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Building Regulations

Proposals for Amending the Energy Efficiency Provisions

A Consultation Paper issued by
Building Regulations Division

June 2000

Department of the Environment, Transport and the Regions

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CONTENTS

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dd June 2000

Dear Consultee

BUILDING REGULATIONS.
PROPOSALS FOR AMENDING THE ENERGY EFFICIENCY PROVISIONS

You are invited to comment on the Government's proposals for amending the requirements in the Building Regulations that address energy efficiency and amending the approved guidance published as Approved Document L on ways in which compliance can be demonstrated. The proposals are conveyed in the following parts of this consultation document:

- Part 1: The draft regulatory impact assessment: this gives our assessment of the national benefits and costs of the proposals and an indication of the impact on some individual building types. It also gives the Government's aims and some background about how the Building Regulations fit into the wider actions on reducing greenhouse gas emissions and improving sustainability.

- Part 2: The proposed changes to the Regulations which govern when the energy efficiency requirements apply: there are proposals to alter the definitions of controlled service in Regulation 2, "building work" in Regulation 3 and to extend the powers in Regulation 16 enabling local authorities to make tests.

- Part 3: The proposed draft of a new edition of Approved Document L: this contains the proposed changes to the technical requirements in Schedule 1 to the Regulations, and sets out the proposed technical guidance on achieving compliance with these requirements as amended. A short summary of the proposals is given later in this letter.

- Part 4: The proposed Carbon Index amendment to SAP-1998: this is a new sub-calculation within the SAP that delivers the Carbon Index given in the proposed new edition of Approved Document L as a way of showing dwellings' compliance.

Also included in this document are:

- Part 5: Current thinking on possible future amendments of the energy efficiency provisions: this sets out the current thinking amongst the Department's technical officers and contractors on how the suggestions collected during the preliminary consultations, that have not been incorporated in this first stage of amendments, could be introduced in the future.

- Part 6: This contains a blank consultee response form and instructions on its completion. An editable version is also available on the Department's web site (see later under further sources of information).

- A list of those organisations who have been consulted (immediately following this letter): if there are any others that you think should receive a copy of this document, please let Joanna Withers know as soon as possible: by telephone at 020 7944 5735 or by e-mail at Jo_Withers@DETR.gsi.gov.uk

The proposals

These can be inspected in detail in the draft Approved Document L, and the main changes are summarised in the Annex attached to the Regulatory Impact Assessment. However the essence of the principal proposals is as described below.

FOR ALL BUILDINGS

- A widening of the definition of "material alteration" in Regulation 3 of the Building Regulations to bring more work on existing buildings within the definition of "building work" in the Regulations. The aim is to make the energy efficiency requirements applicable to more maintenance and alteration works on the existing stock of buildings. At present the Building Regulations only apply to proposed alteration works if the works affect structural safety, means of escape, resistance to fire, access and facilities for the fire service or access and facilities for disabled people.

- A significant increase in the insulating performance standards for building fabric to be achieved in two phases. It is proposed to implement the phases 6 months and 24 months after publishing the amendment. Some examples of the standards being proposed and the construction detail designs needed to achieve them are given in Appendices A and B of the draft Approved Document and more can be seen in the BRE paper posted on our web site.

- Associating the fabric performance standards (U-values) more strongly with the performance of the heating system the builder proposes to install. Within limits, the U-values could be relaxed if the heating system performs better. Different provisions are proposed for dwellings and other buildings as described below.

- Increasing the standards of detail design and site workmanship to reduce the incidence of gaps in insulation and the effects of bridging. Bridging (i.e. bypassing the insulation) can be caused by more conductive paths (such as joists and rafters interspersed in the insulation), and flanking – around the edges of openings (such as windows), and at the joints between elements (such as the joints between walls and floors). The proposed ways of showing compliance are adoption of design details that are acknowledged to be robust or, for new designs, calculating the performance using a new calculation procedure.

- Raising the standards of fabric air tightness to reduce unwanted ventilation. The aim is to improve sealing of the building fabric (excluding the provisions for ventilation to comply with Parts F and J of the Regulations), and hence to reduce ventilation heat losses. The proposed ways of showing compliance are adoption of design details that are acknowledged to be robust, or the achievement of a pass result in a fan pressurisation test that enables direct measurement of the building air leakage rate. It is proposed that fan pressurisation tests should always be undertaken where buildings have a floor area greater than 1,000 square metres.

- Improving the standards of insulation for piping, ducting and vessels by reference to the prospective new edition of the British Standard. The BS includes ways of establishing the economic thickness of insulation.

FOR DWELLINGS

- Improving the existing Elemental Method and Target U-value methods of showing compliance. The new versions take account of heating system performance and hence allow more design flexibility. One set of U-value standards in the draft Approved Document would apply for gas fired central heating with a boiler having a reasonable seasonal efficiency (75%). Another set of better U-values would have to be adopted if the proposed heating system has a worse performance or is to be fired by a fuel having a greater carbon burden (such as oil or mains electricity). It is proposed that the Target U-value Method should include both a simple option and one allowing consideration of all the main variables.

- Introducing a Carbon Index as one (optional) way of showing compliance. This would replace the SAP[1] Energy Rating Method offered in the current Approved Document L. It offers the most design flexibility in return for the attendant calculation work, and it would enable builders to show compliance by achieving a certain minimum on a scale of annual carbon emissions. It would be unaffected by fuel prices. (The SAP Rating, giving prospective purchasers or tenants an indication of an average householder's annual heating and hot water services costs, will still have to be calculated and notified to Building Control Bodies as a separate administrative requirement, but, as at present, there would be no minimum SAP Rating to be achieved.)

- Introducing requirements for properly setting up and adjusting heating and hot water systems and their controls. No significant changes are proposed regarding the provision of controls, but installers would be expected to certify that the systems they have installed have been set up and adjusted to achieve their potential for energy efficiency.

- Introducing requirements for the supply with heating and hot water systems of operating and maintenance instructions. Installers would be expected to supply with boilers and hot water cylinders the information that occupiers need to maintain energy efficient performance. This and the immediately previous provisions would reinforce voluntary efforts by the heating engineers and boiler manufacturers in their Benchmark Scheme.

- Introducing performance standards for internal lighting efficiency and external lighting automatic controls. Builders would be expected to provide a certain number of light fittings (dependent upon the number of rooms in the dwelling) that only accept efficient lamps (such as compact fluorescent lamps without integral ballasts). External lighting fixed to the dwelling would have to be automatically controlled so that it is off in daytime and on at other times either continuously or, when appropriate, only when movement is detected.

1 SAP: The Government's Standard Assessment Procedure for the Energy Rating of Dwellings, 1998, available from BRECSU, Tel 01 923 664 258

FOR BUILDINGS OTHER THAN DWELLINGS

- Introducing new performance standards for avoiding solar overheating. The aim is to reduce unwanted solar heat gains by appropriate sizing and orientation of windows, shading measures and using the thermal mass of the structure to absorb excess heat in daytime and release it at night. Ways of showing compliance include limiting window area and showing by published calculation procedures that internal temperatures will not be excessive.

- Introducing new performance standards for boiler efficiency. The new performance standards are based on assessment of the amount of carbon emitted as a consequence of consuming one kW-hour of energy for heating purposes. The method makes provision for recognising the benefits that combined heat and power systems can deliver. The proposals enable, within limits, some of the benefits of better heating systems to be offset by lower standards of fabric insulation and vice versa. The scope for reducing fabric performance is more restricted however because fabric insulation has a longer service life and is more difficult to retrofit than better heating systems.

- Introducing new performance standards for heating and hot water systems. The proposed standards are those to be published in the Energy Efficiency Best Practice guidance for controls in small commercial and multi-residential buildings. An updated edition of this publication is under preparation but the current one serves to illustrate the scope of what is intended.

- Introducing new performance standards for certain types of lighting fittings. Provisions for lamp efficacy were introduced in the last amendment of Part L in 1995 and the performance requirement for buildings other than offices, industrial and storage buildings remain unchanged (appropriate choice of lamps or an overall performance of not less than 50 lumens per Watt of circuit power). It is proposed that the limit on application should also remain as before: i.e. where more than 100 square metres will be served. However, for offices, industrial and storage buildings, lighting fittings are marketed complete with photometric performance data and this has enabled the proposed introduction of minimum performance standards for fittings for these buildings. The proposed standard is expressed in terms of the light emitted from the fitting per unit circuit power and will be challenging (at 40 luminaire-lumens per Watt). It would however allow more design flexibility for combinations of lamp efficacy, lamp ballasts (starter and frequency controls) and fitting performance, and the degree of sophistication of control systems – especially those that take account of daylighting. The draft Approved Document includes an Appendix that gives ways of showing compliance.

- Introducing new performance standards for display lighting lamps. Display lighting was excluded from the lighting provisions introduced in 1995. It is now proposed to introduce a performance standard that can either be met by the selection of appropriate display lamps or by showing that the building average circuit efficacy is reasonable (not less than 15 lumens per circuit Watt). For display lighting the overall standard is hence less than a third that of the standard for general lighting but this acknowledges the need for more intensity, colour, and light beam control versatility.

- Introducing new performance standards for buildings that are air-conditioned or mechanically ventilated. It is proposed to limit these requirements to buildings and parts of buildings where more than 200 square metres of floor area will be served. For offices a new method of showing compliance is proposed that uses a Carbon Performance Index (CPI) together with pass levels that are based on current "typical" performance. This would eliminate a significant proportion of office building practice that currently falls short of reasonable practice. The draft Approved Document includes a new Appendix describing and giving example applications of this new procedure. It is not yet possible to apply the CPI to other types of buildings and so alternative procedures for showing compliance are given. These include adherence when relevant to the guidance produced by the NHS for hospitals and the DfEE for schools, and the application of a new index of overall building ventilation efficiency. The latter is a calculation of the air volume flow rate per unit of installed fan motor power.

- Introducing two new calculation procedures for showing compliance that are based on assessing the carbon emission potential of proposed buildings. One way adapts the CPI method described above for air conditioned and mechanically ventilated buildings to include heating and lighting performance. It therefore provides the widest design flexibility. The other way is to compare the annual carbon emission of the proposed building with that of a similar building that complies with the simplest approach (the Elemental Method).

- Introducing new requirements for checking that the "As Built" performances of buildings match their approved designs. It is proposed to limit this new requirement in the first instance to apply to buildings with more than 1,000 metres of floor area. Ways of showing compliance include certification by the installer, surveys with infrared cameras and air-leakage pressure testing. The proposals include standards for remedial action in the event of initial test failures that would be considered reasonable provision after the legal requirements for air leakage have been in effect for two years.

- Introducing new requirements for commissioning the heating, hot water, ventilation, air conditioning and lighting building services. Commissioning means setting the systems to work and adjusting them so that their energy performance is in accordance with the approved design intentions. As a way of showing compliance it is proposed that the installers should certify they have commissioned their works in accordance with the relevant parts of the good practice published by the Chartered Institution of Building Services Engineers (CIBSE) and the Building Services Research and Information Association (BSRIA).

- Introducing new requirements for the installation of energy consumption meters and sub-meters. This would enable occupying organisations whether owners or tenants of all or part of buildings to monitor the energy consumption of the main building services (e.g. heating, lighting, air conditioning) during use and to compare these with national benchmarks. The future thinking in Part 5 of this consultation document suggests that the Building Regulations might eventually include provisions for the central reporting and/or publication of such data.

- Introducing new requirements for the provision with energy consuming services of operating and maintenance log books. The aim is to provide information to occupiers on how to operate and maintain the services to sustain efficient energy performance. For buildings having a floor area in excess of 200 square metres it is proposed that the log book should include a design assessment of the average annual carbon emissions of the building services and an appropriate benchmark for performance in use.

Further sources of information

This consultation document and the editable consultee response form can be found on our web site at www.construction.DETR.gov.uk/br05g.htm. You may be interested to see, also on this web site, the technical papers that we have considered in conjunction with the Building Regulations Advisory Committee during the course of developing the amendment proposals.

I would particularly draw your attention to "*The Calculation of U-values using the Combined Method*". This is a paper produced by the Building Research Establishment illustrating the application of the European Standard for calculating heat losses through building fabric (U-values). It gives fabric examples that could be used to meet the proposed new performance standards.

Correlation with other parts of Schedule 1

We must of course ensure that eventual amendments to the technical requirements in Part L correlate with those in the other parts of Schedule 1. In the development of the proposals we have paid particular attention to ensuring that the safety and health provisions in Part F (*Ventilation*) and Part J (*Combustion appliances*) are not undermined. We have also sought to ensure that the proposals are compatible with the aims and the developing thoughts in the current reviews of Part A (*Structure*) and Part E (*Resistance to the Passage of Sound*):

- Increasing cavity widths, as proposed in this consultation document, should not adversely affect the structural performance of buildings provided the wall ties are correctly specified. BS 5628 is currently being amended to accommodate cavity widths up to 300 mm and a similar proposal is being considered by the BRAC Working Party undertaking the review of Approved Document A.

- The design of the external wall also has an affect on sound insulation, and so this is also being considered in the review of Part E. Anticipating the results of this Part E review has been more difficult. But the examples in Appendices A and B in the draft Approved Document L and in the BRE paper mentioned above would suffice in all dwelling types, unless qualified to the contrary.

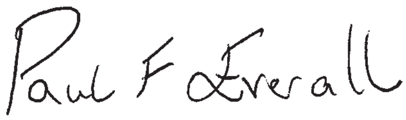
Responding with your comments

The invitation to comment extends to every part of the proposals and comments are welcome on any aspect. However to assist the Department's analysis of responses, consultees are asked to use the response forms provided.

The Department may wish to publish the responses to this consultation or to deposit them in the Department's library for public inspection. If this is done, all responses received will be published or deposited unless a respondent specifically asks for their response to be treated as confidential. Confidential responses will nevertheless be included in any statistical summary of numbers of comments and views expressed.

Please return your response to this consultation as soon as possible, and in any event not later than Friday 29 September 2000, by post to Carol Overnell at BRE, Bucknalls Lane, WATFORD, WD2 7JR, or by e-mail to PartL@bre.co.uk.

Yours faithfully



PAUL F. EVERALL

List of principal organisations consulted

(A full list of all individuals, companies and other organisations to which the consultation document has been sent is available on request to bregsa_br@detr.gov.uk.)

Age Concern England

Air Conditioning & Refrigeration Board

Airport Operators Association

Amalgamated Chimney Engineers

Architectural Association

Architecture & Surveying Institute

Associated Offices Technical Committee

Association for Environment Conscious Building

Association for Specialist Fire Protection

Association for the Conservation of Energy

Association of British Chambers of Commerce

Association of British Insurers

Association of Builders Hardware Manufacturers

Association of Building Engineers

Association of Consultant Architects

Association of Consulting Engineers

Association of Corporate Approved Inspectors

Association of Manufacturers of Domestic Electrical Appliances

Association of Manufacturers of Domestic Unvented Supply Systems Equipment

Association of Plumbing and Heating Contractors

Association of Tank & Cistern Manufacturers

Autoclaved Aerated Concrete Products Association

Barnado's

Basement Development Group

Bingo Association

Boiler & Radiator Manufacturers Association

Brewers & Licensed Retailers Association

Brick Development Association

British Bathroom Council

British Board of Agrement

British Cement Association

British Combustion Equipment Manufacturers Association

British Concrete Masonry Association

British Council for Offices

British Electrical & Allied Manufacturers Association

British Energy Efficiency Federation

British Hospitality Association

British Institute of Architectural Technologists

British Institute of Facilities Management

British Masonry Society

British Non-Ferrous Metals Federation

British Photovoltaic Association

British Plastics Federation

British Plastics Federation – Windows Group

British Plumbing Fittings Manufacturers Association

British Pre-cast Concrete Federation

British Property Federation

British Refrigeration Association

British Retail Consortium

British Rigid Urethane Foam Manufacturers Association

British Standards Institution

British Standards Institution – Construction User Group

British Waterways

British Woodworking Federation

British Youth Council

British Constructional Steelwork Association

Building Control Research Group

Building Control Wales

Building Energy Efficiency Confederation

Building Research Establishment

Building Research Establishment – Scotlab

Building Services Research & Information Association

Building Societies Association

Care and Repair England

Cavity Foam Bureau

Cavity Insulation Guarantee Agency

Central Heating Information Council

Centre for Energy Studies

Centre for Housing Management (Wales)

Chartered Institute of Building

Chartered Institute of Environmental Health

Chartered Institution of Building Services Engineers

Chief & Assistant Chief Fire Officers Association

Cold Rolled Sections Association

Combined Heat and Power Association

Commissioning Specialists Association

Committee of Vice Chancellors & Principals of the Universities of England

Concrete Block Association

Concrete Industry Alliance

Confederation of Business Industry – Building Regulations Working Group

Confederation of Construction Specialists

Conservatories Association

Construction Confederation

Construction Industry Council

Construction Industry Council (Wales)

Construction Industry Council – Energy & Environment Committee

Construction Industry Research & Information Association

Construction Industry Training Board

Construction Products Association

Construction Round Table

Consumers Association

Contract Flooring Association

Corporation of Church House

Council for Aluminium in Building

Council for Energy Efficiency Development

Council of Mortgage Lenders

Council of Registered Gas Installers

Disability Wales

District Surveyors Association

Door & Shutter Manufacturers Association

Draught Proofing Advisory Association

Dry Material Cavity Insulation Council

Electrical Contractors Association

Electricity Association

Energy Conservation & Solar Centre

Energy Council

Energy Efficiency Advice Centre/Community Energy Plus

Energy Saving Trust

Energy Systems Trade Association

Energy Technology Support Unit

Engineering Council

English Heritage

English Nature

English Partnerships

Environment Agency

Environment Audit Committee

EURISOL (UK Mineral Wool Association)

European Phenolic Foam Association

Expanded Polystyrene Cavity Insulation Association

External Wall Insulation Association

Federation of Authorised Energy Rating Organisations

Federation of Building Specialist Contractors

Federation of Civil Engineering Contractors

Federation of Environmental Trade Associations

Federation of Master Builders

Federation of Small Businesses

Fire Brigades Union

Fire Safety Development Group

Fire Service College

Flat Glass Manufacturers Association

Football Licensing Authority

Forestry Commission

Friends of the Earth

Fuel Industry Association

Gas Consumer Council

Glass and Glazing Federation

Greenpeace

Guild of Architectural Ironmongers

Guild of Incorporated Surveyors

Health and Safety Executive

Heating & Ventilating Contractors Association

Heating Equipment Testing & Approval Scheme

House Builders Federation

House Builders Federation (Wales)

House of Commons Environment Select Committee

Housing Corporation

Incorporated Society of Valuers & Auctioneers

Institute of Building Control

Institute of Clerks of Works of Great Britain Incorporated

Institute of Construction Management

Institute of Domestic Heating & Environmental Engineers

Institute of Energy & Sustainable Development

Institute of Healthcare Engineering & Estate Management

Institute of Housing

Institute of Plumbing

Institute of Refrigeration

Institute of Trading Standards

Institution of Civil Engineers

Institution of Electrical Engineers

Institution of Energy

Institution of Fire Engineers

Institution of Gas Engineers

Institution of Incorporated Engineers

Institution of Mechanical Engineers

Institution of Structural Engineers

International Association of Lighting Designers

Joint Mobility Unit

Joint Committee on Mobility of Blind & Partially Sighted People

Joseph Rowntree Foundation

Lighting Association

Lighting Industry Federation

Liquid Petroleum Gas Association

Local Government Association

Local Government Technical Advisers Group

Loss Prevention Council

Masonry Industry Alliance

Metal Cladding & Roofing Manufacturers Association

National Association of Chimney Lining Engineers

National Association of Chimney Sweeps

National Association of Citizens Advice Bureaux

National Association of Estate Agents

National Association of Local Councils

National Association of Loft Insulation Contractors

National Association of New Home Owners

National Association of Shopfitters

National Cavity Insulation Association

National Federation of Builders

National Federation of Builders (Wales)

National Federation of Residential Landlords

National Federation of Roofing Contractors

National Fireplace Association

National Home Improvement Council

National House Building Council

National Housing & Town Planning Council

National Housing Federation

National Housing Forum

National Joint Council for the Building Industry

National Prefabricated Building Association

National Society for Clean Air

National Trust

National Union of Domestic Appliances & General Operatives

Neighbourhood Energy Action

Oil Fire Technical Association for the Petroleum Industry

Passive Fire Protection Federation

Phenolic Foam Manufacturers Association

Philip Light Ltd

Planning Officers Society

Polyethylene Foam Insulation Association

Racecourse Association

Residential Landlords Association

Royal Commission on the Environment and Pollution

Royal Institute of British Architects

Royal Institute of Public Health & Hygiene

Royal Institution of Chartered Surveyors

Royal Institution of Chartered Surveyors (Wales)

Royal National Institute for the Blind

Royal Society for the Promotion of Health

Royal Society of Architects in Wales

Royal Town Planning Institute

Shelter

Shop & Display Equipment Association

Small Landlords Association

Society for the Protection of Ancient Buildings

Society of British Gas Industries

Society of Chief Architects of Local Authorities

Solar Trade Association

Solid Fuel Association

Steel Construction Institute

Steel Window Association

Textile Services Association

Thermal Insulation Contractors Association

Thermal Insulation Manufacturers & Suppliers Association

Timber and Brick Consortium

Timber Industry Alliance

Timber Trade Federation

Town & Country Planning Association

TRADA

Trades Union Congress – Construction Industry Committee

Traditional Housing Bureau

Transport & General Workers Union

UK Climate Impacts Programme

Union of Construction Allied Trades & Technicians

UNISON

Upkeep (Trust for Training & Education in Building Maintenance)

Welsh Development Agency

Welsh Federation of Housing Associations

Welsh Local Government Association

Wood Wool Slab Manufacturers Association

World Wide Fund for Nature – UK

Youth Hostels Association

PART ONE

Draft Regulatory Impact Assessment

Proposed amendments to the building regulations for energy conservation

Outline

1. This draft Regulatory Impact Assessment (RIA) addresses proposals to amend the Building Regulations provisions for energy efficiency. The aim of the proposals is to improve the energy performance of all types of buildings when they are newly built and when existing ones are altered or extended. The proposed amendments are described in the draft of a new edition of Approved Document L that the Government has published together with this RIA for consultation purposes. References to the current regulatory provisions and other background material are given starting at paragraph 5 below. The main changes proposed are summarised in Annex A on page 33.

2. The RIA deals with:

   a) the purpose and intended effect of the proposed amendments;

   b) the options that have been considered;

   c) the compliance costs for builders and building control bodies;

   d) consultations with businesses as litmus tests; and

   e) other costs that may accrue.

3. A contact point is given for further information on page 19

4. A summary of the proposals, and the benefits, costs and recommendations is given on page 30.

Background

THE BUILDING REGULATIONS – PART L

5. The Building Regulations address energy conservation directly through technical requirements supported by approved technical guidance, and indirectly through certain administrative requirements that define building work and under what circumstances and when the technical requirements apply. They address matters such as the resistance of building fabric to heat losses and the energy efficiency of those services such as heating and lighting that bear on the health, welfare, safety and convenience of people in and around buildings. They do not apply to the energy performance of industrial processes.

6. The current technical and administrative requirements are contained in the Building Regulations 1991 (SI 1991 No 2768, as amended by SI 1995 No 1850). The current technical guidance is contained in Approved Document L (1995). The proposals covered by this RIA have been developed as a first stage of amendments to these provisions, and they form part of the wide ranging review launched by Construction Minister Nick Raynsford in January 1998. The regulatory provisions under review comprise:

   a) Part L of Schedule 1 to the Building Regulations which conveys the legal technical requirements for the conservation of fuel and power;

   b) Approved Document L which provides guidance on ways in which the legal technical requirements in Part L can be met; and

   c) certain administrative and defining regulations which have a bearing on the application of the legal technical requirements.

7. The proposals have been developed by the Department of the Environment, Transport and the Regions (DETR) working with the Building Regulations Advisory Committee (BRAC), following extensive contacts with all those having an interest in the energy performance of buildings. Technical workshops and a preliminary public consultation were conducted in 1998, the results of which were made public in January 1999[1]. Meetings with the construction industry also took place last autumn, with the aim of ensuring the proposed changes are practical and these meetings are set to continue during 2000.

8. The Department's review has thus already provided building owners and occupiers, the building and construction professions, the construction industry and energy activists with opportunities to shape the proposed changes to the legal requirements and the technical guidance from the start rather than waiting until these formal consultations.

1 A Review of the Energy Efficiency Requirements in the Building Regulations – A Summary of Responses to the Initial Consultation Paper". This can be found at *www.construction.detr.gov.uk/br/br06d.htm.*

THE KYOTO PROTOCOL AND THE UK CLIMATE CHANGE PROGRAMME

9. The Government published its draft climate change programme on 9 March 2000[2]. This document explains why the Government is tackling climate change, outlines the action being taken internationally and in the UK, and describes the proposed strategy to deliver on the Kyoto and national commitments. This strategy includes seeking the higher energy performance standards in Building Regulations that are being looked for in this review.

10. The operation of building engineering services such as space heating, domestic hot water, mechanical ventilation, air conditioning, lighting etc consume energy which in turn causes carbon dioxide (CO_2) emissions amounting to 46% of the national total (27% from housing and 19% from non-domestic buildings). This amounts to about 235 million tonnes of carbon dioxide (CO_2) per year – or about 63.5 million tonnes of carbon per year (MtC/year) in the internationally preferred units used in the rest of this RIA. However, improving building fabric insulation and the performance of building engineering services can make little contribution to emissions of the other five gases in the Kyoto basket[3] which are mainly produced by manufacturing and industrial combustion processes.

11. The Government has offered to achieve a target under the Kyoto Protocol to reduce emissions of a basket of 6 gases. As a result of a subsequent agreement within the European Union, ratification of the treaty would mean the UK having to achieve a reduction of 12.5%, by comparison with 1990 levels, within the period 2008 to 2012. The Government also intends moving towards its manifesto target of achieving a national reduction in CO_2 emissions alone to 20% below 1990 levels by 2010.

NATIONAL SCOPE

12. This RIA deals with the proposals for amendments to the Building Regulations that apply in England and Wales. A similar review is in progress in Scotland and in due course a review will be launched in Northern Ireland.

The aims of the review

13. The aim of the review is to see what maximum contribution Building Regulations could make to meeting the Government's CO_2 reduction targets, whilst maintaining proportionality, design flexibility and avoiding excessive costs and technical risks. Subordinate aims include achieving the following:

a) sufficient flexibility for designers to meet weather and architectural goals that vary throughout the country;

b) avoidance of unacceptable technical risks;

c) satisfactory resistance to driving rain penetration;

2 "Climate Change, Draft UK Programme": Product Code 99EP0850. for copies Tel 0870-1226-236, Fax 0870-1226-237.

3 Sulphur hexafluoride (SF_6), methane (CH_4), nitrous oxide (N_2O), hydro-fluorocarbons (HFCs) and per-fluorocarbons (PFCs).

d) avoidance of condensation that causes unhealthy indoor air quality or damage to the building fabric;

e) avoidance of overheating through excessive solar gain or reduced ventilation;

f) avoidance of unhealthy indoor air quality caused by inadequate ventilation; that is to say ensuring the aims of Part F of the Building Regulations are not compromised; and

g) assurance that combustion appliances and their flues continue to have sufficient air supply for safe combustion; that is to say ensuring the aims of Part J of the Building Regulations are also not compromised.

14. It is also the aim to ensure that the proposals are practical and can be incorporated into normal building practice without excessive cost increases. The Government has indicated that it intends that the costs of global warming should be taken into account in deciding an appropriate balance between costs and benefits, but for the proposals in this Stage 1 of amendments this has so far proved unnecessary.

THE ISSUE

15. At issue is whether the proposals for amending the energy efficiency provisions within the Building Regulations are consistent with the Government's policies on regulations, that is to say whether the proposals being recommended will be worthwhile, proportionate, and without excessive cost. This draft RIA aims to demonstrate that this is the case.

Proposed administrative action

16. Annex A on page 33 sets out the main changes that are proposed to be made to the legislation and to the scope of Approved Document L.

Technical Risks

17. Technical risks that have been taken into account in developing the Building Regulations amendment proposals by:

a) not demanding building design details that are impractical or outside the capabilities of the construction workforce;

b) not compromising other essential performances such as resistance to rain penetration and overheating etc. are compromised;

c) not making the building services too complex for occupiers to manage successfully; and

d) not making the regulations themselves too complex to interpret and enforce.

18. The aim has been to ensure that these technical risks have been kept within acceptable limits. To be sure on this however, the consultation documents include a questionnaire that encourages responses on these matters, and industry experts have accepted the Department's invitation to help collect and publish guidance on satisfactory construction

practice. The industry experts are briefed to advise the organisations they represent during the formal consultations and to go on to develop improved or new design details as necessary.

Health Risks

19. The amendment proposals have been developed taking into account the need to avoid worsening indoor air quality as a result of:

a) sealing which reduces the ventilation rate. This would increase the risks to safety posed by open-flued combustion appliances and the risks to health posed by reduced dilution of irritants, toxins and other pathogens;

b) rain penetration and/or condensation causing damp surfaces on which moulds with pathogenic spores can flourish;

c) increased insulation and tighter sealing leading to overheating;

d) increasing humidity due to the reduced ventilation; and

e) more complex ventilation systems that through operational and maintenance failures bring harmful particles into the building.

20. Again the aim has been to ensure that these risks to health have been kept within acceptable limits. But consultees have the opportunity of commenting on these matters and the experts looking into the technical risks will be able to contribute.

The Construction Market

21. The proposed amendments would apply wherever building work is undertaken and will therefore affect a significant proportion of the UK economy. Annex B on page 35 gives indications of the scale of activities affected but, as 2 key indicators, the value of construction work in 1998 by all agencies was around £62 billion, i.e. some 8% of GDP, and the construction industry employs around 1.4 million people.

Options

22. The Government is pursuing the reduction of carbon dioxide emissions by a range of voluntary, fiscal, financial and regulatory means aimed at every sector of the economy and private life. A full explanation of its policies and an overarching draft regulatory impact assessment are given in the draft climate change programme[2]. This draft RIA aims to establish the costs and benefits of the changes proposed as a first stage of amendments to the Building Regulations, just one of the initiatives being pursued.

23. The technical and administrative proposals detailed in the consultation package comprise groups of technical and administrative measures arranged to come into effect in two optional phases at different dates. The calculation results below indicate the beneficial and cost implications of adopting either one or both of these phases for one set of timing assumptions.

24. Other technical and timing options could materialise as alternative packages that deliver different balances of costs and benefits. But the Department considers that the best way to approach the definition of these is to proceed with consultations and to reconsider in the light of the response.

Impacts

25. If the proposed amendments were to be implemented, it is expected that there would be significant improvements in the energy performance of new buildings and existing buildings where they are altered or extended. There would be a short delay before the changes make a real impact on new buildings because of the transitional arrangements, and the building industry would need time to prepare for the new standards. The proposals therefore include introducing a first phase that builders can cope with now, pending greater improvements after 2 years.

26. For alteration and extension work however, real benefits would be expected to accrue after six months to a year. These lead times have been taken into account in the cost and benefit calculations summarised below.

The Benefits

27. The express aim is to see what maximum contribution the Building Regulations can make towards achieving the Government's CO_2 targets. The proposals are a first stage of a programme of increasing standards towards achieving this goal. Current thought on how later stages of amendments could be introduced to build on this first stage are given in Part 6 of this consultation document.

28. Achieving the aim will help the Government in its policies of both sustainable construction and managing the effects of global warming. These issues have been subject to separate consultations[2].

29. The existing stock of buildings produces about half the quantity of CO_2 emitted in the UK. New construction in any one year has only a marginal impact on this total (a turnover figure of around 1% is often quoted), but in conjunction with the measures aimed at improving the existing stock, there will be a significant cumulative effect in 2010 and this benefit will accelerate thereafter.

30. Improving the energy performance of new dwellings would also contribute to the achievement of affordable warmth, although in taking this benefit a smaller reduction in CO_2 emissions would result.

31. By-product benefits would include:

a) raising the quality of construction through the development of robust standard details;

b) improving the skills of the construction workforce;

c) encouraging construction materials, components and building design innovation; and

d) contributing to a culture of continual improvement.

Valuing the benefits

GENERAL METHODOLOGY

32. The methods that have been used in this RIA align with those used elsewhere in Government in developing policy on CO_2 emissions.

33. The general approach and the main assumptions used in the calculations are described in Annex C on page 36.

34. The draft new edition of Approved Document L in the consultation documents proposes moving to higher standards of performance in this first stage of amendments in two phases with an interval of 2 years separating them. Three possible outcomes for savings in carbon emissions that would arise from implementing these proposals have been calculated assuming:

a) only the proposed first phase standards come into force in 2002;

b) only the proposed second phase standards come into force in 2004;

c) Both a) and b) take place.

NEW BUILD DWELLINGS

35. Following the approach outlined in Annex C (page 36), calculations indicate that the proposed amendments would produce national improvements as indicated in Table 1 below. Estimates of the prospective effects for individual dwellings are also given in the Summary Tables on pages 31 and 32.

Table 1: **Effect of the proposals for England and Wales on the performance of new dwellings**

Possible outcome	**First phase proposals with effect from 2002 only**	**Second phase proposals with effect from 2004 only**	**Both first and second phases**
Percent reduction in average dwelling carbon emission (approx)	17%	23%	NA
Total annual reduction in carbon emission per annum in 2010 (MtC[1] pa)	0.20[2]	0.20[2]	0.25

Notes
[1] MtC = Million tonnes of carbon
[2] There is no difference between these two figures when expressed to two decimal places because the higher standards apply over a shorter time period.

EXISTING DWELLINGS

36. The proposed amendments would also affect dwellings undergoing material changes of use and material alterations. It is thought that with regard to improvements in fabric insulation, the proposed amendments would have a small impact. However, with regard to the replacement of heating systems, windows, doors and rooflights it is thought that the impact of the proposed amendments would be significant.

37. In the Climate Change Consultation paper[4] it was estimated that installing condensing boilers and controls could produce carbon savings of between 0.53 and 1.26 million tonnes of carbon (MtC) in 2010. However, some part of the eventual out-turn saving will be the result of grant schemes e.g. for condensing boilers.

38. In this RIA it has been assumed that the proposed changes in the Building Regulations would only affect work not covered by the condensing boiler grant schemes. The proposed boiler performance standards in the Building Regulations would be somewhat less than those for condensing boilers, but would nevertheless be a significant improvement on the present average performance of replacement boilers.

39. Assuming the proposed amendments regarding the replacement of heating systems begin to take effect from 2002, and following the calculation methods outlined in the energy efficiency paper[4], the resultant carbon saving in 2010 would be between 0.28 and 0.66 million tonnes of carbon per year.

40. With regard to replacement windows, doors and rooflights, the proposed amendments would require replacements to be of a higher standard than the current average. As a result of the pressure to move to better quality windows for durability reasons, the average energy performance standard of replacement is already better than that given in the current Approved Document L. In this RIA therefore, the carbon savings per replacement contract that would be achieved by the proposed amendments have been calculated assuming the only change would be the use of low-emisivity (Low-E) rather than plain glass. The model dwelling used is representative of the existing stock in terms of size etc and level of insulation.

41. Based on rates of installation of double glazing systems in homes[5] it is estimated that the proposed amendment would produce a carbon saving of around 0.1MtC in 2010 (assuming the proposed amendments come into effect from 2002).

4 *Energy efficiency in the domestic sector – technical support paper* – can be viewed at www.environment.detr.gov.uk/consult/climatechange/technical/index.htm

5 Domestic energy fact file 1998, BRE Report 354, 1998.

NON DOMESTIC BUILDINGS (NATURALLY VENTILATED)

42. Using the approach outlined in Annex C (page 36, the prospective CO_2 savings that would arise from implementing the proposals have been estimated as indicated in Table 2. Estimates of the prospective effects for individual buildings are also given in the Summary Tables on page 31.

Table 2: **Effect of the proposals for England and Wales on the performance of new naturally ventilated non-domestic buildings**

Possible outcome	First phase proposals with effect from 2002 only	Second phase proposals with effect from 2004 only	Both first and second phases
Percent reduction in average non-domestic building carbon emission (approx)	12%	19%	NA
Total annual reduction in carbon emission in 2010 (MtC pa)	0.31*	0.31*	0.35

* There is no difference between these two figures when expressed to two decimal places because the higher standards apply over a shorter time period.

AIR CONDITIONED AND MECHANICALLY VENTILATED (ACMV) BUILDINGS

43. Office buildings are the largest group of consumers of energy used for ACMV but there is little detailed data available on their energy use and the types and sizes of ACMV systems installed (compared with the wealth of detail available for dwellings). Published performance data for other types of ACMV buildings (mainly hotels, shops and hospitals but there are many other smaller applications) are even more scarce and less robust. Furthermore there is no generally accepted and easily applied calculation procedure (analogous to NHER Evaluator for dwellings) that can be used to predict energy use.

