPSs related to sustainable development within broader policy guidelines are listed below.

- PPG 10 Planning and Waste management
- PPG 13 Transport
- PPG 15 Development and Flood Risk
- PPS 22 Renewable energy
- PPS 23 Planning and Pollution control

Designs should be checked for meeting the requirements set by the above guidelines.

Environmental assessment methods: There are a number of voluntary standards, which aim to reduce the environmental impact of new development. These include: BREEAM (non-domestic), energy standards from the Association for Environment Conscious Building (AECB) and the Energy Saving Trust (EST).

Sustainable and Secure Buildings Act 2004: Previously the Building Regulations could only address sustainable development indirectly, for example via Part L (energy efficiency), whereas this Act will allow future revisions to address this issue directly.

DTI Micro-generation Strategy: The objective of this strategy released by DTI in 2006, is to create conditions under which micro-generation becomes a realistic alternative or supplementary energy generation source for the householder, for the community and for small businesses (DTI, 2006). Micro-generation is defined as the small-scale production of heat and/or electricity from a low carbon source. The suite of technologies caught by this definition includes: solar (photovoltaics (PV) to provide electricity and thermal to provide hot water), micro wind (including the new rooftop mounted turbines), micro-hydro, heat pumps, biomass, micro combined heat and power (micro CHP) and small-scale fuel cells.

2.1.3 **Regional**

Regional Spatial Strategies (RSS) are documents prepared by regional assemblies in England (a spatial development strategy is prepared by the Mayor in London). They draw on national policy and provide a broad development strategy for the region over a 15–20 year period. A growing number of assemblies are including sustainable energy and climate change policies in their RSS. Also, sustainability policies pertaining to particular regions have been formulated to address the needs of the region specifically, such as the South East Regional Policy Guideline RPG9.

2.1.4 **Local**

Local planning frameworks include guidance from all of the above policies and additionally list requirements to achieve local planning authority targets. Local development frameworks (LDFs), or unitary development plans (UDPs) in London, are prepared by local authorities and provide the framework for development at the local level. They are the principal consideration in determining planning applications. Prescriptive development plan policies are increasingly being used to deliver climate change and sustainable energy objectives, especially from buildings.

The London Borough of Merton, for example, requires developments (greater than 1000m^2) to incorporate on-site renewable energy generating capacity to supply 10 per cent of the development's predicted annual energy requirements. Other local authorities require achieving a CO_2 reduction target of 10 per cent over the energy demand of a new development.

2.2 Sustainability targets

A range of targets have been set nationally, and internationally, to reduce CO_2 emission and waste: these directly impact buildings.

2.2.1 **UK energy targets**

The Kyoto Protocol was developed in 1997 with countries agreeing to set legally binding targets for reducing greenhouse gas emissions. A target of 12.5 per cent below 1990 levels by 2008-2012 was set for the UK.

The UK Government has also set a voluntary target of 20 per cent reduction in CO_2 emission by 2010. UK is currently on target to meet the Kyoto commitment - but not the voluntary target.

The Government published its Energy White paper in 2003. The key targets and goals relevant to sustainable design and construction include:

- Aspirational target of a 60% reduction in CO_2 emission by 2050 (and real progress by 2020).
- Achieving 10% of total electricity generation in the UK by renewable energy sources by 2010. Aspirational target to double this to 20% by 2020.
- 10% Good Quality Combined Heat and Power by 2010
- Eliminate fuel poverty in Britain by 2016-2018

2.2.2 **UK waste strategy**

The Government published its UK Waste Strategy 2007 for England and Wales in 2007, which includes the following goals relevant for sustainable construction of buildings:

- By 2010, 20% reduction in landfill of industrial and commercial waste from 2004.
- To recycle or compost at least 40% of household waste by 2010, 45% by 2015 and 50% by 2020.
- To recover value from 53% of municipal waste by 2010, at least 30% through recycling or composting.

2.3 Fiscal incentives

The Government has introduced a range of fiscal incentives aimed at encouraging the uptake of sustainable design and construction measures. Examples of some of these incentives are:

Landfill tax provides a fiscal incentive to minimise waste as well as to identify opportunities for dealing with waste in a more productive way. The tax currently at £24, is predicted to rise by £8 annually, until it reaches a rate of £48 per tonne in 2010. The tax raised is used to fund a wide range of environmental projects through the Landfill Tax Credit Scheme (LTCS: www.ltcs.org.uk).

Aggregates levy was introduced in 2002 to encourage use of recycled aggregates in preference to virgin aggregates. The levy of £1.60 per tonne applies to virgin aggregates but not to recycled aggregates. Hence, it is cheaper and more sustainable to build with recycled aggregate. Money raised is used to support the Aggregates Levy Sustainability Fund, which provides grants for sustainable development projects.

Land use incentives: In the 2001 budget, the Government announced plans to abolish stamp duty on redevelopment in certain disadvantaged areas and a reduction of VAT to 5% on properties that have been empty for more than three years. The Finance Bill 2001 also offers an accelerated tax credit (up to 150%) to cover the costs of cleaning up contaminated land.

Low carbon buildings programme: Launched on 1 April 2006, phase 1 of the DTI's low carbon buildings programme will run over three years and replaces the previous DTI Clear Skies and Solar PV grant programmes (www.lowcarbonbuildings.org.uk/home/).

