RIBA

Climate Change Toolkit

04 Low Carbon Standards and Assessment Methods

175

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Cover image Redbrook Hayes School, Staffordshire, Walters & Cohen Architects. The school's design maximises use of passive solar energy. Diffuse shaded east and west light combine to provide good daylight uniformity throughout, while high level windows and roof lights optimise natural day lighting of classroom areas and the heart of the school. The building also includes rainwater harvesting.
Photo Dennis Gilbert/VIEW

About this Document

This is the fourth of eight components of Climate Change Tools, a package of guidance developed by the RIBA to encourage architects to engage with the issue of climate change and to deliver low-carbon new buildings and low-carbon refurbishment of existing buildings.

Low Carbon Standards and Assessment Methods reviews recommended low carbon performance standards and assessment methods for new and existing buildings. The complete toolkit consists of:

01 *Climate Change Briefing*

02 *Carbon Literacy Briefing*

03 *Principles of Low Carbon Design and Refurbishment*

04 *Low Carbon Standards and Assessment Methods*

05 *Low Carbon Design Tools*

06 *Skills for Low Carbon Buildings*

07 *Designing for Flood Risk*

08 *Whole Life Assessment for Low Carbon Design*

Each guide summarises its subject and provides links to other sources of more detailed information.

You can explore all of the RIBA Climate Change Tools at www.architecture.com/climatechange

Introduction

Climate change brought about by man-made emissions of greenhouse gases has been identified as the greatest challenge facing human society at the beginning of the twenty-first century. Carbon dioxide is one of the major greenhouse gases; low carbon buildings are designed to produce significantly lower carbon dioxide emissions than others, helping to mitigate climate change.

This document provides an overview of recommended low carbon performance standards and associated assessment methods for new and existing buildings. These standards are generally more challenging than the minimum regulatory standards, and they are recommended for adoption by architects in order to reduce the greenhouse gas emissions associated with energy use in the buildings they design.

The adoption of low carbon performance standards is a key component of the architectural profession's response to the challenge of climate change.

Local Planning Standards

'The Merton Rule'

Following the issue of Planning Policy Statement 22 *Planning Guidance on Renewable Energy* (PPS22, 2004), the London Borough of Merton included formalised targets for the use of renewable energy in its Adopted Development Plan. They called for the use of on-site renewable energy sources to reduce the carbon dioxide emissions associated with energy use in new developments by 10%.

Local planning standards of this type – which occur at the time of application for planning permission – have become known collectively as 'Merton Rule' standards. The approach has been adopted by many other local and regional authorities, including the Greater London Authority. Typically they adopt one of two approaches:

- A set percentage of the energy demand of the development is met from local renewable energy sources – this is usually between 10 and 20%
- The carbon dioxide emissions associated with energy use in the development must be reduced by a set amount, again usually between 10 and 20%, from the minimum requirements of Building Regulations Part L (and devolved nations' equivalents).

The Government now encourages local planning authorities to adopt policies of this type. The main purpose (other than reducing carbon dioxide emissions associated with energy use in buildings) is to stimulate demand for new and renewable energy systems, and thus strengthen supply chains and reduce capital costs.

There are three issues raised by the requirement to achieve a 10% carbon dioxide emissions reduction from on-site renewable energy sources:

- There is the problem of '10% of what?' – that is, what are the baseline carbon dioxide emissions against which the percentage is measured?
- In the national context, it may not make economic sense to use on-site renewable energy, which is generally less cost effective than renewable energy from larger scale remote sources
- Energy efficiency measures are usually more cost effective than renewable energy systems and have a longer life.

'Merton Rule' standards force developers and their design teams to consider, at an early stage, how their proposals should respond to the challenge of climate change. Early adoption of an appropriate energy strategy for a development helps to identify cost effective design options and to minimise the risk of costly revisions at a later stage.

However, at the time of planning permission, the precise details of a development's construction and services are usually not fixed. It is therefore important for the developer and the design team to keep their options open.

The RIBA recommends that such standards should be set and accepted as conditions of planning approval but enforced at a later, more appropriate stage in the development process, via the building control system.

The Building Regulations

The Building Regulations set minimum standards for energy efficiency in new (and some existing) buildings. They are not, in themselves, low carbon standards; however, they do provide the basis for others. Many low carbon standards are expressed in terms of improvements over the minimum requirements of the Building Regulations.

The key documents addressing energy efficiency, renewable energy and carbon reductions are:

- Part L in England and Wales
- Part F in Northern Ireland (which is similar to Part L)
- Part J in Scotland (which is different from Part L).

This guide deals primarily with the regulations in England and Wales.

Part L was most recently updated in April 2006 to:

- Support the implementation of the EU Energy Performance of Buildings Directive
- Improve the energy efficiency of new buildings by around 20% compared with previous Regulations
- Improve the correlation between the predicted and actual performance of new buildings
- Extend the scope of regulation to existing buildings, to encourage improvements to the existing stock.

Plans for future updates of the Building Regulations Part L include reducing the carbon dioxide emissions permitted from energy use in new homes by 25% in 2010 and 60% in 2013 (based on 2006 standards). By 2016, all new housing is expected to be 'net zero carbon'. These improvements are equivalent to Levels 3, 4 and 6 of the Code for Sustainable Homes (see page 7).

Low Carbon Standards for Domestic Buildings

Building Regulations Part L1

Approved Documents

- *Part L1A – New Dwellings*
- *Part L1B – Existing Dwellings*

Second Tier Document

- The *Domestic Heating Compliance Guide*

Additional standards, codes of practice and good practice guides are also available.

Part L1A

Part L1A presents five criteria for demonstrating compliance for new dwellings:

1 Dwelling Emissions Rate/Target Emissions Rate

The Dwelling Emissions Rate (DER), expressed in kilograms of carbon dioxide per metre squared per year ($kgC0_2/m^2/yr$) must not exceed a Target Emissions Rate.

The DER is calculated as part of a Standard Assessment Procedure (SAP) energy rating calculation for the dwelling as proposed.

The TER is also calculated as part of the SAP energy rating, but for a notional dwelling which is the same size and shape as the one proposed, has gas-fired central heating and complies with Building Regulations Part L1 (2002) by the Elemental Method.

To establish the TER, the calculated emissions rate is adjusted by a fuel factor that raises the emissions target if the proposed dwelling uses a more carbon intensive fuel (e.g. grid electricity for heating). The TER is then reduced by 20%. This means that to comply with this criterion an electrically heated dwelling will require more insulation (or other energy efficiency measures) than an identical dwelling heated by gas.

2 Design Limits

Design limits for the building fabric and services must not be exceeded. In practice, building fabric and services with performance significantly better than the design limits will be required, in order to meet the carbon dioxide emissions reduction target.