44. However using the approach outlined in Annex C on page 36 it is estimated that the proposed amendments would produce improvements as indicated in Table 3 below. Estimates of the prospective effects for individual dwellings are also given in the Summary Tables on page 31.

Table 3: **Effect of the proposals for England and Wales on the performance of new and refurbished air conditioned and mechanically ventilated buildings**

Assuming the proposals come into force with effect from 2002	
Percent reduction in average building carbon emission (approx)	25% to 30%
Total annual reduction in carbon emission per annum in 2010 (MtC pa)	0.03-0.04

Compliance costs

NON-RECURRING COSTS

45. These would include the costs to:

a) all those with an interest in construction of having to familiarise themselves with the new requirements through training etc;

b) builders who would have to modify their standard building types and where relevant, seek revised or new national type approvals perhaps sooner than otherwise intended;

c) building materials and component producers who would need to make changes to their products maybe and to their catalogues and design advice to suit. This might incur previously unplanned development work;

d) building services contractors who could need to invest to increase the capacity for commissioning and testing buildings and their engineering services;

e) building control bodies (BCBs) who could have to commit extra resources to develop a service in professional areas they currently do not cover.

46. It has been found impossible to put a value on the cost to an “average” or “typical” business, or per employee, or per proportion of turnover etc. or indeed, to estimate an aggregate national non-recurring cost. However, it is suggested that most of these non-recurring costs would apply only in the first years following amendment, and could be only marginally greater than those costs already anticipated for e.g. product or staff development, and product and service marketing. The litmus tests proposed in paragraph 58 will give some indicative quantification.

47. The burden on larger construction firms would be small because of their existing research into higher performance building design and on-site experience with numbers of low energy building projects already completed or in progress.

48. The scale of investment needed would also be eased by the availability of low-energy design and construction expertise from mainland Europe and North America as described, for example, in:

a) Some of the papers made available by the DETR in support of this consultation[6]; and,

b) Output from the Department’s Industry Advisory Group Panels[7] addressing robust design details, domestic building services, air conditioning and commissioning and testing.

6 Available for inspection at www.Construction.DETR.gov.uk/br/br05g.htm

7 See paper TWPL(99)P59 At the website address: www.Construction.DETR.gov.uk/br/br05g.htm

RECURRING COSTS

General remarks

49. If the proposals were implemented, costs of some of the features of buildings (such as fabric elements) could be expected to increase but others (for instance space heating and air conditioning plant) would either cost the same or become cheaper because of the reduced capacities needed. It is thought that there would be a small net increase in the short term, but this would dissipate relatively quickly after the first year of implementation as building design and construction, training and experience, product innovation, reduced wastage and familiarity bear fruit.

50. The models used and assumptions made for cost estimating purposes are described in Annex C on page 36.

New Dwellings

51. Table 4 shows, for new dwellings, the costs and benefits in the format agreed for comparing all government proposals for mitigating global warming. Table 5 gives other useful indicators. The tables include costs and savings obtained after 2020 with all figures discounted to 2001 price levels.

Table 4: **Costs and benefits of proposed amendments for new dwellings in England and Wales**

No	Possible outcome	First phase proposals with effect from 2002 only	Second phase proposals with effect from 2004 only	Both first and second phases
1	Number of years in effect	19	17	19
2	Present Value of total benefit (excluding environmental cost savings)	M£ 1,114	M£ 1,241	M£ 1,424
3	Present Value of total costs	M£ 680	M£ 1,023	M£ 1,177
4	Net Present Value (Row 2 – Row 3)	M£ 434	M£ 218	M£ 247
5	Net present value per pound invested (Row 4 ÷ Row 3)	0.64	0.21	0.21
6	Annual average net total benefit (Row 4 ÷ Row 1)	M£ 22.84	M£ 12.82	M£ 13.0
7	Annual average total cost (Row 3 ÷ Row 1)	M£ 35.79 pa	M£ 60.18 pa	M£ 61.95 pa
8	Carbon savings in 2010 (Mtonnes carbon pa)	0.20	0.20	0.25
9	Net total benefit per tonne of carbon saved per year in 2010 (Row 6 ÷ Row 8)	£ 114.2 / tC	£ 64.1 / tC	£ 52 / tC
10	Capital investment per tonne of carbon saved per year in 2010 (Row 7÷ Row 8)	£ 178.95 / tC	£ 300.90 / tC	£ 247.80 / tC

Note 1: Rows 8 to 10 are parameters taken from the Headline Policy Indicator Table given in the Climate Change Programme.

Note 2: The costs in this table exclude VAT.

Table 5: Other indicators of the effects of the proposals for an average new dwelling

Possible outcome	First phase proposals with effect from 2002 only	Second phase proposals with effect from 2004 only
Average increase in construction costs in year 1 for detached and semi-detached dwellings (per dwelling)	£500 to £800	£900 to £1,400
Average increase in construction costs for year 1 for other housing types (per dwelling)	£400 to £800	£600 to £1100
Average improvement in energy performance per dwelling relative to dwellings currently being built	Around 18%	Around 26%
Annual carbon saving per dwelling (tonnes per year) relative to dwellings currently being built.	Around 0.11 (equal to 17%*)	Around 0.15 (equal to 23%*)

Notes
1: The costs in this table exclude VAT
2: * These percentages take account of the national fuel mix and hence differ slightly from the figures for energy performance improvement.

Naturally ventilated non-domestic buildings

52. Table 6 shows, for these buildings, the costs and benefits in the format agreed for comparing all government proposals for mitigating global warming. Table 7 gives other useful indicators. The tables include costs and savings obtained after 2020 with all figures discounted to 2001 price levels.

Table 6: Costs and benefits of proposed amendments for average new and refurbished naturally ventilated non-domestic buildings in England and Wales

No	Possible outcome	First phase proposals with effect from 2002 only	Second phase proposals with effect from 2004 only	Both first and second phases
1	Number of years in effect	19	17	19
2	Present Value of total benefit (excluding environmental cost savings)	M£ 1,847	M£ 2.226	M£ 2,358
3	Present Value of total costs	M£ 1,560	M£ 1,869	M£ 2,247
4	Net Present Value (Row 2 – Row 3)	M£ 287	M£ 357	M£ 111
5	Net present value per pound invested (Row 4 ÷ Row 3)	0.18	0.19	0.05
6	Annual average net total benefit (Row 4 ÷ Row 1)	M£ 15.10	M£ 21.00	M£ 5.84
7	Annual average total cost (Row 3 ÷ Row 1)	M£ 82.10 pa	M£ 109.94 pa	M£ 118.26 pa
8	Carbon savings in 2010 (Mtonnes carbon pa)	0.31	0.31	0.35
9	Net total benefit per tonne of carbon saved per year in 2010 (Row 6 ÷ Row 8)	£ 48.70 / tC	£ 67.74 / tC	£ 16.68 / tC
10	Capital investment per tonne of carbon saved per year in 2010 (Row 7÷ Row 8)	£ 264.84 / tC	£ 354.65 / tC	£ 337.00 / tC

Notes:

1 Rows 8 to 10 are parameters taken from the Headline Policy Indicator Table given in the Climate Change Programme.

2 The costs in this table exclude VAT and Climate Change Levy.

Table 7: Other indicators of the effects of the proposals for an average new naturally ventilated non-domestic building

Possible outcome	First phase proposals with effect from 2002 only	Second phase proposals with effect from 2004 only
Average increase in construction costs after the first year	Around £7/m^2	Around £10/m^2
Average improvement in energy performance over naturally ventilated non-domestic buildings currently being built	Around 19%	Around 26%

Note: The costs in this table exclude VAT and Climate Change Levy.

Air Conditioned and Mechanically Ventilated (ACMV) buildings

53. Table 8 shows, for these buildings, the costs and benefits in the format agreed for comparing all government proposals for mitigating global warming. Table 9 gives other useful indicators. The tables include costs and savings obtained after 2020 with all figures discounted to 2001 price levels.

Table 8: **Costs and benefits of proposed amendments for average new and refurbished air conditioned and mechanically ventilated buildings in England and Wales**

1	Number of years in effect	19
2	Present Value of total benefit (excl environmental cost savings)	M£ 211.00 – 242.00
3	Present Value of total costs	M£ 49.00 – 52.00
4	Net Present Value (Row 2 – Row 3)	M£ 162.00 – 190.00
5	Net present value per pound invested (Row 4 ÷ Row 3)	3.30 – 3.70
6	Annual average net total benefit (Row 4 ÷ Row 1)	M£ 8.50 – £ 10.00
7	Annual average total cost (Row 3 ÷ Row 1)	M£ 2.60 – £ 2.70 pa
8	Carbon savings in 2010 (Mtonnes carbon pa)	0.03 – 0.04
9	Net total benefit per tonne of carbon saved per year in 2010 (Row 6 ÷ Row 8)	£ 283.33– £ 250.00 per tonne
10	Capital investment per tonne of carbon saved per year in 2010 (Row 7 ÷ Row 8)	£ 86.66 – 67.50 per tonne

Notes:
1 Rows 8 to 10 are parameters taken from the Headline Policy Indicator Table given in the Climate Change Programme.
2 The costs in this table exclude VAT and Climate Change Levy.

Table 9: **Other indicators of the effects of the proposals for an average new air conditioned or mechanically ventilated building**

Average increase in construction costs after the first year	£2.50/m^2 to £7/m^2
Average improvement in energy performance over ACMV buildings currently being built	25% to 30%

Note: The costs in this table exclude VAT and Climate Change Levy.

OTHER RECURRING COSTS

54. There could be extra costs for building control bodies (BCBs) because of the additional and more complex requirements. But it is thought that for building work in connection with most new dwellings and the alteration and extension of existing ones, the existing

enforcement arrangements could assimilate the proposed changes quickly and at no extra cost. For more complex non-domestic buildings building control costs might be significantly increased unless the "Competent Firms" proposals[8] are implemented.

55. If building firms' work were to be self-certified, BCBs would incur a small administrative cost incurred when receiving and archiving certificates. If works were to be referred for BCBs for compliance assessment despite the availability of the self-certification option, costs to Approved Inspectors and Local Authorities could be substantial to cover the assessment of the new specialist requirements (or perhaps more likely the costs of subcontracting to experts). These costs could be passed on to the firms seeking Building Regulations approval by this route.

Extent of Consultation

56. Following the announcement of this review in January 1998, there was an initial phase of investigating what possible changes could be made and a round of workshops and a public consultation took place. The results of this were published in 1999 on the Internet[9] and are still available for inspection at this Internet address.

57. The proposals have also been subject to consultation with the Building Regulations Advisory Committee (BRAC) appointed by the Secretary of State as advisers on matters affecting construction. They are now being subject to wide consultation with interested groups, including organisations representing building owners and occupiers, building developers, the construction professions, contractors, BCBs and energy activists.

58. As part of the consultation process small-business-litmus-tests will be undertaken. It will be impossible to identify "average" or "typical" firms because of the diversity of businesses having interests in construction. However it is hoped that the Department's Industry Advisory Group Panel on cost estimates will be able to assist in identifying suitable candidates whose circumstances in response to the proposals would be indicative for the broad audience. The final RIA will include the results of this work.

Enforcement, sanctions, monitoring and review

59. The Building Regulations are enforced by local authority building control departments and private companies acting as approved inspectors. They have been referred to collectively in this paper as building control bodies (BCBs).

60. No new sanctions would be imposed by implementation of the Stage 1 proposals. This may not be the case for later stages of amendments being contemplated in the Government's review however, and consultees have the opportunity to comment on this in response to the "future thinking" paper in the consultation package.

8 See "The Building Act 1984: Taking forward self-certification under the Building Regulations at www.Construction.DETR.gov.uk/br/br05d

9 Website address: www.construction.detr.gov.uk/br/br06d.htm

61. This RIA will be reviewed in the light of the response to consultation and a revised version would be published should it be decided to proceed with amending the Building Regulations to introduce the proposed new requirements.

62. In the event of implementation of the proposals (whether unchanged or in an amended form) it is the Department's practice to investigate experience after a reasonable time to monitor how the regulations are working in practice.

Contact point

63. Enquiries and comments regarding this draft Regulatory Impact Assessment should be addressed to Ted King at:

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Summary

64. This draft Regulatory Impact Assessment (RIA) addresses proposals to amend the technical and administrative requirements in the Building Regulations for England and Wales. Similar work is in progress in Scotland and in Northern Ireland where separate RIAs will in due course be produced.

65. The aim of the proposals is to increase the energy efficiency of buildings and hence reduce the national emission of carbon dioxide. The approach is to see what maximum contribution Building Regulations can make towards achieving the Government's carbon dioxide (CO_2) targets whilst maintaining proportionality, design flexibility and avoiding excessive costs and technical risks. This is one element of the Government's overall strategy for dealing with greenhouse gases, described in a separate consultation[2].

66. Annex A on page 33 sets out the main changes that are proposed to be made as a first stage to the legislation and to the scope of Approved Document L – Conservation of Fuel and Power. The changes would affect all dwellings and other buildings being newly constructed and a wider range of alteration works than at present. They broadly comprise the introduction of a first phase of improvements in fabric insulation standards with effect from 6 months after the amendment date and better standards again in a second phase two years later. New requirements for heating, lighting, air conditioning and mechanical ventilation efficiency are also proposed for implementation with the first phase of improved fabric insulation standards. Current thoughts on how later stages of amendments might look are given in Part 5 of this consultation document.

67. Design flexibility and the possibility of introducing unacceptable technical risks are matters being addressed in other papers in this consultation package. The aim of this paper is to show that the regulatory proposals being recommended will be worthwhile, proportionate, and that they will not lead to excessive costs. Three possible outcomes for costs and savings in carbon emissions in 2010 have been calculated assuming:

a) only the proposed first phase standards come into force in 2002;

b) only the proposed second phase standards come into force in 2004;

c) Both a) and b) take place.

68. Carbon emissions, costs and benefits have been estimated for various models of dwellings and other buildings and financial estimates have been discounted to present value sums in the base year 2001. The calculation results are given in Tables 1 to 9. More detail about the assumptions used to determine these results is given in Annexes C and D on pages 36 and 41 respectively. Summaries of the results are given in Tables 10 to 12 below. Pie charts on pages 45 and 46 show the distribution of carbon savings between each of the building sectors.

Table 10: Summary of the data on prospective reductions in carbon emissions

The annual total emission of Carbon from all buildings in England and Wales is around 60 million tonnes per year.

Possible outcome	First phase proposals with effect from 2002 only (a)	Second phase proposals with effect from 2004 only (b)	Both first and second phases (c)
	Million tonnes of carbon (MtC) in 2010		
Savings from new dwellings	0.2	0.2	0.25
Savings from alterations to dwellings (mean estimate)	0.68	0.68	0.68
Savings from new naturally ventilated non-domestic buildings	0.31	0.31	0.35
Savings from new and refurbished air conditioned or mechanically ventilated non-domestic buildings (mean estimate)	0.035	0.035	0.035
Total annual saving (MtC)	1.22	1.22	1.32
Total annual saving		About 2%	

Notes:
1: The savings are relative to the outcome if no amendments were made.
2: There is no difference between the values in columns (a) and (b) when expressed to two decimal places because the higher standards apply over a shorter time.

Table 11: **Summary of the cost-effectiveness of the proposals**

Possible outcome	First phase proposals with effect from 2002 only	Second phase proposals with effect from 2004 only
	Net present value per pound invested	
New dwellings	0.64	0.21
Naturally ventilated Non-domestic buildings	0.18	0.19
New and refurbished ACMV Non-domestic buildings (mean estimate)	3.5	NA

All the results are positive indicating that the proposed measures are worthwhile. A value of 0 indicates the proposals would be just cost-effective. The higher the figure the more profitable the investment would be.

Table 12: **Summary of prospective extra costs per building type**

Possible outcome	First phase proposals with effect from 2002 only	Second phase proposals with effect from 2004 only
New detached and semi-detached dwellings	£ 500 to £ 800	£ 900 to £ 1,400
Smaller types of new dwellings	£ 400 - £ 800	£ 600 - £ 1,100
Naturally ventilated non-domestic buildings (per square metre)	£ 7 / m^2	£ 10 / m^2
ACMV non-domestic buildings (per square metre) (mean estimate)	£ 4.80 / m^2	NA

ANNEX A:
The main changes proposed

THE LEGAL REQUIREMENTS

1. These are contained in Schedule 1 to the Regulations and invoked by Regulation 4.

2. Part L of Schedule 1 contains the technical energy efficiency requirements and it is proposed to divide it into two subsections with L1 dealing with dwellings and L2 dealing with other buildings. One practical consideration for consultees to consider is whether separate Approved Documents should be published for L1 and L2.

3. New requirements with no limits on application are introduced for dwellings covering:

   a) *efficient lighting systems and appropriate controls*, with new guidance on ways of making reasonable provision given in the Approved Document;

   b) *commissioning the heating, ventilation, hot water and external lighting*, (that is to say setting the systems to work and testing and adjusting them), with new guidance on ways of making reasonable provision given in the Approved Document;

   c) *information about the performance of the heating, ventilation, hot water and external lighting* (that is to say the provision of Owners Manuals), with new guidance on how the information can reasonably be conveyed given in the Approved Document.

4. New requirements are introduced for buildings other than dwellings covering:

   a) *buildings' resistance to solar overheating*, with new guidance on ways of making reasonable provision given in the Approved Document;

   b) *efficient air conditioning and mechanical ventilation systems and appropriate controls*, with new guidance on ways of making reasonable provision given in the Approved Document. This requirement is limited to apply to buildings having more than 200 m^2 conditioned floor area;

   c) *testing and reporting on the building fabric* (that is to say insulation continuity and air leakage testing), with new guidance on ways of making reasonable provision given in the Approved Document. This requirement is limited to apply to buildings having more than 1,000 m^2 floor area;

   d) *commissioning the building engineering services* (that is to say setting the systems to work, testing and adjusting them and including test reports in the operations and maintenance manuals mentioned below), with new guidance on ways of making reasonable provision given in the Approved Document;

e) *information about the performance of the building engineering services* (that is to say the provision of operating and maintenance manuals), with new guidance on how the information can reasonably be conveyed given in the Approved Document.

OTHER CHANGES IN THE APPROVED DOCUMENT

5. Other changes for dwellings proposed in the draft Approved Document include:

a) the substitution of a *Carbon Index Method* for the SAP Rating Method as a way of showing compliance of the whole building;

b) *significantly improved U-values* in the elemental method that would come into effect 2 years after making the amendment, and an intermediate improvement coming into effect after 6 months. The proposals include linking these U-values to the seasonal efficiency of the central heating boiler and the carbon content of the proposed fuel;

c) *adjustment of the target U-value* method to deliver broadly similar overall performance, offering both a full and a simplified equation to offer designers more flexibility, but introducing limits to the amount of trade-off against heating system efficiency.

6. Other changes for buildings other than dwellings proposed in the draft Approved Document include the introduction of:

a) *maximum carbon intensities for heating systems*, with new guidance on reasonable carbon intensities for boilers and CHP systems;

b) *a whole-building carbon index method* of showing compliance. This method is currently only available for offices;

c) *a carbon emissions method* that can be applied to any building. In this approach the prospective annual carbon emission of the proposed building is compared with that of a notional building designed following the Elemental Method;

d) *improved U-values in the elemental method*, as for dwellings;

e) *reasonable levels of performance of lighting fittings:* new guidance for offices and storage buildings;

f) *the provision of meters to enable measurement of the energy consumption of the building (or separate tenancies where appropriate)*: new guidance.

ANNEX B

Scale of the construction market in England and Wales

1. In 1998 the value of building work by all agencies was around £62 billion, i.e. some 8% of UK GDP.

2. There are about 163,000 building firms in England and Wales employing some 1.4 million people, of various qualifications. Nearly two thirds of these workers are self-employed, with the other third being employees.

3. DETR Construction statistics show that the ten-year average (1989-98) for new dwellings in England and Wales is 160,000 per year. It has been assumed that this average rate will continue for the foreseeable future.

4. The value of total repair and maintenance (R&M) work in the construction industry that incorporates alterations and extensions to buildings is around £30 billion per year. This accounts for almost 50% of construction output. Of this value, 22% is accounted for by R&M in the public housing sector, 33% in the private housing sector, 18% in the public ‘other work’ sector and 28% in the private ‘other work’ sector.

5. Potential exists for the scale of the R&M sector to increase if householders come to accept that builders are more trustworthy as a result of the Government’s anti-cowboy trader initiatives.

6. Total new work in the construction industry in 1998 amounted to some £32.4 billion. Some three quarters of this work was done in the non-domestic sector, both public and private, and the rest was public and private new housing.

ANNEX C

Calculation approach & Assumptions used in the cost and benefit analysis

CALCULATION APPROACH

1. The monetary costs and savings associated with implementing the proposals (for example the capital costs of work to higher standards and the fuel cost savings they will yield) have been calculated for all building work up to 2020, for each of the three options in paragraph 34 of the RIA.

2. The future capital costs and fuel cost savings for the three options have been discounted to a present value expressed at 2001 prices using the Treasury Discount Rate of 6%.

3. All those costs and savings occurring in the service life of the building work (for example 60 years for new building structural fabric and 20 years for windows and heating systems have been taken into account).

4. Carbon savings from electricity in future years have been calculated using a carbon emission factor of 0.115 kgC/kWh. This is the average carbon emission factor over the period 2000 to 2020 as projected in DTI's Energy Paper 65. For fossil fuels, the carbon emission factors in the current edition of SAP-1998[10] were used.

Estimation of carbon savings

DWELLINGS – NEW BUILD

5. Five dwelling models were developed to represent the prospective new housing stock: detached, semi-detached, terrace, bungalow and flat. A number of variants of these models were selected as being representative of dwellings to be built over the period up to 2020. The improvement per dwelling in each model variant's energy (and hence CO_2) performance has been calculated as the difference between the following two cases:

   a) assuming the new dwelling complies with the standards in the Elemental Method in the proposed new edition of Approved Document L included in the consultation documents; and

10 SAP-1998: the Government's standard assessment procedure for energy rating of dwellings, 1998 edition, free from BRECSU, Tel: 01923 664258.

b) assuming the new dwelling complies with current practice (slightly better than the standards in the current Approved Document L because of the pressure on builders to adopt better-quality windows).

6. It is unlikely in practice that all new dwellings will be designed following the Elemental Method. However the Target U-value Method (likely to be the most popular) and Carbon Index Method (both also in the proposed new edition of Approved Document L) are intended to deliver dwellings whose annual energy performance is no worse than those designed following the Elemental Method. So the procedure in paragraph 5 of this Annex is robust.

7. To calculate the national total annual carbon savings accumulating from the proposed measures, the rate of construction of new build dwellings in England and Wales has been calculated from DETR construction statistics (see Annex B) on page 35 and the proportion of each of the five dwelling types was obtained from recent NHBC data[11].

8. The approach for each dwelling model was:

a) Calculate U-values using the proposed new EN method;

b) Existing case: Calculate the cost of insulating walls, floors, roofs, windows of each of them to current practice (with window provisions better than in the current Approved Document L), together with the cost of a gas central heating system. Calculate energy use and carbon emissions (the latter is calculated by multiplying the former by an appropriate carbon emission factor);

c) Proposed cases: Calculate the cost of insulating walls, floors, roofs, windows to the proposed first phase and second phase standards together with the cost of the proposed better standard of heating system. Add in the secondary costs associated with the additional insulation. Calculate energy use and carbon emissions;

d) The differences between the costs for each house model are the prospective additional costs. The differences between the respective energy uses and carbon emissions are the savings. Convert the energy saving into a cash saving using current fuel prices;

e) Calculate the national additional cost per year based on the distribution of all dwelling types in the new build stock (NHBC data) and the average number of new dwellings built each year in recent times (DETR Construction Statistics). Calculate the annual national carbon savings in the same way;

f) Assume the same annual rate of building new dwellings over the period of interest (2002 to 2020) with additional costs in second and subsequent years reduced by 60% to take account of maturing market pricing. Discount to 2001 prices at the Treasury's 6% discount rate;

g) Take each new dwelling's service life as 60 years. Discount the fuel (cash) savings achieved each year throughout the service life of each dwelling to 2001 prices;

h) Take each new dwelling's principal maintenance costs into account. Maintenance has been taken to be 2 lots of replacement windows and boilers at 20-year intervals. Discount costs to 2001 prices.

11 National House Building Council: *"New House Building Statistics"*, quarter 1 1999.

9. NHER Evaluator v3.4[12] was used to assess the models' energy performance and the corresponding fuel, carbon and monetary savings. This software conforms to SAP-1998. The fuel prices within NHER Evaluator v3.4 are: 1.38p/kWh for gas and 6.88p/kWh for electricity (on peak).

Non-domestic buildings

10. Electricity costs for non-domestic buildings have been assumed as 6.78p/kWh. Gas costs for non-domestic buildings were assumed to be 1.14p/kWh.

Naturally ventilated buildings

11. The prospective carbon dioxide savings and costs that would arise from implementation of the proposals have been estimated using the Non-Domestic Energy and Emissions Model (N-DEEM)[13]. The N-DEEM database contains detailed data on energy consumption and building structural fabric for a significant sample of non-domestic buildings and national stock data in terms of building use and structural characteristics.

12. The energy savings arising from the proposed amendments to the Approved Document were modelled using a version of 3TC[14] assuming builders adopt the Elemental Method as described in the draft Approved Document in Part 3 of this consultation document. The 3TC model has undergone extensive validation trials and has a good reputation for sound predictions. The Elemental Method was shown in the BRE survey of the implementation of the 1994 amendment of Part L[15] to be the most common method of compliance for non-domestic buildings.

13. Four categories of building were modelled: offices, shops, industrial and "other". The latter includes, for example, restaurants, hotels, pubs and leisure facilities.

14. The improvements per premise were calculated from the difference between the following two cases:

a) assuming the new building complies with the standards in the Elemental Method in the proposed new edition of Approved Document L; and

b) assuming the new building complies with current standards in practice where these are better than the standards in the current Approved Document L.

15. To calculate the national total annual carbon savings accumulating from the proposed measures, the rate of construction of new non-domestic buildings in England and Wales has been calculated from new build planning application data, broken down by building type, obtained from ABI Building Data Ltd.

12 NHER Evaluator v3.4, National Energy Services Ltd., 1999.

13 Non-domestic building energy fact file, BRE Report 339, January 1998.

14 Lumped parameter simulation method for energy evaluation of non-domestic buildings, A W Tindale, S J Irving and P E J Akehurst.

15 Review of the implementation of the 1994 amendment to the Building Regulations (SI 1994 No 1850) and the 1995 edition of Approved Document L – BRE client report CR304/98, 1998.

16. The impact of the proposed amendments on buildings undergoing material changes of use and material alterations were assumed to be small with regard to insulation. However, with regard to the replacement of heating systems and windows, doors and rooflights, it is thought that the impact of the proposed amendments' would be significant.

17. The impact of improved boilers and controls in existing buildings were assessed from N-DEEM survey data on the existing boiler stock. The savings that would be achieved by replacing existing heating systems, windows, doors and rooflights with new ones that meet the proposed new edition of Approved Document were modelled at the individual premise level in a similar way to that for new buildings. However, here the improvements per premise were calculated from the difference between:

a) assuming an equivalent new building that complies the standards in the Elemental Method in the proposed new edition of Approved Document; and

b) an equivalent building in the existing stock.

18. These savings were then scaled to the national level based on the ratios of new build to major refurbishment work indicated by an analysis of planning data[16].

Air conditioned or mechanically ventilated (ACMV) buildings

19. For office buildings there is a statistically significant database of ACMV energy use and system detail that forms the basis for ECON19[17]. For the purposes of the estimates in this RIA therefore, the data in ECON 19 has been extrapolated and adapted using information as follows:

a) the size of the ACMV office building stock and its likely changes (obtained from the Non Domestic Energy Fact file);

b) the CO_2 emissions resulting from energy use in the ACMV office stock (obtained from N-DEEM);

c) the installation and running costs of ACMV systems (from SPON's[18]);

d) the potential measures for greater efficiency (e.g. reduced plant capacity, improved controls, compensatory measures such as solar shading etc.) and their cost (from SPON's and manufacturer's data); and

e) the size of the ACMV office building stock compared with that of the other main types of ACMV buildings.

20. The base assumption was that all the most practical measures necessary to meet the proposed standards of performance are adopted. The overall savings were first estimated assuming proposed measures contribute without diminishing returns. Pragmatic assumptions were then made on likely practical take-up of measures and the effects of diminishing returns if two or more measures are applied.

16 Non-Domestic Building Energy Fact File, BRE Report, Construction Research Communications, London, 1998.

17 Energy Efficiency in Offices – A technical guide for owners and single tenants ECON19 (London, DETR), 1997.

18 SPON's M&E Services Pricebook 1998 and Architects & Builders Pricebook 1998.

21. For new office buildings the proposed performance standard is achievement of a Carbon Performance Index (CPI) of 100. This is modelled on the performance of the ‘typical’ air-conditioned office in ECON 19 – a performance that significant numbers of offices currently fail to achieve.

22. The prospective savings for new office buildings has been calculated assuming those buildings that would have been built to standards below a CPI of 100 in a ‘business as usual’ situation are instead built to the proposed standard. To do this it has been assumed that the distribution of performance and installed equipment represented by the ECON 19 data is broadly representative of the existing stock and of future development. Future carbon savings have then been estimated by calculating the saving obtained by bringing the buildings in the ECON 19 database having a CPI<100 up to 100. That figure has then been scaled up using the N-DEEM national data on total floor areas.

23. For refurbished offices where there is less design freedom, a range of savings has been calculated assuming a 10-point improvement in the CPI or the achievement of a CPI of 90.

24. The carbon savings and costs for offices have then been scaled up to account for other building types using ACMV systems by using the overall energy use data for those building types as obtained from N-DEEM. For example if hotel energy use associated with ACMV is x and that for offices is y, then the overall savings for offices and hotels is given by multiplying the savings estimated for offices, derived as outlined above, by the factor $(x + y)/y$.

ANNEX D

Calculations following the Target U-value method

1. Table D1 shows Target U-values for the detached and semi-detached house models using the full equation (i.e. giving the same rate of heat loss as the Elemental method) and as calculated using the design flexibilities included in the method for the proposed second phase (higher) standards. The focus is on detached and semi-detached houses because they are considered likely to remain the most popular forms of construction and between them make up nearly 65% of all new dwellings.

Table D1: **Target U-Values**

House type	**Total floor area (m^2)**	**Total area of exposed elements (m^2)**	(78%)	(80%)	(85%)	(90%)
(SEDBUK)[1]			**Target U-value**			
Detached	104.0	253.0	0.43	0.44	0.47	0.49
Semi-detached	88.8	191.3	0.45	0.46	0.49	0.51

1 SEDBUK is the Seasonal Efficiency of a Domestic Boiler as determined in the UK.

2. Table D2 shows what are thought to be packages of measures that builders could choose to adopt for a detached dwelling to meet the Target U-Values in table D1. The easing of the target that is obtained by using a boiler of higher efficiency is also shown. The average U-value for a detached house designed following the proposed Elemental method (second phase) is given in the table for comparison. The consultation documents include information on wall, window, roof and floor constructions that will meet the various U-values. Although it is felt that the packages in table D2 are reasonably robust and representative, it is likely that the approach of builders will evolve as they become familiar with the new standards. Changes in material prices and the development of new materials and methods will also affect the approach of builders.

3. An important general case considered is the desire to continue building with masonry cavity walls. Comparatively simple and well-tried designs (e.g. 102mm brick, 50mm cavity, 150mm light concrete block, 24mm insulation and 13mm plasterboard[19]) meet the standard in the current Elemental Method (U-value of 0.45 by the Proportional Area calculation procedure). These designs could still be adopted with suitable compensation elsewhere in the fabric to achieve average U-values that meet the proposed new target U-values (2nd phase). However, it is thought that the practical difficulties could be discouraging.

4. Table D2 shows that for the detached model dwelling to accommodate such a wall would need a (condensing) boiler of higher efficiency (85%) than that specified under the

19 This is derived from Example 4 in the current version of the AD.

Elemental Method (second phase). Using a boiler with a lower level of efficiency would require that the floor and roof had U-values that would be difficult to achieve practically with current building methods. With the higher efficiency boiler the U-values for the floor and roof could be constructed with a reasonable thickness of mineral wool insulation (about 130mm in the floor – although this may be difficult in some circumstances – and about 300mm in the roof) – see column B. In addition, the windows need much better U-values, (e.g. triple glazed windows with (low-E) glass).

5. However, the proposed 2 year transition period would enable training and experience to be gained in the construction of superior masonry walls (e.g. 102mm brick, 50mm cavity, 150mm light concrete block, 31mm insulation and 13mm plasterboard) having a U-value of 0.40 (as calculated by the proposed EN procedure). This would enable levels of insulation in the floor and roof to be reduced and double-glazing with low-E glass to be used. This is illustrated in columns D, E and F in Table D2.

6. Another important basis for packages could be fixing the window U-value at 2.7 (enabling the use of ordinary double-glazed windows with a gap width of 16mm): see Packages H and I. A boiler efficiency of at least 85% is required to accommodate such windows and the U-values of the other elements would need to be reduced. For example, the floor insulation would need to about 130mm and the wall would have to have a U-value of 0.25. Such a wall could consist of 102mm brick, 50mm cavity, 82mm insulation (conductivity 0.025 W/mK), 125mm concrete block and 13mm plaster[20]. It would be practically difficult to achieve the lower floor and wall U-values with current building techniques required for boiler efficiencies less than 85%. Increasing the boiler efficiency to 90% means that the floor, wall and roof U-values can all be relaxed until they are close to the proposed Elemental Method (2nd phase) – see column I.

7. One final case considered is simply reducing the opening area from 25% to 20% of the floor area (Packages J, K and L). (This is extreme and there would be concerns about sufficient daylighting, but the case serves to illustrate the range of flexibilities). Reducing openings to 20% would enable all fabric U-values to be relaxed. For the cases given in Table D2 the window U-value has been relaxed to 2.7 (again enabling the use of ordinary double-glazed windows) to help offset the reduction in daylight levels. It would also reduce costs. The floor and wall U-values need to be reduced to accommodate such windows, but with increasing boiler efficiency the wall U-value can be relaxed until it is comparable to its value in the proposed Elemental Method (2nd phase).

8. Table D3 is the equivalent of Table D4 for the semi-detached dwelling model. The U-values for the various elements required to meet the respective target U-values are similar to those required for the detached house.

20 This is derived from Example 6 in the current version of the AD.

Table D2: **Packages of measures for a detached house to meet the target U-value in table D1 proposed for implementation after 2 years**

Element	**U-values**											
	Package using Elemental Method	Packages selected to enable a wall U-value of 0.45			Packages selected to enable a wall U-value of 0.40			Packages selected to enable a window U-value of 2.7			Packages available if area of openings* is 20% of floor area		
		A	B	C	D	E	F	G	H	I	J	K	L
Floor	0.25	Not viable	0.20	0.20	0.20	0.20	0.20	Not viable	0.20	0.25	0.20	0.20	0.20
Walls	0.30		0.45	0.45	0.40	0.40	0.40		0.25	0.25	0.25	0.30	0.35
Windows	1.8		1.6	1.8	1.5	1.8	2.1		2.7	2.7	2.7	2.7	2.7
Doors	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0
Roof (pitched)	0.16		0.125	0.125	0.125	0.16	0.125		0.125	0.16	0.16	0.125	0.125
Average U-value (i.e. Target U-value)	0.43		0.47	0.49	0.44	0.47	0.49		0.47	0.49	0.43	0.44	0.47
SEDBUK to meet target (Gas fired boiler)	78%	80%	85%	90%	80%	85%	90%	80%	85%	90%	78%	80%	85%
Area of openings* as % of floor area	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	20%	20%	20%

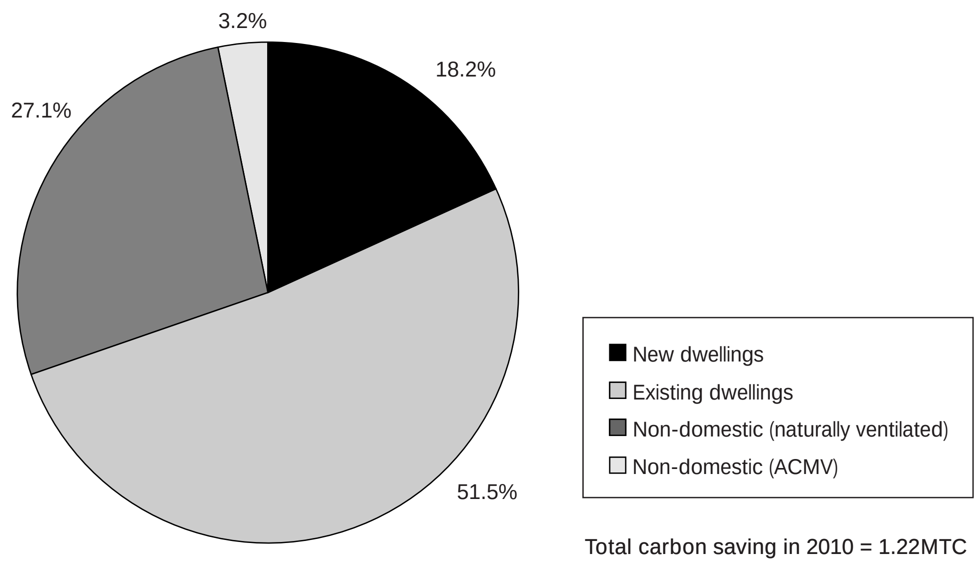
* Openings includes windows, doors and rooflights. The U-values for the windows (1.8) and doors (3.0) in the Elemental Method column give an openings average U-value of 2.0 thereby meeting the requirement for openings under the Elemental Method.