Open to householders, public, not for profit and commercial organisations across the UK (except the Channel Islands and the Isle of Man), the programme demonstrates how energy efficiency and micro-generation can work hand in hand to create low carbon buildings. Phase 2 is currently open for applications of up to £1m for public and charitable sector organisations. Grant levels for Phase 2 vary according to technology and are applied to total installation costs (excluding VAT) as follows:

Solar photovoltaics	50%
Biomass	35%
Ground source heat pumps	35%
Wind turbines	30%
Solar thermal	30%

All Phase 2 installations must be undertaken by one of the dedicated Phase 2 suppliers, or their accredited installers. Colleges can apply for receiving grants for low carbon technologies through this scheme.

Energy Efficiency Commitment scheme (EEC): Energy supply companies are required to fund measures to reduce CO_2 emission from energy use in buildings. Each company has a target they must meet which is measured based on the number of energy saving schemes they fund. Energy suppliers have developed framework agreements with private developers that subsidise the provision of measures, including, A-rated appliances and boilers and low energy light bulbs (see: www.ofgem.gov.uk).

3. MECHANISMS:
how to go about commissioning it

This section describes the mechanisms for commissioning a sustainable project in FE colleges, and the various factors that should be considered. The key mechanisms to commission sustainable construction include:
- Developing comprehensive project briefs
- Forming a multi-disciplinary team
- Setting firm standards and targets
- Using appropriate assessment and benchmarking tools
- Evaluation before hand-over
- Post-occupancy evaluation

What underlies these mechanisms is the need to consider responsibly the energy, life cycle costing and environmental implications of proposed new buildings, systems and activities.

3.1 Developing comprehensive project briefs

Briefing is about defining requirements, in order to inform building designs that meet clients' needs. Simply producing buildings that meet needs will considerably reduce the wastage of energy, materials, space and human effort. FE Colleges comprise various types of buildings to meet different functions, and the requirements of each should be considered before developing any project brief. In most cases the project sponsor will need to carefully develop this over a period of time, consulting interested people and organisations in the process.

Typically a project brief to commission a sustainable building should include:
- Context, and the project's set of requirements, opportunities and constraints.
- Good-practice environmental parameters, and energy consumption figures (discussed in section 3.3).
- Broad initial assessments to identify the cost of integrating sustainable features into the design, and their life-cycle costs. Research shows that sustainable solutions are invariably less expensive to operate, and usually cost little more than conventional buildings in initial capital cost.

To ensure that work is carried out as per the project brief, the client could ensure that the following stages are included whilst commissioning sustainable construction:

Conceptual design: At this stage the design team is required to indicate in broad terms which design strategies are cost effective and appropriate to the requirements of the space. This should include an assessment of the influence of the building and its surroundings, as well as the services, on energy-efficient building operation.

First report: This report describes the options for building construction and services. At this stage the concept for building form and services will be established. The report is produced and discussed with the construction client before detailed design begins.

Detailed design and second report - This includes an analysis and details of specific energy efficiency measures that have been recommended or rejected. The second report is produced and discussed by the design team prior to tender and construction.

Clearly, a comprehensive project brief will have a number of advantages. It will:
- Set a target against which requests for changes can be assessed and costed.
- Protect the client by informing the architect clearly of what is required.
- Protect the client from unapproved changes generated by user groups.

3.2 Forming a multi-disciplinary design team

A multi-disciplinary design team, involving energy/environmental consultants, architectural firm with expertise in sustainable building design, engineers and voluntary code assessors, is essential to clearly identify opportunities for integrating sustainability in design and construction, and also allocate the available resources for the project. It is essential to set up and engage the team early on in the project.

3.3 Setting firm standards and targets

When commissioning sustainable construction in colleges, it is essential to set a combination of overall sustainability standards, as well as specific targets for reducing energy use and associated CO_2 emissions, water consumption and waste generated from construction process. A detailed environmental strategy can then be outlined for the project.

To meet the specified standards and targets, the design and building team would incorporate appropriate features or strategies. This would lead to outcomes such as reduced energy use or water consumption, which could be used to measure the success of the deployed strategies, and fine-tune relevant features to achieve the targets. Lessons learnt from this process could be disseminated to the entire team involved and used for future commissions by the college and other colleges in the sector.

For example, a standard is set to achieve a ‘four star rating’ within the Code for Sustainable Homes, and a corresponding target is set so that annual water consumption is reduced by 5% over good-practice benchmarks. The strategy deployed to achieve this target could include installing low-flush WCs and self-closing taps, which may result in the outcome that water consumption, is 105 litres per person per day. Figure 1 illustrates this approach for energy and carbon emissions.