For the building fabric:

- There are maximum thermal transmittance values (U values), expressed as individual values for each element and as area-weighted averages for all the elements of each type
- Accredited construction details (or details with equivalent performance demonstrated by calculation) must be used
- The air permeability of the building fabric must not exceed 10 m^3/m^2h, in a 50 Pa pressure test.

For building services:

- The *Domestic Heating Compliance Guide* sets out minimum efficiencies for heating appliances, minimum controls and minimum insulation for primary pipework, warm air ducts and hot water storage cylinders
- For continuously operating ventilation equipment, there are design limits expressed in terms of worst acceptable specific fan-power and heat recovery efficiency
- Fixed internal lighting must include at least one fitting that will only accept energy efficient lamps (efficacy > 40 lm/W) per 25 m^2 of floorspace or per four fixed lighting outlets (whichever is the greater)
- Fixed external lighting must either have controls that switch off the lamps when there is sufficient daylight and when lighting is not required at night (maximum 150 W/lamp), or must use fittings that only accept energy efficient lamps

Ventilation, heating and hot water systems must be commissioned by competent persons and commissioning certificates provided.

3 Overheating

There must not be a high risk of the dwelling overheating in warm summer weather. The SAP 2005 energy rating calculation includes a grading of the risk of summer overheating, with designs graded as High Risk not meeting the requirements of Building Regulations.

4 Thermal Bridges and Air Permeability

The dwelling as constructed must include no significant thermal bridges and the 'as-built' DER, including tested air permeability, must not exceed the TER.

If accredited construction details are used, then one dwelling of each type must be pressure tested to establish the tested air permeability for incorporation into the DER calculation. If accredited construction details are not used, then around twice as many examples of each dwelling type must be pressure tested.

Tests must be carried out in accordance with the Air Tightness Testing and Measurement Association's Technical Standard 1.

If testing shows the 'as-built' DER (incorporating the tested air permeability) to exceed the TER, then remedial measures must be implemented, the dwelling must be re-tested to confirm compliance and another dwelling of the same type must be tested.

For developments of no more than two dwellings, the Building Control Body may accept a pressure test certificate for a dwelling of the same type constructed within the previous 12 months. Alternatively, if no pressure testing is carried out, an assumed air permeability of 15 m^3/m^2h may be assumed in the 'as-built' DER, which must still not exceed the TER.

5 Operating and Maintenance Instructions

Owners or occupants of dwellings must be provided with operating and maintenance instructions for the heating and hot water systems and any ventilation or air conditioning systems.

Part L1B

Part L1B provides guidance about the requirements that apply when work is carried out on existing dwellings:

1 Historic Buildings

Historic buildings are not exempt from Building Regulations, but improvements in energy efficiency should not prejudice the character of the building or increase the risk of deterioration. Local historic building officers should be consulted about proposals.

2 Thermal Elements

Thermal elements are heat-loss walls, roofs and floors separating the internal, conditioned spaces from the exterior or from adjacent unheated spaces.

Energy efficiency considerations occur when thermal elements are provided (e.g. a building extension), replaced, retained in a material change of use (e.g. when a warehouse is converted into flats) or renovated (defined as

treating more than 25% of the surface area of the element by adding or replacing any layer of the construction). In each case, maximum thermal transmittance values (U values) apply to newly provided and replacement thermal elements.

Target 'improved' U values apply to retained thermal elements where the original U values do not meet specified 'threshold' values. For renovations, Appendix A of *Approved Document L1B* identifies potential improvement opportunities, standards and technical considerations. In each of these cases, improvements are not expected to involve measures with simple payback periods exceeding 15 years.

3 Controlled Fittings

Controlled fittings are windows, roof windows and external doors.

Maximum U values (area-weighted averages) or minimum window energy ratings are specified for new and replacement fittings.

4 Controlled Services

Controlled services are heating, hot water, ventilation and lighting.

The *Domestic Heating Compliance Guide* sets out minimum efficiencies for new or replacement heating appliances, minimum controls and minimum insulation standards for primary pipework, warm air ducts and hot water storage cylinders. It also sets out commissioning requirements.

A replacement heating device must meet the appropriate efficiency standard in the Guide and must not be more than 2% worse than the appliance it replaces.

For new or replacement continuously operating ventilation equipment, there are design limits expressed in terms of worst acceptable specific fan-power and minimum heat recovery efficiency.

New internal lighting (in extensions) and replacement lighting (in existing dwellings) must include at least one fitting that will only accept energy efficient lamps (efficacy > 40 lm/W) per 25 m^2 of floorspace or per four fixed lighting outlets (whichever is the greater). New, fixed external lighting must either have controls that switch off the lamps (maximum 150 W/lamp) when there is sufficient daylight and when lighting is not required at night, or must only accept energy efficient lamps.

5 Extensions

Extensions must meet the requirements for the provision of new thermal elements, controlled fittings and controlled services.

The area of glazed openings in an extension must not exceed 25% of the floor area, plus the area of any openings in the original dwelling that are covered by the extension.

The thermal properties of exposed walls, roofs and floors, and the thermal properties and areas of glazed openings may be traded-off against each other, subject to design limits.

A SAP 2005 assessment may be used to show that the carbon dioxide emissions of the extended dwelling as proposed are no greater than they would have been if all the elemental standards had been applied to the extension, but required improvements to the original dwelling may not be traded off against a lesser standard of performance in the extension.

6 Conservatories

A conservatory is an attached structure that has at least three-quarters of its roof and at least half of its walls made of translucent material, and which is thermally separated from the dwelling to which it is attached. Structures that do not meet all of this definition are treated as extensions.

Conservatories with more than 30 m^2 of floorspace must meet the standards for new or replacement thermal elements and controlled fittings (including roof glazing), and any fixed heating must have independent on/off and temperature control, and meet the requirements for controlled services.

Conservatories with up to 30 m^2 floorspace are exempt from the Building Regulations.

7 Material Alterations

Material alterations must include reasonable provision for energy efficiency, in accordance with the requirements for thermal elements, controlled fittings and controlled services, where these are provided, replaced, retained or renovated.

8 Material Changes of Use

Material changes of use (where a dwelling is created by conversion of another type of building) must include reasonable provision for energy efficiency, in accordance with the requirements for thermal elements, controlled fittings and controlled services.

Existing windows, external doors and roof windows with U values worse than 3.30 W/m^{2}K must be replaced by new fittings that meet the requirements for new or replacement controlled fittings. Alternatively, a SAP 2005 assessment may be used to show that the carbon dioxide emissions of the proposed dwelling are no greater than they would have been if all the elemental standards had been applied to the conversion.