Table D3: **Packages of measures for a semi-detached house to meet the target U-value in table D1 proposed for implementation after 2 years**

Element	**U-values**												
	Package using Elemental Method	Packages selected to enable a wall U-value of 0.45			Packages selected to enable a wall U-value of 0.40			Packages selected to enable a window U-value of 2.7			Packages available if area of openings* is 20% of floor area		
		M	N	O	P	Q	R	S	T	U	V	W	X
Floor	0.25	0.20	0.20	0.20	0.20	0.20	0.20	Not viable	Not viable	0.25	0.25	0.20	0.25
Walls	0.30	0.45	0.45	0.45	0.40	0.40	0.40			0.25	0.25	0.30	0.30
Windows	1.8	1.4	1.7	1.9	1.6	1.8	2.1			2.7	2.7	2.7	2.7
Doors	3.0	3.0	3.0	3.0	3.0	3.0	3.0			3.0	3.0	3.0	3.0
Roof (pitched)	0.16	0.125	0.125	0.125	0.125	0.125	0.16			0.125	0.125	0.125	0.16
Average U-value (i.e. Target U-value)	0.45	0.46	0.49	0.51	0.46	0.49	0.51			0.51	0.45	0.46	0.49
SEDBUK to meet target (Gas fired boiler)	78%	80%	85%	90%	80%	85%	90%	80%	85%	90%	78%	80%	85%
Area of openings* as % of floor area	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	20%	20%	20%

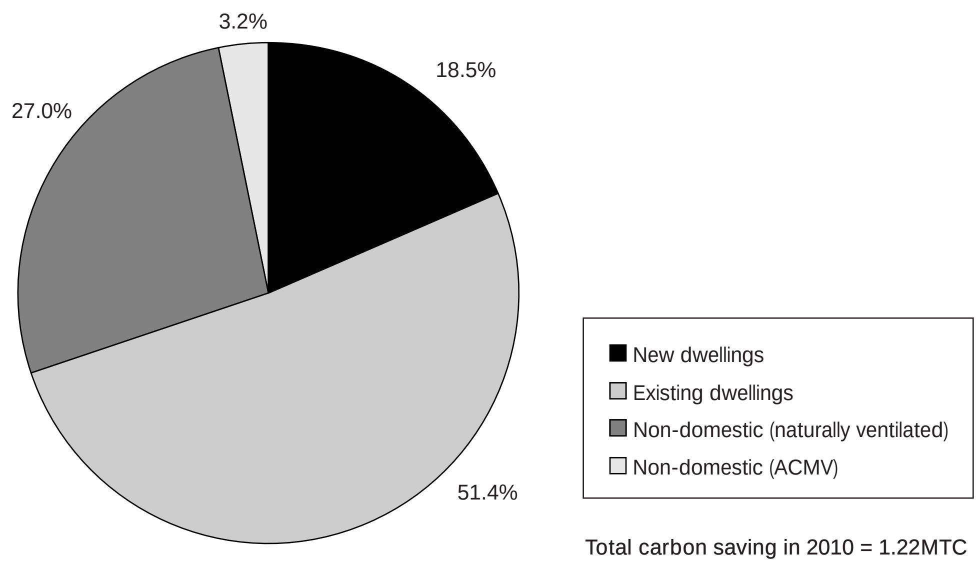
* Openings includes windows, doors and rooflights. The U-values for the windows (1.8) and doors (3.0) in the Elemental Method column give an openings average U-value of 2.0 thereby meeting the requirement for openings under the Elemental Method.

Carbon savings in 2010 in E&W arising from proposed amendments to Part L*



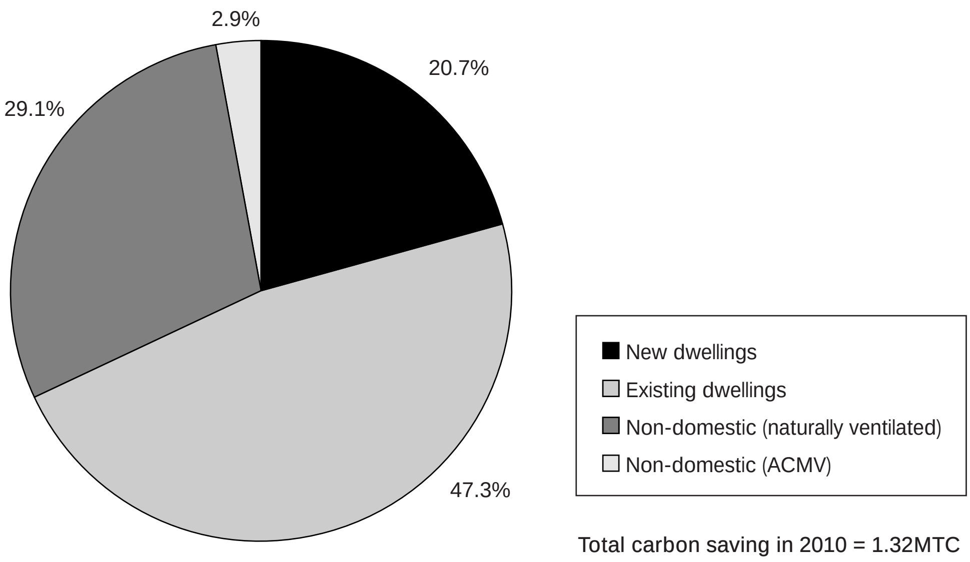
* If only the proposed first phase comes into effect in 2002

Carbon savings in 2010 in E&W arising from proposed amendments to Part L*



* If only the proposed second phase comes into effect in 2004

Carbon savings in 2010 in E&W arising from proposed amendments to Part L*



* If both phases come into effect as proposed

PART 2

Proposals for administrative changes and transitional provisions

Outline

1. This section sets out the proposed administrative changes to the Building Regulations that are intended to underpin the proposed amendments to Part L conveyed in Part 3 of this consultation document. These are:

   a) amendments to regulations 2 & 3 of the Building Regulations which define building work;

   b) amendments to regulation 16 of the Building Regulations and the introduction of a parallel regulation in the Building (Approved Inspectors etc.) Regulations 1985; and

   c) the proposed transitional provisions.

Including Part L in the definition of "Controlled Service" in Regulation 2 and widening the definition of "material alteration" in Regulation 3

2. The aim is to bring more work relevant to energy efficiency on existing buildings within the definition of "building work" in the Regulations. In this way the energy efficiency requirements can have an impact on improving the performance of the existing stock of buildings. It is proposed to add Part L to:

   a) the definition of controlled services in Regulation 2(1) of the Building Regulations;

   b) the list of relevant requirements in Regulation 3 (3) of the Building Regulations.

3. At present the Building Regulations only apply to proposed alteration work if the works affect structural safety, means of escape, resistance to fire, access and facilities for the fire service or access and facilities for disabled people. The effect of the proposed amendment would be to make any work which would affect compliance with Part L of Schedule 1 a material alteration. This would include, for example, replacement windows.

4. This would mean that the alteration work being carried out would have to comply with the relevant performance requirements in Part L of Schedule 1 ruling at the time in the particular case, under the provisions of Regulation 4. It would also mean that the work would have to comply with any applicable requirements in the other Parts of Schedule 1. After completion of the building work involving the extension or alteration of a building, the building must comply with the relevant requirements of Schedule 1, or where it did not comply with any such requirement, be no more unsatisfactory in relation to that requirement than before the work was carried out.

5. However the proposals do not mean that an owner's intention to provide or extend a "Part L" controlled service or fitting or to carry out a "Part L" material alteration to a building or its services or fittings would trigger a requirement to upgrade the whole building. This would not be possible under the enabling powers in the Building Act 1984.

6. In addition the performance requirements exemplified by the standards given in the proposed draft AD L are less rigorous for most types of alteration or refurbishment work that affect or are influenced by the existing building fabric. This is in recognition of the practical limitations of working in existing buildings.

Introducing further powers to make tests in Regulation 16

7. Regulation 16 gives local authorities the power to make tests of any drain or private sewer to ensure compliance with Part L. It is proposed to amend this regulation to enable local authorities to make tests of the building fabric and on services and fittings as necessary to establish whether it complies with the requirements in Part L. A parallel regulation would be introduced into the Building (Approved Inspectors etc) Regulations 1985 to allow approved inspectors to make the same tests.

8. Testing would be aimed principally at establishing whether the "As built" fabric of new buildings meets the requirements for thermal conductance and air tightness, and would be restricted to buildings with floor areas in excess of 1,000 square metres.

The proposed transitional provisions

9. The transitional provisions will need to address the two phase implementation of the guidance on requirements for raising the performance for insulation in building fabric as indicated in the draft Approved Document.

10. The amendments of the regulations, and the new Approved Document, would come into force 6 months after publication of the Amendment Regulations and the Approved Document. Work begun at any time up to the date of coming into force would remain subject to all the current provisions.

11. From the date of coming into force, new work would be subject to the amendments to Regulations 2 & 3, and to the requirements of the revised Part L of Schedule 1 to the Regulations.

12. New work started in the first 18 months after the date of coming into force would be expected to have the performance indicated in the guidance in the new edition of Approved Document L, including the first phase performance standards for insulation but not the second phase ones.

13. An exception would be that new work started in the first 18 months after the date of coming into force, pursuant to plans approved (either by a local authority or an approved inspector) before the date of coming into force, would not have to comply with the new performance requirements.

14. New work started 18 months or more after the date of coming into force, would be expected to have the performance indicated in the guidance in the new edition of Approved Document L, including the second phase performance standards for insulation instead of the first phase ones.

15. An exception would be that new work started 18 months or more after the date of coming into force, pursuant to plans approved (either by a local authority or an approved inspector) in the previous 18 months, would not have to comply with the second phase performance standards for insulation.

16. Guidance on what constitutes "start of work" in relation to the erection of a building was given in the DETR Circular letter dated 12 March 1999, which was issued to clarify this point in the context of the transitional provisions for the 1998 amendments to Part M of the Building Regulations. This stated:

    "We consider that the start of the erection of a building would usually be marked by work such as:

    a) excavation for strip or trench foundations or for pad footings;

    b) digging out and preparation of ground for raft foundations;

    c) vibroflotation (stone columns) piling, boring for piles or pile driving.

17. We consider that the following sorts of work would not be likely to constitute the start of erection of a building:

    a) removal of vegetation;

    b) removal of top soil;

    c) removal or treatment of contaminated soil;

    d) excavation of trial holes;

    e) dynamic compaction;

    f) general site servicing works (e.g. roadways and drainage)."

PART 3

Proposed draft of a new edition of Approved Document L

CONTENTS

APPENDICES

Use of guidance

The Approved Documents

This document is one of a series that has been approved by the Secretary of State as practical guidance on meeting the requirements of Schedule 1 and Regulation 7 of the Building Regulations 1991 (SI 1991 No 2768) as amended by:

the Building Regulations (Amendment) Regulations 1992 (SI 1992 No 1180);

the Building Regulations (Amendment) Regulations 1994 (SI 1994 No 1850);

the Building Regulations (Amendment) Regulations 1995 (SI 1995 No 1356);

the Building Regulations (Amendment) Regulations 1997 (SI 1997 No 1904);

the Building Regulations (Amendment) Regulations 1998 (SI 1998 No 2561);

the Building Regulations (Amendment) Regulations 1999 (SI 1999 No 77);

the Building Regulations (Amendment) Regulations 1999 (SI 1999 No 3410); and

the Building Regulations (Amendment) Regulations 2001 (SI 2001 No xxxx).

The document replaces the 1995 edition of Approved Document L.

At the back of this document is a list of those documents currently published by the Department of the Environment, Transport and the Regions and the Welsh Office which have been approved for the purpose of the Building Regulations 1991.

The Approved Documents are intended to provide guidance for some of the more common building situations. However, there may well be alternative ways of achieving compliance with the requirements. Thus there is no obligation to adopt any particular solution contained in an Approved Document if you prefer to meet the relevant requirement in some other way.

Other requirements

The guidance contained in an Approved Document relates only to the particular requirements of the Regulations which that document addresses. The building work will also have to comply with the Requirements of any other relevant paragraphs in Schedule 1 to the Regulations.

There are Approved Documents that give guidance on each of the other requirements in Schedule 1 and on Regulation 7.

Limitation on Requirements

In accordance with regulation 8, the requirements in Parts A to K and N of Schedule 1 to the Building Regulations do not require anything to be done except for the purpose of securing reasonable standards of health and safety for persons in or about the building.

Materials and workmanship

Any building work which is subject to the requirements imposed by Schedule 1 of the Building Regulations should, in accordance with Regulation 7, be carried out with proper materials and in a workmanlike manner.

You may show that you have complied with Regulation 7 in a number of ways.
These include:

- the appropriate use of a product bearing CE marking in accordance with the Construction Products Directive (89/106/EEC)[1] as amended by the CE marking Directive (93/68/EEC)[2]; or

- a product complying with an appropriate technical specification (as defined in those Directives), a British Standard, or an alternative national technical specification of any State which is a contracting party to the European Economic Area which, in use, is equivalent; or

- a product covered by a national or European certificate issued by a European Technical Approval Issuing body, and the conditions of use are in accordance with the terms of the certificate.

You will find further guidance in the Approved Document supporting regulation 7 on materials and workmanship.

Independent certification schemes

There are many UK product certification schemes. Such schemes certify compliance with the requirements of a recognised document that is appropriate to the purpose for which the material is to be used. Materials that are not so certified may still conform to a relevant standard.

Many certification bodies that approve such schemes are accredited by UKAS.

Technical specifications

Building Regulations are made for specific purposes: health and safety, energy conservation and the welfare and convenience of disabled people. Standards and technical approvals are relevant guidance to the extent that they relate to these considerations. However, they may also address other aspects of performance such as serviceability, or aspects which although they relate to health and safety are not covered by the Regulations.

When an Approved Document makes reference to a named standard, the relevant version of the standard is the one listed at the end of the publication. However, if this version of the standard has been revised or updated by the issuing standards body, the new version may be used as a source of guidance provided it continues to address the relevant requirements of the Regulations.

The appropriate use of a product that complies with a European Technical Approval as defined in the Construction Products Directive will meet the relevant requirements.

The Workplace (Health, Safety and Welfare) Regulations 1992

The Workplace (Health, Safety and Welfare) Regulations 1992 contain some requirements which affect building design. The main requirements are now covered by the Building Regulations, but for further information see: *Workplace health, safety and welfare, The Workplace (Health, Safety and Welfare) Regulations 1992, Approved Code of Practice and Guidance*; The Health and Safety Commission, L24; published by HMSO 1992; ISBN 0-11-886333-9.

The Workplace (Health, Safety and Welfare) Regulations 1992 apply to the common parts of flats and similar buildings if people such as cleaners, wardens and caretakers are employed to work in these common parts. Where the requirements of the Building Regulations that are covered by this Part do not apply to dwellings, the provisions may still be required in the situations described above in order to satisfy the Workplace Regulations.

1 As implemented by the Construction Products Regulations 1991 (SI 1991 No 1620).

2 As implemented by the Construction Products (Amendment) Regulations 1994 (SI 1994 No 3051).

Definitions

The following definitions have been adopted in this Approved Document for the purposes of conveying the Building Regulations requirements and approved guidance for the conservation of fuel and power.

General terms

1. *Exposed element* means an element exposed to the outside air (including a suspended floor over a ventilated or unventilated void, and elements so exposed indirectly via an unheated space), or an element in the floor or basement in contact with the ground. In the case of an element exposed to the outside air via an unheated space (previously known as a "semi-exposed element", the U-value should be determined using the method given in the SAP-1998. Party walls, separating two dwellings or other premises that can reasonably be assumed to be heated to the same temperature, are assumed not to need thermal insulation.

2. *Inspection* of building services systems means establishing at completion of installation that the provisions for efficient operation have all been put properly in place.

3. SAP *means* the Government's Standard Assessment Procedure for Energy Rating of Dwellings. SAP-1998 means the edition published in 1998.

4. *Conservatory* means a building having not less than three-quarters of the area of its roof and not less than half the area of its external walls made of translucent material.

Airtightness

5. An Air Leakage Index quantifies this. It measures the resistance of the building envelope to inward or outward air permeation. It is defined as the average volume of air (in cubic metres per hour) that passes through each square metre of the building envelope (in square metres) when subject to an internal to external pressure difference of 50 Pa. It is expressed in units of cubic metres per hour, per square metre of envelope area, at a pressure difference of 50 Pa. The envelope area of the building is defined as the total area of the floor, walls and roof separating the interior volume from the outside environment i.e. the conditioned space.

Lighting terms

6. *Emergency escape lighting means* that part of emergency lighting that provides illumination for the safety of people leaving an area or attempting to terminate a dangerous process before leaving an area.

7. *Specialist process lighting* means lighting intended to illuminate specialist tasks within a space, rather than the space itself. It could include theatre spotlights, projection equipment, lighting in TV and photographic studios, medical lighting in operating theatres and doctors' and dentists' surgeries, illuminated signs, coloured or stroboscopic lighting, and art objects with integral lighting such as sculptures, decorative fountains and crystal chandeliers.

8. *Display lighting means* lighting intended to highlight displays of exhibits or merchandise, or lighting used in spaces for public entertainment such as dance halls, auditoria, conference halls and cinemas.

9. *Circuit-Watts* means the power consumed by lamps and their associated control gear and power factor correction equipment.

10. *High efficiency control gear* means control gear (including the starter component) that has power consumption not exceeding that shown in the following table.

Nominal lamp rating (Watts)	Control gear power consumption (Watts)
Less than or equal to 15	6
Greater than15, Not more than 50	8
Greater than 50, Not more than 70	9
Greater than 70, Not more than 100	12
Greater than 100	15

11. *Switch* includes dimmer switches and *switching* includes dimming. As a general rule dimming should be effected by reducing rather than diverting the energy *supply*.

12. *Light output ratio* means *the* ratio of the total light output of a luminaire under stated practical conditions to that of the lamp or lamps contained in the luminaire under reference conditions.

Air conditioning & mechanical ventilation terms

13. *Mechanical ventilation* systems use fans to supply outdoor air to meet ventilation requirements. Systems may be extensive and can include air filtration, air handling units and heat reclamation, but they do not provide any active cooling from refrigeration equipment. The definition would not apply to a naturally ventilated building, which makes use of individual wall, or window mounted extract fans to improve the ventilation of a small number of rooms.

14. *Air conditioning systems* are principally used to reduce the temperature of spaces, to obtain a more comfortable thermal environment or to prevent the overheating of equipment. Control of relative humidity is often an additional feature. Air conditioning can be provided from stand alone refrigeration equipment in the cooled space, from centralised or partly centralised equipment, and from systems which combine the cooling function with mechanical ventilation.

15. *Treated areas*; these are the floor areas of spaces that are served by the system in question and should be established by measuring between the internal faces of the surrounding walls. Spaces that are not conditioned or otherwise treated such as plant rooms, service ducts, lift-wells etc. are excluded.

16. *Process requirements*; for office activities, process requirements can be taken to include any significant area in which an activity takes place which is not typical of the office sector, and where the resulting need for servicing is significantly different to that of typical office areas. For the assessment of Carbon Performance Index (Appendix K), areas within the building which are air conditioned because of process requirements, should be subtracted from the total treated area of the building, together with the plant capacity, or proportion of the plant, that is provided to service those areas. Activities and areas in office buildings considered to represent process requirements would thus include:

   – Staff restaurants and kitchens;

   – Large, dedicated, conference rooms;

   – Sports facilities;

   – Dedicated computer or communications rooms.

Legal Requirements

This Approved Document which takes effect on *ddmmyy* deals with the following requirements from Part L of Schedule 1 to the Building Regulations 1991 as amended by the Building Regulations (Amendment) Regulations 20*yy*.[1]

Requirement	Limits on application
L1: Reasonable provision shall be made for the conservation of fuel and power in **dwellings** by: a. limiting the heat loss: i) through the fabric of the building; ii) from hot water pipes and hot air ducts used for space heating; iii) from hot water vessels and hot water service pipes. b. providing space heating and hot water systems with sufficient controls so that energy can be used efficiently; c. providing lighting systems with sufficient controls so that energy can be used efficiently; d. commissioning the heating, ventilation, hot water and external lighting systems so that they use no more energy than is reasonable in the circumstances; e. providing information with the heating and hot water services so that building owners and occupiers can effectively operate and maintain them.	

1 The precise scope and language of the legal requirements must be settled with Government lawyers in the light of the response to consultations.

Requirement	Limits on application
L2: Reasonable provision shall be made for the conservation of fuel and power in **buildings or parts of buildings other than dwellings** by:	
a. limiting the heat loss:	
i) through the fabric of the building;	
ii) from hot water pipes and hot air ducts used for space heating;	
iii) from hot water vessels and hot water service pipes;	
b. providing space heating and hot water systems with sufficient controls so that energy can be used efficiently;	
c. limiting exposure to solar overheating;	
d. making provisions including sufficient controls, where air conditioning and mechanical ventilation systems are installed, so that no more energy needs to be used than is reasonable in the circumstances;	Requirement L2(d) applies only within buildings and parts of buildings where more than 200 m^2 of floor area is to be served by air conditioning or mechanical ventilation systems.
e. limiting the heat gains by chilled water and refrigerant vessels and pipes that serve air conditioning systems;	
f. providing lighting systems with sufficient controls so that energy can be used efficiently;	Requirement L2(f) applies only within buildings and parts of buildings where more than 100 m^2 of floor area is to be served by artificial lighting.
g. providing building fabric with reasonable energy performance;[2]	Requirement L2(g) applies only to buildings and parts of buildings with more than 1000 m^2 of floor area.
h. commissioning the building engineering services so that they use no more energy than is reasonable in the circumstances and recording their performance;	
i. providing information with the relevant services so that the building can be effectively operated and maintained.	

Other changes to the Building Regulations 1991.

Attention is particularly drawn to the following changes to the requirements in the Building Regulations 1991 (as amended) which are brought into effect by the Building Regulations 20*yy* (Amendment) Regulations.

2 See the proposed aim of amending Regulation 16 in the Building Regulation 1991 and introducing a new regulation in the Building (Approved Inspectors) Regulations 1985 regarding powers to make tests.

Change in the definition of "Controlled Service"

The definition of "controlled service" in Regulation 2 is widened to include any service or fitting addressed by Part L.

New definition of "Commissioning"

A new definition is added to Regulation 2:

Commissioning of building services systems means the advancement of an installation from the state of static completion to full working order to the specified requirements. It includes the setting-to-work of an installation, the regulation of that system, and the calibration and setting up of the associated automatic control systems.

Change in the definition of "Material Alteration".

The definition of "material alteration" in Regulation 3 is widened to include Part L in the list of relevant requirements.

Prospective change to Regulation 16 – Testing …

Regulation 16 in the Building Regulations 1991 is widened to include local authorities making such tests of the building fabric and the building services as may be necessary to establish whether building work complies with requirement L2(g). This amendment would apply in cases where a local authority is the building control body but the Department also proposes to introduce a new requirement in the Building (Approved Inspectors) Regulations 1985 to address the same matters. The guidance in the Approved Document anticipates these changes.

Section 0 – General

Performance

0.1 In the Secretary of State's view requirements L1 (a) and (b), and L2 (a) and (b) will be met by the provision of energy efficiency measures which:

a) limit the heat loss through the roof, wall, floor, windows and doors etc, and where appropriate permit the benefits of solar heat gains and more efficient heating systems to be taken into account; and

b) limit unnecessary ventilation heat loss by reducing air leakage around openings and through the building fabric; and

c) limit the heat loss from hot water vessels and heating and hot water pipes and ducts where such heat does not make an efficient contribution to the space heating by applying suitable thicknesses of insulation; and

d) include equipment for the metering of energy consumption; and

e) include efficient heat sources; and

f) systems for the effective control of:

i) the times during which the heating and hot water systems operate; and

ii) the space and hot water temperatures.

0.2 In the Secretary of State's view requirement L1 (c) will be met by the provision of lighting systems that:

a) utilise energy-efficient artificial light sources where this is appropriate; and

b) can be effectively controlled by manual switching or automatic switching, or both manual and automatic switching, to avoid unnecessary use.

0.3 In the Secretary of State’s view requirement L1 (d) will be met by commissioning the heating and hot water services in the dwelling so that they perform effectively for the purposes of energy efficiency.

0.4 In the Secretary of State’s view requirement L1 (e) will be met by providing information with the relevant services about how they can be operated and maintained effectively for the purposes of energy efficiency.

0.5 In the Secretary of State’s view requirement L2 (c) will be met by limiting glazing which receives direct sunlight by, for example, limiting the area of glazing exposed to the sun or adopting shading measures.

0.6 In the Secretary of State's view requirement L2 (d) will be met by:

a) limiting the demands from within the building for heating and cooling; and

b) limiting the demands from within the building for circulation of air, water and refrigerants; and

c) selecting energy-efficient plant; and

d) including equipment for the metering of energy consumption; and

e) including systems for the effective control of:

   i) the times during which the systems operate; and

   ii) the physical properties of the air.

0.7 In the Secretary of State's view requirement L2 (e) will be met by limiting the heat gains to chilled water and refrigerant vessels and pipes and air ducts by applying suitable thicknesses of insulation including vapour barriers.

0.8 In the Secretary of State's view requirement L2 (f) will be met by providing lighting:

a) comprising energy-efficient light sources and luminaires where this is appropriate; and

b) including appropriate combinations of manually-operated switches, timers or other automatic controls which take account of daylight and the absence of people, such that building users can obtain the maximum benefit of daylight; and

c) including, where appropriate, equipment for the metering of energy consumption.

0.9 In the Secretary of State's view requirement L2 (g)[1] will be met by providing building fabric that:

a) has a thermal conductance consistent with these requirements; and

b) has insulation which is reasonably continuous; and

c) is satisfactorily airtight.

0.10 In the Secretary of State's view requirement L2 (h) and (i) will be met by providing information with the relevant services about how the building and its services can be effectively operated and maintained for the purposes of energy efficiency.

1 See the proposed aim of amending Regulation 16 in the Building Regulations 1991 and introducing a new regulation in the Building (Approved Inspectors) Regulations 1985 regarding powers to make tests.

Introduction to the Provisions

Reasonable provision in marginal cases

0.11 Buildings with low levels of heating or no heating do not require special measures to limit heat transfer through the fabric. The insulation properties of the fabric chosen for operational reasons can be regarded as reasonable provision.

0.12 For small extensions to dwellings, reasonable provision would be to use construction details that are no worse in energy performance terms than those in the existing building.

Technical risk

0.13 Guidance on avoiding technical risks (such as rain penetration, condensation etc) which might arise from the application of energy conservation measures is given in BRE Report No 262: "*Thermal Insulation: avoiding risks*" . Guidance is also available in the NHBC/EEO publication: "*A guide to thermal insulation and ventilation*"). As well as giving on ventilation for health (F1), Approved Document F also contains guidance on the provision of ventilation to reduce the risk of condensation in roof spaces (F2).

0.14 Guidance on satisfactory design details is given in the report on robust standard details[2].

Thermal conductivity and transmittance

0.15 The thermal conductivity (ie the λ-value) of a material is a measure of the rate at which that material will pass heat and is expressed in units of Watts per metre per degree of temperature difference (W/mK).

0.16 Thermal transmittance (ie the U-value) is a measure of how much heat will pass through one square metre of a structure when the air temperatures on either side differ by one degree. U-values are expressed in units of Watts per square metre per degree of temperature difference (W/m^{2}K).

0.17 Builders should ensure that the U-values of actual construction elements are not compromised during construction by insulation being improperly installed such that it is compressed, discontinuous, continuously wetted, bridged more frequently than intended etc.

This new paragraph provides guidance on meeting legal requirement L2 (g)

0.18 In the absence of certified manufacturers' information thermal conductivities (W/mK) and thermal transmittances (U values) (W/m^{2}K) may be taken from the tables in this Approved Document or alternatively in the case of U-values they may be calculated. If certified test results for particular materials and makes of products are available however they should be used in preference. Certified manufacturers' information means measurements made at a laboratory accredited for the test concerned by a body recognised

2 In preparation. Details for minimising the adverse effects of thermal bridging and air leakage, Government/Industry collaborative project.

by the government of one of the States who are contracting parties to the European Economic Area. Measurements of thermal conductivity should be made according to BS EN 12664 or BS EN 12667. Measurements of thermal transmittance should be made according to BS EN ISO 8990.

U-value reference tables

0.19 Appendix A contains tables of U-values and examples of their use which provide a simple way to establish the amount of insulation, needed to achieve a given U-value for some typical forms of construction. Appendix A also contains tables of indicative U-values for windows, doors and rooflights. The values in the tables have been derived taking account of typical thermal bridging where appropriate.

Calculation of U-values

0.20 When calculating U-values the thermal bridging effects of for instance timber joists, structural and other framing, normal mortar bedding and window frames should generally be taken into account using the procedure given in BS EN ISO 6946 (some examples are given in Appendix B). Thermal bridging can be disregarded however where the difference in thermal resistance between the bridging material and the bridged material is less than 0.1 m^2K/W. For example normal mortar joints need not be taken into account in calculations for brickwork.

Basis for calculating areas

0.21 The dimensions for the areas of walls, roofs and floors should be measured between finished internal faces of the external elements of the building including any projecting bays. In the case of roofs they should be measured in the plane of the insulation. Floor areas should include non-useable space such as builders' ducts and stairwells.

Energy rating of dwellings

0.22 Under separate provisions of the Building Regulations[3] a new dwelling created by building work or by a material change of use in connection with which building work is carried out must be given an energy rating using the SAP. The SAP is explained and defined, along with appropriate reference data and a calculation worksheet, in "The Government's Standard Assessment Procedure for Energy Rating of Dwellings – the edition, that is, having the Secretary of State's approval at the relevant time in the particular case". There is, however, no obligation under Regulations 14A and 10A to achieve a particular SAP rating.

0.23 The Carbon Index is derived using a calculation contained within the SAP.

See Part 4 of this consultation document.

3 Regulation 14A in the Building Regulations 1991 (as amended 1994) and Regulation 10A in the Building (Approved Inspector) Regulations 1985 (as amended 1995).

Section 1 – Dwellings

Insulation of the building fabric

ALTERNATIVE METHODS OF SHOWING COMPLIANCE

1.1 Three methods are shown for demonstrating reasonable provision for limiting heat loss through the building fabric:

a) An Elemental method;

b) A Target U-value method;

c) A Carbon Index method.

Elemental method

The U-values in columns (d) and (e) of Table 1 are divided by a factor of 1.13 to go some way towards compensating for the higher carbon emission rate

STANDARD U-VALUES FOR CONSTRUCTION ELEMENTS

1.2 When using the Elemental Method, the requirement will be met for new dwellings by selecting construction elements that provide the U-value thermal performances given in Table 1.

Table 1: Elemental Method: U-values (W/m²K) for construction elements

	Type of heating system			
Exposed Element	Gas or oil central heating with boiler SEDBUK[1] not less than the relevant entry in Table 2		Other gas or oil central heating, or any electric heating system or solid fuel central heating[2] or undecided	
	With effect from T[1]	**With effect from T + 18 mths**	**With effect from T**	**With effect from T + 18 mths**
(a)	(b)	(c)	(d)	(e)
Pitched roof [3 4] With insulation between rafters	0.25	0.2	0.22	0.18
Pitched roof [4] With insulation between joists	0.2	0.16	0.18	0.16
Flat roof	0.25	0.25	0.22	0.22
Wall	0.35	0.3	0.31	0.27
Floor	0.3	0.25	0.27	0.22
Windows, doors and rooflights (overall average)	2.2	2.0	2.0	1.8

Notes to Table 1:
1 SEDBUK is the Seasonal Efficiency of a Domestic Boiler in the UK, defined in The Government's Standard Assessment Procedure for the Energy Rating of Dwellings 1998 Edition. For boilers for which the SEDBUK is not available, the appropriate value from Table 4b of the same publication may be used.
2 A solid fuel boiler should have an efficiency not less than that recommended for its type in the HETAS certification scheme.
3 Any part of a roof having a pitch of 70° or more can be considered as a wall.
4 For the sloping parts of a room-in-the-roof constructed as a material alteration, a U-value of 0.3 W/m²K would be reasonable.

Table 2: Elemental Method: Minimum boiler SEDBUK to enable adoption of the U-values in Table 1 Column (b) or Column (c)

Central heating system fuel	SEDBUK %	
	With effect from T[1]	**With effect from T + 18 months**
Mains natural gas	75	78
LPG	82	85
Oil	85	88

[1]T is the date when this Approved Document comes into effect.

1.3 One way of achieving the U-values in Table 1 is by providing insulation of an appropriate thickness estimated from the tables in Appendix A. An alternative for walls and roofs is to use the combined method of calculation outlined in Appendix B and set out in more detail in the CIBSE Guide Section A3 1999 Edition. An alternative for floors is to use the data given in Appendix C. An alternative for basements is given in the BCA/NHBC Approved Document (1997) ISBN 0-7210-1508-5.

> Should the minimum boiler efficiencies be increased at T + 2 years, as well as tightening U-values? This would mean condensing boilers for LPG and oil, and very few condensing oil boilers are presently available.

1.4 The U-values of windows, doors and rooflights can be calculated according to EN ISO 10077-1, or the indicative U-values in Appendix A, Tables A1 to A3 may be used. Alternatively they can be established by measurement in a hot box conforming to EN ISO 12567-1 at a laboratory accredited for hot box testing by a body recognised by the government of one of the States who are contracting parties to the European Economic Area.

1.5 Door designs can include various panel arrangements but the indicative U-values given in Appendix A, Table A1 will generally be acceptable. Single-glazed panels can be acceptable in external doors provided that the heat loss through all the windows, doors and rooflights does not exceed that of the standard provision given in paragraphs 1.7 to 1.9 below.

1.6 Care should be taken in the selection and installation of appropriate sealed double-glazed windows in order to avoid the risk of condensation forming between the panes. Guidance on avoiding this problem is given in BRE Report No 262 “Thermal insulation: avoiding risks” (NEW EDITION 2000 IN PREPARATION).

AREAS FOR WINDOWS, DOORS AND ROOFLIGHTS

Standard Area Provision

1.7 The requirement would be met if the average U-value of windows, doors and rooflights matches the relevant figure in Table 1 and the area of the windows, doors and rooflights together does not exceed 25% of the total floor area.

1.8 The average U-value is an area-weighted average for the whole dwelling, and depends on the individual U-values of the glazed components and door components proposed and their proportions of the total area of openings. Examples of how the average U-value is calculated are given in Appendix E.

Adapting the Standard Area Provision for particular Cases

1.9 Areas of windows, doors and rooflights larger than that given in paragraph 1.7 may be adopted in particular cases by using the Target U-value Method to demonstrate compliance. Another option would be to reduce the area of windows, doors and rooflights to compensate for a higher average U-value (ie lower performance glazing). However reducing glazing area could lead to inadequate daylighting.

EXTENSIONS TO DWELLINGS

1.10 The average U-value of windows, doors and rooflights in extensions to existing dwellings should not exceed the relevant values in Table 1. An appropriate area provision for windows, doors and rooflights for extensions could be established by keeping within the total area of windows, doors and rooflights of the existing dwelling, or by application of the standard area provision in paragraph 1.7 to either:

a) the floor area of the extension itself; OR

b) the floor area of the existing dwelling and extension together and then deduct the area of existing windows and doors that will remain after completion of the extension work.

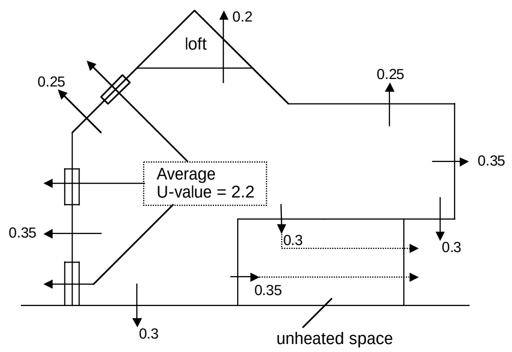
1.11 Alternatively, a way of establishing a reasonable standard area provision for an extension would be to add to 25% of the floor area, the area of any windows and doors that the extension covers over.