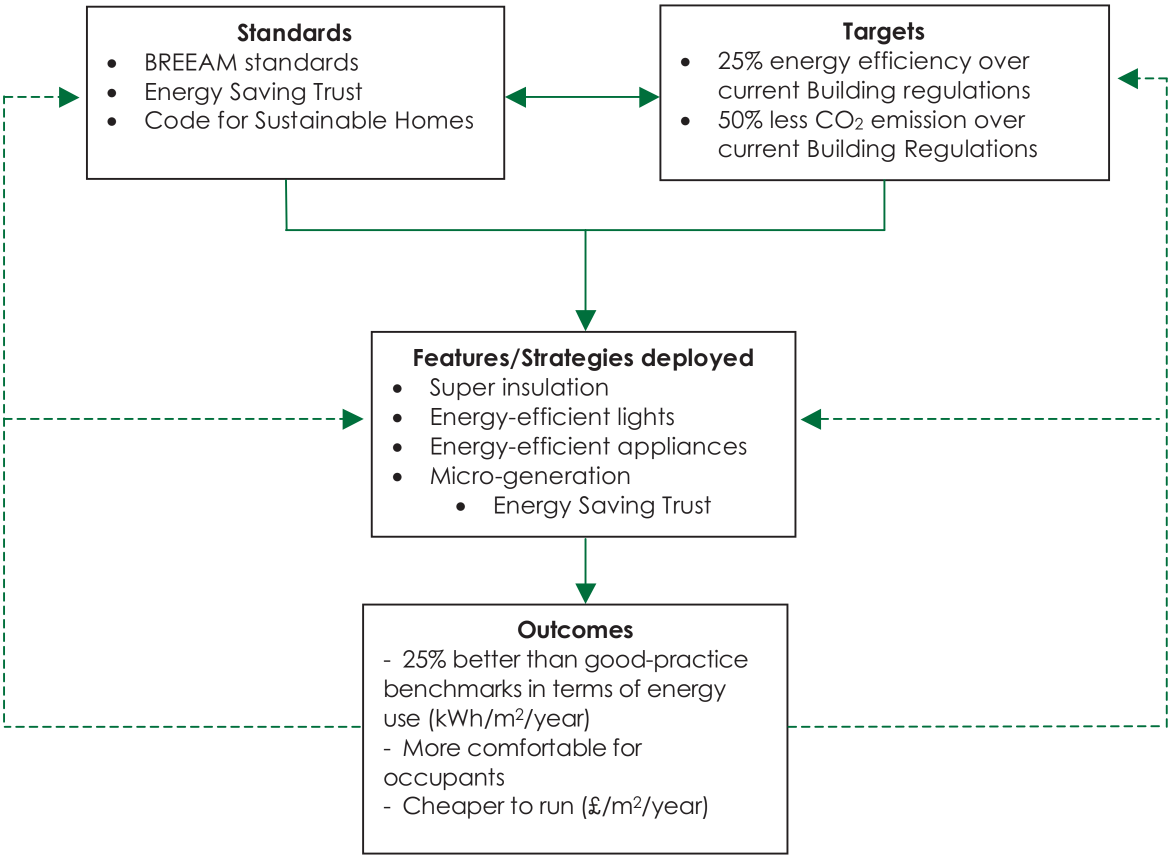

Figure 1. Relationship between standards, targets and outcomes when commissioning sustainable construction.

3.3.1 **BREEAM: a sustainability standard**

One of the ways of setting overall sustainability targets when commissioning sustainable construction is by using the Building Research Establishment Environmental Assessment Method (BREEAM) (see: www.bre.co.uk/breeam), which is a well-known method for assessing a broad range of environmental aspects of buildings.

BREEAM has over a decade's track record, and is now widely used in the UK. It works by creating a specification for a building with a number of individual criteria (grouped into Management, Energy, Health and Well-being, Pollution, Transport, Land use, Ecology and Materials). Each criterion is weighted in importance by having credits or points attached to it (typically between 1 and 5).

When the building is assessed (which can be done at several stages - design, post-occupation and operation), points are awarded for each criterion, and then added for a total score. This score will correspond to a particular band, ranging from Excellent through Very Good, Good and Pass. These bands can be used to set standards for new buildings to achieve. If any BREEAM standards are set, it is important that they encourage good environmental performance - which in practice means Excellent ratings for new buildings and Very Good for refurbishments.

In addition, specific targets can also be set for energy use, CO_2 emission, and waste generation in terms of typical or good practice benchmarks, which can be later used for comparison against outcomes. These benchmarks are explained in Chapter 4.

3.4 Using appropriate assessment and benchmarking tools

A wide range of benchmarking tools and checklists are available which address wider sustainability issues, and these can be used at various stages of the building design and construction process to evaluate if targets are being met, or if they need to be reassessed or redefined. A detailed list of assessment tools is provided in Table 1 on the following page, for a range of development stages and project scales. Typically, such tools fall into three categories: simulation models, correlation tools and scorecard rating tools.

Simulation models are computer programs which are used to generate a performance prediction from calculations. A modelled scenario is simulated against pre-recorded data - typically relating to materials, equipment and climate - in order to establish the likely performance and determine the efficiency of a design, for example, Simplified Building Energy Model (SBEM) for non-domestic buildings (see Appendix 1).

Correlation tools, often referred to as labelling or performance-based tools, usually measure a particular element such as energy efficiency or thermal comfort and focus on providing a quick evaluation of a proposed design in the form of a simple indicator. These tools have often been derived from multiple results generated by simulation models, such as Standard Assessment Procedure (SAP) for domestic buildings (see Appendix 1).