Energy Saving Trust: Best Practice Energy Standards

The Energy Saving Trust's Energy Best Practice in Housing programme has published a set of standards for those who want to go beyond the Building Regulations see www.est.org.uk/housingbuildings/standards

These standards have been incorporated within the Code for Sustainable Homes (see page 7). The Advanced Practice standard is similar to the PassivHaus standard, which is emerging as a European standard for low carbon dwellings and which also features in the Carbon Lite standards (see page 8).

The Best Practice Energy Standards have three levels:

Good Practice

This represents a 10% improvement on current Building Regulations (i.e. the DER must be at least 10% lower than the TER), with no 'trading off' the thermal properties of the building fabric and a maximum air permeability of 5 m^3/m^{2}h at 50 Pa.

The Good Practice standard has more demanding design limits than those set by Building Regulations, including maximum U values, 40% of fixed lighting to only accept energy efficient lamps and any domestic appliances supplied to be Energy Saving Recommended. Mechanical cooling must not be used.

This standard provides a recipe for meeting Level 1 of the Code for Sustainable Homes.

Best Practice

This represents a 25% improvement on current Building Regulations, again with no trading off the thermal properties of the building fabric and with a maximum air permeability of 3 m^3/m^{2}h at 50 Pa.

There are more demanding design limits than those set by the Good Practice standard including lower maximum U values, more efficient and better controlled heating and 75% of fixed lighting to only accept energy efficient lamps. Again, any domestic appliances supplied should be Energy Saving Recommended.

Mechanical extract ventilation (MEV) or whole-house mechanical ventilation with heat recovery (MVHR) must be used, and specific fan power must not exceed set limits. Mechanical cooling must not be used.

This standard provides a recipe for meeting Level 3 of the Code for Sustainable Homes.

Advanced Practice

This represents a 60% improvement on current Building Regulations and requires:

- No trading off the thermal properties of the building fabric
- A maximum tested air permeability of 1 m^3/m^{2}h at 50 Pa
- Energy demand for space heating limited to 15kWh/m^2/yr
- Total primary energy use (for heating, hot water, cooking and appliances) limited to 120kWh/m^2/yr
- Lower maximum U values than the Best Practice standard
- 100% of fixed lighting should only accept energy efficient lamps
- Any domestic appliances supplied should be Energy Saving Recommended
- Whole-house MVHR must be used and specific fan power must not exceed set limits
- Mechanical cooling must not be used.

Code for Sustainable Homes

The Code for Sustainable Homes (see www.communities.gov.uk/thecode) is a standard for new dwellings that sets levels of performance for a range of environmental impacts. The Code is likely to underpin future updates of the Building Regulations in England and Wales, and possibly in Northern Ireland.

The Code for Sustainable Homes deals with more than energy use and carbon dioxide emissions. There are nine performance categories:

- Energy use and carbon dioxide emissions
- Water
- Materials
- Surface water run-off
- Waste
- Pollution
- Health and well-being
- Management
- Ecology.

The Code incorporated six levels for compliance, each of which has mandatory carbon dioxide emissions standards.

Code level	Reduction in carbon dioxide emissions compared with Building Regulations, Part L (2006)
1	10%
2	18%
3	25%
4	44%
5	100%
6	'Net Zero Carbon'

For Code Levels 1-5, the carbon dioxide emissions reductions are assessed by means of the Target Emissions Rate (TER) incorporated in Building Regulations Part L1A. The TER deals only with emissions related to energy use for heating, hot water and internal lighting. Level 6 of the Code – net zero carbon – covers all energy use including cooking and the use of electrical appliances.

Since April 2007, all new publicly-funded housing has been required to meet Level 3 of the Code. Some local planning authorities and development agencies (such as English Partnerships) are using the Code as the basis for environmental standards for new dwellings in their areas.

The Government made assessment of new dwellings against the Code mandatory from May 2008. Any new dwelling that is not assessed for compliance with the Code must have a 'null rating' certificate.

Zero-Carbon Standards

'Zero-carbon' standards for new dwellings have been proposed for three slightly different purposes: for HM Treasury's Stamp Duty Relief; for Level 6 of the Code for Sustainable Homes (see above); and for the Building Regulations, Part L in 2016. The Government and the house-building industry have set up the Zero Carbon Hub (see www.zerocarbonhub.org) to facilitate the definition and implementation of a single zero-carbon standard, in due course. The Government undertook a public consultation on the definition of 'zero-carbon' for both domestic and non-domestic buildings, in early 2009. The implications of this challenging target – which covers all energy uses, including electrical and electronic goods – are still being worked out. Current proposals (mid 2009) include:

- Significant improvements to the performance of the building fabric
- Improvements to the efficiency of building services
- The use of on-site renewable energy systems
- 'Allowable solutions' for any remaining emissions through other local measures (e.g. investment in a community energy scheme, or insulating existing housing in the vicinity of a new housing development).

In the meantime HM Treasury has developed a zero carbon standard for new dwellings. Dwellings that meet this standard (via a certification process) qualify for Stamp Duty Relief on first sale only (for a period of five years from 1 October 2007). Zero-carbon homes sold for up to £500,000 are exempt from Stamp Duty, and those sold for more than £500,000 qualify for a £15,000 reduction in Stamp Duty. To meet the standard, new dwellings must:

- Incorporate fabric insulation standards significantly better than those required by the Building Regulations (Heat Loss Parameter ≤ 0.8 W/m^{2}K)
- Have no connection to the gas main
- Generate sufficient electricity from on-site renewable sources to match the demand for lighting and the use of appliances.

A very small number of new dwellings has been built to this standard, and taken advantage of the tax relief.

The PassivHaus Standard

The PassivHaus standard was developed in Germany in the early 1990s and, supported by the European Commission, is rapidly becoming a pan-European standard for low carbon dwellings. More than 6,000 dwellings have been built to the PassivHaus standard.

The PassivHaus standard is similar to the Energy Saving Trust's Advanced Practice standard (see above) and has been incorporated into the AECB's Carbon Lite standards (see below).

The standard is performance based and at its heart are requirements that annual space heating demand does not exceed 15kWh/m^2/yr and that primary energy use (for all purposes) does not exceed 120kWh/m^2/yr.

The standard also requires:

- Fabric U values not exceeding 0.15W/m^{2}K
- Window U values not exceeding 0.8W/m^{2}K
- Air permeability not exceeding 0.6 air changes per hour at 50 Pa (demonstrated by a pressure test of the completed building)
- Advanced whole-house mechanical ventilation with heat recovery with at least 75% heat recovery efficiency and electricity use no greater than 0.4W/ m^3 of supply air.