SUMMARY OF PROVISIONS IN THE ELEMENTAL METHOD

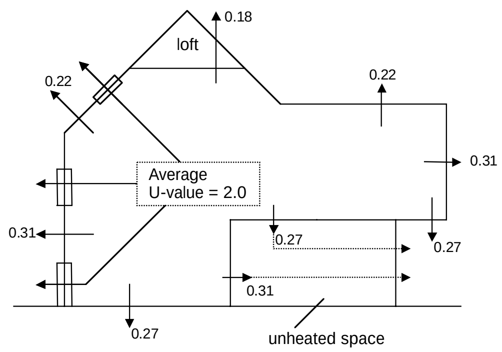
1.12 Diagram 1.1 summarises the fabric insulation standards and allowances for windows, doors and rooflights given in the Elemental method. Examples of the procedures used in this method are given in Appendices A to C. Appendix D includes a flow chart.

Diagram 1.1 Elemental U-values for new dwellings

With effect from T[1]

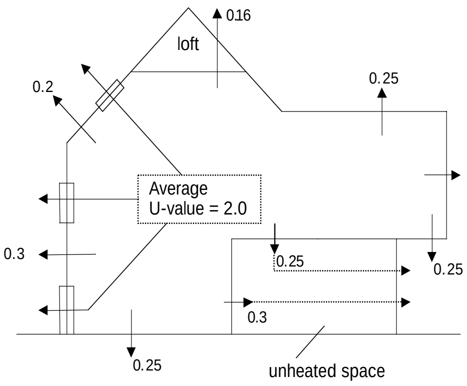


Gas or oil central heating with boiler SEDBUK not less than the relevant entry in Table 2

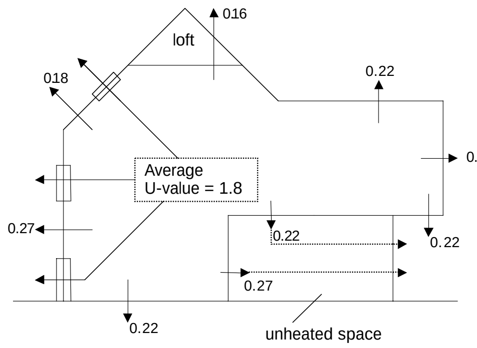


Other heating system

With effect from T + 18 months



Gas or oil central heating with boiler SEDBUK not less than the relevant entry in Table 2



Other heating system

Target U-value method for new dwellings

1.13 Within certain limits, this method allows greater flexibility than the Elemental Method in selecting the areas of windows, doors and rooflights, and the insulation levels of individual elements in the building envelope, taking more account of the efficiency of the heating system and enabling solar gain to be addressed. However the aim is to achieve an overall performance broadly similar to that obtained by following the Elemental Method. The Target U-value equation given below and the associated guidance is applicable only to new dwellings.

1.14 The requirement would be met if the calculated average U-value of the dwelling does not exceed the Target U-value, corrected for the proposed method of heating, as determined from the following paragraphs.

1.15 With effect from the date when this Approved Document comes into effect the base target U-value is to be determined from either of the following equations:

$$U_T = [0.35 - 0.15(A_R/A_T) - 0.05(A_{GF}/A_T) + 0.463(A_F/A_T)] \quad (1)$$

$$U_T = [0.28 + 0.463(A_F/A_T)] \quad (2)$$

where:-

U_T is the base target U-value prior to any adjustment for heating system performance or solar gain (see paragraphs 1.18 to 1.20);

A_R is the exposed roof area;

A_{GF} is the ground floor area;

A_F is the total floor area (all storeys); and

A_T is the total area of exposed elements of the dwelling.

Equation (2) is easier to use but is more approximate. For practical cases, it provides a target U-value that is not greater than that obtained using equation (1). Equation (1) provides the same rate of heat loss as the Elemental Method but provides more design flexibility.

1.16 With effect from 18 months after the date this Approved Document comes into effect the base target U-value is to be determined from either of the following equations:

$$U_T = [0.30 - 0.14(A_R/A_T) - 0.05(A_{GF}/A_T) + 0.425(A_F/A_T)] \qquad (3)$$

$$U_T = [0.24 + 0.425(A_F/A_T)] \qquad (4)$$

1.17 The total area of exposed elements should be calculated in accordance with paragraph 0.21.

1.18 For dwellings to be heated by boilers with reference SEDBUK as indicated in Table 3 no adjustment to the Target U-value is necessary. Where the proposed boiler has a SEDBUK that is better or worse than the tabulated value, the basic Target U-value can be eased or should be tightened as appropriate by adding δU to the target U-value where:

$$\delta U = 0.005 \times [\text{Proposed boiler SEDBUK (\%)} - \text{Reference SEDBUK (\%)}] \qquad (5)$$

Table 3: **Reference boiler SEDBUK for use in the Target U-value Method.**

Central heating system fuel	Reference SEDBUK %	
	With effect from T[1]	**With effect from [T + 18 months]**
Mains natural gas	75	78
LPG	82	85
Oil	85	88

[1]T is the date when this Approved Document comes into effect.

1.19 For dwellings that are to be heated by electricity or by solid fuel, or if the heating system is undecided, the base target U-value should be reduced (i.e. improved) by dividing by a factor of 1.13 to go some way towards compensating for the higher carbon emission rate.

OPTIONAL ALLOWANCE FOR SOLAR GAINS

1.20 The Target U-value equation assumes equal distribution of glazed openings on North and South elevations. Where the area of glazed openings on the South elevations exceeds that on the North, the benefit of solar heat gains can be taken into account to ease the target U-value by adding δS to the target U-value, where:-

$$\delta S = 0.04 \times [(A_S - A_N) / A_T] \qquad (6)$$

A_S = Area of glazed openings facing south;

A_N = Area of glazed openings facing north;

A_T = Total area of glazed openings;

and

South-facing is defined as South ± 30°;

North-facing is defined as North ± 30°; and

the area of glazed openings includes the area of the frames.

1.21 If adjustments to the target U-value are being made for both heating system and for solar gain, the adjustment for heating system should be applied first.

1.22 Example calculations for determining Target U-values and average U-values are given in Appendix F. Appendix D includes a flow chart.

Carbon Index method

1.23 The aim in this method is to provide more flexibility in the design of new dwellings whilst achieving similar overall performance to that obtained by following the Elemental Method. The Carbon Index adopted in this method is defined in SAP 1998 as amended 2000[1]. When this Approved Document comes into effect the requirement would be met if the Carbon Index for the dwelling (or each dwelling in a block of flats or converted building) is not less than:

a) 7.8 for the following 18 months; but

b) 8.2 thereafter.

Constraints when using the calculation procedures

POOREST ACCEPTABLE U-VALUES

1.24 When using the calculation procedures in the Target U-value and Carbon Index methods it may be possible to achieve satisfactory solutions where the U-values of some elements are worse than those set out in Table 1, if the poorer performance is compensated by better performance of the other elements. However such local reductions in performance should be limited having regard for the avoidance of condensation risks on inner surfaces and within the fabric as well as the overall aim of the conservation of fuel and power.

1 See Part 4 of this consultation document.

1.25 When proposing to make such compensations, a way of showing compliance would be to avoid the adoption of poorer performing elements that have U-values worse than those in Table 4.

Table 4: **Poorest U-values (W/m²K) acceptable as a general rule when using the Target U-value and Carbon Index Methods**

Element	Poorest acceptable U-value	
	Gas or oil central heating where boiler efficiency is being used to offset poorer fabric; other gas or oil central heating; any electric or solid fuel heating system; or undecided	Gas or oil central heating where boiler efficiency is not being used to offset poorer fabric
Pitched roofs	0.25	0.35
Flat roofs	0.35	0.35
Exposed walls and floors	0.45	0.7
Windows, doors and rooflights (overall average)	3.3	3.3

Note: These values can only be used if, by way of compensation, other parts of the fabric are built to higher standards than those in Table 1 or a heating system with a higher SEDBUK than the relevant entry in Table 3 is used.

Limiting thermal bridging at junctions and around openings

1.26 The building fabric should be constructed so that there are no significant thermal bridges or gaps in the insulation layer(s) within the various elements of the fabric, at the joints between elements, and at the edges of elements such as those around window and door openings.

1.27 A way of meeting the requirements would be to show that you have adopted the recommendations in the report on robust standard details[2], which gives examples of design details and constructional practices that can deliver the required performances.

1.28 An alternative way of meeting the requirements would be to demonstrate by calculation that the performance of the building fabric is at least as a good as it would be by following paragraph 1.27. BRE Information Paper IP xx/00 [TO BE PUBLISHED] illustrates how this can be done.

Limiting infiltration

1.29 Reasonable provision should be made to reduce air infiltration (that is to say unwanted leakage) through extraneous air paths in the building fabric.

1.30 Guidance on some ways of reducing infiltration is given in the report on robust standard details[2]. The main principle is to provide a continuous barrier to air movement around the

2 In preparation: Details for minimising the adverse effects of thermal bridging and air leakage, Government/industry collaborative project.

living space (including separating walls and the edges of intermediate floors) that is in contact with the inside of the thermal insulation layer.

1.31 An alternative method of showing satisfactory provision has been made would be to show by pressure-testing following the method given in CIBSE TM 23 (to be published shortly) that the dwelling Air Leakage Index does not exceed 10 cubic metres per hour per square metre of external surface area at an applied pressure difference of 50 Pascals.

Space heating system controls

1.32 The following guidance covers provisions which are appropriate for the more common varieties of heating system excluding space heating provided by individual solid fuel, gas and electric fires or room heaters.

1.33 The requirement would be met by the appropriate provision of:

a) zone controls; and

b) timing controls; and

c) boiler control interlocks.

ZONE CONTROLS

1.34 A way of demonstrating compliance would be (for hot water central heating systems, fan controlled electric storage heaters and electric panel heaters) to control the times of operation and the temperatures independently in areas (such as separate sleeping and living areas) that have different heating needs. The control devices would include separate timers for each zone and the temperature controllers could be room thermostats and/or thermostatic radiator valves or any other suitable temperature sensing devices.

1.35 In most dwellings one timing zone divided into two temperature control sub-zones would be appropriate. However in single-storey open-plan flats and bed-sitters, for example, sub-zoning of temperature control would be inappropriate.

TIMING CONTROLS

1.36 Timing devices should be provided for each zone to control the periods when the heating systems operate. This provision should be made for gas fired and oil fired systems and for systems with solid fuel fired boilers where forced-draught fans operate when heat is required. Timing systems would be inappropriate for systems with solid fuel boilers which operate only by natural draught.

> Should this be extended to require independent timing of space heating and water heating?

BOILER CONTROL INTERLOCKS

1.37 Gas and oil fired hot water central heating system controls should switch the pump and the boiler off when no heat is required whether control is by room thermostats or by thermostatic radiator valves:

a) The boiler (and pump) in systems controlled by thermostats should operate only when a space heating or cylinder thermostat is calling for heat.

b) Where it is proposed to effect control by thermostatic radiator valves, a room thermostat (or other device such as a flow switch) should also be provided to switch off the boiler and the pump when there is no demand for heating or hot water.

Hot Water Service (HWS) controls

1.38 For a system other than one heated by a solid fuel fired boiler, a way of meeting the requirement would be to provide a hot water cylinder complying with the recommendations in BS 1566 or BS 3198 and:

a) where the heat exchanger coil has sufficient heating capacity for effective control and is served by a pumped primary system and;

b) a thermostat (or other suitable device) is provided which shuts off the supply of heat when the storage temperature is reached, and which in the case of a hot water central heating system is interconnected with the room thermostat(s) to switch off the boiler and the pump when no heat is required; and

c) a timer is provided either as part of the central heating system or as a local device which enables the supply of heat to be shut off for the periods when water heating is not required.

> Should this be extended to require independent timing of space heating and water heating?

1.39 For systems with solid fuel fired boilers where the cylinder is not providing the slumber load the requirement would be met by the provision of a thermostatically controlled valve.

Alternative approaches for space heating and HWS systems

1.40 The requirement would be met by adopting the relevant recommendations in the following standards provided they include zoning, timing and interlock features similar to the above:

a) BS 5449 (1990): “Specification for forced circulation hot water central heating systems for domestic premises”.

b) BS 5864 (1989): “Specification for installation in domestic premises of gas-fired ducted air-heaters of rated output not exceeding 60 kW”.

c) BRECSU GPG 143: Wet central heating systems.

Testing and Commissioning of heating and HWS systems

1.41 Heating and HWS systems should be inspected, commissioned and tested to make reasonably certain they can operate efficiently for the purposes of the conservation of fuel and power.

1.42 A way of showing compliance with the requirements for inspection, commissioning and testing would be for the installer to self-certify that his work meets the relevant requirements of the Regulations.

Operating and Maintenance instructions for heating and hot water systems

1.43 The building owner and/or occupier should be given information on the operation and maintenance of the heating and hot water systems. A way of complying would be to provide a suitable set of operating and maintenance instructions in an accessible format in each new dwelling, or whenever the systems in an existing dwelling are substantially altered. The instructions should explain to householders how to operate the systems so that they can perform efficiently, and what routine maintenance is advisable for the purposes of sustaining efficient operation.

Insulation of vessels pipes and ducts

1.44 Reasonable provision should be made for insulating vessels, pipes and ducts to conserve heat and hence maintain the temperature of the water or air heating service, and in the case of HWS systems to avoid losses between useful draw-offs. Some ways of meeting the requirement comprise:

a) insulating vessels with a 35 mm thick, factory-applied coating of PU-foam having zero ozone-depletion potential and a minimum density of 30 kg/m^3. (For unvented hot water systems additional insulation should be provided to control the heat losses through the safety fittings and pipe work but without impeding safe operation and visibility of warning discharges. See Approved Document G3.)

b) wrapping space heating pipe work located outside the building fabric insulation layer(s) with insulation material having a thermal conductivity not exceeding 0.035 W/mK and a thickness equal to the outside diameter of the pipe up to a maximum of 40 mm; OR

c) for pipes and in the case of warm air ducts providing insulation in accordance with the recommendations of BS 5422, 1990: *"Methods for specifying thermal insulation materials on pipes, ductwork and equipment in the temperature range –40 C to +700 C"* (currently being amended).

d) insulating the hot pipes connected to hot water storage vessels, including the vent pipe, and the primary flow and return to the heat exchanger, where fitted, to the standard in (b) above for at least 1 metre from their points of connection (or they should be insulated up to the point where they become concealed).

e) insulating the hot water piping from instantaneous water heaters serving outlets more than 2 metres away and/or in more than one room to the standard in (b) above.

1.45 It should be noted that central heating and hot water pipe work in unheated areas may need increased insulation thicknesses for the purpose of protection against freezing. Guidance on suitable protection measures is given in BRE Report No 262: “Thermal insulation: avoiding risks”.

Internal Lighting

1.46 Reasonable provision should be made for dwelling occupiers to obtain the benefits of efficient lighting. A way of showing compliance with the requirement would be to provide at a reasonable number of locations, where lighting can be expected to have most use, fixed lighting (comprising either basic lighting outlets or complete luminaires) that only take lamps having a luminous efficacy greater than 40 lumens per circuit Watt. Examples of lamps that achieve this efficacy include fluorescent tubes and compact fluorescent lamps.

1.47 Guidance on identifying suitable locations for efficient lighting is given in General Information Leaflet GIL20 *Low energy domestic lighting*[3]. A way of establishing how many locations to equip for efficient lighting would be to follow the recommendations in Table 5.

Table 5: **Method for determining the number of locations to be equipped as a reasonable provision for efficient lighting**

Number of rooms in dwelling[1]	Recommended number of locations[2]
1-3	1
4-6	2
7-9	3
10-12	4

Notes to Table 5:
1 Rooms include circulation spaces such as hallways and landings
2 Excludes garages, lofts and outhouses

External lighting fixed to the building

1.48 External lighting includes lighting in porches, but not lighting in garages and carports. When providing external lighting, reasonable provision should be made to enable effective control and/or the use of efficient lamps. A way of showing compliance when providing external lighting would be to install systems that:

a) automatically extinguish when there is enough daylight, and when not required at night; OR

3 Available from BRECSU Publications, tel: 01962 664758.

b) have sockets that can only be used with lamps having an efficacy greater than 40 lumens per circuit Watt (such as fluorescent or compact fluorescent lamp types).

Conservatories

1.49 When a conservatory is attached to and built as part of a new dwelling:

a) Where there is no separation between the conservatory and the dwelling, the conservatory should be treated as an integral part of the dwelling;

b) Where there is separation between the conservatory and the dwelling, energy savings can be achieved if the conservatory is not heated. If fixed heating installations are proposed, however, they should have their own separate temperature and on/off controls.

1.50 When a conservatory is attached to an existing dwelling and an opening is enlarged or newly created as a material alteration, provision should be made to enable the heat loss from the dwelling to be limited so that it will be no worse than it is before the work is undertaken. Ways of meeting the requirement would be:

a) to retain the existing separation where the opening is not to be enlarged; or

b) to provide separation as or equivalent to windows and doors having the average U-value given in Table 1 where the opening is to be newly created or enlarged.

1.51 For the purposes of satisfying the requirements for the conservation of fuel and power, separation between a dwelling and a conservatory means:

a) Separating walls and floors insulated to at least the same degree as the exposed walls and floors;

b) Separating windows and doors with the same U-value and draught-stripping provisions as the exposed windows and doors elsewhere in the dwelling.

1.52 Attention is drawn to the safety requirements of Part N of the Building Regulations regarding conservatory glazing.

Metering of energy consumption

1.53 For individual dwellings, no special provisions are necessary.

Material alterations

1.54 Material alterations are defined in Regulation 3(2) as follows.

An alteration is material for the purposes of these Regulations if the work, or any part of it, would at any stage result –

in a building or controlled service or fitting not complying with a "relevant requirement" where previously it did; or *in a building or controlled service or fitting which before the work commenced did not comply with a "relevant requirement", being more unsatisfactory in relation to such a requirement*.

1.55 "Relevant requirement" is defined in Regulation 3(3) as follows.

"Relevant requirement" in regulation 3(2) means any of the following applicable requirements of Schedule 1, namely –

Part A (structure)

Paragraph B1 (means of escape)

Paragraph B3 (internal fire spread – structure)

Paragraph B4 (external fire spread)

Paragraph B5 (access and facilities for the fire service)

Part L [conservation of fuel and power)

Part M (access and facilities for disabled people).

1.56 The requirement may be satisfied in the following ways although the extent of provision will depend upon the circumstances in each case:

a) roof insulation: when substantially replacing any of the major elements of a roof structure – providing insulation to achieve the U-value for new dwellings;

b) floor insulation: where the structure of a ground floor is to be substantially replaced or re-boarded – providing insulation in heated rooms to the standard for new dwellings;

c) wall insulation: when substantially replacing complete exposed walls or their internal renderings or plaster finishes or the internal renderings and plaster of separating walls to an unheated space – providing a reasonable thickness of insulation;

d) sealing measures: when carrying out any of the above work, including reasonable sealing measures;

e) windows, doors and rooflights: where these elements are to be replaced on whole façades – providing new draught-proofed units with an average U-value not exceeding the appropriate U-value in Table 1. This could be inappropriate in conservation work and other situations where the existing window design needs to be retained;

f) heating systems: where heating systems are to be substantially replaced, providing a new heating system as if for a new dwelling with minimum SEDBUK (if based on a gas or oil boiler) not less than the appropriate entry in Table 2 and following the guidance beginning at paragraph 1.32; and in lesser work making reasonable provision for insulation, zoning and timing and interlock controls;

g) hot water systems: when replacing hot water systems, pipes and cylinders – providing more efficient systems and/or controls and insulation as if they are for a new dwelling following the guidance beginning at paragraph 1.38, and in lesser work making reasonable provision for insulation, timing and thermostatic controls.

h) testing and commissioning and providing operating and maintenance instructions where heating and hot water systems are to be altered as in paragraphs (f) and (g), by following the guidance in paragraphs 1.41 to 1.43.

Material changes of use

1.57 Material changes of use are defined in Regulation 5 as follows.

For the purposes of … these Regulations, there is a material change of use where there is a change in the purposes for which or the circumstances in which a building is used, so that after that change –

(a) the building is used as a dwelling, where previously it was not;

(b) the building contains a flat, where previously it did not;

(c) there has been a re-arrangement of internal partitions to make new dwellings or flats.

1.58 When undertaking a material change of use some ways of satisfying the requirements would be as follows although the extent of the provision will depend upon the circumstances in each case:

a) accessible lofts: when upgrading insulation in accessible lofts, providing additional insulation to achieve a U-value not exceeding 0.25 W/m^2K where the existing insulation provides a U-value worse than 0.35 W/m^2K;

b) roof insulation: when substantially replacing any of the major elements of a roof structure, providing insulation to achieve the U-value for new dwellings and reasonable sealing;

c) floor insulation: when substantially replacing the structure of a ground floor, providing insulation in heated rooms to the standard for new dwellings;

d) wall insulation: when substantially replacing complete exposed walls or their internal renderings or plaster finishes or the internal renderings and plaster of separating walls to an unheated space, providing a reasonable thickness of insulation and incorporating reasonable sealing measures;

e) sealing measures: when carrying out any of the above work, including reasonable sealing measures;

f) windows, doors and rooflights: where these elements are to be replaced on whole facades – providing new draught-stripped units with an average U-value not exceeding the appropriate U-value in Table 1. This could be inappropriate in conservation work and other situations where the existing window design needs to be retained;

g) heating systems: where heating systems are to be substantially replaced, providing a new heating system as if for a new dwelling with minimum SEDBUK (if based on a gas or oil boiler) not less than the appropriate entry in Table 2 and following the guidance beginning at paragraph 1.32; and in lesser work making reasonable provision for insulation, zoning and timing and interlock controls;

h) hot water systems: when replacing hot water systems, pipes and cylinders – providing more efficient systems and/or controls and insulation as if they are for a new dwelling following the guidance beginning at paragraph 1.38, and in lesser work making reasonable provision for insulation, timing and thermostatic controls;

i) testing and commissioning and providing operating and maintenance instructions where heating and hot water systems are to be altered as in paragraphs (g) and (h), by following the guidance in paragraphs 1.41 to 1.43;

j) providing lighting in accordance with the guidance in paragraphs 1.46 to 1.48.

Section 2 – Non-domestic building design

2.1 In order to achieve energy efficiency in practice, the building and its services systems have to be appropriately designed (Section 2), constructed (Section 3) and operated (Section 4). This Approved Document provides guidance on meeting the requirements at each of these important stages of procuring a building, whether it be a new construction or a refurbishment project (specific guidance on alterations and changes of use are given in Section 5). More detailed guidance on energy efficiency measures can be found in the CIBSE Guide on Energy Efficiency in Buildings[1].

2.2 In large complex buildings, it may be sensible to consider the provisions for conservation of fuel and power separately for the different parts of the building in order to establish the measures appropriate to each part.

Alternative methods of showing compliance

2.3 Three methods are given for demonstrating that reasonable provision has been made for the conservation of fuel and power. These different methods offer increasing design flexibility in return for greater demands in terms of the level of calculation required. However the overall aim is to achieve the same standard in terms of carbon emissions. The methods are:

a) the Elemental Method starting at paragraph 2.5. This method considers the performance of each aspect of the building individually. To comply with the provisions of Part L, a minimum level of performance must be achieved in each of the elements.

b) the Whole Building Carbon Index Method for offices starting at paragraph 2.56. This method considers the overall performance of the whole building, but is currently only available for office buildings. To comply with the provisions of Part L, the heating, ventilation, air conditioning and lighting systems must be capable of being operated such that the building will emit no more carbon per square metre per annum than a benchmark based on the ECON 19 data[2].

1 CIBSE Guide, *Energy efficiency in buildings*, CIBSE, 1998.
2 *Energy use in offices – Energy Consumption Guide 19*, DETR, 1998.

c) the Carbon Emissions Calculation Method starting at paragraph 2.58. This method also considers the performance of the whole building, but can be applied to any building type. To comply with the provisions of Part L, the annual carbon emissions from the building must be no greater than from an equivalent building that meets the compliance criteria of the elemental method. The carbon emissions from the proposed building and the equivalent reference building must be estimated using an appropriate calculation tool.

2.4 Appendix D contains a checklist detailing what needs to be done for each of the three methods.

The Elemental Method

2.5 To show compliance following the Elemental Method, the building envelope has to provide certain minimum levels of insulation, and the various building services systems have to each meet defined minimum standards of energy efficiency as follows –

Standard U-values for construction elements

2.6 The requirement will be met if the thermal performances of the construction elements are no worse than those listed in Table 2.1 (as illustrated in figure 2.1). One way of achieving the U-values in Table 2.1 is by providing insulation of a thickness estimated from the Tables in Appendix A as illustrated in the examples. An alternative procedure for demonstrating satisfactory provision for floors is given in Appendix C.

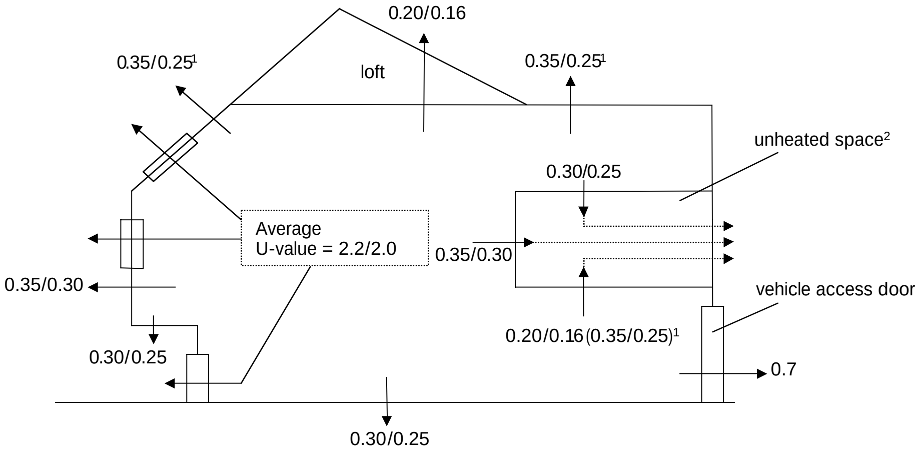
Table 2.1: **Standard U-values (W/m^2K) of construction elements**

When these values come into effect.	**T[1]**	**T + 18 months**
Roofs with horizontal insulation between/over joists	0.20	0.16
Roofs with integral insulation	0.35	0.25
Walls	0.35	0.30
Exposed floors and ground floors	0.3	0.25
Windows, rooflights and doors (area weighted average for the whole building)	2.2	2.0
Vehicle access and similar large doors	0.7	0.7

1 T is the date this Approved Document comes into effect.

Fig 2.1 Standard U-values for non-domestic buildings;

(The first of each pair of numbers comes into effect at the date this Approved Document comes into effect. The second will come into effect 18 months later.)



[1] 0.35/0.25 is the elemented U-value for roofs with integral insulation.

[2] for the calculation of U-values to unheated spaces, the U-value factor associated with the domestic SAP calculation may be used. Alternatively the procedure in BS EN ISO 6946 for elements adjoining unheated spaces may be used.

Wherever possible, manufacturers certified data should be used for the U-values of windows, doors and rooflights. In the absence of such data, the indicative U-values for different window, door and rooflight configurations can be taken from the tables in Appendix A.

Thermal bridging at junctions and around openings

As the standard of the main construction elements improves, the relative impact of thermal bridging becomes more important. It is therefore essential to minimise the effect of thermal bridging at junctions between envelope elements (walls/floors, wall/wall, and wall/roof), around openings (windows and doors) and between the envelope and elements of the structure (walls/beams, roof/columns, and floor/columns).

2.7 The building fabric should be constructed so that there are no significant thermal bridges or gaps in the insulation layer(s) within the various elements of the fabric, at the joints between elements, and at the edges of elements such as those around window and door openings.

2.8 One way of demonstrating compliance would be to utilise details and practice that have been independently demonstrated as being satisfactory. A selection of these is given in the report on robust standard details[3].

2.9 An alternative way of meeting the requirements would be to demonstrate by calculation that the performance of the building fabric is at least as a good as it would be by following paragraph 2.8. BRE Information Paper IP xx/00 [TO BE PUBLISHED] illustrates how this can be done.

3 In preparation, *Details for minimising the adverse effects of thermal bridging and air leakage*, Government/Industry collaborative project.

Maximum areas of windows, doors and rooflights

Glazing is important in providing daylight and a view of the outside for occupants of the building. However, conduction heat flows are much greater through glazed elements, and large glazed areas can result in excessive solar gain and glare problems

2.10 Provision should be made to limit the rate of heat loss through glazed elements of the building. One way of demonstrating compliance is if the total area of windows, doors and rooflights does not exceed the values given in Table 2.2, unless compensated for in some other way.

Table 2.2 **Maximum area of openings unless compensation measures are taken**

Building type	**Windows and doors % exposed wall area**	**Rooflights % of roof area**
Residential buildings (where people temporarily or permanently reside)	30	20
Places of assembly, offices and shops	40	20
Industrial and storage buildings	15	20
Vehicle access doors	As required	

2.11 Guidance on designing for daylighting is contained in CIBSE LG10[4]. To avoid potential problems of excessive solar gain and glare, shading provisions should be considered. Suitable guidance on shading is contained in BRE report 364[5].

2.12 Care should be taken in the selection and installation of glazed systems to avoid the risk of condensation. Guidance can be obtained from BRE Report 262[6].

Trade-off between construction elements

2.13 In order to provide greater design flexibility, the U-values of construction elements and the areas of windows, doors and rooflights may vary from the values given in Tables 2.1 and 2.2 if suitable compensating measures are taken.

2.14 Compliance with the provisions of Part L will be demonstrated provided that:

a) the rate of heat loss from the proposed building does not exceed that from an equivalent building that meets the criteria set out in Tables 2.1 and 2.2; and

b) the U-value of any element does not exceed the values given in the following table.

4 CIBSE, *Daylight and window design*, LG10, CIBSE, 1999.

5 Littlefair P, *Solar shading of buildings*, BRE 364, CRC Ltd, 1999.

6 BRE, *Thermal insulation: avoiding risks*, BRE262, BRE, New edition in preparation.

Table 2.3: Poorest U-values (W/m^2K) acceptable as a general rule when trading off between construction elements

Element	Poorest acceptable U-value
Roofs	0.45
Walls and floors	0.70
Windows and doors	3.3

2.15 As further constraints however:

a) if the U-value of the floor in the proposed building is better than the elemental floor requirement from Table 2.1 with no added insulation, the better floor standard should also be assumed for the notional building; and

b) if the area of the openings in the proposed building is less than the values shown in Table 2.2, this smaller area should also be used for the notional building.

Building air leakage standards

2.16 Buildings should be reasonably airtight to avoid unnecessary space heating and cooling demand and to facilitate the effective performance of ventilation systems. The requirement will be met if the air leakage index is not greater than 10 cubic metres per hour per square metre of external surface area ($m^3/h/m^2$) at an applied pressure difference of 50Pa.

2.17 In order to achieve satisfactory air leakage performance the following measures can be adopted:

a) a reasonably continuous air barrier in contact with the insulation layer should be provided over the whole thermal envelope (including separating walls). Special care must be taken at junctions between elements and around door / window openings. A selection of satisfactory design details and installation practice is described in the report on robust standard details[4].

In the longer term, a more specific requirement based on emerging weather tightness European Standards may be included.

b) sealing of gaps around service penetrations.

c) external doors and opening windows should be fitted with draughtstrips.

Avoiding solar overheating

This approach does not restrict a client's choice to provide cooling. It should however prevent the situation where a subsequent user of the building would prefer not to have comfort cooling but cannot avoid it because envelope performance is poor.

2.18 Buildings should incorporate reasonable provisions to limit the effects of solar gain. One way of achieving this is through the appropriate specification of glazing area and the incorporation of other passive measures such as shading and exposed thermal capacity combined with night ventilation[7].

2.19 Buildings should be constructed such that:

a) those spaces that rely on natural ventilation should not overheat when subject to a moderate level of internal heat gain and

b) those spaces that incorporate mechanical cooling do not require excessive cooling plant capacity to maintain the desired space conditions.

2.20 In naturally ventilated spaces with glazing only in the walls, possible ways of complying with the requirements would be:

a) to show that the space has a window area no greater than 40% of its exposed wall area, OR

b) for office-type buildings, using the design tables in the BRE Environmental Design Guide[8], to demonstrate that the space temperature would not exceed 28˚C[9] when subject to an internal gain of 15W/m^2.

2.21 In naturally ventilated spaces with glazing in the walls and the roof, possible ways of demonstrating compliance include:

a) to show that the total area of glazing does not exceed 20% of the floor area OR

b) demonstrating using an approved calculation procedure that the space will not experience internal dry resultant temperatures greater than 28˚C on more than 10 days in 10 years when subject to internal gains of 15W/m^2 that operate between the hours of 08:00 and 18:00. One acceptable calculation procedure would be the admittance method as outlined in the CIBSE Guide A.

2.22 One way of complying with the requirements for air-conditioned and mechanically ventilated buildings is to demonstrate that the carbon emissions due to the use of such system(s) are not unreasonable. This can be demonstrated through the use of the Carbon Performance Index as detailed in paragraphs 2.51, 2.52, 2.56 and 2.57.

7 Energy Efficiency Best Practice programme, Avoiding or minimising the use of air-conditioning, GIR 31, HMSO, 1995.

8 BRE, *The Environmental Design Guide*, BR345, BRE, 1998.

9 This is the dry resultant temperature that is likely to be exceeded on 10 days in every 10 years.

Heating system efficiency

2.23 Heating plant should be reasonably efficient. A way of complying with the requirement would be to show that:

a) the rating-weighted average carbon intensity of the individual elements of the heat generating equipment at the design capacity of the system is not worse than the value shown in Table 2.4 column (a) AND

b) that the rating-weighted intensity when the system is producing 30% of the design capacity is not worse than the value shown in Table 2.4 column (b).

This is based on a set of gas-fired standard boilers with a lead condensing boiler and oil-fired low-temperature boilers. The efficiencies are as per the Boiler Efficiency Regs.

The only electrical system that could comply with the elemental requirements would be a heat pump system with CoP>1.68. A coal-fired boiler could not satisfy these standards. The carbon index method or the carbon emissions calculation method would have to be used to show such buildings meet the requirements through enhanced energy efficiency measures in other areas.

The boiler efficiencies are required in terms of net (rather than gross) calorific value. This is to be consistent with the Boiler Efficiency Regulations. It should be noted that for dwellings the SEDBUK seasonal efficiency is based on gross calorific value.

Table 2.4: **Maxiumum carbon intensities of heating systems**

	Maximum carbon intensities (kg C/kWh)	
Fuel	**(a) at design capacity**	**(b) at 30% of design capacity**
Gas	0.061	0.058
Other fuels	0.083	0.083

2.24 The carbon intensity of the heating plant is based on the carbon emitted per useful kWh of heat output. This definition of carbon intensity is applicable to boilers, heat pump systems and electrical heating, and is given by:

$$\varepsilon_c = \frac{C_f}{\eta_t} \qquad 2.(1)$$

Where ε_c = the carbon intensity of the heating system (kgC/kWh of useful heat).

η_t = the <u>net</u> thermal efficiency of the heating system (kWh of heat/kWh of delivered fuel).

C_f = the carbon emission factor of the fuel (kg C/kWh of delivered fuel) (Table 2.5).

Table 2.5: **Carbon emission factors**

Delivered energy	**Carbon emission factor (kgC/kWh)**
Gas	0.053
Oil	0.074
Coal	0.086
Electricity (average)	0.139

2.25 Where a combined heat and power system (CHP) is proposed, the carbon intensity of the CHP can take account of the benefit of the on-site generation in reducing emissions from power stations feeding the national grid. For the purpose of calculating the carbon intensity of the heating system, the maximum contribution from the CHP to the overall system output is limited to 30%. The carbon intensity of the CHP engine is given by:-

$$\varepsilon_c = \frac{C_f}{R_H} R_E . C_{elec} \qquad 2.(2)$$

where R_H is the heat output ratio of the CHP engine (kWh of heat per kWh of delivered fuel)

R_E is the electrical output ratio of the engine (kWh of electricity per kWh of delivered fuel)

C_{elec} is the carbon emission factor for grid supplied electricity (kgC/kWh).

This assumes all the heat is useful, which is likely to be the case in the heating season. In the summer, the CHP may dump heat, which may be carbon inefficient, but is something that cannot readily be controlled by Building Regulations.