Scorecard rating tools provide an assessment where performance is measured through a point-scoring system. Points are achieved by meeting established criteria and the level of compliance determines the performance outcome. Scorecard programs are effectively checklists which focus on a holistic approach and outline intent and requirements. In addition, they also have the potential to incorporate possible design solutions by listing suggested methods to achieve the desired result. Various categories are often weighted depending on perceived importance and local requirements, and the total points are calculated to give a final rating.

Sustainability checklists provided by the local planning councils or by BRE, are a scorecard rating tool covering a wide range of environmental criteria. Other voluntary codes, such as BREEAM, and Code for Sustainable Homes are benchmarking and assessment tools which can be used at different stages of new and existing buildings to inform the design. A one-off 'bespoke' assessment matrix developed by BRE is at a ball-park cost of around £15,000-£20,000.

The success of BREEAM lies in its ability to address a number of environmental performance criteria and not focus on just a single element.

Assessment can be done at either or both the stages – initial design or completion.

Assessment/ Benchmarking tools

Description	Issue (s) addressed	Application stage	Building type and size	Result/ output	Additional information
SAP **Standard assessment procedure** UK Government	Energy performance	Demonstrates compliance with Part L1 of the Building Regulation	Dwellings under 450m ^{2}	- Energy consumption per unit area - Energy cost rating(SAP rating) from 1 to 100 - Environmental impact rating(based on CO_2 emissions) - Dwelling CO_2 emission rate (DER) – $kgCO_2/m^2/year$	www.projects.bre.co.uk/sap2005/pdf/SAP2005.pdf
SBEM **Simplified Building Energy Model** UK Government	Energy performance	Demonstrates compliance with part L2 of the building regulation	- Non-domestic buildings - Dwellings above 450 m^2	Target CO_2 emission rate (TER) - $kgCO_2/m^2/year$	www.ncm.bre.co.uk
BREEAM **Building Research Establishments Energy Assessment Method** Building Research Establishment (BRE)	Energy and Environmental performance	Applicable at various stages Design Completion Post - occupation	Domestic buildings (houses and apartments) - ECOHOMES /Code for sustainable homes Non-domestic buildings - BREEAM Offices - Bespoke BREEAM (For all other building types)	Each criteria is weighted by a credit system Scores correspond to a particular band to provide rating as - - Pass - Good - Very good - Excellent	www.breeam.org
ENVEST 2 Building research establishment (BRE)	Environmental impact of building materials . Whole life costs	Design stage	Used for all project types	- Range of 12 environmental impacts - Single Ecopoint score for environmental performance - Whole life costs	http://www.bre.co.uk

Table 1. List of tools to assess and benchmark the environmental impact of buildings

Assessment/ Benchmarking tools					
Description	**Issues addressed**	**Application stage**	**Project size**	**Result/ output**	**Link/additional information**
SPeAR **Sustainable Project Appraisal Routine** Developed by Arup	Energy Environmental Social economic	Design process Management information tool	- Urban regeneration schemes - Development plans - Manufacturing processes and products	- Provides a methodology for appraising performance of sustain ability indicators - Diagram visually representing sustainability profile of the project	http://www.arup.com/environment/feature.cfm?pageid=1685
SEEDA checklist South East England Development Agency	Energy Environmental Economic social	Checklist for Planning stages ; Completion assessment appraisal	- Strategic Planning level for entire developments - Specific parts for only building and infrastructure related analysis	Scoring based on likelihood of certainty from 0 - 1 with 1=certainty Output as scores in three parts - Environmental - Social - Economic impacts	www.sustaianability - checklist.co.uk/
CABE **Design Quality Indicators** Commission for architecture and the built environment	Environmental Social	Key stages of development Design brief; Mid-design; Completion; In-use	Used for all project types	DQI weightings based on : - respondents views on various building aspects - significance of factors Fundamental , Added value & Excellence Graphically represented comparisons between various stages and factors	www.dqi.org.uk/DQI/common/DQIOnline.pdf
EIA **Environmental impact analysis**	Environmental Energy	Analysis at project planning level	Large scale projects or developments	- Environmental statement describing effect on each factor - Ways to mitigate these	www.environment - agency.gov.uk/

Some of the rating tools might be seen as a specialist piece of box ticking which have little influence on the general design process, and being environmentally-focused do not reflect social and ethical criteria. Therefore it is useful to categorise such benchmarking and assessment tools depending upon the strands of sustainability they address, be it environment, social and/or economic, as shown in Figure 2. This would in turn help in making an informed decision.

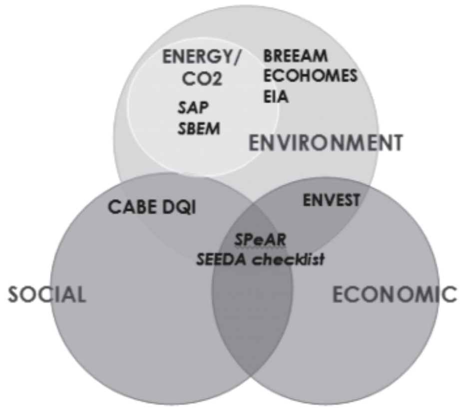

Figure 2. Assessment tools addressing various sustainability aspects

3.5 Evaluation before hand-over

- On completion of a project, air pressure tests to check if construction is airtight, as well as checking of boilers and other services is recommended.
- Assessments by approved benchmarking tools should be made to evaluate the building against the earlier defined set of criteria.
- This also allows the building to gain recognition for the high sustainability standards achieved in the building.