Performance against the PassivHaus standard is assessed using the work-book based simulation software PassivHaus Planning Package (PHPP) (see page 10). PHPP may be used to accredit the compliance of a completed building with the PassivHaus standard. It should be noted that PHPP has a different mathematical formulation and uses different measurement and representation conventions from those associated with domestic energy ratings in the UK (e.g. the SAP energy rating).

The PassivHaus standard has recently been extended to apply to some non-domestic buildings.

For more information about PassivHaus, visit www.passivehouse.com or www.passivhaus.org.uk

The AECB Carbon Lite Standards

The Association for Environment Conscious Building (AECB), with support from the Carbon Trust, has launched a Carbon Lite programme aimed at improving the 'carbon literacy' of the construction industry.

At the heart of the programme is a set of three energy standards (see www.aecb.net/energyinbuildings.php):

- The Silver Standard is roughly equivalent to the EST Best Practice standard. It limits useful space heating energy to 40 kWh/m^2/yr, primary energy use to 120 kWh/m^2/yr and carbon dioxide emissions to 22 kg/m^2/yr (with some permissible variation). Maximum U values are in the range 0.15 to 0.25 W/m^{2}K (1.0 to 2.0 W/m^{2}K for windows and doors) and maximum air permeability of 3 m^3/m^{2}h at 50 Pa. Whole-house MEV or MVHR is required. Smart metering must be used for monitoring performance
- The middle standard is the PassivHaus standard (see above)
- The Gold Standard attains the performance levels required by the PassivHaus standard, with the addition of renewable energy to reduce fossil fuel use for water heating, lighting, appliances and ventilation. The standard limits useful space heating energy to 15 kWh/m^2/yr, primary energy use to 58 kWh/m^2/yr and carbon dioxide emissions to 4 kg/m^2/yr (with some permissible variation). Maximum U values for the main fabric elements are 0.15 W/m^{2}K (0.9 to 1.2 W/m^{2}K for windows and doors) and maximum air permeability of 0.75 m^3/m^{2}h at 50 Pa. Efficient whole-house MVHR is required (with at least 75% heat recovery efficiency and electricity use no greater than 0.4 W/m^3 of supply air). Smart metering must be used for monitoring performance.

Assessment Methods for Domestic Buildings

BREDEM

The assessment methods used for most of the UK's energy standards for domestic buildings are based on BREDEM, the Building Research Establishment Domestic Energy Model.

This predicts annual fuel use, fuel costs and carbon dioxide emissions under a standard occupancy pattern (a typical, floorspace-dependent pattern incorporating a standard heating regime). Standard occupancy is used for most assessments because the rating refers to the dwelling, not the way it is used by a particular household.

Some versions of BREDEM will also (in parallel) predict fuel use, fuel costs and carbon dioxide emissions under specified occupancy.

Specified occupancy is useful for predicting households' actual costs and ensuring the availability of affordable warmth.

BREDEM is the basis of both the National Home Energy Rating and the Standard Assessment Procedure (see below). It is a thoroughly validated model that predicts annual fuel use under standard occupancy to an accuracy of ±5% in 95% of cases.

Assessment against Local Planning Standards

For domestic developments, assessment against local planning standards (i.e. 'Merton Rule' standards) is best carried out by means of BREDEM-based performance simulation.

The first step is to establish the energy demand and carbon dioxide emissions of the building as specified to meet the minimum requirements of Part L of the Building Regulations. This establishes the 'base case' to which the performance standard for the proposed building is related.

The same simulation tool is then used to identify design and specification options, and to demonstrate how the standard will be met.

Appropriate responses to standards can also be identified by adopting the principles of low-carbon design that are set out elsewhere in this RIBA Climate Change Tools package.

The National Home Energy Rating

The National Home Energy Rating (NHER) is the leading domestic energy rating scheme in the UK.

The NHER of a dwelling is based on the estimated total annual fuel use (for space heating, water heating, cooking, lighting and the use of appliances), per square metre of floorspace, under standard occupancy. It is expressed on a scale of 0 (very inefficient) to 20 (very low carbon), to an accuracy of one decimal place.

NHER assessments are location-dependent, so for example three identical dwellings in Cornwall, Cheshire and Caithness will all have different NHERs, depending on the regional climate and the exposure of the site. For more information visit www.nher.co.uk

The Standard Assessment Procedure (SAP)

The Standard Assessment Procedure (SAP) energy rating is the Government's preferred domestic energy rating. It provides the basis of assessment against the energy standards in the Building Regulations (in England and Wales, and Northern Ireland), the Energy Saving Trust's Energy Best Practice Standards and the Code for Sustainable Homes. It is also the basis of assessments for the production of Energy Performance Certificates (EPCs) for new dwellings. SAP was introduced in 1995 and is updated on a regular basis to incorporate improved understanding of domestic energy use and reflect changes in the technologies used in dwellings. The current version is SAP 2005, and a major update is expected in 2010, to coincide with the next major revision to Part L of the Building Regulations.

The SAP of a dwelling is based on the annual fuel use for space heating, water heating and fixed internal lighting only, per square metre of floorspace, under standard occupancy. It is expressed on a scale of 1 (very inefficient) to 100+ (very efficient). Dwellings with SAP energy ratings greater than 100 are net energy exporters (due to local microgeneration).

SAP energy ratings are independent of location – all dwellings are assumed to be located in the East Midlands. This means that three identical dwellings built in Cornwall, Cheshire and Caithness will all have the same SAP.

Existing dwellings may be assessed with a version of SAP known as Reduced Data SAP (RDSAP). This procedure uses 'least unlikely' default data for inputs such as external wall and ground floor insulation, window areas and ventilation, in order to reduce the cost and complexity of energy surveys. It is therefore slightly less accurate than the 'full SAP' procedure that is used for assessments of new dwellings. RDSAP is the basis of assessments for the production of Energy Performance Certificates (EPCs) for existing dwellings.

SAP energy ratings of new dwellings should be obtained from accredited On Construction Domestic Energy Assessors (OCDEAs). SAP assessments that are used to demonstrate compliance with Part L of the Building Regulations or the Code for Sustainable Homes, or to produce EPCs for new dwellings, must be obtained from accredited OCDEAs.

SAP energy ratings of existing dwellings, for which drawings and specifications are not available, should be obtained from accredited Domestic Energy Assessors (DEAs). RDSAP assessments that are used to produce EPCs for existing dwellings must be obtained from accredited DEAs.

Accredited OCDEAs and DEAs can be identified via the Government's 'Landmark' registry at www.hcrregister.com

It is recommended that architects with substantial housing workloads should train at least one in-house OCDEA and/or DEA, and acquire approved SAP software for use as a design tool and for demonstrating and certifying compliance with Part L of the Building Regulations and other standards. Architects who only intermittently undertake housing design or refurbishment may prefer to obtain their SAP assessments via a consultant accredited OCDEAs and DEAs.