Trade-off between construction elements and heating system efficiency

2.26 In order to allow greater design flexibility, limited trade-off (in either direction) is allowed between the average U-value of the envelope and the carbon intensity of the heating system. Because fabric insulation is a more robust and longer term measure, greater latitude is allowed in terms of trading off reduced heating system efficiency for better fabric performance than vice-versa:

a) if a heating system with a carbon intensity worse than that shown in Table 2.4 is to be used, the average U-value of the envelope should be improved according to the following equation.

$$U_{adj} = U_{avg} * \frac{\varepsilon_{ref}}{\varepsilon_{act}} \qquad 2.(3)$$

where U_{adj} = the adjusted average U-value

U_{avg} = the average U-value of the building constructed to the elemental standards of Table 2.1

ε_{ref} = the carbon intensity of the heating system as required by Table 2.4 column a)

ε_{act} = the carbon intensity of the actual heating system at design capacity

b) if a heating system with a carbon intensity better than that shown in Table 2.4 is to be used, the average U-value of the envelope can be downgraded according to the following equation, provided no element of the fabric has a U-value worse than that given in Table 2.6.

This is the equation of the line with slope 50% of that given in sub-clause a). This is to recognise that improved heating efficiency is a less robust strategy than good insulation for new building work.

$$U_{adj} = \frac{U_{avg}}{2} * \left(\frac{\varepsilon_{ref}}{\varepsilon_{act}} + 1\right) \qquad 2.(4)$$

Table 2.6: **Poorest U-values (W/m^2K) acceptable as a general rule when trading against the carbon intensity of the heating system**	
Roofs with loft space and insulation between/over joists	0.25
Roofs with integral insulation (residential buildings)	0.35
Roofs with integral insulation (non-residential buildings)	0.45
Walls	0.45
Exposed floors and ground floors	0.45
Windows, rooflights and doors (area weighted average for the whole building)	3.30

Space heating controls

2.27 Controls should be provided such that each separate part of the building is maintained at the required temperature only during the period that particular part of the building is normally occupied.

2.28 Additional controls may be provided to allow sufficient heating to prevent condensation or frost damage when the heating system would otherwise be switched off.

2.29 A way of meeting the requirement in buildings with a heating capacity no greater than 100kW would be to follow the guidance in GPG 132[10]. In larger, more complex buildings, reasonable provision could be certification by a competent person that the control systems meet the requirements. Detailed guidance for such buildings is contained in the CIBSE Applications Guide[11].

Hot water systems and their control

2.30 Hot water should be provided safely, making efficient use of energy and thereby minimising carbon emissions. Ways of achieving the requirement include –

a) avoiding oversizing of hot water storage systems.

b) avoiding low load operation of heat raising plant.

c) avoiding the use of grid-supplied electric water heating except where hot water demand is low.

d) providing solar water heating.

e) minimising the length of circulation loops.

f) minimising the length and diameter of dead legs.

10 Energy Efficiency Best Practice Programme, *Heating controls in small commercial and multi-residential buildings*, GPG 132, being updated.

11 *Building Control Systems: Applications Guide*, CIBSE, to be published.

2.31 A way of satisfying the requirements for conventional hot water storage systems would be to provide controls that shut off heating when the required water temperature is achieved. The supply of heat should also be shut off during those periods when hot water is not required.

2.32 A way of meeting the requirement in small buildings would be to follow the guidance in GPG 132[10]. In larger, more complex buildings or for alternative systems (e.g. solar hot water heating), reasonable provision could be certification by a competent person that the control systems meet the requirements. Guidance is contained in the CIBSE Applications Guide[11].

Insulation of pipes, ducts and vessels

Limit of application:

2.33 This section only applies to pipework, ductwork and vessels for the provision of space heating, space cooling (including chilled water and refrigerant pipework) and hot water supply for normal occupation. Pipework, ductwork and vessels for process use are outside the scope of the Building Regulations.

Meeting the requirement

2.34 A way of meeting the requirement would be to apply insulation to the standards required in BS5422 (1990) (currently under review) to all pipework, ductwork and storage vessels. The requirement for storage vessels should be taken as that given in BS5422 for flat surfaces.

2.35 Insulation would not be necessary for compliance with Part L if the heat flow through the walls of the pipe, duct or vessel is always useful in conditioning the surrounding space when fluid is flowing through the pipe or duct, or is being stored in the vessel in question. However, it may be prudent to provide it to ensure control stability.

Lighting efficiency standards

2.36 Lighting systems should be reasonably efficient and make effective use of daylight where appropriate.

General lighting efficacy in office, industrial and storage buildings

2.37 Electric lighting systems serving buildings with large internal spaces, whether or not divided by demountable partitions or racking, should be provided with reasonably efficient lamp/luminaire combinations. A way of meeting the requirements would be to provide lighting with an initial efficacy averaged over the whole building of not less than 40 luminaire-lumens/circuit-Watt. This allows considerable design flexibility to vary the light output ratio of the luminaire, the luminous efficacy of the lamp or the efficiency of the control gear.

> This approach does not guarantee that the luminaires are in a daylit space. One assumption would be that the owners would not pay for an inappropriate daylight control just to pass the requirement. They could better spend the same money on a better lamp/luminaire.
>
> An alternative approach that defines a daylit space is offered, but this brings with it the problems of compliance checking, and perhaps the need for self-certification by a competent person.

2.38 The average luminaire-lumens/circuit-watt is calculated by:

$$\phi_{lum} = \frac{1}{P} . \sum \frac{L.O.R.* \lambda_{lamp}}{C_L} \qquad (2.5)$$

where

ϕ_{lum} = the luminaire efficacy (luminaire-lumens/circuit-Watt)

L.O.R = the light output ratio of the luminaire

λ_{lamp} = the sum of the average initial (100hour) lumen output of all the lamp(s) in the luminaire

P = the total circuit watts for all the luminaires

C_L = the factor applicable when controls reduce the output of the luminaire when electric light is not required. The values of C_L are given in the following table

Table 2.7: **Luminaire control factors**

Control function	C_L
a) The luminaire is in a daylit space (see para 2.39), and its light output is controlled by	
• A photoelectric switching or dimming control, with or without manual override, or	
• Local manual switching (see para 2.47a)	0.80
b) The luminaire is in a space that is likely to be unoccupied for a significant proportion of working hours and where a sensor switches off the luminaire in the absence of occupants but switching on is done manually	0.80
c) a) and b) above combined.	0.75
d) None of the above.	1.00

Whether or not the space is unoccupied for significant periods may be more a function of the building use rather than of the building itself

2.39 For the purposes of this Approved Document, a daylit space is defined as any space within 6m of a window wall, provided that the window area is at least 20% of the internal wall area. Alternatively it can be rooflit, with a glazing area at least 10% of the floor area. The normal light transmittance of the glazing should be at least 70%, or, if the light transmittance is reduced below 70%, the glazing area could be increased proportionately, but subject to the considerations given in paragraphs 2.10 and 2.14.

2.40 This guidance need not be applied in respect of a maximum of 500W of installed lighting in the building, thereby allowing flexibility for the use of feature lighting etc.

2.41 Appendix J gives examples that show how the luminaire efficacy requirement can be met either by selection of appropriate lamps and luminaires or by calculation.

General lighting efficacy in all other building types

2.42 For electric lighting systems serving other building types, it may be appropriate to provide luminaires that have not been photometered and/or lower powered and less efficient lamps. For such spaces, the requirements would be met if the installed lighting capacity has an initial (100 hour) efficacy of not less than 50 lumens per circuit-Watt. A way of achieving this would be to provide at least 95% of the installed lighting capacity using lamps with circuit efficacies not less than those in Table 2.8.

Table 2.8: Light sources meeting the criteria for general lighting

Light source	Types and ratings
High pressure Sodium	All types and ratings
Metal halide	All types and ratings
Induction lighting	All types and ratings
Tubular fluorescent	26mm diameter (T8) lamps, and 16mm diameter (T5) lamps rated above 11W, provided with low-loss or high frequency control gear. 38mm diameter (T12) linear fluorescent lamps 2400mm in length
Compact fluorescent	All ratings above 11 W
Other	Any type and rating with an efficacy greater than 50 lumens per circuit Watt.

Display lighting in all buildings

2.43 Because of the special requirements of display lighting, it may be necessary to accept lower energy performance standards for display lighting. Reasonable provision should nevertheless be made and a way of complying would be to demonstrate that the installed capacity of display lighting has an initial (100 hour) efficacy of not less than 15 lumens per circuit-Watt.

2.44 As an alternative, it would be acceptable if at least 95% of the installed display lighting capacity in circuit-Watts comprises lighting fittings incorporating lamps of the type shown in Table 2.9.

Table 2.9: Light sources meeting the criteria for display lighting

Light source	Types and ratings
High pressure Sodium	All types and ratings
Metal halide	All types and ratings
Tungsten halogen	All types and ratings
Compact and tubular fluorescent	All types and ratings
Other	Any type and rating with an efficacy greater than 15 lumens per circuit Watt.

Emergency escape lighting and specialist process lighting

2.45 Emergency escape lighting and specialist process lighting are not subject to the requirements of Part L.

Lighting controls

2.46 Where it is practical, the aim of lighting controls should be to encourage the maximum use of daylight and to avoid unnecessary lighting during the times when spaces are unoccupied. However, the operation of automatically switched lighting systems should not endanger the passage of building occupants. Guidance on the appropriate use of lighting controls is given in BRE IP …[12].

Controls in offices and storage buildings

2.47 A way of meeting the requirement would be met by the provision of local switches in easily accessible positions within each working area or at boundaries between working areas and general circulation routes. The distance on plan from any local switch to the luminaire it controls should generally be not more than eight metres, or three times the height of the light fitting above the floor if this is greater. Local switching can be supplemented by other controls such as time switching and photoelectric switches where appropriate. Local switches could include:

a) switches that are operated by the deliberate action of the occupants either manually or by remote control. Manual switches include rocker switches, push buttons and pull cords. Remote control switches include infra red transmitter, sonic, ultra sonic and telephone handset controls.

b) automatic switching systems which switch the lighting off when they sense the absence of occupants.

Controls in buildings other than offices, storage buildings and dwellings

2.48 A way of meeting the requirement would be to provide one or more of the following types of control system arranged to maximise the beneficial use of daylight as appropriate:

a) local switching as described in paragraph 2.47;

b) time switching, for example in major operational areas which have clear timetables of occupation;

c) photo-electric switching.

Controls for display lighting (all building types other than dwellings).

2.49 A way of meeting the requirement would be to connect display lighting in dedicated circuits that can be switched off at times when people will not be inspecting exhibits or merchandise or being entertained. In a retail store, for example, this could include timers that switch the display lighting off outside store opening hours, except for displays designed to be viewed from outside the building such as shop window displays.

12 BRE IP …, *Photoelectric control of lighting: design, set-up and installation issues,* to be published.

Air-conditioning and mechanical ventilation (ACMV)

2.50 Buildings with ACMV should be designed and constructed such that:

a) the form and fabric of the building do not result in a requirement for excessive installed capacity of cooling equipment. In particular, the suitable specification of glazing ratios and solar shading are an important way to limit cooling requirements (see paragraph 2.18).

b) components such as fans, pumps and refrigeration equipment are reasonably efficient and appropriately sized to have no more capacity for demand and standby than is necessary for the task.

c) suitable facilities are provided to manage, control and monitor the operation of the equipment and systems.

2.51 In the case of an office development, one way of demonstrating that the requirements have been met is to use the Carbon Performance Index (CPI). This relates the performance of the proposed building to a benchmark based on the measured consumption data contained in ECON19 [2]. The performance of the proposed building is estimated from the installed capacity of the equipment, as this combines the effect of load reduction by good envelope design and energy efficient system design into a single parameter. The detail of the CPI calculation is contained in appendix K.

2.52 Acceptable performance would be demonstrated if –

a) for new buildings a CPI of 100 or more is achieved.

b) for a new ACMV system being added to an existing building, a minimum CPI of 90 is attained.

c) for a building that already contains an ACMV system and substantial alteration is being made to the existing ACMV system, the CPI is increased by 10 points, or to a value exceeding 90, whichever is the least demanding.

> The proposed pass score of 100 represents the median of the dataset in the current (1998) edition of ECON19. The level proposed in the earlier industry consultation (1995-97) aimed at a level somewhat better than the median, but was based on the older dataset supporting the original ECON19 (1993). Consultees are asked to consider whether the proposed pass score could have a better basis.
> For refurbishment, the reduced design freedom makes it more difficult to install energy efficiency measures, and so a lower score is required.

2.53 When replacing existing equipment, the product of the installed capacity per unit treated area (P) and the control management factor (F) should be

a) reduced by at least 10%, OR

b) to meet a level of performance equivalent to the component benchmarks given in CIBSE TM22[13] (i.e. the product of service provision, efficiency and control factor), whichever is the least demanding.

13 CIBSE, *Energy Assessment and Reporting Methodology: Office Assessment Method,* TM22, CIBSE, 1999.

2.54 For hospitals and schools, a way of complying with the requirements would be to show that the proposed building conforms with one of the following guidance documents:–

a) for hospitals, with the NHS Estates guides[14]

b) for schools, with the DfEE guidance note[15]

> It should be possible to introduce CPI benchmarks for hotel and retail buildings in the next amendment. Sufficient robust data for these sectors does not yet exist, but is currently being gathered.

2.55 For other buildings, it is only possible at present to define an overall performance requirement for the mechanical ventilation systems (whether or not the air being supplied/extracted is heated or cooled). In such cases, the requirement will be met if the specific fan power (SFP) is less than the values given in the following sub-clauses. The specific fan power is the design power of all fans in the air distribution system divided by the design ventilation rate through the building:

> Consultees are asked to comment on whether the proposed SFP limits are appropriate for all sectors.

a) for ACMV systems in new buildings, the SFP should be no greater than 2.0 W/litre/second.

b) for new ACMV systems in refurbished buildings, or where an existing ACMV system in an existing building is being substantially altered, the SFP should be no greater than 3.0 W/litre/second.

The whole building carbon index method for offices

2.56 The Whole Building Carbon Index method is a development of the CPI described in paragraph 2.51. In this compliance route, the index is expanded to cover lighting and space heating as explained in detail in BRE report 80678[16]. This approach allows greater design flexibility in trading off between the building envelope and the building services systems whilst maintaining a level of performance equivalent to that obtained if following the elemental compliance route.

2.57 The requirement would be met if:

a) the whole office carbon index achieves the scores as described in paragraph 2.52 AND

b) the envelope meets the requirements of paragraph 2.16 and Table 2.6.

> The limiting U-values and air leakage standards (sub-para 2.57.b)) are included to prevent a situation where a super-efficient system compensates for a poor thermal envelope, as this is not considered to be a robust solution.

14 NHS Estates: *Achieving energy efficiency in new hospitals,* HMSO,1994

15 DfEE, *Guidelines for environmental design in schools,* Building Bulletin 87, HMSO, 1997.

16 Grigg P, *The Carbon Performance Index for offices,* Report no. 80678, BRE, 2000

The carbon emissions calculation method

2.58 This is a calculation method allowing completely free design of buildings using any valid energy conservation measure and taking account of useful solar and internal heat gains to show that:

a) the calculated annual carbon emissions of the proposed building are less than the calculated annual carbon emissions of a similar reference building designed to comply with the Elemental Method. When establishing the parameters of the reference building, the requirements of paragraph 2.15 should be applied.

b) the envelope meets the requirements of paragraph 2.16 and Table 2.6.

2.59 The calculations should be carried out using an acceptable calculation procedure. A way of obtaining acceptance for a calculation procedure would be to show:

a) that it has been proved as satisfactory against the benchmark tests described in CIBSE AM11[17] and

b) that it has been accepted by the third party certifying the submitting organisation's quality assurance procedures.

Compliance could then be demonstrated by submitting with the calculations a completed copy of Appendix B of AM11 – *Checklist for choosing BEEM software*, showing that the software used is appropriate for the purpose to which it has been applied. The checklist should be signed by an appropriately qualified competent person.

17 CIBSE, *Building Energy and Environmental Modelling,* AM11, CIBSE 1998.

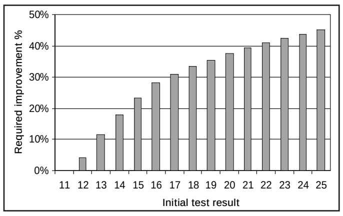
Section 3 – Non-domestic buildings: Construction

The Building Fabric

3.1 The insulating material must be installed securely and continuously and the effect of thermal bridging minimised. Ways of demonstrating compliance with the requirements include –

a) submitting to the building control body a report signed by a competent person, detailing the use of appropriate fixing techniques and design details with a supporting regime of site practice and inspection (see paragraphs 2.7 and 2.17).

b) submitting to the building control body a report signed by a competent person, giving the results of infra-red thermography inspections that show that the insulation is reasonably continuous over the whole visible envelope.



3.2 In order to demonstrate the integrity of the air leakage provisions, a report signed by a competent person should be submitted to the building control body that records the results of an air leakage test carried out according to the procedures set out in CIBSE TM23[18]. The building will meet the requirements of Part L if the air leakage index is no greater than the value defined in paragraph 2.16.

The required standard in this draft ADL is not considered to be onerous. However it is recognised that it may take a little while for industry to adjust to these requirements, hence the proposed interim measure. The above graph illustrates the improvement required during the interim period as a function of the initial test result. The approach provides an incentive to 'get it right first time', in order to avoid the costs associated with identifying and fixing leaks.

3.3 If on first testing the building fails to comply, the major sources of air leakage should be identified using the techniques described in TM23. With effect from 18 months after this Approved Document comes into effect reasonable provision will be taken to include remedial action and re-testing until the leakage standard is achieved. As an interim measure, an acceptable standard of performance would be obtained if on re-test

a) the air leakage index improved by 75% of the difference between the first test and the standard given in paragraph 2.16, OR

b) the air leakage on re-testing was within 15% of the standard given in paragraph 2.16.

18 CIBSE, *Air leakage testing of buildings,* TM23, CIBSE, to be published.

Initial Testing and Commissioning of the Building Services

3.4 The building services installation should:

a) be capable of operating with reasonable efficiency and

b) incorporate adequate provisions to allow testing and commissioning to be carried out satisfactorily.

> The overall system commissioning and regulation will have to be completed once the building is occupied and the systems are under realistic operating loads, that is to say beyond the remit of the Building Regulations at present. However, before the building work is complete, all plant and control items should be demonstrated to be working as intended.

3.5 A way of demonstrating this would be for a competent person to prepare a commissioning plan in accordance with the CIBSE Commissioning Codes and BSRIA Commissioning Guides. Following completion of the activities defined in the commissioning plan, a competent person should then submit a report confirming that the building services equipment have been effectively commissioned to that plan and that as far as is reasonably practical, the systems achieve their specified intentions in an energy efficient way.

Section 4 – Non-domestic buildings: Providing Information

The building log-book

4.1 The owner/occupier of the building should be provided with details of the installed building services plant and controls, their method of operation, state of maintenance, and details forecasting annual energy consumption for the building.

4.2 The details could reasonably be expected to include:

a) a schedule of the floor areas of each of the building zones categorised by environmental servicing type (e.g. air-conditioned, naturally ventilated);

b) the purpose of the individual building services systems;

c) the location of the relevant plant and equipment;

d) the installed capacities (input power and output rating) of the services plant;

e) simple descriptions of the operational and control strategies of the energy consuming services in the building;

f) operating and maintenance instructions that include provisions enabling the specified performance to be sustained during occupation;

g) a schedule of the building's energy supply meters and sub-meters, indicating for each meter, the fuel type, its location, identification and description. The schedule should indicate how the normalised energy performance of the building (or each separate tenancy in the building where appropriate) can be calculated from the individual metered energy readings to facilitate comparison with published benchmarks (see paragraph 6 in Appendix K). Guidance on appropriate metering strategies is given starting at paragraph 4.3 below;

h) for systems serving an office floor area greater than 200 m^2, a design assessment of the building services systems carbon emissions and the comparable performance benchmark (see paragraph 4 in Appendix K);

i) the measured air leakage index of the building (see paragraph 3.2 above).

The installation of energy meters

4.3 Sufficient meters and sub-meters should be installed such that the user of the building (or separate tenancy where appropriate) can compare energy consumption with published performance benchmarks.

4.4 A metering strategy should be prepared such that the occupant of each building or separately tenanted area greater than 500m^2 can attribute the majority of the expected total annual energy consumption to its end uses with reasonable accuracy. A copy of this metering strategy should be included in the operation and maintenance information provided for the building occupant (paragraph 4.2.g).

4.5 Incoming meters should be provided in each individual building such that the consumption of electricity, gas, oil and LPG can be accurately monitored.

4.6 The heat that is provided by a district-heating scheme to each building or separately tenanted space should be determined. Reasonable provision would be

a) for buildings or separately tenanted spaces greater than 2,500m^2, a meter capable of directly measuring heat energy input.

b) for smaller buildings or separately tenanted spaces less than 2,500m^2, it would be reasonable to estimate and apportion the heat energy supplied based on the total metered heat supplied by the system.

4.7 Additional meters should be provided within buildings to monitor the consumption of electricity, gas, oil and LPG provided to each separately tenanted area that is greater than 500m^2.

4.8 In developing the metering strategy, allocation of energy consumption to the various end uses can be achieved through

a) direct metering of the end-use.

b) measuring the run hours of a piece of equipment that operates at a constant known load.

c) estimating the energy consumption, e.g. from metered water consumption for HWS, the known water supply and delivery temperatures and the known efficiency of the water heater.

d) Estimating consumption by difference, e.g. measuring the total consumption of gas, and estimating the gas used for catering by deducting the measured gas consumption for heating and hot water.

e) estimating non-constant small power loads using the procedure outlined in Chapter 11 of the CIBSE Energy Efficiency Guide[19].

19 *Chapter 11, General electric power,* Energy Efficiency in Buildings, CIBSE, 1998.

4.10 It is probably impractical to accurately account for all the energy consumption by a combination of the above methods. Reasonable provision would be for at least 90% of the estimated annual energy consumption to be accounted for by a combination of the methods listed above.

4.11 Each meter and sub-meter should be labelled with its fuel type, location, and identification to correspond with the details in the metering strategy (paragraph 4.4).

Section 5 – Non-domestic buildings: Material Alteration and Change of Use

5.1 In order to effect energy efficiency improvements to the existing building stock, it is essential that opportunities to incorporate energy efficiency measures are taken when material building work is carried out.

Material Alterations

5.2 Material alterations are defined in Regulation 3(2) as follows.

> *"An alteration is material for the purposes of these Regulations if the work, or any part of it, would at any stage result –*
>
> *(a) in a building or controlled service or fitting not complying with a "relevant requirement" where previously it did; or*
>
> *(b) in a building or controlled service or fitting which before the work commenced did not comply with a "relevant requirement", being more unsatisfactory in relation to such a requirement."*

5.3 "Relevant requirement" is defined in Regulation 3(3) as follows.

"In paragraph (2) "relevant requirement" means any of the following applicable requirements of Schedule 1, namely –

> *Part A (structure)*
>
> *paragraph B1 (means of escape)*
>
> *paragraph B3 (internal fire spread – structure)*
>
> *paragraph B4 (external fire spread)*
>
> *paragraph B5 (access and facilities for the fire service)*
>
> <u>*Part L (conservation of fuel and power*</u>*)*
>
> *Part M (access and facilities for disabled people)."*

5.4 The requirement may be satisfied in the following ways, although the extent of provision would depend upon the circumstances in each case:

a) **roof insulation**: when substantially replacing any of the major elements of a roof structure – providing insulation to achieve the U-value for new buildings.

b) **floor insulation**: where the structure of a ground floor is to be substantially replaced – providing insulation in heated rooms to the standard for new buildings.

c) **wall insulation**: when substantially replacing complete **external** walls or replacing their internal renderings and plaster, providing a reasonable thickness of insulation and incorporating reasonable sealing measures.

d) **airtightness**: when carrying out substantial alterations to the external envelope, make reasonable provisions for improving the airtightness.

e) **windows, doors and rooflights**: when these elements are to be replaced, provide units that meet the requirements for new buildings. This could be inappropriate in conservation work and other situations where the existing window design needs to be retained.

f) **heating systems**: where heating systems are to be substantially replaced, providing a new heating system and controls as if they are new installations. In lesser work, make reasonable provision for insulation, zoning, timing, temperature and interlock controls.

g) **hot water systems**: when replacing hot water systems, pipes and cylinders – providing controls and insulation as if they are new installations. In lesser work, make reasonable provision for insulation, timing and thermostatic controls.

h) when replacing **electric lighting systems**, providing new lighting systems and controls as if they are new installations.

i) when carrying out building work on **air conditioning or mechanical ventilation systems**, improving the Carbon Performance Index in line with the guidance in paragraph 2.52 and 2.53 of this Approved Document.

5.5 When carrying out work under paragraph 5.4 sub-clauses f) to i):

a) the work should be tested and commissioned following the guidance in paragraphs 3.4 and 3.5.

b) the building log-book should prepared or updated as necessary (paragraphs 4.1 and 4.2).

c) the metering strategy should be prepared or reviewed and revised as necessary, and additional metering provided where needed (paragraphs 4.3 to 4.11).

Material changes of use

5.6 Material changes of use are defined in Regulation 5 as follows.

"*For the purposes of … these Regulations, there is a material change of use where there is a change in the purposes for which or the circumstances in which a building is used, so that after that change –*

(a) the building is used as a hotel or boarding house where previously it was not;

(b) the building is used as an institution where previously it was not;

(c) the building is used as a public building where previously it was not;

(d) the building is not a building described in Classes I to VI in Schedule 2 (i.e. an exempt building), where previously it was."

5.7 When undertaking a material change of use one way of satisfying the requirements would be as follows although the extent of the provision would depend upon the circumstances in each case:-

a) upgrading insulation in accessible lofts: additional insulation should generally be provided to achieve a U-value not exceeding 0.25 W/m^2K where the existing insulation provides a U-value worse than 0.45 W/m^2K;

b) roof insulation: when substantially replacing any of the major elements of a roof structure – providing insulation to achieve the U-value for new buildings;

c) floor insulation: where the structure of a ground floor is to be substantially replaced – providing insulation to the standard for new buildings.

d) wall insulation: when substantially replacing complete exposed walls or replacing their internal renderings and plaster, providing a reasonable thickness of insulation and incorporating reasonable sealing measures.

e) windows, doors and rooflights: when these elements are to be replaced, provide units that meet the requirements for new buildings. This could be inappropriate in conservation work and other situations where the existing window design needs to be retained.

f) airtightness: when carrying out substantial alterations to the external envelope, make reasonable provisions for improving the airtightness.

g) heating systems: where heating systems are to be substantially replaced, providing a new heating system and controls as if they are new installations. In lesser work, make reasonable provision for insulation, zoning, timing, temperature and interlock controls.

h) hot water systems: when replacing hot water systems, pipes and cylinders – providing controls and insulation as if they are new installations. In lesser work, make reasonable provision for insulation, timing and thermostatic controls.

i) when replacing electric lighting systems, providing new lighting systems and controls as if they are new installations.

j) when carrying out building work on air conditioning or mechanical ventilation systems, improve the Carbon Performance Index in line with the guidance in paragraph 2.52 and 2.53 of this Approved Document.

5.8 When carrying out work under paragraph 5.7 sub-clauses g) to j):

a) the work should be tested and commissioned following the guidance in paragraphs 3.4 and 3.5.

b) the building log-book should be prepared or updated as necessary (paragraphs 4.1 and 4.2)

a) the metering strategy should be prepared or reviewed and revised as necessary, and additional metering provided where needed (paragraphs 4.3 to 4.11).

PART 4

The proposed carbon index amendment to SAP – 1998

Background

1. SAP is the Government's Standard Assessment Procedure for the energy rating of dwellings. The SAP 1998 publication sets out the method of calculation of the SAP energy rating. It also provides for the optional calculation of CO_2 emissions, expressed in tonnes/year.

2. This proposed amendment introduces a new optional Carbon Index (CI) calculation which could be used as a way of showing compliance with Part L (see paragraph 1.23 in Part 3 of this consultation document). The CI is based on the CO_2 emission figure, but adjusted for floor area so that it is essentially independent of dwelling size for a given built form. It is expressed on a scale of 0.0 to 10.0, the higher the number the better the performance. The achievement of a specified level of the CI is proposed as one way of demonstrating compliance with the next revision of Building Regulations for the Conservation of Fuel and Power.

SAP Version

3. The version of the SAP worksheet incorporating the calculation of the Carbon Index is known as Version 9.61.

Data required for the calculation of the CI

4. The calculation of the CI requires the same data about the dwelling as the calculation of the SAP rating. No additional data are required.

Optional extension of SAP Worksheet for calculation of the CI

Conventional heating or community heating without CHP

5. Undertake the worksheet calculations following the existing SAP 1998 specification up to box (104). Continue with the calculation of boxes (105) to (107) according to the revised worksheet version 9.61 to obtain the Carbon Index.

Community heating with CHP

6. Undertake the worksheet calculations following the existing SAP 1998 specification to box (113*). Continue with the calculation of boxes (114*) to (116*) according to the revised worksheet version 9.61 to obtain the Carbon Index.

New Table 16

7. The final page of the worksheet with these proposed additions is appended. A new Table 16 is proposed as below which derives the Carbon Index from the Carbon Factor.

Table 16: **Carbon Index**

Carbon Factor (CF) kg/m^3	**Carbon Index (CI)**	**Carbon Factor (CF) kg/m^2**	**Carbon Index (CI)**
8 or less	**10.0**	30	**4.8**
9	**9.5**	32	**4.6**
10	**9.1**	34	**4.3**
11	**8.7**	36	**4.1**
12	**8.4**	38	**3.9**
13	**8.1**	40	**3.7**
14	**7.8**	45	**3.2**
15	**7.5**	50	**2.8**
16	**7.3**	55	**2.4**
17	**7.0**	60	**2.1**
18	**6.8**	65	**1.8**
19	**6.6**	70	**1.5**
20	**6.4**	75	**1.2**
21	**6.2**	80	**1.0**
22	**6.0**	85	**0.7**
24	**5.7**	90	**0.5**
26	**5.4**	95	**0.3**
28	**5.1**	100	**0.1**
		102 or more	**0.0**

Alternatively, the carbon index may be calculated by the formulae:
$CF = CO_2/(TFA + 45.0)$
$CI = 18.1 - 9.0 \log_{10} (CF)$
Where: CO_2 is the CO_2 emissions in kg/year;
TFA is total floor area in m^2.

Quotation of results

8. The Carbon Index should be expressed as a number between 0.0 and 10.0 rounded to one decimal place. It is anticipated that the Carbon Index will take the place of CO_2 emission figure. If, however, the CO_2 emission figure is quoted it should be expressed in tonnes/year rounded to one decimal place.

SAP worksheet (version 9.61)

Note: boxes up to box (100) are identical to SAP version 9.60

Carbon dioxide emissions from fuel use for conventional and community heating without CHP

	Energy, GJ/year		Emission factor (Table 15)		Emissions (kg/year)	
Water heating – from box (51) *if heated by community boilers (51) x (85*) ÷ 0.75*		x		=		(101)
Space heating, main – from box (85) *if heated by community boilers (87*) ÷ 0.75*		x		=		(102)
Space heating, secondary – from box (86) *if heated by community boilers enter '0'*		x		=		(103)
Electricity for pumps and fans – box (87) or (88*)		x		=		(104)
Total CO_2 (space and water), kg/year			*[(101) + (102) + (103) + (104)]*	=		(105)
Total CO_2 (space and water), tonnes/year			*(105)* ÷ 1000	=		(105a)
Carbon Factor (CF)			*(105)* ÷ [*(5)* + 45.0]	=		(106)
Carbon Index (Table 16)				=		(107)

Carbon dioxide emissions from fuel use for community heating schemes with CHP

Electrical efficiency of CHP unit (e.g. 25) *from operational records or the CHP design specification*		(101*)				
Heat efficiency of CHP unit (e.g. 0.50) *from operational records or the CHP design specification*		(102*)				
CO_2 emission factor for the CHP fuel from Table 15				(103*)		
CO_2 emission factor for electricity from Table 15				(104*)		
Calculate CO_2 emitted by CHP per 1GJ of generated electricity (103*)÷ (101*) =						(105*)
Heat to Power ratio *(GJ heat /GJ electricity)* *enter if known, otherwise (102*) ÷ (101*)*						(106*)
Calculate CO_2 emission factor for heat *if negative enter "0" in box (107*)*			*= [(105*) – (104*)] ÷ (106*)*	=		(107*)

	Energy		Factor		Emissions	
HWS by CHP, (51) x (83*) x (85*) =	GJ/year	x	box (107*)	=		(108*)
HWS by boilers, (51) x (84*) x (85*) ÷ 0.75		x	Table 15	=		(109*)
If HWS by immersion heater, box (51)	box (51)	x	Table 15	=		(110*)
Space heating from CHP, box (86*)	box (86*)	x	box (107*)	=		(111*)
Space heating from boilers, *(87*) ÷ 0.75*		x	Table 15	=		(112*)
Electricity for pumps and fans, box (88*)	box (88*)	x	Table 15	=		(113*)
Total CO_2 (space and water), kg/year			*[(108*) + ... + (113*)]*	=		(114*)
Total CO_2 (space and water), tonnes/year			*(105) ÷ 1000*	=		(114a*)
Carbon Factor (CF)			*(114*) ÷ [(5) + 45.0]*	=		(115*)
Carbon Index (Table 16)						(116*)

PART 5

Current thinking on possible future amendments of the energy efficiency provisions

Introduction

1. During 1998, an initial consultation exercise was undertaken to generate ideas for possible changes to the energy efficiency requirements of the Building Regulations. This generated many suggestions for measures that could be incorporated into the Regulations[1]. The DETR Press Notice of January 1999 reports Construction Minister Nick Raynsford's comments on the way these ideas would be taken forward. A series of staged amendments was anticipated, and current thoughts on how this staging might best be achieved are described below.

2. It is clear that if national CO_2 emissions are to be reduced, then further significant improvements in performance of the building stock will be required. The first round of consultation made it very plain that industry recognised this fact and would welcome the concept of a rolling programme of changes, where the requirements in, say, five years time were signalled well in advance. This would give time and motivation to develop products and construction practice to meet the anticipated standards. Such a concept was employed successfully in relation to the Montreal Protocol.

3. During 1999, discussions were held with industry representatives under the aegis of the Industry Advisory Groups (IAG). The IAGs were formed from representatives of various trade and professional organisations covering the full spectrum of those involved with the design and construction of buildings. Separate IAGs were formed for dwellings and non-domestic buildings. The discussions with these IAGs were helpful in determining the Department's thinking on the timing of when various measures should be introduced and the standards that might apply.

Current proposals for staging

4. The following stages of amendment are proposed.

   a) Stage 1; these are the specific proposals for changes in the regulations, technical requirements and Approved Document L contained in Parts 2 & 3 of this consultation document. In most cases, implementation of new standards 6 months after amendment

1 Oscar Faber for DETR, Summary of Responses to the Initial Consultation Paper, October 1998, available from www.construction.detr.gov.uk/br/br06d.htm

date is proposed, but in some cases deferred implementation until 2 years after amendment date is proposed to allow industry the time to adjust to the changes. In some cases, the proposed standards push at the limits of current products and building expertise.

b) Stage 2; these are measures where more time is needed to ensure that there are no technical, market availability or building control enforcement reasons that would make proposals unacceptable. These could be implemented about a year after the second phase of the Stage 1 changes. No measure introduced or amended in Stage 1 will be altered in Stage 2. ***In the following paragraphs, stage 2 proposals are highlighted in bold, italic type.***

c) Stage 3; these are measures that would require amendment to the Building Act. The timing of these changes depends on the parliamentary timetable, but a best estimate is that such changes are unlikely before 2005. *In the following paragraphs, stage 3 proposals are highlighted in underlined, italic type.*

d) Stage 4; this stage would implement further revisions to the standards that have been set in Stages 1 and 2. It would be implemented no sooner than 5 years after the second phase of the Stage 1 implementation. *In the following paragraphs, stage 4 proposals are highlighted in italic type.*

5. It may be that Stages 3 and 4 are implemented together. However, for the purpose of this document they are identified separately.

6. With this approach, other than the case where interim measures are introduced in stage 1A, it is proposed that no individual requirement will be changed at an interval of less than five years.

The 1998 consultation

7. Many of the ideas generated by the 1998 consultation have been taken up and included in the Stage 1 proposals. This paper highlights the current thinking amongst the Department's specialist staff, its contractors and advisors on the measures being considered for later stages. Consultees are invited to give their views on the benefit and appropriateness of these ideas, the direction in which they are being developed and alternative proposals that they feel may offer greater promise.

8. The 1998 consultation also identified a number of other approaches that hold promise of improving energy efficiency, but which cannot be pursued through Building Regulations alone. This second group of ideas could only be pursued through changes in other law and through voluntary and, for instance, grant-aided schemes. These ideas have been drawn to the attention of the relevant divisions within DETR and the Treasury. Further thinking on these ideas has taken place, and the progress is discussed in paragraph 59 et seq below. Consultees' views on how these suggestions could be successfully, and perhaps more swiftly, pursued would also be welcomed.