3.6 Post-occupancy evaluation (POE)

Monitoring of performance in the initial years of use is beneficial to correctly adjust the building systems to the occupancy requirements. BRE also recommends that organisations do an internal post-occupancy assessment to ensure that important design features are still in place and working (Gupta, 2006).

A typical post-occupancy evaluation includes:
- Energy audit and survey
- Environmental audit
- Assessment of the occupancy satisfaction

A key message that has emerged from POE Studies of over 20 sustainable buildings is to *keep it simple, do it well, and manage it properly* – this is the most effective recipe for success. (Further details about POE can be found in the sister guide on 'how to conserve energy in further education colleges).

4. ACTION PLAN:
Key sustainable construction measures and costs

This chapter lists a range of measures (and their capital costs), which could be incorporated in a sustainable construction, relating to:

- Reducing energy use and associated CO_2 emission
  - Energy efficiency measures related to design, fabric, service systems and controls
  - Low carbon and zero carbon technologies
- Encouraging water efficiency by reducing, recycling and reusing water.
- Minimising construction waste
- Deploying materials with low environmental impacts
- Enhancing biodiversity
- For the construction client to measure the success of these measures, specific standards relating to energy consumption, CO_2 emission, water use and waste generation, are also suggested.

4.1 Reducing energy use and CO_2 emission

The key first step for any sustainable construction is to employ strategies to reduce the operational energy use and associated CO_2 emission. This involves deploying energy efficiency measures to reduce the demand for energy; and supplying this reduced demand for energy by low carbon technologies and renewable energy systems (zero carbon technologies).

Whilst renewable energy comes from the elements - sun, wind and water; low-carbon technologies deliver energy (e.g. heat) to a building with as little CO_2 production as possible.

Typically, energy efficiency measures exploit passive design strategies and the properties of building fabric to heat or cool a building, and to provide natural light and ventilation. Passive strategies are used to reduce overall energy loads before efficient building services and controls are put in. These are summarised below and listed in Table 2 with indicatory costs.

Design and building fabric:

- Passive design measures such as proper orientation, good daylight and natural ventilation, thermal mass and controlling solar gain.
- Adequate insulation and airtight construction.

Building services and controls:

- Efficient building services and equipment for heating, cooling and lighting.
- Simple and effective controls such as window blinds, occupancy and daylight sensors.

Low carbon and zero carbon technologies:

- Low carbon technologies such as combined heat and power or ground source heat pumps.
- Renewable sources such as solar thermal for hot water, solar photovoltaic and wind energy for electricity.

Table 2. Typical costs of measures to reduce energy use from institutional buildings.

Energy Efficiency Measure	Cost (£)	Additional Information
Built Fabric		
Fabric insulation in roof and walls	£2940 (additional cost) Improvement over building regulations	2 storey naturally ventilated office. (BRE)
Air-tight construction	£10,000 for a fan pressurisation test	Typical factory unit (DTI and Faber Maunsell, 2006)
Building services		
Energy efficient lighting	£4-12 for a single CFL (compact fluorescent lamps)	For a 10,000 hours life, a CFL will save around £50.(DTI and Faber Maunsell, 2006)
Lighting controls	£10-20/unit of control device	
Occupancy sensors Daylight sensors	£7403 cost of daylight sensors in all areas	2 storey naturally ventilated office.(BRE)
Condensing boilers	£1000 (additional cost above standard boilers)	Typical factory unit (DTI and Faber Maunsell, 2006)
Heating/cooling zoned controls	£1000 cost for thermostatic radiator valves and similar controls	Typical factory unit (DTI and Faber Maunsell, 2006)
Energy sub-metering	£1906 (cost of sub-meters for major plant and both floors)	2 storey naturally ventilated office(BRE)
	£2000	Typical factory unit (DTI and Faber Maunsell, 2006)
Low carbon technologies		
CHP	Extra cost of £50,000 for a CHP unit (over and above standard heating). Costs are site-specific and dependent on loads served.	DTI-funded Sustainable construction project
Ground source heat pumps	Additional cost of installing pipes is around £2000-£3000 depending on ground conditions and length or depth of pipes.	
Zero carbon technologies		
Solar thermal system	£ 700/m² (flat plate solar collectors)	DTI-funded Sustainable construction project
Solar photovoltaic system	£4000-8000/kWp roof mounted £10-£15,000/kWp for façade or atrium systems	
Wind turbine	£5,000-£25,000 (1.5kW to 10kW)	

Note: All costs are indicative for new builds and have been derived from two sources.

- DTI funded sustainable construction project- Industrial & commercial measures – costs for a typical factory unit (5000m² production &1000m² office)
- BRE (2005) Putting a price to sustainability – costs for Building regulations compliant 'base case' 2 storey naturally ventilated office.

While commissioning sustainable construction, it is important for the client to set firm standards and targets (as mentioned in section 3.3) for energy use and CO_2 emission, against which the success of the various measures could be evaluated.