Passive House Planning Package

The Passive House Planning Package (PHPP) is the means of assessing compliance with the PassivHaus standard and with the AECB Carbon Lite standards. The package has several thousand users throughout Europe, and it has proven accurate and reliable; it is however more complex than the SAP, demanding more input from a more experienced user.

The PHPP includes tools for:

- Calculating the U values of components with high thermal insulation
- Calculating energy balances
- Designing comfort ventilation
- Calculating the heat load
- Summer comfort calculations.

PHPP 2007 includes weather data for UK locations.

PHPP is a clearly structured Excel-workbook based design tool that can be used directly by architects and designers. At its core are worksheets for establishing heating energy balances (annual demand or monthly method), heat distribution and supply, electricity demand and primary energy demand.

The CEPHEUS project, undertaken as part of the European Thermie programme, evaluated housing developments constructed according to passive house standards at 14 European locations. The PHPP energy balance module was shown to be able to predict the energy performance of passive houses surprisingly accurately. This applies particularly to the technique for calculating the heating load, which was developed specifically for PassivHaus standard houses.

Figure 1 below shows the results of a comparison between measurements and PHPP predictions for different passive houses at different locations. In all cases, irrespective of the thermal insulation standard of the buildings and occupant behaviour, the calculations are in strong agreement with the average measurement results.

The English version of the PHPP is available from PassivHaus UK. See www.passivhaus.org.uk

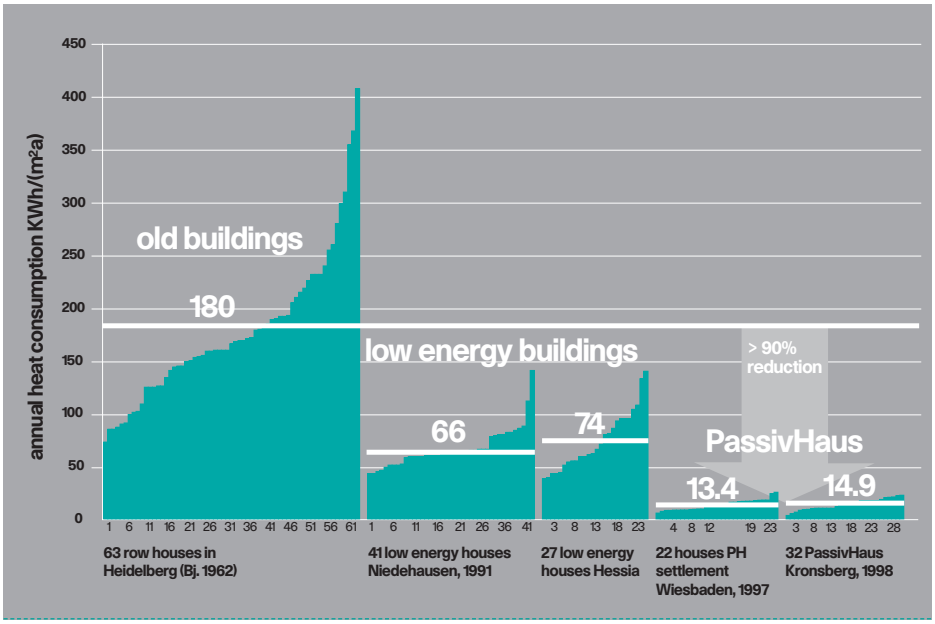

Figure 1 Occupants' influence: the average is important.
Source: PassivHaus/BRE

EcoHomes XB

EcoHomes XB is an environmental assessment method for existing housing, developed by the Building Research Establishment in collaboration with the Housing Corporation.

It is designed to enable property managers and landlords to assess the environmental efficiency of their housing stocks, to identify potential for improvement and to measure improvement when works have been carried out.

EcoHomes XB takes into consideration the constraints of the existing stock, such as site issues (access to local amenities, transport, ecology) and practical issues such as the building fabric, heating systems and ventilation.

Topics covered by EcoHomes XB are:

- Management policies
- Energy use
- Transport
- Pollution
- Water use
- Health
- Waste.

EcoHomes XB consists of three components: the Guidance, which sets out the criteria to be fulfilled; the Credit Estimator, a guide as to what rating score might be achieved; and the Summary Score Sheet which gives a rating score for the stock (on a scale of 0 to 100).

The basic procedure for using EcoHomes XB is:

- Start the assessment using only information to hand, to set a benchmark
- Set a target of what might realistically be achieved over the next year, through planned maintenance and refurbishment and by using more detailed data as it becomes available
- Finally, establish a 'goal' score that can be realistically attained over a period of years, in order to achieve the best practicable environmental performance.

Assessments under EcoHomes XB are for the guidance of housing associations and local authorities; they are not mandatory requirements.

Low Carbon Standards for Non-Domestic Buildings

Standards and assessment methods relating to energy use and carbon dioxide emissions from non-domestic buildings have changed dramatically in recent years.

These changes are largely a result of the Energy Performance of Buildings Directive (EPBD).

Requirements of the EPBD

All EU member states must:

- **Implement national or regional calculation methodologies for assessing the energy performance of new and existing buildings**
- **Establish energy performance standards for new buildings and benchmarks for existing buildings**
- **Require 'consequential improvements' to the energy efficiency of buildings over 1,000 m² undergoing refurbishment**
- **Arrange for all buildings to have an Energy Performance Certificate (EPC) available whenever they are offered for sale or rent. A small number of buildings are exempt (e.g. some heritage buildings). The EPCs of large buildings to which the public has access must be displayed.**

The full Directive can be found at www.diag.org.uk/media/18835/cibse_briefing.pdf

In response to this Directive, the Government introduced updated Building Regulations in England and Wales in April 2006. The most significant change was the development and implementation of a National Calculation Methodology (NCM) that standardises the carbon dioxide emissions from energy use in non-domestic buildings.

These new calculation procedures and standards are being used not only to demonstrate compliance with Building Regulations but also earlier in the design process, often in response to Merton Rule requirements associated with planning permission.

The Building Regulations Part L2

Approved Documents

- *Part L2A – New Buildings Other Than Dwellings*
- *Part L2B – Existing Buildings Other Than Dwellings.*

Second Tier Documents

- *The Non-Domestic Heating, Cooling and Ventilation Compliance Guide*
- *Low and Zero Carbon Energy Sources – Strategic Guide.*

Additional standards, codes of practice and good practice guides are also available.

Part L2A

Part L2A presents five criteria for demonstrating compliance for new non-domestic buildings:

1 Building Emissions Rate

The Building Emissions Rate (BER, measured in $kgCO_2/m^2/yr$) must not exceed the Target Emissions Rate (TER).