Measures for the building envelope

Window performance standards

9. For the proposed Stage 1 amendment, the required performance of windows is primarily in terms of window U-value with a general indication that they should be draught-stripped. Windows are a means of providing beneficial solar heat gain in winter, and the use of an elemental U-value does not recognise this benefit. *Consequently, from Stage 2, it is thought that the approved guidance could incorporate the proposed domestic window energy-rating scheme as the base performance measure.* This is a composite measure that recognises heat gains and losses via conduction, solar gain and air leakage.

10. For non-domestic buildings, there is no corresponding window energy rating system in prospect. This is because of the greater complexity of the energy balance in such buildings, where daylight and cooling to control unwanted solar gain are additional issues.

Thermal bridging

11. In the prospective Stage 1 amendment, the effects of thermal bridging at junctions and openings are recognised in qualitative terms only, through encouraging the use of proven standard details. A linear transmittance concept is being developed as a way of quantifying the effect of heat loss at junctions. *We think that from Stage 2, this concept (as described in BS EN ISO 14683) could beneficially be used to quantify the effects of thermal bridges.* This approach is thought to be necessary, because as general insulation standards improve, the importance of the thermal bridges becomes relatively much more significant.

Longer term insulation standards

12. The following table contains the indicative standards that have been suggested for stage 4 in comparison with the current proposals for Stage 1.

Longer term *indicative* standards for fabric insulation

	Stage 1		Stage 4 (after another 5 years or so)
	T[1]	T + 18 mths	
	U-Values W/m²K		
Roof (insulated between/over joists): all sectors	0.20	0.16	0.16
Roof (integral insulation in roof structure): dwellings	0.25	0.20	0.16
Roof (integral insulation in roof structure): non-domestic	0.35	0.25	0.16
External walls	0.35	0.30	0.25
Ground floors	0.30	0.25	0.22
Average of all windows, doors and rooflights	2.2	2.0	1.8

[1] T is the date when the new Approved Document L comes into effect.

13. These standards are already achievable in practice, since they have been demonstrated in this and in other countries. Changes in design and construction practice will need to be made (along with the attendant training commitments) to achieve the cost reductions that will allow such standards to become routine practice. However the advance notice gives industry time to prepare for such changes.

14. A particular point should be noted in respect of roof standards. Currently, and as proposed for Stage 1, the standard for roofs where the insulation is at rafter level is less demanding than where the insulation is between/over the joists. *The current thinking is that there should be a progressive move toward roof standards that result in equivalent rates of heat loss wherever the insulation is placed*. Such a change has not been thought practical for Stage 1 because the technical solutions are not yet in place to achieve U-values of $0.2W/m^2K$ or better.

Improved correlation between calculated and actual performance

15. *Another idea being explored for Stage 4 is to make the envelope standards more demanding, unless there is a clear commitment to quality control procedures in the construction process*. This approach is used in Germany and Sweden as a way of ensuring better correlation between calculated and actual performance. The main concern with this approach is the demands it places on the building control body to check that the promised procedures are actually carried out in practice. However, one readily identifiable distinction could be between site construction and pre-fabrication, whereby the elemental standard for a construction element that is totally factory fabricated might be less demanding than that required for on-site construction.

Target U-value for dwellings

16. *For Stage 2 it has been suggested that the guidance on what is reasonable provision should be based on the Target U-value method rather than the Elemental Method.* The reasons for this suggestion are –

    a) It allows much greater design flexibility for trade-off between construction elements.

    b) It avoids the somewhat arbitrary cut-offs at specific numerical values in the elemental method that in turn can be inconsistent with the dimensions of insulation layers in practical construction.

    c) It would eliminate the complication of having to set elemental linear thermal transmittances (see paragraph 11 above), although model combinations of elements that meet the standard could be given for reference.

17. The Target U-value formulation would have to be developed to handle the beneficial solar gain from windows in a way that is consistent with the Domestic Window Energy Rating scheme (see paragraph 9 above).

18. A deficiency with both the Elemental and Target U-value Methods is that whilst they control the heat loss through the fabric, they do not address the influence of size or shape on energy efficiency. *Consequently a further refinement being considered for Stage 4 is that buildings should meet both an overall envelope insulation standard and a carbon emissions index*.

Airtightness

19. In the Stage 1 proposals, an airtightness standard has been defined (an air leakage index of 10 $m^3/hr.m^2$ at 50 Pa), for both dwellings and the non-domestic stock. However, mandatory performance testing is only being proposed for buildings other than dwellings. This is not to say that there would not be a benefit in mandatory testing for dwellings (in the stage 1 proposals, it is an optional way of demonstrating compliance). However, it is clear that the testing of every new dwelling is impractical, and so more consideration needs to be given to a sampling protocol, and to establishing sensible procedures in the event of dwellings failing the test. ***Consequently, mandatory airtightness testing of dwelling samples is being considered as a Stage 2 measure***.

20. In the Stage 1 proposals the guidance indicates that windows should be weather-stripped. It is thought that more specific, quantitative guidance could be appropriate once the new European Standard is published. ***This will be considered for Stage 2 amendments, but a separate requirement may be unnecessary for dwellings if the window energy-rating scheme is adopted (see paragraph 9)***.

21. *In the longer term, it is proposed that the airtightness standard for non-domestic buildings be progressively reduced from the currently proposed 10 $m^3/hr.m^2$ at 50 Pa to 5 in Stage 4 and then perhaps to 3 a further five years or so after that*.

22. The situation with regard to dwellings is less clear, since many houses rely on adventitious ventilation to meet the fresh air requirements. If the airtightness standard is enhanced in dwellings, more effort will be required to provide specific ventilation openings and/or whole house mechanical ventilation. Such provision should mean that the ventilation is more controlled, but the robustness and cost effectiveness of this approach in the housing sector needs more detailed consideration. *Air leakage standards for dwellings in stage 4 and beyond have therefore to be considered in more detail*.

Control of Overheating

23. The Stage 1 proposals contain the first ideas for control of overheating in respect of non-domestic buildings. ***For Stage 2, we are looking at ideas to control overheating in dwellings***. This may be increasingly important as insulation standards improve, both in terms of avoiding discomfort and a possible increased demand for domestic air conditioning.

24. ***Specifically, an approach to limiting overheating in dwellings (as already adopted in Germany) is being explored for its potential application to dwellings in the UK***. This approach limits the “effective solar aperture” on each façade to a given percentage of the total façade area. The effective solar aperture is the product of total solar heat gain coefficient of the glazing, the shading factor and the fenestration ratio.

25. Because of the variation in effective thermal capacity of the different construction methods used in the UK, an additional factor reflecting this characteristic may be required for effective application of the overheating criteria in the UK.

Measures relating to building services

26. The Stage 1 proposals introduce requirements such that most building services work in dwellings and non-domestic buildings is covered by the requirements of the Regulations. Some refinements of these requirements are being considered, as well as a continuing improvement of the standards.

Sizing of heating systems

27. There is a general concern across all sectors that boiler plant is often substantially oversized. *For Stage 2, consideration will be given to whether or not it is appropriate to include guidance limiting boiler sizing.*

   a) In the dwellings sector, consideration will need to be given to the fact that the output of a single specific boiler can be “field-adjusted” across quite a wide range. This issue could be picked up as part of the commissioning requirements.

   b) In the non-domestic sector, the issue of multiple boilers including redundancy to ensure continuous availability would need to be addressed, probably through controls provisions.

28. It is recognised that as insulation and airtightness standards improve, and especially in buildings with high thermal capacity, low levels of continuous heating may become the preferred heating strategy. This will need to be reflected in the control requirements.

Heating system efficiencies for dwellings

29. Improvement in the standard of heating system efficiency is seen as particularly important in the context of improving the existing stock. Boiler replacements will become a material alteration if the Stage 1 proposals are accepted. Because boiler replacement is a relatively frequent improvement (~15 years), a significant increase in the required standard of boiler efficiency will deliver substantial cost effective energy/CO_2 reductions, even without any fabric improvements.

30. An issue of concern is the efficiency of secondary heating appliances. Appliance efficiency may be very low, but because of their decorative features may be used for more hours than the central heating system. Also, as insulation standards improve (as proposed in the Stage 1 proposals and the Stage 4 thinking), conventional central heating may become unnecessary, but the benefits of better fabric insulation could be lost if this resulted in the use of low efficiency heating appliances. *We are considering how the present regulatory controls on dwelling space heating might best be widened to address primary and secondary use room heaters as well as central heating systems as part of the Stage 2 work.* Whether the issue can best be pursued through Building Regulations or through some form of appliance performance legislation is also a moot point.

31. The current guidance concentrates on systems for individual dwellings. It is recognised that group heating for blocks of flats etc may become more common. *Consequently, the preparation of additional guidance on heating and HWS provision for flats is being considered for Stage 2.*

32. The Stage 1 proposals base the requirement for dwellings on a reference gas-fired boiler of SEDBUK efficiency of 75% (1A) and 78% (1B). The use of other fuels requires either higher efficiency boilers or/and improved insulation standards to make some compensation for their higher carbon emissions. *For the stage 4 revision it may be appropriate to raise the standard by making the reference a gas boiler with a performance at the lower end of the condensing boiler range, i.e. about 83%.*

33. The concept of recognising the differing carbon impact by requiring higher efficiency systems and/or better insulation standards for less efficient fuels has been proposed for Stage 1. The impact on other fuels of the improved standards suggested in the paragraph above would need to be considered carefully when making the Stage 4 amendments.

Hot water service provision in dwellings

34. The Stage 1 proposals continue to concentrate on HWS systems with storage vessels that are served by the central heating boiler. *For Stage 2, we are considering widening the approved guidance to cover other systems, either within the Approved Document itself, or by reference to other appropriate publications.* Increasingly, hot water is being supplied by instantaneous systems (e.g. combi-boilers and multi-point water heaters). With the proposed longer-term development in the envelope insulation standards, the space heating demand may be significantly less than that for the HWS. It may therefore become more common to separate the heating and HWS functions. The use of solar water heating may also become more widespread, as it will offer additional design flexibility for builders to meet the overall carbon emissions standard.

35. *The guidance on pipework insulation will also be reviewed for the Stage 2 amendments.* In particular, the Stage 1 proposals continue to say that heating system pipework inside the insulated envelope of the building does not require insulation. This presupposes that the heat emitted by these pipes is useful in heating the building, which may not be the case.

Combined Heat and Power

36. *For stage 2, we are considering how best to further recognise the environmental benefits of CHP.* In terms of estimating carbon emissions from CHP, one approach would be to calculate the carbon emissions from the fuel burned and reduce this by the amount of carbon that would have been generated by the grid supplied electricity that has been displaced. This approach has been included in the Stage 1 proposals, but it can overestimate the environmental benefit. This is because in some circumstances, CHP is used to generate electricity because of the available tariffs, and the heat generated is "dumped" to atmosphere. In such situations, the CHP-generated electricity may have a higher carbon impact than grid electricity.

37. One approach to this problem might be to always require schemes utilising CHP to demonstrate compliance using a carbon emissions method. This would have to assume a particular way of operating the CHP, a way that may not be utilised in practice. Another alternative might be to down-rate the assumed efficiency of CHP if generation with heat rejection to atmosphere is part of the scheme.

Humidity control

38. Some concerns have been expressed over the health implications of extreme levels of humidity in buildings (both too low and too high). Humidification and especially de-humidification can be energy intensive processes. *For Stage 4, more consideration is needed to determine whether and how humidity control might be brought within the scope of the legal technical requirements*.

Commissioning and on-going operations

39. In the Stage 1 proposals, a start is made at using the Regulations to improve the operation of buildings (as opposed to just their construction). The proposals are intended to ensure that the building is set to operate according to the design intent, and that control, monitoring and maintenance instructions are provided to facilitate effective use. The way this information might be integrated with the Health and Safety file required by the CDM Regulations is also being explored.

40. Many consultees who responded to the initial round of consultations in 1998 suggested that sanctions should be applied if initial commissioning is not be carried out satisfactorily. The Building Act 1984 does not give powers to make such regulations, but we feel that these issues should be addressed when the Act is reviewed. *We are therefore considering as a Stage 3 item that a building should not be occupied until the work has been certified as fully compliant with the requirements for the commissioning plan and provision of information*.

41. ***For the Stage 2 amendment we are investigating ways in which the regulations might require the improvement of operating efficiency during building occupation and use.*** The powers available in the Building Act 1984 enable making regulations that require tests and/or the making of reports. There is no power to require improvement work to be done if those tests or reports show the building to be energy inefficient. This matter could be addressed when the Building Act 1984 is reviewed, but in the meantime two approaches are being considered as follows-

Regular tests and reporting

42. *For stage 2, the Regulations might require regular tests to be carried and reports to be made (the "MoT test"),* with the results being put into the public domain. This could create a market incentive as the result of public pressure for organisations to improve, especially if league tables were produced showing the worst offenders in each sector. Plant inspections are already a regular feature of building operation (e.g. for lifts, pressure vessels etc). Although these are carried out on Health and Safety grounds, it is felt that there would be a consensus in favour of implementing similar requirements for energy efficiency reasons.

43. It is thought that proposals could be developed requiring testing and the recording of operating performance data together with investment programmes for improvement. Any action taken as a result of such advice and which involved replacement plant or equipment would then be picked up under the "material alteration" provision.

44. We currently envisage that implementation should be limited in the first instance to larger buildings, since figures suggest that 43% of the energy is used in the 2% of the buildings that have more than 2,500 m^2 of floor area. It is also thought that testing and reporting should be pragmatically limited to those systems where checking is relatively straightforward (boiler efficiency, insulation of pipework, lighting systems). The size of building and the systems checked could be extended with time as knowledge and experience with the approach grew.

45. If this approach were to be adopted, there is the question as to who should receive and analyse these reports. This has been the role of the Local Authority, but there is an argument that it would be better to utilise some central agency to receive, analyse and publish the data (perhaps in a way similar to the RICS BCIS system). With such data available, an agency would be able to improve the quality and robustness of the supporting data (e.g. the non-domestic energy fact file) and the national benchmarks (such as ECON 19).

Legal issues relating to regular tests and reporting

46. Regular testing of the performance of buildings and their heating, ventilation and air conditioning (HVAC) and lighting systems may require that Section 33 of the Building Act be put into effect. *The powers in section 2(2)(b) of the Act may not allow inspection as to use (as opposed to design and construction), and an amendment may therefore be needed which would mean that this matter would have to be deferred to Stage 3.*

47. The current Regulations allow inspection work to be carried out by Approved Inspectors, but enforcement can only be carried out by the Local Authority. The consensus coming from the 1998 consultation was that measures would be impractical unless there were approved competent persons who could self-certify compliance. ***This would require the provisions for inspection work to be broadened. This is being investigated for implementation as a Stage 2 measure,*** *but if this proves impossible, it will be considered as part of review of the Building Act in Stage 3.*

Performance targets

48. It would be impractical to define non-acceptable plant conditions for each and every possible system configuration with every possible building use. ***Consequently, it has been suggested that from Stage 2, satisfactory operating performance be defined through performance targets in terms of carbon emissions.***

49. These performance targets could be:

   a) based on national benchmarks for each sector (adjusted as necessary for annual variations in climate and usage patterns), or

   b) the previous year's performance for the building in question.

50. The combination of these two possibilities is probably the most sensible scenario, i.e. a system where building users would have to show continuous improvement on previous year's performance until within the benchmark.

51. The benchmark could be some performance percentile of the national stock for the building type. The disadvantage of this is that it does not discriminate between a poor building being operated extremely well and a good building being managed inefficiently. For example, it should be expected that an office building constructed to the proposed Stage 1 standards should consume considerably less energy than a 1960s office building. A single office benchmark like ECON19 does not recognise this distinction. Therefore, a building specific benchmark may be more appropriate. This could be achieved by normalising the actual performance to the building specific Carbon Performance Index introduced in the Stage 1 proposals.

52. The other main question is how to deal with non-compliance with such requirements. The powers available under Stage 2 are likely to be limited to requiring the preparation of reports. ***Therefore, one approach being considered for Stage 2 is to require that a building failing to meet the target has a detailed energy survey carried out. This would identify the areas of wastage and propose an action plan for improvement.*** This would present the building owner with a cost, but would identify the means through which those costs could be recouped quite quickly. There would be more carrot than stick with this approach.

53. The Energy Assessment and Reporting Method (EARM) described in the Chartered Institution of Building Services Engineers (CIBSE) Technical Memorandum TM22 provides for a series of hierarchical surveys, each level giving more and more information on performance. ***The Stage 2 requirements might be arranged such that when a building fails, this triggers a requirement for a given level of EARM survey. If the following year there is no improvement and the building again fails to meet the target, then the next, more detailed EARM survey would be required.*** Thus the building owner's costs would escalate and this should provide the incentive to bring energy use under control.

54. There was a general feeling amongst previous consultees that to be fully effective, inspection must have "teeth" to require faults and disrepair to be rectified. *To achieve this power would require amendment to the Building Act 1984 itself, and so will be considered as part of the Stage 3 amendments*. The ultimate sanction might be a withdrawal of a licence to operate the building, but this may be thought to be rather draconian. However, it has been suggested that this final sanction would only apply if after (say) three successive years of non-compliance with the procedures.

Improvements to the existing stock

55. It is clear that in order to achieve significant reductions in carbon dioxide emissions, improvements must be made to the existing building stock. Grant schemes, encouragement and exhortation have made some impact, but the reduction in the real cost of energy has meant that energy efficiency continues to receive scant consumer attention. The 1998 consultation showed that there was considerable support for Building Regulations to require improvement. However, there are a number of difficulties, including how to identify times at which the requirements might be imposed upon a building owner, and determination of what would be a reasonable improvement.

56. The proposals for the Stage 1 amendment included widening the definition of material alteration to include any work covered by Part L. However, this proposal can only apply to work that owners propose to undertake for themselves. *A requirement demanding improvement would need new powers in the Building Act, and is therefore being considered as part of Stage 3.* It is thought that such an approach might be acceptable in non-domestic buildings, but would be far less so for dwellings. An alternative approach for dwellings, involving a possible initiative much wider than Building Regulations, is presented at paragraphs 65 to 67 below.

57. The consensus from a special workshop on trigger points for non-domestic buildings was that some progressive improvements to existing buildings could be required. The main suggestion was not to be too ambitious, especially in the initial stages of implementation. *The most favoured "trigger" and therefore the one being investigated for Stage 3 is a change of occupancy in whole or part of the building (either as a tenant or owner-occupier).* This would mean that the space being newly occupied would be being re-organised. Therefore any disruption caused by introducing energy efficiency measures would be minimised. The way such an improvement could be required needs more investigation, but it would need a change to the Building Act and so cannot be considered before Stage 3.

58. It is suggested that initially at least, the proposals should only address larger buildings (say over 2,000m^2). In large multi-tenanted buildings, it would be impractical to require improvements to central plant when a single tenant changed, and so the focus should probably be on terminal equipment. Lighting improvement is seen as the most likely first candidate (ECON 19 shows that lighting amounts to between 15-25% of CO_2 emissions in typical office buildings). Additional sub-metering might also be required, in order that the occupier could pay for energy used, rather than as an element of a general service charge.

Other possible initiatives

59. Changes to the energy efficiency requirements of the Building Regulations are only one way of improving energy efficiency in the building sector. The 1998 consultation identified a number of other possible initiatives that could help lever improvement, and these were given considerable endorsement by consultees. In some cases, the idea impacts on other parts of the regulations and so cannot be considered in isolation by the Part L review alone. In other cases, the ideas are not addressed by Building Regulations at all, but they are re-iterated here to stimulate further debate. Consultees are invited to comment on these ideas, and to add any additional suggestions.

Conservatories

60. The Department and others are becoming increasingly concerned over the way in which conservatories less than $30m^2$ floor area are exempted from all the requirements of the Regulations. To remove the exemption would impact on all parts of the Regulations, not just Part L. The implications of this are to be studied by a new BRAC Working Party that is expected to convene later this year. Our current thinking with regard to how Part L could be made applicable is summarised below.

61. Some control of their energy performance is exercised in the current Regulations where they are built as an integral part of a new dwelling, but there is a large demand for conservatory extensions. Market research shows conservatories are mainly purchased as extensions to living space and they are heated more often than not (frequently using electric heating). Conservatory heating can consume more energy than the rest of the house. An increasing proportion of conservatories is also being mechanically cooled in summer.

62. Experience shows conservatories are usually heated as a living space, and we feel that they should therefore be considered as part of the heated envelope of the building. North facing conservatories could be discouraged by demanding glazing performance standards that cannot be met without taking account of solar gain.

63. Considering the conservatory as part of the heated envelope would require compensating improvements in the standards of insulation in other elements of the house such that the overall dwelling achieved an appropriate standard. This could be demonstrated using the Target U-value or carbon index approach:

a) If the conservatory is built as an integral part of a new house, then the average U-value of the house including conservatory would have to meet the target U-value standard defined in the Approved Document L.

b) If the conservatory is added subsequently as a material alteration, the new dwelling would have to meet a standard that was no worse in average U-value or Carbon Index terms than the unextended dwelling.

Improvements to the existing housing stock

64. The main impediments to improvement are seen as persuading house owners to improve their property and the additional burden any requirement would impose on building control departments and approved inspectors. A strong consensus emerged from a special workshop of consultees held to discuss this issue. They proposed that energy efficiency measures should be more closely linked with the “Sellers Pack” initiative, and that the Government should consider the possibilities for more financial incentives like the condensing boiler cash-back scheme.

65. The consultees suggested that having in Approved Document L a list of appropriate energy efficiency upgrades that could be applied cost-effectively to existing dwellings could make the link to the Building Regulations. It was suggested that the list should include adequate insulation to the loft, weather stripping and cavity wall insulation, replacement boiler and central heating controls, cylinder jacket and external pipework insulation. The

Department has taken the view that such a special list would be inappropriate in Approved Document L and the information is already being made known to the public by the Energy Efficiency Best Practice Programme. However the changes to the definition of building work proposed in Part 2 of this consultation document mean that, if householders propose such works then the performance standards in the proposed new edition of Approved Document L would apply.

66. In October 1999 Ministers announced proposals to require any person marketing a home to provide a pack of standard information and documents for prospective buyers. This will require a change in the law and the necessary legislation will be introduced at the earliest possible opportunity. The Department has proposed that the pack will include an energy rating calculated in accordance with the Standard Assessment Procedure (SAP). This will provide an effective means of getting important information to prospective home buyers early in the process. The Pack, including the energy rating, is currently being piloted in Bristol.

67. The practical difficulties of enforcement suggest that requiring improvement on the change of individual tenants is unrealistic. Previous consultees thought that the best option would be to require Local Authorities and Housing Associations to have formal improvement plans as part of their HECA strategy. Private landlords could probably only be influenced by the change of owner requirements (see above) and by on-going requirements.

Energy efficiency issues and planning

68. The earliest stages of a project, when site location, orientation, building form and infrastructure planning are being established are often the most important as far as getting the fundamentals of energy efficiency in place. DETR Planning Directorate have been invited to consider the opportunities for influencing energy efficiency through planning.

Removing Crown and Statutory Undertaker exemptions

69. Crown buildings conform to Building Regulations as a matter of policy, although there is no statutory obligation on the Crown to comply with them. Such an obligation could be created through implementing Section 44 of the Building Act 1984. Previous consultees have suggested that by implementing this Section Government would show the lead and encourage better practice from the industry. This is currently being considered. It has been suggested that the Government should adopt the Best Practice Standards published by BRECSU for the Department.

70. Several Statutory Undertakers still benefit from exemption from the requirements of the Building Regulations, as a result of Section 4 of the Building Act 1984. Again it has been suggested that it would set a good example to others if Statutory Undertakers would take a lead in demonstrating good practice, and part of this would be being statutorily obliged to comply with the Building Regulations. It is recognised however that primary legislation would be required to achieve this.

Encouraging the use of Best Practice standards

71. Previous consultees have suggested that BRECSU disseminating activities should be intensified and that the Government should look for other ways such as grant and cash-back schemes to encourage the adoption of these practices. Some have suggested that Approved Document L should identify what are currently regarded as Best Practice standards as well as conveying what are considered to be reasonable standards for compliance with the legal requirements. The higher standards might be those that could be anticipated for the next major revision of the requirements. The Department and BRAC have ruled out this suggestion as being inconsistent with the aims of the Approved Document system. However it has been agreed that the Department should indicate its view of what standards could apply in the future and paragraph 12 above does this.

Reducing the period for the validity of approvals

72. Building Regulations approval is given at time of application, and does not lapse provided certain work has begun within 3 years of the approval being granted (See Part 2 of this consultation document). This can result in a time lag in the effective application of new standards, which many people regard as an undesirable situation. One suggestion was that work should be required to be completed within (say) three years of approval being granted. Failing this, the design would have to be re-submitted to demonstrate compliance with the then current requirements. Sensible lead-in times and short overlaps between the applicability of different standards would be a necessary part of this approach. Such a change would have implications for all aspects of the regulations, not just those standards covered by Part L. These wider implications would therefore need to be considered.

PART 6

Response form for Consultees' use

Note: This form is also available on the DETR website at www.construction.detr.gov.uk/br/br05g.htm

Leave blank for BR Ref:

Response form for the consultation on the **proposals to amend the building regulations provisions for energy performance.**

Respondent Details	Please return by **29/09/00** to:
Name: **Organisation:** **Address:** **Town/City:** **County/Postcode:** **Telephone:** **Fax:** **E-mail:**	Mrs Carol Overnell BRE Bucknalls Lane WATFORD WD2 7JR **Fax:** 01 923 664 995 **E-mail:** partl@BRE.co.uk

Is your response confidential?	**Yes:**	**No:**

Guidance on completing the response form

In order to facilitate the analysis of replies, it is important that everyone uses the response sheet in a consistent way, especially in the use of the AGREE/DISAGREE boxes.

Tick the AGREE box if you
a) agree with the proposal as detailed in the consultation package, OR

b) agree with the principle behind the proposal, but feel the standard proposed is not demanding enough. In this case, it would be helpful to explain how and why you think the standard should be improved.

Tick the DISAGREE box if you
a) disagree with the proposal as detailed in the consultation package both in the principle and the detail. Please explain why you feel the principle is wrong. OR

b) agree with the principle, but feel the proposed standard is too demanding. In this case, explain why you feel the standard is too demanding. In this case it would be helpful to explain why you think the standard is too demanding and if you gave details of a standard you feel would be acceptable.

This guidance on how to vote is summarised in the table at the bottom of each page of the response form like this:–

Principle	**Proposed standard**	**Response required**	**Comment required**
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

The requirements and general guidance

0.1). The definition of what constitutes a "material alteration" should include matters relating to Part L.

Agree:	Disagree:	No View:

Comments:

0.2). Separate Approved Documents should be published: one for dwellings, the other for buildings other than dwellings.

Agree:	Disagree:	No View:

Comments:

0.3). New requirements for dwellings should be introduced covering a) lighting systems, b) commissioning and c) the provision of information.

Agree:	Disagree:	No View:
a) b) c)	a) b) c)	a) b) c)

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

0.4). New requirements for buildings other than dwellings should be introduced covering a) limiting exposure to solar overheating, b) air conditioning and mechanical ventilation, c) testing the compliance of building work, d) commissioning and e) the provision of information.

Agree:	**Disagree:**	**No View:**
a) b) c) d) e)	**a) b) c) d) e)**	**a) b) c) d) e)**

Comments:

0.5). U-values should be calculated using the new European Standard methods for determining thermal conductivities and transmittances as described in paragraph 0.18 in the draft Approved Document rather than the current methods.

Agree:	**Disagree:**	**No View:**

Comments:

Questions relating to the dwellings section in the draft Approved Document

1.1). The U-value performance standards should be improved in two phases: a) the interim provisions applying when the Approved Document comes into effect and b) the full provisions coming into effect 18 months later as detailed in Table 1.

Agree:	**Disagree:**	**No View:**
a) b)	**a) b)**	**a) b)**

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

1.2). The U-value performance standards should depend on the efficiency of the chosen heating system as proposed in Table 1.

Agree:	Disagree:	No View:

Comments:

1.3). Minimum boiler SEDBUK efficiencies should be included in the Elemental Method as proposed in Table 2.

Agree:	Disagree:	No View:

Comments:

1.4). With effect from 18 months after the Approved Document comes into effect, minimum boiler efficiencies should be increased along with the U-values as proposed in Table 2.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

1.5). When using the calculation methods, the trade-off between insulation standards and heating system efficiency should be less than that allowed between different parts of the envelope as proposed in Table 4.

Agree:	Disagree:	No View:

Comments:

1.6). The design and constructional practice proposals for limiting thermal bridging and infiltration will achieve acceptable performance.

Agree:	Disagree:	No View:

Comments:

1.7). There should be separately timed circuits for the provision of space heating and hot water services.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

1.8). A room thermostat (or other device such as a flow switch) should be provided in systems with TRVs to switch off the boiler and pump when there is no demand for heat or hot water.

Agree:	**Disagree:**	**No View:**

Comments:

1.9). The proposals for determining a reasonable number of fittings that only take lamps with a luminous efficacy of more than 40lumen/W are acceptable as a practical way of improving lighting energy efficiency.

Agree:	**Disagree:**	**No View:**

Comments:

Questions relating to the non-domestic buildings sections in the draft Approved Document

2.1). The standard U-values should be improved in two phases: a) the interim provisions applying when the Approved Document comes into effect and b) the full provisions coming into effect 18 months later as detailed in Table 2.1.

Agree: **a) b)**	**Disagree:** **a) b)**	**No View:** **a) b)**

Comments:

Principle	**Proposed standard**	**Response required**	**Comment required**
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

2.2). Air leakage should be controlled through the introduction of a maximum air leakage index of $10m^3/hr/m^2$ at 50Pa.

Agree:	Disagree:	No View:

Comments:

2.3). The proposed guidance on avoiding solar overheating will be an acceptable practical way of showing compliance.

Agree:	Disagree:	No View:

Comments:

2.4). The proposed minimum heating system efficiency standards should be introduced.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

2.5). For buildings with electric space heating systems (other than heat pump systems with seasonal CoP>1.7), it is reasonable to indicate that the Whole Building Carbon Index or Carbon Emissions Calculation methods or some other acceptable method should be used to demonstrate compliance.

Agree:	**Disagree:**	**No View:**

Comments:

2.6). It is appropriate to credit all of the carbon savings from a CHP engine to the heating system.

Agree:	**Disagree:**	**No View:**

Comments:

2.7). The facility to reduce fabric standards through the use of high efficiency systems should be limited by more stringent limiting U-values as indicated in Table 2.6.

Agree:	**Disagree:**	**No View:**

Comments:

Principle	**Proposed standard**	**Response required**	**Comment required**
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

2.8). In office, industrial and storage buildings, lighting standards should be based on the proposed combined efficacy of the lamp/luminaire combination.

Agree:	Disagree:	No View:

Comments:

2.9). It should be demonstrated that a luminaire is in a daylit space if credit for daylight linked controls is taken when calculating the average luminaire-lumens per circuit-watt.

Agree:	Disagree:	No View:

Comments:

2.10). It is appropriate to include a control factor for presence detection, even though this is more a function of the use of the spaces within the building than of the building itself.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

2.11). A minimum lamp efficacy of 15 lumens/W is an appropriate standard for display lighting (typically allowing tungsten halogen but not ordinary tungsten lamps).

Agree:	**Disagree:**	**No View:**

Comments:

2.12). The proposed Carbon Performance Index is an appropriate measure of the efficiency of ACMV buildings for regulations purposes.

Agree:	**Disagree:**	**No View:**

Comments:

2.13). The proposed pass scores for ACMV buildings, based on the median of the 1998 ECON19 data, are appropriate performance standards for the purposes of the Building Regulations.

Agree:	**Disagree:**	**No View:**

Comments:

2.14). The proposed guidance on building envelope testing is a worthwhile and practically enforceable way of achieving reasonable energy performance.

Agree:	**Disagree:**	**No View:**

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

2.15). The proposed guidance on commissioning plans and reports is a worthwhile and practically enforceable way of achieving reasonable energy performance.

Agree:	Disagree:	No View:

Comments:

2.16). The proposed guidance on the supply to building occupiers of As Built and As Installed records and operating performance data is worthwhile and practically enforceable.

Agree:	Disagree:	No View:

Comments:

2.17). The proposals regarding the installation of energy meters are worthwhile and practically enforceable.

Agree:	Disagree:	No View:

Comments:

Principle	**Proposed standard**	**Response required**	**Comment required**
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

2.18). It is worthwhile and practically enforceable to widen the definition of what constitutes a "material alteration" to include matters covered by Part L.

Agree:	**Disagree:**	**No View:**

Comments:

Questions on the Regulatory Impact Assessment in Part 1 of this consultation document

3.1). The Treasury's recommended 6% discount rate is appropriate when assessing the net present value of energy saving measures that have service lives of between 20 and 60 years.

Agree:	**Disagree:**	**No View:**

Comments:

3.2). Estimates of carbon saving from reduced electricity use should be based on the projected average carbon emission factor for the period 2000 to 2020.

Agree:	**Disagree:**	**No View:**

Comments:

Principle	**Proposed standard**	**Response required**	**Comment required**
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

3.3). The assumed dwelling types used in the analysis are a reasonable representation of the likely new build activity.

Agree:	Disagree:	No View:

Comments:

3.4). The assumptions used to calculate the carbon savings from a) boiler and b) window replacements in existing dwellings are reasonable and do not include double-counting of impacts from other energy saving initiatives

Agree:	Disagree:	No View:
a) b)	a) b)	a) b)

Comments:

3.5). The assumed non-domestic building categories used in the analysis are a reasonable representation of the likely new build activity.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

3.6). It is reasonable to assume that the marginal costs of new standards reduce to 40% of their initial value after the first year to reflect maturing markets for products and materials and increased workforce familiarity with working to the new standards.

Agree:	**Disagree:**	**No View:**

Comments:

3.7). The following fuel prices are reasonable for use in the cost effectiveness calculation Dwellings: gas 1.38 p/kWh, electricity 6.88p/kWh (on-peak) Non-domestic: gas 1.14 p/kWh, electricity 6.78p/kWh.

Agree:	**Disagree:**	**No View:**

Comments:

3.8). The following should be excluded from the cost effectiveness calculations, a) VAT and b) the cost of the climate change levy on fuels.

Agree:	**Disagree:**	**No View:**
a) b)	**a) b)**	**a) b)**

Comments:

Principle	**Proposed standard**	**Response required**	**Comment required**
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

3.9). Should a monetary value of carbon emission saving be included in the calculation of the benefit of energy efficiency measures as well as the fuel cost saving.

Agree:	Disagree:	No View:

Comments:

3.10). The packages of measures in Annex D are a realistic prediction of what builders would be likely to adopt.

Agree:	Disagree:	No View:

Comments:

3.11). The treatment of the consequential costs of installing additional levels of insulation in floors and walls is reasonable.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

Questions on Part 5 in the consultation document on possibilities for the future

4.1). The staged approach with the indications as to the likely evolution of requirements and standards is beneficial to industry.

Agree:	Disagree:	No View:

Comments:

4.2). An energy rating scheme that gives credit for beneficial solar gains as well as conduction losses is to be preferred to U-values as a measure of the energy impact of windows in dwellings.

Agree:	Disagree:	No View:

Comments:

4.3). The effect of thermal bridges and junctions around openings should be quantified by linear thermal transmittances, and included in the total heat loss from the building.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

4.4). Insulation standards should be further improved as part of a stage 4 revision about 5 years after Stage 1 is implemented.

Agree:	Disagree:	No View:

Comments:

4.5). The required insulation standard should be less demanding if there is a clear commitment to quality procedures in the construction process.

Agree:	Disagree:	No View:

Comments:

4.6). The Target U-value Method should become the means of establishing the reference performance standard for dwellings.

Agree:	Disagree:	No View:

Comments:

4.7). The size and shape of a building should be included in the assessment of energy efficiency, e.g. maximum carbon emissions per unit floor area should be required in addition to envelope insulation standards.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

4.8). Sample testing of airtightness in dwellings should be introduced at stage 2.

Agree:	**Disagree:**	**No View:**

Comments:

4.9). Air tightness standards in non-domestic buildings should be progressively tightened in Stages 2 and 4 and at other future revisions.

Agree:	**Disagree:**	**No View:**

Comments:

4.10). A requirement limiting the risk of overheating in dwellings should be introduced.

Agree:	**Disagree:**	**No View:**

Comments:

4.11). Guidance limiting the oversizing of heating equipment should be introduced.

Agree:	**Disagree:**	**No View:**

Comments:

Principle	**Proposed standard**	**Response required**	**Comment required**
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

4.12). Guidance should be introduced to cover the efficiency of primary and secondary-use room heaters.