Such standards are usually based on typical and good practice benchmarks for gas and electricity consumption, and associated CO_2 emissions in colleges, as listed in the table below. Specific benchmarks for different building types within the FE sector are also included. These could be used to set targets depending upon the type of building being commissioned.

Table 3. Good-practice and typical benchmarks for fossil fuel use and associated CO_2 emission for various building types in FE Colleges. (Source: CIBSE, 2004)

Space type/category	Good practice benchmarks			Typical practice benchmarks		
	Electricity (kWh/m²/yr)	Fossil fuel (kWh/m²/yr)	CO_2 (kgCO_2/m²/yr)	Electricity (kWh/m²/yr)	Fossil fuel (kWh/m²/yr)	CO_2 (kgCO_2/m²/yr)
Lecture room arts	67	100	50	76	120	58
Lecture room science	113	110	73	129	132	84
Science laboratory	155	110	92	175	132	106
Library air-conditioned	292	173	167	404	245	232
Library naturally ventilated	46	115	43	64	161	60
Catering bar/restaurant	137	182	98	149	257	117
Catering fast food	200	438	175	218	618	218

Also, all new build schemes must comply with the 2006 Part L Building Regulation amendments for energy conservation and CO_2 performance. Refurbishment, extensions and alterations to existing buildings should seek to upgrade the estate to the current Part L of the Building Regulations. For example, installing double glazing throughout the whole building, and not just in the windows being altered under the scheme.

4.2 Encouraging water efficiency

Water is a scarce resource and a sustainable construction should incorporate features to:

- Reduce water consumption through efficient fixtures,
- Recycle using grey water systems
- Reuse water through rain water harvesting and filtering technologies such as reed beds.
- Landscaping and site layout should avoid run-off by creation of sustainable urban drainage systems.

These strategies are listed in Table 4 along with their associated costs.

The Government does not currently provide mandatory water efficiency targets to be met in colleges. However, a number of voluntary targets are available, and a consultation by the Department for Communities and Local Government (DCLG) has been released in December 2006, seeking views on proposals to set minimum standards for water efficiency in new dwellings, and new business premises in England and Wales (DCLG, 2006b).

Some of the available benchmarks for water efficiency are as follows:
- The Watermark projects' benchmarks developed in 2003, were based on self reporting questionnaires from offices in the public sector. Benchmarks representing water use for 'average' and 'best practice' were developed of $0.62m^3/m^2$/year and $0.40m^3/m^2$/year.
- BREEAM office assessment tool uses three ranges to assign credits based on predicted annual water consumption per person per year in non-domestic buildings, based on a standard procedure. The lower the water consumption, the higher is the number of credits achieved. For more information refer to guide '*How to conserve water in further education colleges*'.

Table 4. Typical costs of measures to increase water efficiency in buildings.

Measure	Estimated cost	Additional information
Water saving fixtures & fittings		Additional cost above a standard fitting in a new build (cost extracted from domestic measures, DTI, multi buy options could reduce costs)
6/4 liters flush WC	£ 80	
Aerated tap	£50	
Sub – metering	£ 231[1]	
Leak detection system	£ 462 -635[1]	
Grey water recycling	Site-specific basis	
Rain water collection & use	£6263-32,073[1]	
Sustainable urban drainage system (SUDS)	Site-specific basis	

[1]Costs are representative and have been extracted from estimates by BRE for the Building Regulations compliant 'base case' naturally ventilated (lower range) and air-conditioned office (higher range) published in 'Putting a price to sustainability'

4.3 Minimising construction waste

A large amount of waste is generated in the construction process, apart from the waste generated by building use and occupation. Waste generated from construction sites can be reduced by:
- Ensuring minimum waste on site through design specifications, by avoiding cutting, and specifying standard component sizes. This will also enable faster construction and reduce costs.
- Managing waste on site, and avoiding wastes going to landfill by sending it for recycling.
- Offsite production

Further guidance is available through organizations such as WRAP, and BRE's *SMARTWaste* tool to audit and manage wastes. A waste management strategy for the institution should also be developed to ensure minimisation of various kinds of waste generated by use in the FE sector.

4.4 Using materials with low environmental impacts

A lot of energy is expended in building materials from its extraction, production and finally, transport to the construction site. This is called the embodied energy of materials. Material extraction from quarries and mines as well as their processing process can also have adverse environmental impacts. Specifying sustainable and 'green' materials is essential. Some of the key considerations while specifying materials are:

- Locally sourced materials require less energy for transportation to the site and relate to the context of the surroundings.
- Low embodied energy and preferably natural materials.
- Promote use of recycled materials, especially, for high embodied energy materials like steel and aluminium.
- Use of reclaimed materials such as reclaimed bricks for landscaping.
- Design for ease of demolition to enable reuse and recycling later.
- Timber should be sourced from sustainably managed forests, certified by appropriate bodies. The Forest Stewardship Council (FSC) and the Pan European Forest Certification Scheme (PEFC) are the two most well established and reputable certification bodies.
- The Green Guide to Housing Specification and Green Guide to Specification (available from BRE) provide a simple method of comparing the lifecycle impacts of different construction materials and methods of construction (Anderson et al., 2002).

Modern methods of construction

The term 'Modern Methods of Construction' (MMC) embraces a range of technologies involving various forms of prefabrication and/or off-site assembly.