The BER must be calculated for the proposed building by an accredited model, using the NCM. One implementation of the NCM is called the Simplified Building Energy Model (SBEM). Free SBEM software (known as iSBEM) may be downloaded from www.ncm.bre.co.uk

The TER is also calculated using the NCM, but for a notional building which is the same shape and size as the one proposed and which complies with Building Regulations Part L2 (2002) by the Elemental Method. This process is summarised in Figure 2 and described below:

The notional building's annual carbon dioxide emissions rate is adjusted by an improvement factor and a low and zero carbon technologies (LZC) factor. The improvement factor is 0.15 for naturally ventilated buildings and 0.20 for mechanically ventilated or air conditioned buildings. The LZC adjustment assumes that 10% of the emissions will be displaced by low/zero carbon technologies. The combined effect of these two adjustments is to reduce the carbon dioxide emissions rate of the notional building by between 23.5 and 28%; the resulting figure becomes the TER.

2 Design Limits

Design limits for the building fabric and services must not be exceeded.

For the building fabric, there are maximum thermal transmittances (U values) expressed as individual values for each element and as area-weighted averages for all the elements of each type (i.e. walls, floors, roofs and openings). The assumed 'design air permeability' of the building fabric must not exceed 10 m^3/m^2 hr at 50 Pa excess pressure.

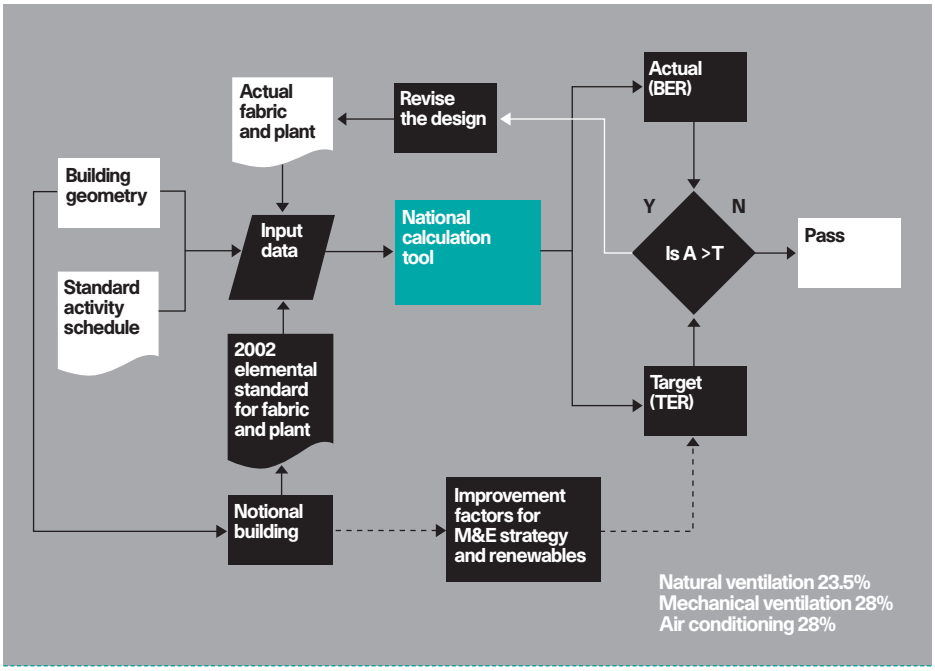

Figure 2 Estimating the carbon dioxide emissions rate of a notional building

For building services, the Non-Domestic Heating, Cooling and Ventilation Compliance Guide sets out minimum efficiencies for heating and hot water and air conditioning plant, minimum control sets for various types of systems, and minimum insulation standards for pipework, warm air ducts and hot water storage vessels.

For air handling equipment, there are design limits expressed in terms of worst acceptable specific fan-power (SPF) and ductwork air leakage.

Fixed internal lighting must achieve an average efficacy of at least 45 lm/W in offices, industrial and storage areas (in all building types) and at least 50 lm/W in all other areas.

Display lighting must achieve an average efficacy of at least 15 lm/W and have dedicated circuits that can be switched off when people are not inspecting the display.

Energy meters and sub-meters must be installed to account for at least 90% of the use of each fuel, assigned by end-use. Low and zero carbon systems should be separately metered. Buildings of more than 1,000 m^2 floor area should have facilities for automatic meter reading and data collection.

In practice building fabric and services with performance significantly better than the design limits will be required, in order to meet the carbon dioxide emissions target.

3 Overheating

It is important to minimise the need to retrofit energy-hungry air conditioning into buildings. This means that there must not be a high risk of overheating of spaces that do not have comfort cooling.

Solar control measures as identified in BRE Report BR 364 and CIBSE Application Manual 10 should be considered.

Combined solar and internal gains (from people and lights) should not exceed 35 W/m^2 (averaged over the occupancy period), or the internal operative temperature for an office should not exceed 28˚C for an appropriate number of occupancy hours.

4 As-Built

The building as constructed should perform as well as or better than predicted and, to assist in checking this, a report identifying the key features of the design that deliver the predicted BER must be supplied to the Building Control Body.

The building fabric must include no significant thermal bridges and the 'as-built' BER, including the tested air permeability, must not exceed the TER.

Accredited construction details (or details recommended by the Metal Cladding and Roofing Manufacturers' Association) should be used. Other details may be used provided equivalent or better thermal performance is demonstrated using the calculation procedures in *BRE Information Paper IP 1/06*. The Building Control Body must be provided with a report from a suitably qualified person to confirm that appropriate details have been properly constructed.

The Building Control Body must also be provided with a report from a suitably qualified person confirming the results of a pressure test to confirm that the design air permeability has been achieved. Pressure tests must be carried out by suitably qualified persons (i.e. members of the Air Tightness Testing and Measurement Association (ATTMA)) and in accordance with ATTMA Technical Standard 1. If the tested air permeability exceeds the design air permeability then the building must be re-tested after remedial work has been carried out. However, the design air permeability may be adjusted provided that it does not exceed the design limit and the as-built BER incorporating the tested air permeability does not exceed the TER.

For small buildings of less than 500 m^2 floor area, if no pressure testing is carried out, an air permeability of 15 m^3/m^2h at 50 Pa may be used in the as-built BER calculation (which still must not exceed the TER).

Ductwork must be air-leakage tested in accordance with the *Heating Ventilating and Air Conditioning Association Guide DW143*, in order to demonstrate that it achieves the minimum standard assumed in the BER calculation. Ductwork that fails to meet the standard must be subjected to remedial work and re-tested.