Agree:	Disagree:	No View:

Comments:

4.13). Requirements covering energy efficient control of humidity should be introduced.

Agree:	Disagree:	No View:

Comments:

4.14). It should be illegal to occupy a building before commissioning has been completed satisfactorily.

Agree:	Disagree:	No View:

Comments:

4.15). The Building Act should be amended to enable requirements to be made for regular MoT tests of non-domestic buildings.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

4.16). The Building Act should be amended to enable requirements to be made for the measurement and reporting of building performance in use.

Agree:	Disagree:	No View:

Comments:

4.17). The Building Act should be amended to enable requirements obliging building owners to produce survey reports in the event of unacceptable correlation with energy performance benchmarks.

Agree:	Disagree:	No View:

Comments:

4.18). The Building Act should be amended to enable official removal of licences to occupy buildings in the event of continuing non-conformity with energy performance benchmarks.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

4.19). In non-domestic buildings, the most appropriate "trigger" at which to require improvement would be at change of occupancy (either of a separate tenancy, or the whole building).

Agree:	Disagree:	No View:

Comments:

4.20). Conservatories should be considered as part of the heated envelope and their exemption from the requirements should be removed.

Agree:	Disagree:	No View:

Comments:

4.21). For dwellings, an appropriate "trigger" at which improvement should be encouraged is change of owner. The encouragement would be enhanced by appropriate voluntary measures linked to the Sellers Pack.

Agree:	Disagree:	No View:

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

4.22). The opportunities for influencing energy efficiency through planning should be explored in more detail.

Agree:	**Disagree:**	**No View:**

Comments:

4.23). Organisations that benefit from Crown exemption and Statutory Undertakers should be encouraged to set Best Practice standards rather than complying with the guidance given in Approved Document L.

Agree:	**Disagree:**	**No View:**

Comments:

4.24). The Government should look for other ways, such as grant and cash-back schemes to encourage the take up of best practice.

Agree:	**Disagree:**	**No View:**

Comments:

4.25). The period of validity of approvals should be reduced to prevent construction to standards that have been superseded.

Agree:	**Disagree:**	**No View:**

Comments:

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

Leave blank for BR Ref:

Response form for the consultation on the
proposals to amend the building regulations provisions for energy performance.

Other Comments *(copy this page as necessary):*

Principle	Proposed standard	Response required	Comment required
Supported	Accepted	Agree	None
Supported	Not demanding enough	Agree	Suggest preferred standard and why
Supported	Too demanding	Disagree	Suggest preferred standard and why
Objected to	N/A	Disagree	Explain why proposal is inappropriate

APPENDIX A

Tables of U-values

Contents

TABLES

Building materials

Notes: The values in these tables have been derived using the combined method, taking into account the effects of thermal bridging where appropriate. Intermediate values can be obtained from the tables by linear interpolation. As an alternative to using these tables, the procedures in Appendices B and C can be used to obtain a more accurate calculation of the amount of insulation required.

The tabulated values take account of future European Standard data on insulation density, conductivity, gaps between batts and wall-tie materials and frequency where relevant.

EXAMPLE CALCULATIONS

Roofs

Walls

Ground floors

Windows, Doors and Rooflights

Full details about how to calculate the U-value of a window or door are given in BS EN ISO 10077-1. This Appendix provides indicative U-values for windows, rooflights and doors. Table A1 applies to windows (and rooflights) with wood or PVC-U frames. Table A2 applies to windows with metal frames, for which the adjustments (for thermal breaks and/or rooflights) in Table A3 should be applied.

The U-value of a window or rooflight containing low-E glazing is influenced by the emissivity, ε_n, of the low-E coating. Low-E coatings are of two principal types, known as 'hard' and 'soft'. Hard coatings generally have emissivities in the range 0.15 to 0.2, and the data for $\varepsilon_n = 0.2$ should be used for hard coatings, or if the glazing is stated to be low-E but the type of coating is not specified. Soft coatings generally have emissivities in the range 0.05 to 0.1. The data for $\varepsilon_n = 0.1$ should be used for a soft coating if the emissivity is not specified.

When available, manufacturers' certified U-values for windows, or rooflights or doors should be used in preference to the data given in these tables.

Table A1: **Indicative U-values (W/m^{2}K) for windows with wood or PVC-U frames**

	Gap between panes 6 mm	12 mm	16 mm or more	Adjustment or rooflights in dwellings[3]
Single glazing		4.8		+0.3
Double glazing (air filled)	3.1	2.8	2.7	↑
Double glazing (low-E, ε_n = 0.2)[1]	2.8	2.3	2.1	
Double glazing (low-E, ε_n = 0.1)	2.7	2.1	2.0	
Double glazing (low-E, ε_n = 0.05)	2.6	2.0	1.9	
Double glazing (argon filled)[2]	2.9	2.7	2.6	
Double glazing (low-E ε_n = 0.2, argon filled)	2.5	2.1	2.0	
Double glazing (low-E ε_n = 0.1, argon filled)	2.4	1.9	1.8	
Double glazing (low-E ε_n = 0.05, argon filled)	2.3	1.8	1.7	+0.2
Triple glazing	2.4	2.1	2.0	
Triple glazing (low-E, ε_n = 0.2)	2.1	1.7	1.6	
Triple glazing (low-E, ε_n = 0.1)	2.0	1.6	1.5	
Triple glazing (low-E, ε_n = 0.05)	2.0	1.5	1.4	
Triple glazing (argon filled)	2.2	2.0	2.0	
Triple glazing (low-E ε_n = 0.2, argon filled)	1.9	1.6	1.5	
Triple glazing (low-E ε_n = 0.1, argon filled)	1.8	1.5	1.4	
Triple glazing (low-E ε_n = 0.05, argon filled)	1.7	1.4	1.3	
Solid wooden door[4]		3.0		↓

1 The emissivities quoted are normal emissivities. (Corrected emissivity is used in the calculation of glazing U-values.) Uncoated glass is assumed to have a normal emissivity of 0.89.

2 The gas mixture is assumed to consist of 90% argon and 10% air.

3 No adjustment need be applied to rooflights in buildings other than dwellings.

4 For doors which are half-glazed the U-value of the door is the average of the appropriate window U-value and that of the non-glazed part of the door (e.g. 3.0 W/m^{2}K for a wooden door).

Table A2: **Indicative U-values (W/m²K) for windows with metal frames (4mm thermal break)**				
		Gap between panes		
		6 mm	**12 mm**	**16 mm or more**
Single glazing	5.7			
Double glazing (air filled)		3.7	3.4	3.3
Double glazing (low-E, ε_n = 0.2)		3.3	2.8	2.6
Double glazing (low-E, ε_n = 0.1)		3.2	2.6	2.5
Double glazing (low-E, ε_n = 0.05)		3.1	2.5	2.3
Double glazing (argon filled)		3.5	3.3	3.2
Double glazing (low-E, ε_n = 0.2,argon filled)		3.1	2.6	2.5
Double glazing (low-E, ε_n = 0.1, argon filled)		2.9	2.4	2.3
Double glazing (low-E, v = 0.05, argon filled)		2.8	2.3	2.1
Triple glazing		2.9	2.6	2.5
Triple glazing (low-E, ε_n = 0.2)		2.6	2.2	2.0
Triple glazing (low-E, ε_n = 0.1)		2.5	2.0	1.9
Triple glazing (low-E, ε_n = 0.05)		2.4	1.9	1.8
Triple glazing (argon-filled)		2.8	2.5	2.4
Triple glazing (low-E, ε_n = 0.2, argon filled)		2.4	2.0	1.9
Triple glazing (low-E, ε_n = 0.1, argon filled)		2.2	1.9	1.8
Triple glazing (low-E, ε_n = 0.05, argon filled)		2.2	1.8	1.7

For windows (or rooflights) with metal frames incorporating a thermal break other than 4 mm, the following adjustments should be made to the U-values given in Table A2.

Table A3: **Adjustments to U-values in Table A2 for frames with thermal breaks**		
	Adjustment to U-value (W/m²K)	
Thermal break (mm)	**Window or rooflight in building other than a dwelling**	**Rooflight in dwellings**
0 (no break)	+0.3	+0.7
4	+0.0	+0.3
8	–0.1	+0.2
12	–0.2	+0.1
16	–0.2	+0.1

Note: Where applicable adjustments for both thermal break and rooflight should be made. For intermediate thicknesses of thermal breaks, linear interpolation may be used.

Roofs

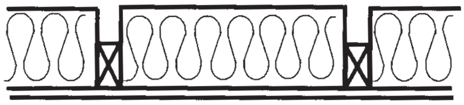


Table A4: Base thickness of insulation between ceiling joists or rafters

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	0.15	371	464	557	649	742	835	928
2	0.20	180	224	269	314	359	404	449
3	0.25	118	148	178	207	237	266	296
4	0.30	92	110	132	154	176	198	220
5	0.35	77	91	105	122	140	157	175
6	0.40	67	78	90	101	116	130	145

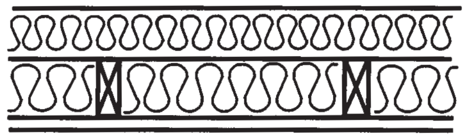


Table A5: Base thickness of insulation between and over ceiling joints or rafters

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	0.15	161	188	217	247	277	307	338
2	0.20	128	147	167	188	210	232	255
3	0.25	108	122	137	153	170	187	205
4	0.30	92	105	117	130	143	157	172
5	0.35	77	91	103	113	124	136	148
6	0.40	67	78	90	101	110	120	130

Note: Tables A4 and A5 are derived for roofs with the proportion of timber at 8%, corresponding to 48 mm wide timbers @ 600 mm centres, excluding noggings. For other proportions of timber the U-value can be calculated using the procedure in Appendix B.

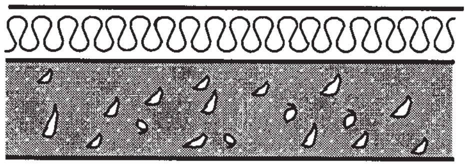


Table A6: Base thickness for continuous insulation

		Thermal conductivity of insulant (W/m·K)						
	Design U-value (W/m²K)	0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	0.15	131	163	196	228	261	294	326
2	0.20	97	122	146	170	194	219	243
3	0.25	77	97	116	135	154	174	193
4	0.30	64	80	96	112	128	144	160
5	0.35	54	68	82	95	109	122	136
6	0.40	47	59	71	83	94	106	118

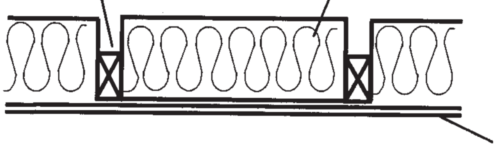
Table A7: Allowable reduction in thickness for common roof components

		Thermal conductivity of insulant (W/m·K)						
		0.020	0.025	0.030	0.035	0.040	0.045	0.050
	Concrete slab density (kg/m)	**Reduction in base thickness of insulating material for each 100mm of concrete slab**						
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1	600	10	13	15	18	20	23	25
2	800	7	9	11	13	14	16	18
3	1100	5	6	8	9	10	11	13
4	1300	4	5	6	7	8	9	10
5	1700	2	2	3	3	4	4	5
6	2100	1	2	2	2	3	3	3
	Other materials components	**Reduction in base thickness of insulating material (mm)**						
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
7	10mm plasterboard	1	2	2	2	3	3	3
8	13mm plasterboard	2	2	2	3	3	4	4
9	13mm sarking board	2	2	3	3	4	4	5
10	12mm calcium silicate liner board	1	2	2	2	3	3	4
11	Roof space (pitched)	4	5	6	7	8	9	10
12	Roof space (flat)	3	4	5	6	6	7	8
13	19mm roof tiles	0	1	1	1	1	1	1
14	19mm asphalt (or 3 layers of felt)	1	1	1	1	2	2	2
15	50mm screed	2	3	4	4	5	5	6

Example 1: Pitched roof with insulation between ceiling joists or between rafters

Determine the thickness of the insulation layer required to achieve a U-value of 0.20 W/m^{2}K if insulation is between the joists, and 0.25 W/m^{2}K if insulation is between the rafters.

For insulation placed between ceiling joists (U-value 0.20 W/m^{2}K)



Using Table Al:
From column D, row 2 of the table, the base thickness of insulation required is 269 mm.

The base thickness may be reduced by taking account of the other materials as follows:

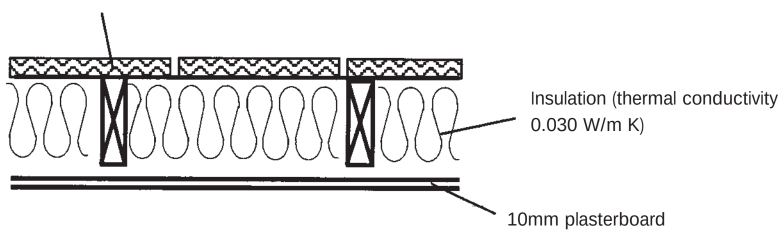
from Table A7:

19 mm roof tiles	column D, row 13	= 1 mm
Roofspace (pitched)	column D, row 11	= 6 mm
10 mm plasterboard	column D, row 7	= 2 mm
Total reduction		= 9 mm

The minimum thickness of the insulation layer between the ceiling joists required to achieve a U-value of 0.20 W/m^{2}K is therefore:

Base thickness less *total reduction* i.e. 269 – 9 = 260 mm.

For insulation placed between rafters (U-value 0.25 W/m²K)



Using Table Al:

From column D, row 4 in the table, the base thickness of insulation required is 178 mm.

The reductions in the base thickness are obtained as follows:

from Table A7:

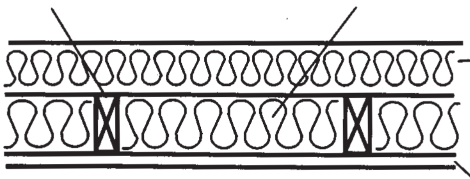
19 mm roof tiles	column D, row 13	= 1 mm
10 mm plasterboard	column D, row 7	= 2 mm
Total reduction		= 3 mm

The minimum thickness of the insulation layer between the rafters required to achieve a U-value of 0.35 W/m²K is therefore:

Base thickness less *total reduction* ie 178 – 3 = 175 mm.

Example 2: Pitched roof with insulation between and over ceiling joists

Determine the thickness of the insulation layer above the joists required to achieve a U-value of 0.20 W/m^2K for the roof construction shown below:



It is proposed to use mineral fibre insulation between and over the joists with a thermal conductivity of 0.04 W/m·K.

Using Table A5:

From column F, row 2 of the table, the base thickness of insulation layer = 210 mm.

The base thickness may be reduced by taking account of the other materials as follows:

from Table A7:

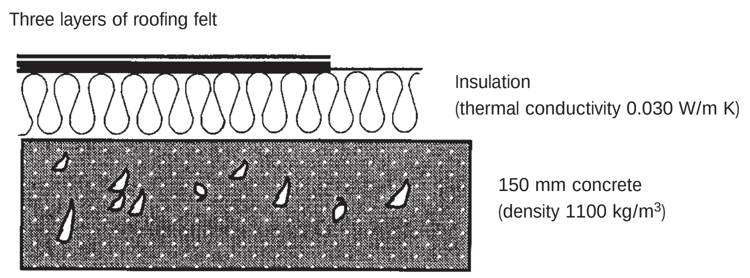
19 mm roof tiles	column F, row 13	= 1 mm
Roofspace (pitched)	column F, row 11	= 8 mm
10 mm plasterboard	column F, row 7	= 3 mm
Total reduction		= 12 mm

The minimum thickness of the insulation layer over the joists, required in addition to the 100 mm insulation between the joists, to achieve a U-value of 0.20 W/m^2K is therefore:

Base thickness less *total reduction* ie 210 – l00 – 12 = 98 mm.

Example 3: Concrete deck roof

Determine the thickness of the insulation layer required to achieve a U-value of 0.25 W/m^2K for the roof construction shown below.



Using Table A6:

From column D, row 3 of the table, the base thickness of the insulation layer is 116 mm.

The base thickness may be reduced by taking account of the other materials as follows:

from Table A7:

3 layers of felt	column D, row 14	= 1 mm
150 mm concrete deck	column D, row 3	
	adjusted for 150 mm thickness (1.5 x 8)	= 12 mm
Total reduction		= 13 mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.25 W/m^2K is therefore:

Base thickness less *total reduction* i.e. 116 – 13 = 103 mm.

Walls

Table A8: Base thickness of insulation layer

	Design U-value (W/m^2K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	0.20	97	121	145	169	193	217	242
2	0.25	77	96	115	134	153	172	192
3	0.30	63	79	95	111	127	142	158
4	0.35	54	67	81	94	107	121	134
5	0.40	47	58	70	82	93	105	117
6	0.45	41	51	62	72	82	92	103

Table A9: Allowable reductions in base thickness for common components

	Component	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Reduction in base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	Cavity (25 mm or more)	4	5	5	6	7	8	9
2	Outer leaf brick	3	3	4	5	5	6	6
3	13 mm plaster	1	1	1	1	1	1	1
4	13 mm lightweight plaster	2	2	2	3	3	4	4
5	9.5 mm plasterboard	1	2	2	2	3	3	3
6	12.5 mm plasterboard	2	2	2	3	3	4	4
7	Airspace behind plasterboard drylining	2	3	4	4	5	5	6
8	9 mm sheathing ply	1	2	2	2	3	3	3
9	20 mm cement render	1	1	1	1	2	2	2
10	13 mm tile hanging	0	0	0	1	1	1	1

Table A10: Allowable reductions in base thickness for concrete components

	Density (Kg/m^3)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Reduction in base thickness of insulation (mm) for each 100mm of concrete						
	A	B	C	D	E	F	G	H
Concrete inner leaf								
1	600	9	11	13	15	17	20	22
2	800	7	9	10	12	14	16	17
3	1000	5	6	8	9	10	11	13
4	1200	4	5	6	7	8	9	10
5	1400	3	4	5	6	7	8	8
6	1600	3	3	4	5	6	6	7
7	1800	2	2	3	3	4	4	4
8	2000	2	2	2	3	3	3	4
9	2400	1	1	2	2	2	2	3
Concrete outer leaf or single leaf wall								
10	600	8	11	13	15	17	19	21
11	800	7	9	10	12	14	15	17
12	1000	5	6	7	8	10	11	12
13	1200	4	5	6	7	8	9	10
14	1400	3	4	5	6	6	7	8
15	1600	3	3	4	5	5	6	7
16	1800	2	2	3	3	3	4	4
17	2000	1	2	2	3	3	3	4
18	2400	1	1	2	2	2	2	3

Table A11: Allowable reductions in base thickness for insulated timber framed walls

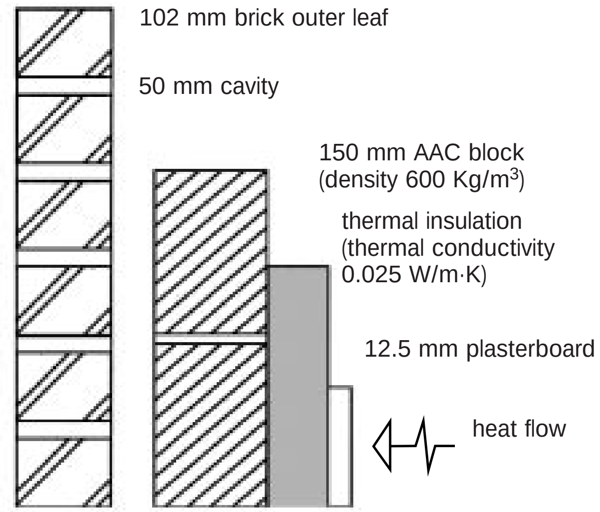
	Thermal conductivity of insulation within frame (W/m^{2}K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Reduction in base thickness of insulating material (mm) for each 100mm of frame (mm)						
	A	B	C	D	E	F	G	H
1	0.035	42	53	63	74	84	95	105
2	0.040	38	48	58	67	77	87	96

Note: The table is derived for walls for which the proportion of timber is 12%, which corresponds to 48 mm wide studs at 400 mm centres. For other proportions of timber the U-value can be calculated using the procedure in Appendix B.

Example 4: Masonry cavity wall with internal insulation

(For the buildings other than detached buildings, this construction may not provide adequate resistance to flanking sound transmission.)

Determine the thickness of the insulation layer required to achieve a U-value of 0.35 W/m^2K for the wall construction shown below.



Using Table A8:

From column C, row 4 of the table, the base thickness of the insulation layer is 67 mm.

The base thickness may be reduced by taking account of the other materials as follows: from Table A9:

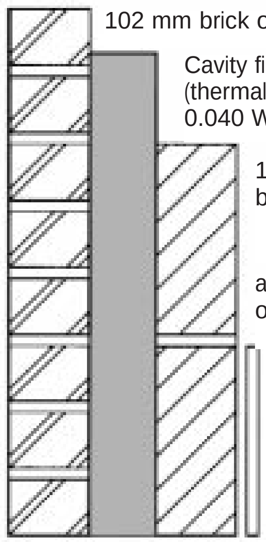
Brick outer leaf	column C, row 2	= 3 mm
Cavity	column C, row 1	= 5 mm
Plasterboard	column C, row 6	= 2 mm
And from table A10		
Concrete block	column C, row 1	
	adjusted for 150 mm block thickness (1.5 x 11)	
		= 17 mm
Total reduction		= 27 mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.35 W/m^2K is therefore:

Base thickness less *total reduction* i.e. 67 – 27 = 40 mm

Example 5: Masonry cavity wall filled with insulation with plasterboard on dabs

Determine the thickness of the insulation layer required to achieve a U-value of 0.35 W/m^{2}K for the wall construction shown below. (This calculation assumes the effect of wall ties to be negligible.)



Using Table A8:

From column F, row 4 of the table, the base thickness of the insulation layer is 107 mm.

The base thickness may be reduced by taking account of the other materials as follows: from Table A9:

Brick outer leaf	column F, row 2	= 5 mm
Plasterboard	column F, row 6	= 3 mm
Airspace behind plasterboard	column F, row 7	= 5 mm

And from Table A10:

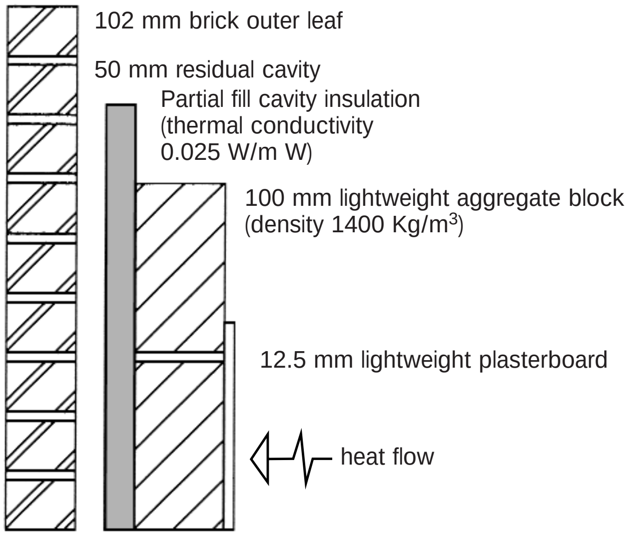
Concrete block	column F, row 1	= 3 mm
Total reduction		= 16 mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.35 W/m^{2}K is therefore:

Base thickness less *total reduction* i.e. 107 – 16 = 91 mm

Example 6: Masonry wall with partial cavity-fill

Determine the thickness of the insulation layer required to achieve a U-value of 0.3 W/m^{2}K for the wall construction shown below. (This calculation assumes the effect of wall ties to be negligible.)



Using Table A8:

From column C, row 3 of the table, the base thickness of the insulation layer is 79 mm.

The base thickness may be reduced by taking account of the other materials as follows: from Table A9:

Brick outer leaf	column C, row 2	= 3 mm
Cavity	column C, row 1	= 5 mm
Lightweight plaster	column C, row 4	= 2 mm

And from Table A10:

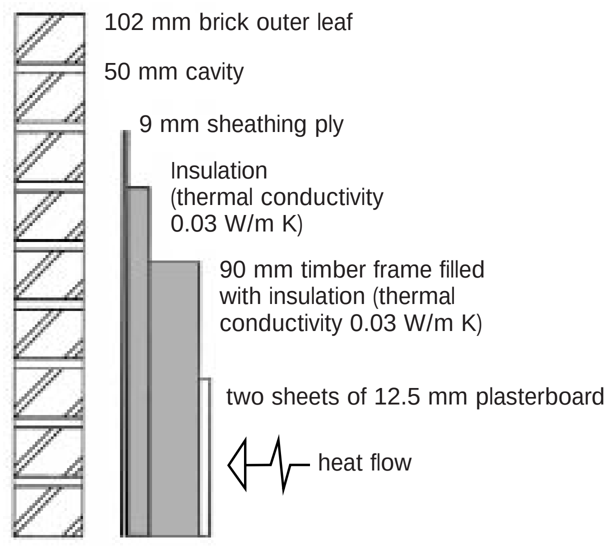
Concrete block	column C, row 3	= 4 mm
Total reduction		= 14 mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.3 W/m^{2}K is therefore:

Base thickness less *total reduction* i.e. 79 – 14 = 65 mm

Example 7: Timber-frame wall

Determine the thickness of the insulation layer required to achieve a U-value of 0.3 W/m^{2}K for the wall construction shown below.



Using Table A8:

From column D, row 3 of the table, the base thickness of the insulation layer is 95 mm.

The base thickness may be reduced by taking account of the other materials as follows: from Table A9:

Brick outer leaf	column D, row 2	= 4 mm
Cavity	column D, row 1	= 5 mm
Sheathing ply	column D, row 8	= 2 mm
Plasterboard	column D, row 6	= 2 mm
Plasterboard	column D, row 6	= 2 mm

And from Table A11:

Timber frame	column D, row 1	
	adjusted for shallower member (0.9 x 63 mm)	= 57 mm
Total reduction		= 72 mm

The minimum thickness of the insulation layer required to achieve a U-value of 0.3 W/m^{2}K is therefore:

Base thickness less *total reduction* i.e. 95 – 72 = 23 mm

Ground floors

Note: in using the tables for floors it is first necessary to calculate the ratio P/A, where P is the floor perimeter length in metres and A is the floor area in square metres

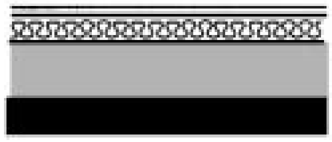


Table A12: **Insulation thickness for solid floors in contact with the ground**

		Thermal conductivity of insulant (W/m·K)						
	P/A	**0.020**	**0.025**	**0.030**	**0.035**	**0.040**	**0.045**	**0.050**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
		Insulation thickness (mm) for U-value of 0.20 W/m²K						
1	1.00	81	101	121	142	162	182	202
2	0.90	80	100	120	140	160	180	200
3	0.80	78	98	118	137	157	177	196
4	0.70	77	96	115	134	153	173	192
5	0.60	74	93	112	130	149	167	186
6	0.50	71	89	107	125	143	160	178
7	0.40	67	84	100	117	134	150	167
8	0.30	60	74	89	104	119	134	149
9	0.20	46	57	69	80	92	103	115
		U-value of 0.25 W/m²K						
10	1.00	61	76	91	107	122	137	152
11	0.90	60	75	90	105	120	135	150
12	0.80	58	73	88	102	117	132	146
13	0.70	57	71	85	99	113	128	142
14	0.60	54	68	82	95	109	122	136
15	0.50	51	64	77	90	103	115	128
16	0.40	47	59	70	82	94	105	117
17	0.30	40	49	59	69	79	89	99
18	0.20	26	32	39	45	52	58	65
		U-value of 0.30 W/m²K						
19	1.00	48	60	71	83	95	107	119
20	0.90	47	58	70	81	93	105	116
21	0.80	45	56	68	79	90	102	113
22	0.70	43	54	65	76	87	98	108
23	0.60	41	51	62	72	82	92	103
24	0.50	38	47	57	66	76	85	95
25	0.40	33	42	50	59	67	75	84
26	0.30	26	33	39	46	53	59	66
27	0.20	13	16	19	22	25	28	32

Note:P/A is the ratio of floor perimeter (m) to floor area (m^2).

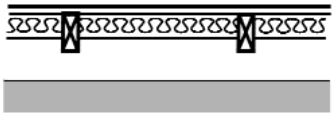


Table A13: **Insulation thickness for suspended timber ground floors**

	P/A	Thermal conductivity of insulant (W/m·K)						
		0.020	**0.025**	**0.030**	**0.035**	**0.040**	**0.045**	**0.050**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
		Insulation thickness (mm) for U-value of 0.20 W/m²K						
1	1.00	127	145	164	182	200	218	236
2	0.90	125	144	162	180	198	216	234
3	0.80	123	142	160	178	195	213	230
4	0.70	121	139	157	175	192	209	226
5	0.60	118	136	153	171	188	204	221
6	0.50	114	131	148	165	181	198	214
7	0.40	109	125	141	157	173	188	204
8	0.30	99	115	129	144	159	173	187
9	0.20	82	95	107	120	132	144	156
		U-value of 0.25 W/m²K						
10	1.00	93	107	121	135	149	162	176
11	0.90	92	106	119	133	146	160	173
12	0.80	90	104	117	131	144	157	170
13	0.70	88	101	114	127	140	153	166
14	0.60	85	98	111	123	136	148	161
15	0.50	81	93	106	118	130	142	154
16	0.40	75	87	99	110	121	132	143
17	0.30	66	77	87	97	107	117	127
18	0.20	49	57	65	73	81	88	96
		U-value of 0.30 W/m²K						
19	1.00	71	82	93	104	114	125	135
20	0.90	70	80	91	102	112	122	133
21	0.80	68	78	89	99	109	119	129
22	0.70	66	76	86	96	106	116	126
23	0.60	63	73	82	92	102	111	120
24	0.50	59	68	78	87	96	104	113
25	0.40	53	62	70	79	87	95	103
26	0.30	45	52	59	66	73	80	87
27	0.20	28	33	38	42	47	51	56

Notes:P/A is the ratio of floor perimeter (m) to floor area (m^2). The table is derived for suspended timber floors for which the proportion of timber is 12%, which corresponds to 48 mm wide timbers at 400 mm centres. For other proportions of timber the U-value can be calculated using the procedure in Appendix B.

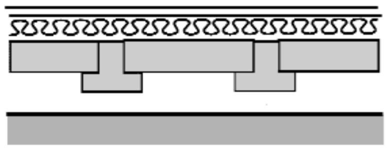


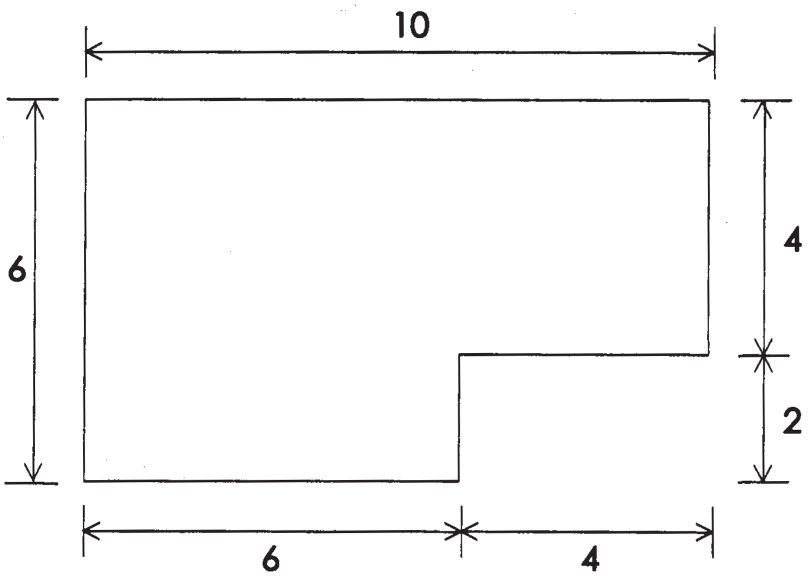
Table A14: Insulation thickness for suspended concrete beam and block ground floors

		Thermal conductivity of insulant (W/m·K)						
	P/A	**0.020**	**0.025**	**0.030**	**0.035**	**0.040**	**0.045**	**0.050**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
		Insulation thickness (mm) for U-value of 0.20 W/m²K						
1	1.00	82	103	123	144	164	185	205
2	0.90	81	101	122	142	162	183	203
3	0.80	80	100	120	140	160	180	200
4	0.70	79	99	118	138	158	177	197
5	0.60	77	96	116	135	154	173	193
6	0.50	75	93	112	131	150	168	187
7	0.40	71	89	107	125	143	161	178
8	0.30	66	82	99	115	132	148	165
9	0.20	56	69	83	97	111	125	139
		U-value of 0.25 W/m²K						
10	1.00	62	78	93	109	124	140	155
11	0.90	61	76	92	107	122	138	153
12	0.80	60	75	90	105	120	135	150
13	0.70	59	74	88	103	118	132	147
14	0.60	57	71	86	100	114	128	143
15	0.50	55	68	82	96	110	123	137
16	0.40	51	64	77	90	103	116	128
17	0.30	46	57	69	80	92	103	115
18	0.20	36	45	54	62	71	80	89
		U-value of 0.30 W/m²K						
19	1.00	49	61	73	85	97	110	122
20	0.90	48	60	72	84	96	108	120
21	0.80	47	59	70	82	94	105	117
22	0.70	45	57	68	80	91	102	114
23	0.60	44	55	66	77	88	98	109
24	0.50	41	52	62	72	83	93	104
25	0.40	38	48	57	67	76	86	95
26	0.30	33	41	49	57	65	73	81
27	0.20	22	28	33	39	44	50	56

Note: P/A is the ratio of floor perimeter (m) to floor area (m²).

Example 8: Solid floor in contact with the ground

Determine the thickness of the insulation layer required to achieve a U-value of 0.3 W/m^{2}K for the ground floor slab shown below.



It is proposed to use insulation with a thermal conductivity of 0.025 W/m·K.
The overall perimeter length of the slab is:
(10 + 4 + 4 + 2 + 6 + 6) = 32 m.
The floor area of the slab is:
(6 x 6) + (4 x 4) = 52 m^2.
The ratio:

$$\frac{\text{perimeter length}}{\text{floor area}} = \frac{32}{52} = 0.6$$

Using Table A12, column C, row 23 indicates that 51 mm of insulation is required.

Example 9: Suspended timber floor

If the floor shown above was of suspended timber construction, the perimeter length and floor area would be the same, yielding the same ratio of:

$$\frac{\text{perimeter length}}{\text{floor area}} = \frac{32}{52} = 0.6$$

To achieve a U-value of 0.30 W/m^2·K, using insulation with a thermal conductivity of 0.04 W/m·K, Table A13 column F, row 23 indicates that the insulation thickness between the joists should be not less than 102 mm.

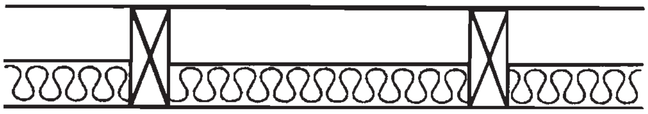


Table A15: Upper floors of timber construction

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulation between joists to achieve design U-values						
	A	B	C	D	E	F	G	H
1	0.20	167	211	256	298	341	383	426
2	0.25	109	136	163	193	225	253	281
3	0.30	80	100	120	140	160	184	208

Note: Table A15 is derived for floors with the proportion of timber at 12% which corresponds to 48 mm wide timbers at 400 mm centres. For other proportions of timber the U-value can be calculated using the procedure in Appendix E.

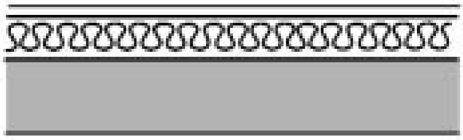


Table A16: Upper floors of concrete construction

	Design U-value (W/m²K)	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Base thickness of insulation to achieve design U-value						
	A	B	C	D	E	F	G	H
1	0.20	95	119	142	166	190	214	237
2	0.25	75	94	112	131	150	169	187
3	0.30	62	77	92	108	123	139	154

Table A17: Upper floors : allowable reductions in base thickness for common components

	Component	Thermal conductivity of insulant (W/m·K) 0.020	0.025	0.030	0.035	0.040	0.045	0.050
		Reduction in base thickness of insulating material (mm)						
	A	B	C	D	E	F	G	H
1	10 mm plasterboard	1	2	2	2	3	3	3
2	19 mm timber flooring	3	3	4	5	5	6	7
3	50 mm screed	2	3	4	4	5	5	6

Table A18: Thermal conductivity of some common building materials

	Density (kg/m³)	Conductivity (W/m·K)
Walls		
Brickwork (outer leaf)	1700	0.77
Brickwork (inner leaf)	1700	0.56
Lightweight aggregate concrete block	1400	0.57
Autoclaved aerated concrete block	600	0.18
Concrete (medium density) (inner leaf)	1800	1.13
	2000	1.33
	2200	1.59
Concrete (high density):	2400	1.93
Reinforced concrete (1% steel)	2300	2.3
Reinforced concrete (2% steel)	2400	2.5
Mortar (protected)	1750	0.88
Mortar (exposed)	1750	0.94
Gypsum	600	0.18
	900	0.30
	1200	0.43
Gypsum plasterboard	900	0.25
Sandstone	2600	2.3
Limestone, soft	1800	1.1
Limestone, hard	2200	1.7
Fibreboard	400	0.1
Plasterboard	900	0.25
Tiles ceramic	2300	1.3
Timber (softwood)	500	0.13
Timber (hardwood)	700	0.18
Wall tiles (stainless steel)	7900	17.0
Surface finishes		
External rendering	1300	0.57
Plaster (dense)	1300	0.57
Plaster (lightweight)	600	0.18
Roofs		
Aerated concrete slab	500	0.16
Asphalt	2100	0.70
Felt/bitumen layers	1100	0.23
Screed	1200	0.41

Note: If available, certified test values should be used in preference to those in the table.