The key feature of MMC is that much of the process is removed from the site to controlled factory conditions, which reduces the amount of time spent on site and impacts on the locality. This allows a quicker return on investment for the client, and reduced overheads.

MMC is increasingly regarded as a realistic means of improving quality, improving on-site safety and addressing skills shortages in the construction sector.

However there are key features to consider before specifying MMC for sustainable construction, such as:

- Costs and availability of replacement parts, including any bespoke components.
- Costs and availability of labour, particularly the ease with which local tradesmen could undertake repairs/alterations, or need to employ manufacturer-approved contractors.
- Extent and speed to which building could be dried out after a flood.
- Degree of inter-connectness between building components, e.g. bathroom or kitchen pods.

4.5 Enhancing biodiversity

The impact of buildings on their surroundings should be considered while commissioning a project such that there is minimal intervention. New development sites should ideally be on areas of land of low ecological value to decrease the destruction of natural habitats and the wildlife they support. An ecological survey by an accredited professional should be carried out on any proposed development site, as soon as possible so that any features of ecological value can be protected during construction.

This can be done by:
- Promoting local habitats by maintaining local plants and wildlife.
- Sensitive landscaping on site and designing for green areas such as green roofs.
- Green roofs can either support larger and more elaborate vegetation (inc. trees) utilising deep soil bases (intensive) or support mainly mosses and sedums using shallow soil bases (extensive). Depending on the type of green roof used additional structural strength may be required to deal with increased loading.

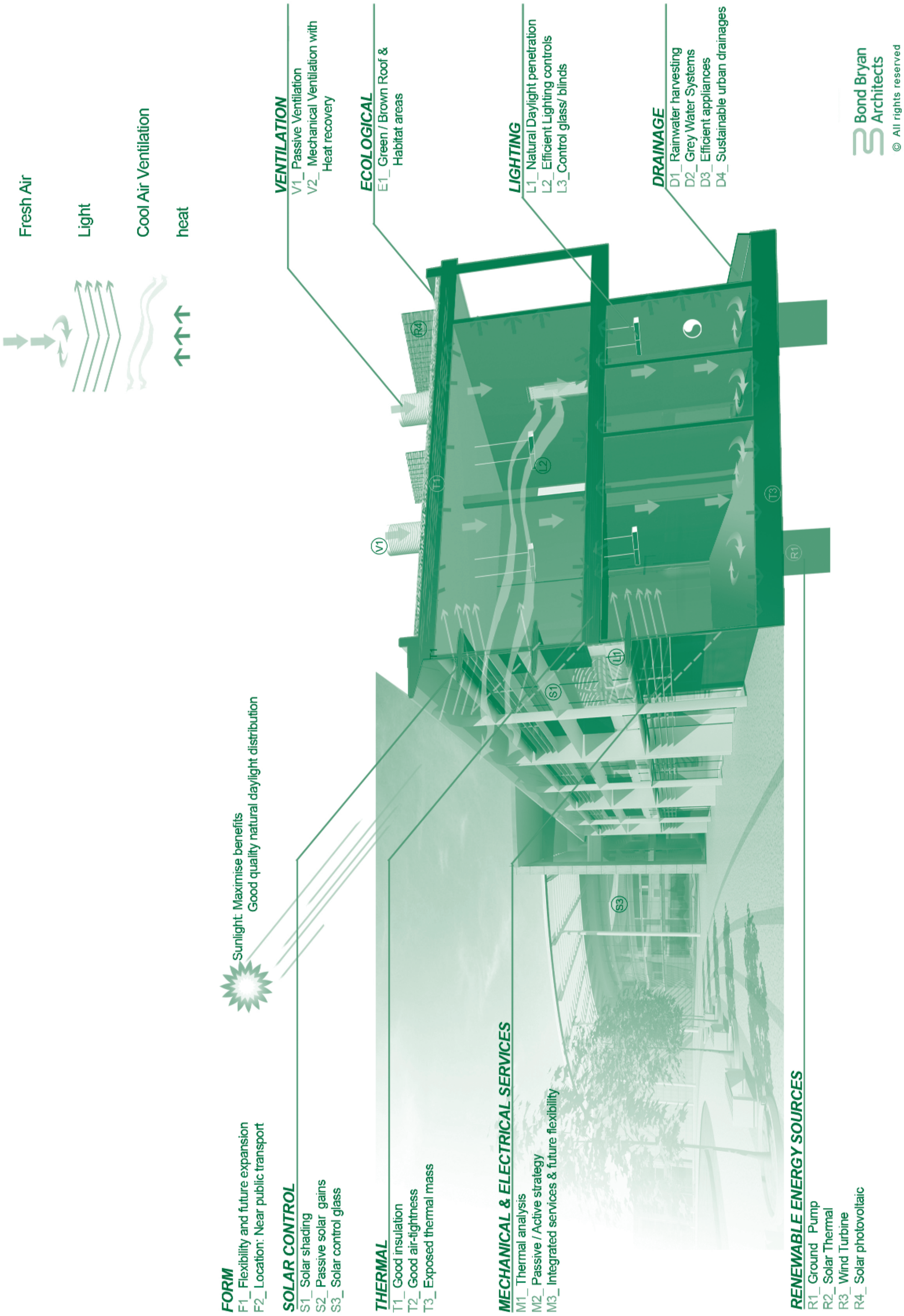

Figure 3. Conceptual representation of sustainability measures in a building
Source: Bond Bryan Architects

5. OVERCOMING BARRIERS

This section raises key barriers which hinder sustainable construction within the FE sector, and discusses methods to overcome them. One of the key barriers is availability of capital funds to commission sustainable construction, which is addressed by the recently-launched sustainable construction strategy by LSC, which for the first time explicitly states that FE Colleges must include green proposals in their designs if they are to win funding.