Completed heating, hot water, ventilation and air conditioning systems must be commissioned by competent persons to appropriate standards (e.g. CIBSE Code M) and a commissioning report must be provided by a suitably qualified person (e.g. a member of the Commissioning Specialists Association).

5 Building Log-Book

The building owner or occupants must be provided with a building log-book, which must identify:

- The installed building services and their controls
- The intended method of operation and maintenance
- Details of the installed energy metering and monitoring systems
- The data used to calculate the BER
- The 'operational rating' of the building (as described in the updated version of *CIBSE Technical Memorandum 22*).

Building log-books should be 'suitable for day-to-day use' and follow the guidance in *CIBSE Technical Memorandum 31* and *Good Practice Guide 348*.

Part L2B

Part L2B provides guidance about the requirements that apply when work is carried out on existing non-domestic buildings:

1 Historic Buildings

Historic buildings are not exempt from Building Regulations, but improvements in energy efficiency should not prejudice the character of the building or increase the risk of deterioration. Local historic building officers should be consulted about proposals.

2 Thermal Elements

'Thermal elements' are walls, roofs and floors separating the internal, conditioned spaces from the exterior, or from adjacent unheated spaces.

Reasonable provision for energy efficiency is required when thermal elements are provided (e.g. in a building extension), replaced, retained (in a material change of use) or renovated. 'Renovation' means treating more than 25% of the surface area of the element.

Maximum elemental U values apply to the provision and replacement of thermal elements.

Target 'improved' U values apply to retained thermal elements whose original U values are worse than specified 'threshold' values, but improvements are not expected to involve investments whose simple paybacks exceed 15 years.

For renovation, *Approved Document L2B* refers to Appendix A to *Approved Document L1B*, which identifies potential improvement opportunities, standards and considerations. Again, improvements are not expected to involve investments whose simple paybacks exceed 15 years.

3 Controlled Fittings

Controlled fittings are windows, roof windows and external doors (including high usage entrance doors and vehicle access doors).

Maximum U values (area-weighted averages) are specified for new fittings (in extensions) and for replacement fittings in existing buildings. Less demanding U values may be acceptable in buildings with high internal heat gains.

4 Controlled Services

Controlled services are heating, hot water, ventilation, air conditioning and lighting.

The *Non-Domestic Heating, Cooling and Ventilation Compliance Guide* sets out minimum efficiencies for new or replacement plant, minimum controls and minimum insulation for pipework, air ducts and hot water storage cylinders. It also contains commissioning requirements.

The efficiency of replacement plant must meet the standard in the Guide and must not be worse than the efficiency of the plant that it replaces. Cooling loads should be reduced, if possible, before cooling plant is provided or replaced.

For new or replacement ventilation equipment, there are design limits expressed in terms of worst acceptable specific fan-power and minimum heat recovery efficiency.

New internal lighting (in extensions) and replacement lighting (in existing buildings) must achieve average efficacy of at least 45 lm/W in offices, industrial and storage areas (in buildings of any type) or at least 50 lm/W in all other types of space.

Display lighting must achieve an average efficacy of at least 15 lm/W and have dedicated circuits that can be switched off when people are not inspecting the display. Emergency lighting and process lighting are not subject to control under Part L2B.

Where a controlled service is provided, controls should be upgraded, energy meters should be provided and the plant should be

commissioned, as required by the *Non-Domestic Heating, Cooling and Ventilation Compliance Guide*. The building logbook should be updated, or a new logbook provided.

5 Extensions

An extension that exceeds 100 m^2 of floorspace *and* exceeds 25% of the floor area of the original building is treated as a new building.

Other extensions must meet the requirements for the provision of new thermal elements, controlled fittings and controlled services.

There are maximum areas for glazed openings (except for vehicle entrance doors and display windows).

The thermal properties of exposed walls, roofs and floors, and the thermal properties and areas of glazed openings may be traded-off against each other, subject to design limits. Approved construction details, or other details with equivalent or better thermal performance, should be used.

An SBEM assessment may be used to show that the carbon dioxide emissions of the extended building are no greater than they would have been if all the elemental standards had been applied to the extension, but required improvements to the original building (e.g. the improved efficiency of a replacement boiler) may not be traded off against a lesser standard of performance in the extension.

6 Conservatories

A conservatory is an attached structure that has at least three-quarters of its roof and at least half of its walls made of translucent material, and that is thermally separated from the building to which it is attached. Structures that do not meet all of this definition are treated as extensions.

Conservatories with more than 30 m^2 of floorspace must meet the standards for new or replacement thermal elements and controlled fittings (including roof glazing), and any fixed heating must have independent on/off and temperature control, and meet the requirements for controlled services.

Conservatories with up to 30 m^2 floorspace are exempt from the Building Regulations.

7 Material Alterations

Material alterations must include reasonable provision for energy efficiency, in accordance with the requirements for thermal elements, controlled fittings and controlled services.

8 Material Changes of Use

Material changes of use must include reasonable provision for energy efficiency, in accordance with the requirements for thermal elements, controlled fittings and controlled services.

Existing windows, external doors and roof windows with U values worse than 3.30 W/m^2K must be replaced by new fittings that meet the requirements for replacement controlled fittings.

An SBEM assessment may be used to show that the carbon dioxide emissions of the building as proposed are no greater than they would have been if all the elemental standards had been applied to the conversion.

9 Consequential Improvements

Consequential improvements apply only to buildings with total useful floor areas greater than 1,000 m^2. In these cases, improvement of the energy efficiency of the *whole* building must be made if:

- The floorspace is increased, or;
- The capacity of any fixed building service is increased, or;
- A new fixed building service is provided where it was not provided before.

Consequential improvements might include:

- Upgrading thermal elements in line with the requirements for retained thermal elements
- Replacement of windows, doors and roof windows that have U values worse than 3.30 W/m^2K
- Replacement of heating, air handling or cooling plant that is more than 15 years old
- Upgrading of any lighting system that serves an area of more than 100 m^2 and has an average efficacy less than 40 lm/W
- Increasing the provision of energy from on-site low or zero carbon technologies, if it is less than 10%.

Consequential improvements should achieve a simple payback of capital cost (via fuel cost savings) within 15 years, and the expected capital investment is up to 10% of the cost of the principal works that trigger the requirement. However, this 10% rule does not apply where a new service is added to a building or its existing capacity is increased; in these cases all of the thermal elements enclosing the newly-treated areas must be improved in accordance with the requirements for retained thermal elements and (in the case of new or extended cooling systems) the cooling load should be reduced.