5.1 Commitment and awareness

Lack of commitment to sustainability at senior management level is the biggest barrier in enforcing environmental policies within the sector.

- Awareness about the benefits of sustainable construction can be generated through seminars, workshops for energy and estate managers.
- The users of college buildings also need to be made aware about sustainability within the institution to achieve results.

5.2 Energy policy

Environmental policies without measurable goals have little or no impact on building performance when projects are commissioned.

- An environmental policy should broadly address all issues of sustainability and include quantitative benchmarks.
- It should facilitate evaluation of the project at key stages against a defined set of goals.
- Sustainability checklists available by the BRE and SEEDA, and design quality indicators are useful tools to define sustainability objectives and key areas for policies.

5.3 Capital costs

Budget holders are concerned that there is strict adherence to capital budgets for refurbishments or new building projects, even at the cost of integrating energy measures. To ensure this, it is recommended that :

- Whole life costing of sustainability measures should be done to decide cost versus long term benefit of each measure.
- An integrated design approach towards sustainability should be followed instead of cost-based competitive tendering.
- Grants are provided by the government for encouraging certain technologies. Micro-generation grants up to £1m are available to public sector organisations. The technologies supported are solar PV and thermal, wind turbines, ground source heat pumps and biomass (automated wood pellet stoves and wood-fuelled boilers), with support ranging from 30-50% depending on the technology. Since the situation regarding grants is always changing, it has not been specified here. Check for recent sources of information when planning a project.
- Mandatory requirements for reporting of energy performance or design

criteria, and capital funding of certain energy efficiency measures by FE funding bodies are some other ways to ensure that sustainability measures are incorporated in FE colleges.

5.4 Capital funding from LSC: sustainable construction strategy

In February 2007, the Learning and Skills Council (LSC) revealed their strategy for building greener colleges of the future, which builds on the LSC's strategy From here to Sustainability launched in 2005. The 2007 strategy states that in future, for FE Colleges to qualify for LSC capital funds, all proposals will need to address sustainable construction by:

- Meeting and preferably exceeding, the requirements of Part L of Building Regulations.
- Ensuring that the completed development meets the criteria to achieve a minimum of **Very Good** Building Research Establishment Environmental Assessment Method (BREEAM) Ratings.
- Looking for innovative solutions to sustainability which will attract additional capital eligibility of up to 10% of net construction costs.
- Embedding the principles of sustainability in the design of buildings and building systems.

As part of this strategy, the key actions to producing sustainable buildings in the future are:

- *Environmental management system (EMS):* undertake an audit of the existing consumption and management of energy, water and waste with a view to implementing an effective EMS or adopting a sound sustainability policy
- *Building and design:* promote and deliver good sustainable practice in all design, new build and refurbishment activities.
- *Procurement:* ensure that all procurement practices reflect social, environmental, as well as economic costs.
- *Biodiversity:* implement a locally appropriate biodiversity programme that best manages the site for conservation.
- *Travel:* implement a travel plan that tackles the issue of providing access for all and reduces the environmental impact of travel.

To achieve this, the Government will make a commitment to rebuilding the FE Estate, investing £750 million annually on capital projects by 2011. Indeed, if there was ever an overriding driver to commission sustainable construction in FE colleges, it is now.

6. FURTHER INFORMATION

Key organizations

1 **Carbon Trust** advises business and the public sector to cut carbon emissions, and supports the development of low carbon technologies. www.carbontrust.co.uk

2 **Energy Saving Trust** provides guidance and funding for energy efficiency and low carbon technologies in buildings. www.est.org.uk

3 **Building Research Establishment** provides a complete range of consultancy, testing and commissioned research services related to all aspects of the built environment. www.bre.co.uk

4 **Environment Agency** is the leading public body for protecting and improving the environment in England and Wales. www.environment-agency.gov.uk

5 **CABE**, the Commission for Architecture and the Built Environment, is the government's advisor on architecture, urban design and public space. It provides clients with hands-on advice on ways to get better value through better design. www.cabe.org.uk

6 **LSC,** the Learning and Skills Council. www.lsc.gov.uk

Other sources

1 **Higher Education Environmental Performance Improvement** is a project funded by the HEFCE to create awareness and disseminate information related to energy and environment in the higher education sector. http://www.heepi.org.uk/

2 **Environment Association for Universities and Colleges, EAUC**, is the sector champion for sustainability in the UK. The EUAC network stimulates and supports all aspects of the sector to become more sustainable. http://www.eauc.org.uk

3 **Waste and Resources Action Programme, WRAP**, works in partnership, helping businesses and the general public to reduce and recycle waste. http://www.wrap.org.uk

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