The following links provide reference to the main documents covering the above regulation and procedures:

Approved Documents from www.planningportal.gov.uk

Building Regulations Part L2A: www.tinyurl.com/2wcaw9

Building Regulations Part L2B: www.tinyurl.com/2h9frr

Second Tier Guidance from www.planningportal.gov.uk

Non-domestic Heating, Cooling and Ventilation Compliance Guide: www.tinyurl.com/yqz7hs

Low and Zero Carbon Energy Sources – Strategic Guide: www.tinyurl.com/yvhbod

National Calculation Methodology
iSBEM: www.ncm.bre.co.uk

CIBSE Benchmarks

The Chartered Institute of Buildings Services Engineers publishes comprehensive guidance on energy efficiency and sustainability in buildings. This guidance includes:

- *CIBSE Guide F Energy Efficiency in Buildings*[1], which includes energy performance benchmarks for new and existing buildings of various types
- *CIBSE Guide L Sustainability*[2] recommends broader environmental performance standards
- *The CIBSE Energy Assessment and Reporting Methodology (TM22)*[3] provides a comprehensive procedure for assessing the energy performance of an existing, occupied building based on metered energy use; this document is available on CD-ROM with an implementation of the method as computer software
- *Energy Benchmarks (TM46)*[4] offers comprehensive building energy benchmarks, including what they are, how they were developed and how to use them. As well as the benchmarks themselves, it provides details of separable energy uses and includes weather and occupancy adjustments.

For further information, see www.cibse.org

BREEAM

The Building Research Establishment Environmental Assessment Method (BREEAM) is a voluntary scheme that aims to quantify and reduce the environmental burden of buildings by rewarding designs and operational procedures that take positive steps to minimise their environmental impact. BREEAM assessments can be undertaken using a number of standardised methods, for different building types:

- Offices
- Education
- Higher Education
- Retail
- Industrial
- Prisons
- Courts
- Multi-residential buildings.

Where a building does not fall into one of the above categories, or accommodates a mix of activities, a 'bespoke' BREEAM assessment can be undertaken. A BREEAM International assessment can also be undertaken if the building is not in the UK and therefore subject to different energy standards and regulations.

Projects are assessed using a system of credits. These credits are grouped into the following categories:

- Management
- Health & Wellbeing
- Energy
- Transport
- Water
- Materials
- Waste
- Land & Ecology
- Pollution.

1 CIBSE (2004) *Energy Efficiency in Buildings*, Guide F, ISBN 1903287340

2 CIBSE (2007) *Sustainability*, Guide L, ISBN 9781903287828

3 CIBSE (2006) *Energy Assessment and Reporting Methodology,* Technical Memorandum 22, ISBN 190328760X

4 CIBSE (2008) *Energy Benchmarks, Technical Memorandum 46*, ISBN 9781903287958

The assessment process results in a report covering the above credit categories. The full assessment is submitted to the BRE for quality assurance, checking and certification. Certificates are awarded depending on a rating scale and will result in a building being awarded a 'pass', 'good', 'very good', 'excellent' or 'outstanding' rating.

In order for a BREEAM assessment score to give an appropriate balance across such a broad selection of issues, the BRE has developed a weighting system to provide a relative importance to each of the credit categories. The current weightings (BREEAM 2008) are as follows:

Category	Weighting
Management	12%
Health & Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12.5%
Waste	7.5%
Land Use & Ecology	10%
Pollution	10%

In order to achieve credits, information must be submitted to a trained and licensed BREEAM Assessor who will then award credits based on the current compliance criteria. The weightings are then applied to the sum total for each credit category to achieve an overall score. In the case of a pre-assessment, this is an informal process; for the full assessment, this information must be documented in detail for the BREEAM Assessor as confirmation of commitment to achieve each credit. The resulting score is then used to identify the overall BREEAM rating using the following ranges:

Rating	BREEAM Score
Pass	≥ 30
Good	≥ 45
Very Good	≥ 55
Excellent	≥ 70
Outstanding	≥ 85

Once the final assessment has been carried out, a report is written which describes which credits have been awarded. This report then goes to the BREEAM team at the BRE for Quality Assurance procedures before a certificate is issued.

When a BREEAM standard must be met, it is recommended that a BREEAM Assessor is engaged in the design team at an early stage in the design process. The Assessor will then be able to advise on which credits are likely to be readily achievable and which may be more challenging, and assist with the identification of the most cost effective options for meeting the required standard.

Further information about BREEAM including a list of licensed Assessors can be found at www.breeam.org

LEED

Developed in the USA, the LEED (Leadership in Energy and Environmental Design) Green Building Rating System is a voluntary standard for sustainable buildings. LEED was created to:

- Define 'green building' by establishing a standard of measurement
- Promote integrated, whole-building design practices
- Recognise environmental leadership in the building industry
- Stimulate green competition
- Raise consumer awareness of green building benefits
- Transform the building market.

LEED provides a framework for assessing building performance and meeting sustainability goals. It is based on well-founded scientific standards and incorporates sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

LEED standards are currently available or under development for:

- New commercial construction and major renovation projects (LEED-NC)
- Existing building operations (LEED-EB)
- Commercial interiors projects (LEED-CI)
- Core and shell projects (LEED-CS)
- Homes (LEED-H)
- Neighbourhood Development (LEED-ND)

For more information www.leedbuilding.org

Other Standards

The Carbon Trust publishes a wealth of guidance about energy efficiency in buildings and some guides include energy performance standards. Notable amongst these is *Energy Use in Offices*[5], which provides performance benchmarks for four types of office buildings. See www.carbontrust.co.uk

Environmental standards for secondary schools in England and Wales are set out in the Government's *Briefing Framework for Secondary School Projects* (*Building Bulletin 98*)[6], which includes the requirement that new schools achieve BREEAM ratings of 'good', 'very good' or 'excellent'. The Carbon Trust also publishes guidance on energy efficiency in schools.

UK hospital buildings are rated according to the NHS Environmental Assessment Tool (NEAT)[7]. All new hospital buildings must achieve an 'excellent' rating, and refurbishment projects must achieve 'very good'. NEAT aims to identify the environmental impact created during day-to-day operational activities.

For more information on design tools to achieve low carbon standards, see the guide to *Low Carbon Design Tools* in this RIBA Climate Change Tools package.

5 *Energy Use in Offices*, ECG019
www.carbontrust.co.uk/publications

6 See
www.teachernet.gov.uk
www.tinyurl.com/2cymq2

7 See
www.dh.gov.uk
www.tinyurl.com/2t55f4

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Bill Gething (Sustainability + Architecture)
Lynne Sullivan (sustainableBYdesign)

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Royal Institute of British Architects
66 Portland Place
London W1B 1AD
T 020 7580 5533
www.architecture.com

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Energy Saving Trust
21 Dartmouth Street
London SW1H 9BP
T 0845 120 7799
www.energysavingtrust.org.uk/housing

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