Table A18: **Thermal conductivity of some common building materials** (continued)

	Density (kg/m^3)	**Conductivity** (W/m·K)
Stone chippings	2000	2.0
Tiles (clay)	2000	1.0
Tiles (concrete)	2100	1.5
Wood wool slab	500	0.10
Floors		
Cast concrete	2000	1.35
Metal tray (steel)	7800	50.0
Screed	1200	0.41
Hardwood timber	700	0.18
Softwood timber, plywood, chipboard	500	0.13
Insulation		
Expanded polystyrene (EPS) board	15	0.04
Mineral wool quilt	12	0.042
Mineral wool batt	25	0.038
Phenolic foam board	30	0.025
Polyurethane board	30	0.025

Note: If available, certified test values should be used in preference to those in the table.

APPENDIX B

Calculating of U-values using the Combined Method

Introduction

1. For building elements which contain repeating thermal bridges, such as timber joists between insulation in a roof or mortar joints around lightweight blockwork in a wall, the effect of thermal bridges should be taken into account when calculating the U-value. The calculation method, known as the Combined Method, is set out in BS EN ISO 6946 and the following examples illustrate the use of the method for typical wall, roof and floor designs.

2. In cases where the joists in roof, wall or floor constructions project beyond the surface of the insulation, the depths of the joists should be taken to be the same as the thickness of insulation for the purposes of the U-value calculation (as specified in BS EN ISO 6946).

3. Conductivity values for common building materials can be obtained from the CIBSE Guide Section A3 or from prEN ISO 12524. For specific insulation products, however, data should be obtained from manufacturers.

4. The procedure in this paper does not address elements containing metal connecting paths, for which the reader is directed to BRE IP 5/98 and it does not deal with ground floors (which are dealt with in BS EN ISO 13370, BRE IP 3/90 and BRE IP 7/93) or basements (which are dealt with in BRE IP 14/94).

The procedure

5. The U-value is calculated by applying the following steps:

a) Calculate the upper resistance limit (R_{upper}) by combining in parallel the total resistances of all possible heat-flow paths (i.e. sections) through the plane building element.

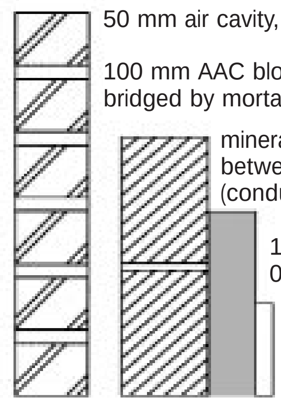
b) Calculate the lower resistance limit (R_{lower}) by combining in parallel the resistances of the heat flow paths of each layer separately and then summing the resistances of all layers of the plane building element.

c) Calculate the U-value of the element from $U = l/R_T$,

where $R_T = \dfrac{R_{upper} + R_{lower}}{2}$

Example 1: Cavity wall with lightweight masonry leaf and insulated dry-lining

6. In this example there are two bridged layers – insulation bridged by timber and lightweight blockwork bridged by mortar (for a single bridged layer see the next example). (Note that this wall construction is only suitable for detached buildings because of its limited sound attenuating performance,



Total thickness	353.5 mm
U-value	0.31 W/m²K

Figure B1: **Wall construction with two bridged layers**

Layer	Material	Thickness (mm)	Thermal conductivity (W/m·K)	Thermal resistance (m²K/W)
	external surface	–	–	0.040
1	outer leaf brick	102	0.77	0.132
2	air cavity	50	–	0.180
3(a)	AAC blocks (93.4%)	100	0.11	0.909
3(b)	mortar (6.6%)	(100)	0.88	0.114
4(a)	mineral wool (90.5%)	89	0.038	2.342
4(b)	timber battens (9.5%)	(89)	0.13	0.685
5	plasterboard	12.5	0.25	0.050
	internal surface	–	–	0.130

Upper resistance limit

7. There are four possible sections (or paths) through which heat can pass. The upper limit of resistance is therefore given by $R_{upper} = 1 / (F_1 / R_1 + ... + F_4 / R_4)$ where F_m is the fractional area of section m and R_m is the total thermal resistance of section m.

8. A conceptual illustration of the upper limit of resistance is shown below:-

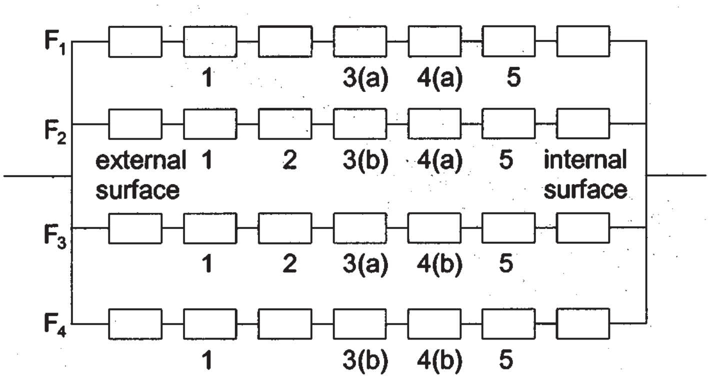


FIGURE B.2 CONCEPTUAL ILLUSTRATION OF THE UPPER LIMIT OF RESISTANCE

9. Resistance through section containing AAC blocks and mineral wool

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of AAC blocks	= 0.909
Resistance of mineral wool	= 2.342
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance $R_{b,ins}$	= 3.783 m^2 K/W

Fractional area $F_{b,ins}$= 93.4% × 90.5% = 0.845

10. Resistance through section containing mortar and mineral wool

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of mortar	= 0.114
Resistance of mineral wool	= 2.342
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance $R_{m,ins}$	= 2.988 m^2 K/W

Fractional area $F_{m,ins}$= 6.6% × 90.5% = 0.060

11. Resistance through section containing AAC blocks and timber

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of AAC blocks	= 0.909
Resistance of timber	= 0.685
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance $R_{b,t}$	= 2.126 m^2 K/W

Fractional area $F_{b,t}$ = 93.4% × 9.5% = 0.089

12. Resistance through section containing mortar and timber

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of mortar	= 0.114
Resistance of timber	= 0.685
Resistance of plasterboard	= 0.050
Internal surface resistance	= 0.130
Total thermal resistance $R_{m,t}$	= 1.331 m^2 K/W

Fractional area $F_{m,t}$ = 6.6% × 9.5% = 0.006

13. Combining these resistances we obtain:

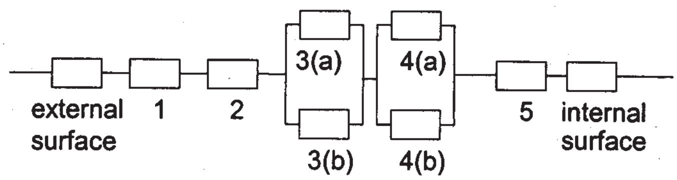
$$R_{upper} = \frac{1}{\frac{F_{b,ins}}{R_{b,ins}} + \frac{F_{b,t}}{R_{b,t}} + \frac{F_{m,ins}}{R_{m,ins}} + \frac{F_{m,t}}{R_{m,t}}} = \frac{1}{\frac{0.845}{3.783} + \frac{0.060}{2.988} + \frac{0.089}{2.126} + \frac{0.006}{1.331}}$$

= 3.450 m^2 K/W.

Lower resistance limit

14. A conceptual illustration of the lower limit of resistance is shown in the following diagram:

FIGURE B.3 CONCEPTUAL ILLUSTRATION OF THE LOWER LIMIT OF RESISTANCE



15. The resistances of the layers are added together to give the lower limit of resistance. The resistance of the bridged layer consisting of AAC blocks and mortar is calculated using:

$$R = \frac{1}{\frac{F_b}{R_b} + \frac{F_m}{R_t}}$$

and the resistance of the bridged layer consisting of insulation and timber is calculated using:

$$R = \frac{1}{\frac{F_{ins}}{R_{ins}} + \frac{F_t}{R_t}}$$

16. The lower limit of resistance is then obtained by adding together the resistances of the layers:

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.180
Resistance of first bridged layer	

$$= \frac{1}{\frac{0.934}{0.909} + \frac{0.066}{0.114}} = 0.622$$

Resistance of second bridged layer

$$= \frac{1}{\frac{0.905}{2.342} + \frac{0.095}{0.685}} = 1.904$$

Resistance of plasterboard	= 0.050
Internal surface resistance	= <u>0.130</u>
Total (R_{lower})	= <u>3.058</u> m^2 K/W

Total resistance of wall

17. The total resistance of the wall is the average of the upper and lower limit of resistances:

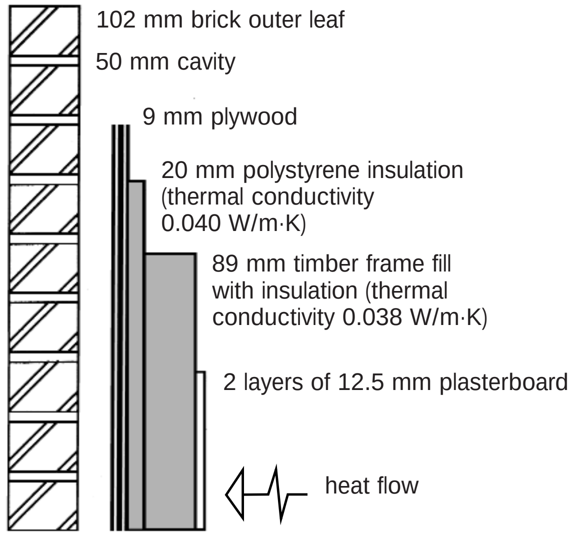
$$R_T = \frac{R_{upper} + R_{lower}}{2} = \frac{3.450 + 3.058}{2} = 3.254 \text{ m}^2 \text{ K/W}$$

Therefore,

$U = 1 / R_T = 1/3.254 = 0.31$ W/m^2 K.

Example 2: Timber framed wall

What is the U-value of the proposed wall construction shown below?



Total thickness	295 mm
U-value	0.33 W/m^{2}K

FIGURE B.4 THE WALL CONSTRUCTION

18. In this example there is a single bridged layer in the wall, namely insulation bridged by timber studs.

19. The thicknesses of each layer, together with the thermal conductivities of the materials in each layer, are shown in the following table. For each homogeneous layer and for each section through a bridged layer the thermal resistance is calculated by dividing the thickness (in metres) by the thermal conductivity.

Layer	Material	Thickness (mm)	Thermal conductivity (W/m·K)	Thermal resistance (m^{2}K/W)
	external surface	–	–	0.040
1	outer leaf brick	102	0.77	0.132
2	air cavity	50	–	0.090
3	plywood	9	0.13	0.069
4	polystyrene insulation	20	0.040	0.500
5(a)	mineral wool between 38 mm x 89 mm timber studs	89	0.038	2.342
5(b)	38 mm x 89 mm timber studs at 400 mm centres	(89)	0.13	0.685
6	plasterboard (2 x 12.5)	25	0.25	0.100
	internal surface	–	–	0.130

20. Both the upper and lower limits of thermal resistance are calculated by combining the alternative resistances of the bridged layer in proportion to their respective areas, as illustrated below. The method of combining differs in the two cases.

Upper resistance limit

21. When calculating the upper limit of thermal resistance, the building element is considered to consist of two thermal paths (or sections). The upper limit of resistance is calculated from:

$$R_{upper} = \frac{1}{\frac{F_1}{R_1} + \frac{F_2}{R_2}}$$

where F_1 and F_2 are the fractional areas of the two sections and R_1 and R_2 are the total resistances of the two sections. The method of calculating the upper resistance limit is illustrated conceptually in Figure B.5.

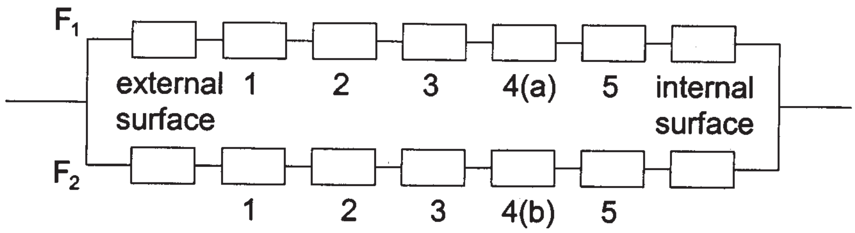


FIGURE B.5 A CONCEPTUAL ILLUSTRATION OF THE UPPER LIMIT OF THERMAL RESISTANCE

22. Resistance through section containing timber stud

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.090
Resistance of plywood	= 0.069
Resistance of polystyrene insulation	= 0.500
Resistance of timber studs	= 0.685
Resistance of plasterboard	= 0.100
Internal surface resistance	= 0.130
Total (R_t)	= 1.746 m^2 K/W

23. Resistance through the section containing insulation

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.090
Resistance of plywood	= 0.069
Resistance of polystyrene insulation	= 0.500
Resistance of insulation	= 2.342
Resistance of plasterboard	= 0.100
Internal surface resistance	= 0.130
Total (R_{ins})	= 3.403 m^2 K/W

24. Fractional area of timber stud:

$$F_t = \frac{\text{width of stud}}{\text{stud spacing}}$$

25. Fractional area of insulation: $F_{ins} = (1 - F_t) = 0.905$

The upper limit of resistance is then:

$$R_{upper} = \frac{1}{\frac{F_t}{R_t} + \frac{F_{ins}}{R_{ins}} + \frac{0.905}{3.403} + \frac{0.095}{1.746}} = 3.122 \text{ m}^2\text{K/W}$$

Lower resistance limit

26. When calculating the lower limit of thermal resistance, the resistance of the bridged layer is determined by combining in parallel the resistances of the unbridged part and the bridged part of the layer. The resistances of all the layers in the element are then added together to give the lower limit of resistance.

27. The resistance of the bridged layer is calculated using:

$$R = \frac{1}{\frac{F_{ins}}{R_{ins}} + \frac{F_t}{R_t}}$$

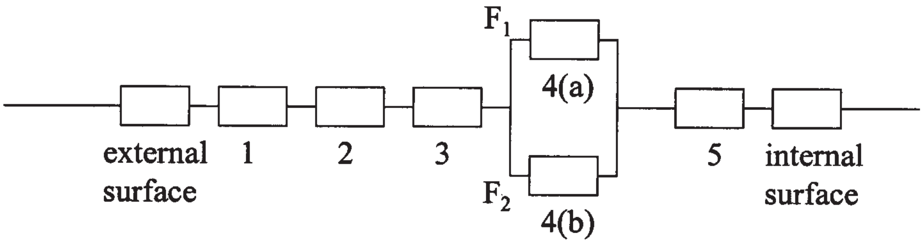


FIGURE B.6 A CONCEPTUAL ILLUSTRATION OF THE LOWER LIMIT OF THERMAL RESISTANCE

28. The lower limit of resistance (see Fig B.6) is then obtained by adding up the resistances of all the layers:

External surface resistance	= 0.040
Resistance of bricks	= 0.132
Resistance of air cavity	= 0.090
Resistance of plywood	= 0.069
Resistance of polystyrene insulation	= 0.500
Resistance of bridged layer $= \frac{1}{\frac{0.905}{2.342} + \frac{0.095}{0.685}}$	= 1.904
Resistance of plasterboard	= 0.100
Internal surface resistance	= 0.130
Total (lower resistance limit) R_{lower}	= 2.965 m^{2}K/W

Total resistance of wall

29. The total resistance of the wall is the average of the upper and lower resistance limits:

$$R_T = \frac{R_{upper} + R_{lower}}{2} = \frac{3.122 + 2.965}{2} = 3.044 \text{ m}^2\text{K/W}$$

and $U = 1/R_T = 1/3.044 = 0.329$ W/m^{2}K.

Correction for air gaps

30. In the calculation of the above U-value it is assumed that the insulation is tightly fitted between the timber battens. If, however, the insulation is not tightly fitting or if there are any air gaps penetrating the insulating layer, a correction[1] of $(R_I/R_T)^2 \times \Delta U''$ is added to the U-value where R_I is the thermal resistance of the insulating layer and R_T is the total resistance of the element. If no air circulation is possible on the warm side of the insulation then $\Delta U''$ is set to 0.01 W/m^{2}K, otherwise $\Delta U''$ is 0.04 W/m^{2}K.

31. This leads to final U-values (to two decimal places) as given in the following table below, where in all cases R_I is 1.904 m^{2}K/W and R_T is 3.044 m^{2}K/W and the U-value prior to the air gap correction is 0.329 W/m^{2}K.

Description of air gap	**Correction level**	**$\Delta U''$ (W/m^{2}K)**	**$(R_I/R_T)^2 \times \Delta U''$ (W/m^{2}K)**	**Final U-value (W/m^{2}K)**
Insulation installed in such a way that no air circulation is possible on the warm side of the insulation. No air gaps penetrating the entire insulation layer.	0	0.00	0.000	0.33
Insulation installed in such a way that no air circulation is possible on the warm side of the insulation. Air gaps may penetrate the insulation layer.	1	0.01	0.004	0.33
Air circulation possible on the warm side of the insulation. Air gaps may penetrate the insulation.	2	0.04	0.016	0.35

1 Using Table D.1 of BS EN ISO 6946

APPENDIX C

U-values of ground floors and basements

1. The Regulation states that a ground floor should not have a U-value exceeding 0.3 W/m^2K if the Elemental Method of compliance is to be used. This can normally be achieved without the need for insulation if the perimeter to area ratio is less than 0.15 m^{-1} for solid ground floors or less than 0.13 m^{-1} for suspended floors. For most buildings, however, some ground floor insulation will be necessary. For basement floors the standard Elemental U-value is also 0.30 W/m^2K but for basement walls it is 0.35 W/m^2K. For exposed floors and for floors over unheated spaces the reader is referred to Appendix B.

2. Full details about how to calculate the U-value of a ground floor, a basement floor or a basement wall are given in BS EN ISO 13370 and in CIBSE Guide Section A3 (1999 edition). This Appendix provides a summary of how to determine the U-value which will suffice for most common constructions.

3. For ground floors and basements the U-value depends upon the type of soil beneath the building. Where the soil type is unknown, clay soil should be assumed as this is the most typical soil type in the UK. The tables which follow refer to this soil type. Where the soil is not clay or silt, the U-value should be calculated using the procedure in BS EN ISO 13370.

4. Floor dimensions should be measured in accordance with the convention described in paragraph 0.21 of this Approved Document. In the case of semi-detached or terraced premises, blocks of flats and similar, the floor dimensions can either be taken as those of the premises themselves, or of the whole building. When considering extensions to existing buildings the floor dimensions may be taken as those of the complete building including the extension.

5. Care should be taken to avoid thermal bridging at the floor edge. See BRE Report BR 262 *Thermal insulation: avoiding risks*.

6. Unheated spaces outside the insulated fabric, such as attached garages or porches, should be excluded when determining the perimeter and area but the length of the wall between the heated building and the unheated space should be included when determining the perimeter.

7. Tables C1 to C6 below have been derived from BS EN ISO 13370. For the purposes of regulations for the conservation of fuel and power it will be sufficient to derive the U-values from the tables using linear interpolation where necessary.

Example of how to obtain U-values from the tables

The following example serves as an illustration of how to use the tables supplied in this appendix, interpolating between appropriate rows or columns.

Example of the use of Table C.1 for a solid ground floor

A proposed dwelling has a perimeter of 38.4 m and a ground floor area of 74.25 m^2. The floor construction consists of a 150 mm concrete slab, 75 mm of rigid insulation (thermal conductivity 0.04 W/mK) and a 65 mm screed. Only the insulation layer is included in the calculation of the thermal resistance.

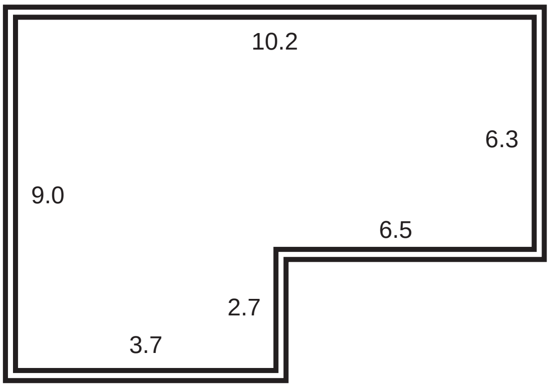


FIGURE C.1

The perimeter to area ratio is equal to (38.4 ÷ 74.25 = 0.517) m^{-1}. Table C.1 provides values for perimeter/area ratios of 0.50 and 0.55 but not for any values between 0.50 and 0.55. In this case, the U-value corresponding to a perimeter to area ratio of 0.50 should be used since 0.517 is closer to 0.50 than to 0.55.

The thermal resistance of the insulation is obtained by dividing the thickness (in metres) by the conductivity. The resistance is then 0.075 ÷ 0.04 = 1.875 m^{2}K/W.

The relevant part of table C.1 is shown below with the U-values underlined for clarity:

	Thermal resistance (m^{2}K/W)	
perimeter/area	1.5	2.0
0.50	0.33	0.28

The U-value corresponding to a thermal resistance of 1.875 m^2K/W is obtained by linear interpolation as below:

$$U = 0.33 \times \frac{2.0–1.875}{2.0–1.5} + 0.28 \times \frac{1.875–1.5}{2.0–1.5}$$

$$= 0.33 \times 0.25 + 0.28 \times 0.75$$

$$= 0.29\ W/m^2K$$

The U-value of this ground floor is therefore 0.29 W/m^2K.

Note. In the example for Table C.1 the appropriate row was chosen and interpolation was carried out between the appropriate columns. For all of the other tables, however, the appropriate column in the table should be selected and interpolation should be carried out between the appropriate rows.

Solid ground floors

Solid ground floors are taken to mean ground floors in which there is no significant air layer separating the building from the ground. Listed in the table below are U-values for solid ground floors. U-values are given in the following table for various perimeter-to-area ratios for a range of insulation levels. Where the floor is uninsulated the column corresponding to a thermal resistance of 0 should be used.

Table C1: **U-values for solid ground floors (W/m^2K)**

	Thermal resistance of all-over insulation (m^2K/W)				
perimeter/area	**0**	**0.5**	**1**	**1.5**	**2**
0.05	0.13	0.11	0.10	0.09	0.08
0.10	0.22	0.18	0.16	0.14	0.13
0.15	0.30	0.24	0.21	0.18	0.17
0.20	0.37	0.29	0.25	0.22	0.19
0.25	0.44	0.34	0.28	0.24	0.22
0.30	0.49	0.38	0.31	0.27	0.23
0.35	0.55	0.41	0.34	0.29	0.25
0.40	0.60	0.44	0.36	0.30	0.26
0.45	0.65	0.47	0.38	0.32	0.27
0.50	0.70	0.50	0.40	0.33	0.28
0.55	0.74	0.52	0.41	0.34	0.28
0.60	0.78	0.55	0.43	0.35	0.29
0.65	0.82	0.57	0.44	0.35	0.30
0.70	0.86	0.59	0.45	0.36	0.30
0.75	0.89	0.61	0.46	0.37	0.31
0.80	0.93	0.62	0.47	0.37	0.32
0.85	0.96	0.64	0.47	0.38	0.32
0.90	0.99	0.65	0.48	0.39	0.32
0.95	1.02	0.66	0.49	0.39	0.33
1.00	1.05	0.68	0.50	0.40	0.33

As an alternative to the Table C1, the methods described in BS EN ISO 13370 may be used.

Ground floors with edge insulation

Where horizontal or vertical edge insulation is used, the U-value of the floor is adjusted by $\Psi \times P/A$ to account for the effects of edge insulation, where P/A is the perimeter (m) to area (m^2) ratio and Ψ is the edge insulation factor obtained from one of the following two tables.

Table C2: **Edge insulation factor (Ψ) for horizontal edge insulation**

insulation width (m)	**thermal resistance of insulation (m^2K/W)**			
	0.5	**1.0**	**1.5**	**2.0**
0.5	–0.13	–0.18	–0.21	–0.22
1.0	–0.20	–0.27	–0.32	–0.34
1.5	–0.23	–0.33	–0.39	–0.42

Table C3: **Edge insulation factor (Ψ) for vertical edge insulation**

insulation width (m)	**thermal resistance of insulation (m^2K/W)**			
	0.5	**1.0**	**1.5**	**2.0**
0.25	–0.13	–0.18	–0.21	–0.22
0.50	–0.20	–0.27	–0.32	–0.34
0.75	–0.23	–0.33	–0.39	–0.42
1.00	–0.26	–0.37	–0.43	–0.48

As an alternative to Tables C2 and C3 the methods described in BS EN ISO 13370 or BRE IP 7/93 may be used.

Uninsulated suspended ground floors

The following table gives U-values of uninsulated suspended floors for various perimeter to area ratios and for two levels of ventilation (expressed in m^2/m) below the floor deck. The data apply for the floor deck at a height not more than 0.5 m above the external ground level where the wall surrounding the underfloor space is uninsulated.

Table C4: **U-values of uninsulated suspended floors**

perimeter to area ratio	**Height of floor deck above ground level and ventilation opening area per unit perimeter of underfloor space (m^2/m)**	
	0.0015 m^2/m	**0.0030 m^2/m**
0.05	0.15	0.15
0.10	0.25	0.26
0.15	0.33	0.35
0.20	0.40	0.42
0.25	0.46	0.48
0.30	0.51	0.53
0.35	0.55	0.58
0.40	0.59	0.62
0.45	0.63	0.66
0.50	0.66	0.70
0.55	0.69	0.73
0.60	0.72	0.76
0.65	0.75	0.79
0.70	0.77	0.81
0.75	0.80	0.84
0.80	0.82	0.86
0.85	0.84	0.88
0.90	0.86	0.90
0.95	0.88	0.92
1.00	0.89	0.93

As an alternative to Table C4, the methods described in BS EN ISO 13370 may be used.

Insulated suspended floors

The U-value of an insulated suspended floor should be calculated using

$U = 1 / [(1/U_0) – 0.2 + R_f]$

where U_0 is the U-value of an uninsulated suspended floor obtained using the above table or another approved method. R_f, the thermal resistance of the floor deck, is determined from U_f, the U-value of the floor deck, where

$$R_f = \frac{1}{U_f} - 0.17 - 0.17$$

and where U_f is calculated using the Combined Method, as described in BS EN ISO 6946, assuming thermal resistances of 0.17 m^2K/W for both the upper and lower surfaces of the floor deck.

Uninsulated basement floors

Table C5: **U-values of uninsulated basement floors**

	Basement depth (m)				
perimeter to area ratio	**0.5**	**1**	**1.5**	**2**	**2.5**
0.1	0.20	0.19	0.18	0.17	0.16
0.2	0.34	0.31	0.29	0.27	0.26
0.3	0.44	0.41	0.38	0.35	0.33
0.4	0.53	0.48	0.44	0.41	0.38
0.5	0.61	0.55	0.50	0.46	0.43
0.6	0.68	0.61	0.55	0.50	0.46
0.7	0.74	0.65	0.59	0.53	0.49
0.8	0.79	0.70	0.62	0.56	0.51
0.9	0.84	0.73	0.65	0.58	0.53
1.0	0.89	0.77	0.68	0.60	0.54

As an alternative to Table C5 the methods described in BS EN ISO 13370 may be used.

Insulated basement floors

Determine the U-value of an insulated basement floor from

$U = 1 / [(1/U_0) + R_{ins}]$

where U_0 is the U-value determined from Table C5 (or other approved method) for uninsulated basements and R_{ins} is the thermal resistance of the insulation in m^2K/W. The value of R_{ins} may be calculated from the thickness of the insulation divided by its conductivity.

Basement walls

Table C6 below provides the U-value of a basement wall for a given basement depth and basement wall resistance.

Table C6: U-values of basement walls

Basement wall resistance (m^2K/W)	Basement depth (m)				
	0.5	**1**	**1.5**	**2**	**2.5**
0.2	1.55	1.16	0.95	0.81	0.71
0.5	0.98	0.78	0.66	0.58	0.52
1.0	0.61	0.51	0.45	0.40	0.37
2.0	0.35	0.30	0.27	0.25	0.24
2.5	0.28	0.25	0.23	0.21	0.20

APPENDIX D

Routes to compliance in this Approved Document

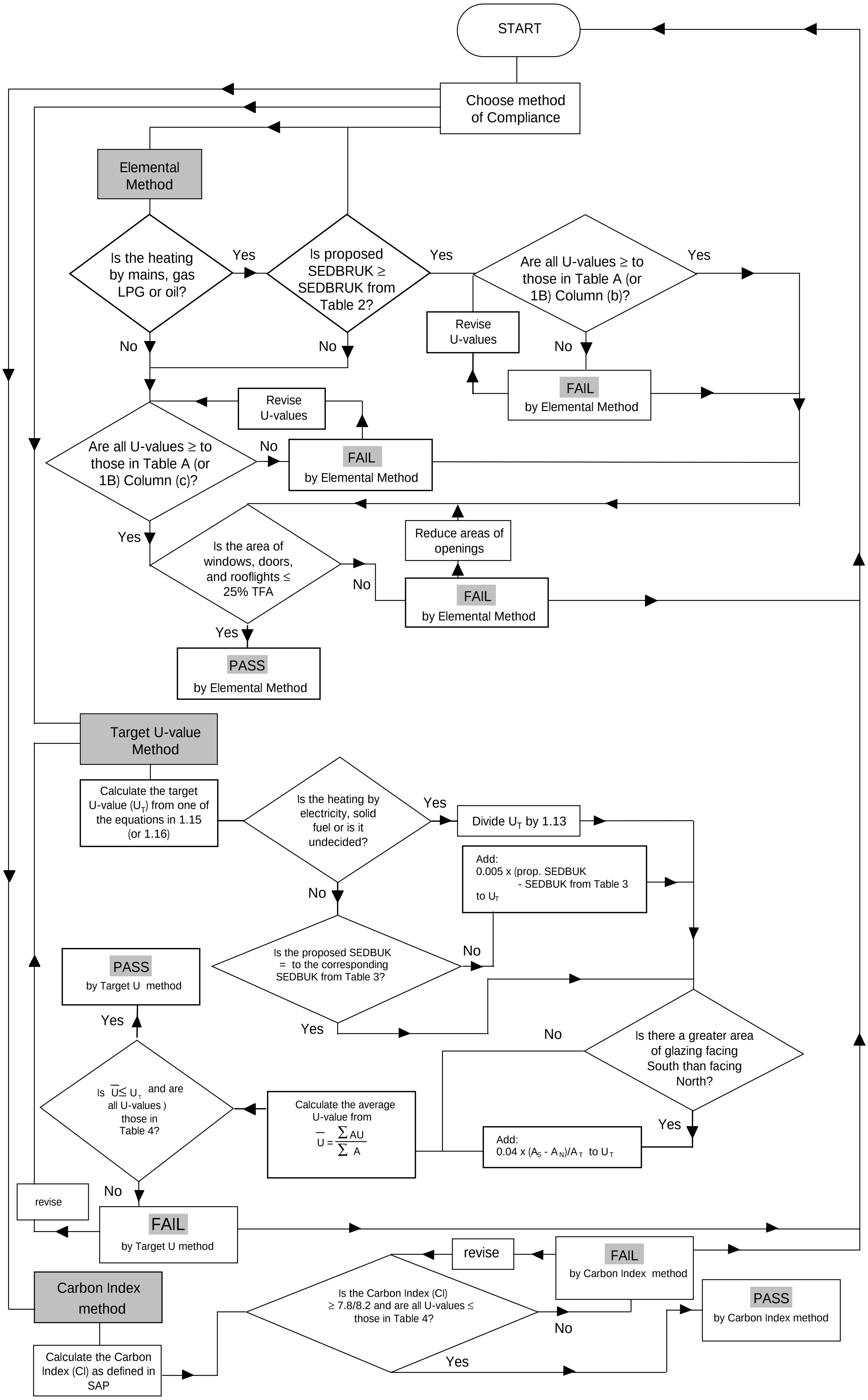
INSULATION OF THE BUILDING FABRIC: DWELLINGS

(Note that thermal bridging also needs to be limited as described in paragraphs 1.26 to 1.28).

START	**Choose method of compliance**		
	Elemental method		go to 1
	Target U-value method		go to 6
	Carbon Index method		go to 14
	Compliance by Elemental method		
1	Is the heating by mains gas, LPG or oil?	YES NO	go to 3 continue
2	Are all U-values of proposed dwelling ≤ to the corresponding values from Table 1, column (d) or (e) as applicable?	YES	go to 5
		NO	**FAIL** by Elemental Method – revise U-values and repeat 2 or go to **START**
3	Is the SEDBUK of proposed heating system ≥ SEDBUK from Table 2?	NO YES	go to 2 continue
4	Are all U-values of proposed dwelling ≤ to the corresponding values from Table 1, column (b) or (c) as applicable?	NO	**FAIL** by Elemental Method – revise U-values and repeat 4 or go to **START**
		YES	continue
5	Is the area of windows, doors and rooflights ≤ 25% of total floor area?	NO	**FAIL** by Elemental Method – reduce area of openings and repeat 5 or go to **START**
		YES	**PASS** by Elemental Method
	Compliance by Target U-value method		
6			Calculate the target U-value (U_T) from one of the equations in 1.15 (or 1.16)
7	Is the heating by electricity, solid fuel or is it undecided?	YES	Divide the target U-value (U_T) by 1.13 and go to 9
		NO	continue
8	Is the proposed SEDBUK for the heating system equal to the corresponding SEDBUK from Table 3?	NO	Add: 0.005 x (proposed SEDBUK – SEDBUK from Table 3) to the target U-value (U_T)
		YES	continue
9	Is there a greater area of glazing facing South than is facing North?	YES	Add: 0.04 x (AS – AN)/AT to the target U-value (U_T)
		NO	continue
10			Calculate the average U-value from $\bar{U} = \frac{\sum AU}{\sum A}$
11	Is $\bar{U} \leq U_T$ and is the U-value of each element ≤ corresponding value from Table 4?	NO	**FAIL** by Target U-value Method – revise and repeat from 6 or go to **START**
		YES	**PASS** by Target U-value method
	Compliance by Carbon Index method		
12			Calculate the carbon Index (CI) as defined in SAP – 2000[1]
13	Is the Carbon Index (CI) ≥ 7.8/8.2 and is the U-value of each element ≥ corresponding value from Table 4?	NO	**FAIL** by Carbon Index Method – revise and go to 12 or go to **START**
		YES	**PASS** by Carbon Index method

1 See Part 4 of this Consultation Document.

The following is an alternative way of presenting the routes to compliance in the Approved Document for dwellings. Consultees are asked to indicate which of the two they consider to be clearest and simplest to use.



Compliance check list for non-domestic buildings

Condition	Possible alternative action if response is "No"
A: DESIGN FOR ENERGY EFFICIENT CONSTRUCTION	
A1: ELEMENTAL METHOD	
Are all U-values no greater than those in table 2.1?	Trade-off between construction elements (2.2.5) OR Trade-off with system efficiency (2.2.9) OR Alternative compliance route
Are all opening areas less than those in table 2.2?	Trade off opening area against U-value (2.2.5) OR Alternative compliance route
Does design meet air leakage standard? (2.16)	None
Does design meet overheating criteria? (2.19)	Alternative compliance route
Does heating system meet the carbon intensity standards? (2.23)	Trade off with U-value of construction elements (2.2.9) OR Alternative compliance route
Do space-heating controls meet requirements? (2.2.7)	None.
Do hot water system controls meet the requirements? (2.30)	None.
Does insulation of pipes/ducts/vessels meet standards? (2.34)	Show that heat flow through pipe/duct/vessel wall is always useful in conditioning the space.
Do the lighting systems meet the performance standards? (2.37, 2.42, 2.43)	Alternative compliance route
Do the lighting controls meet the performance standards? (2.47 to 2.49)	Alternative compliance route
Do the ACMV systems (if installed) meet the Carbon Performance Index standards? (2.52)	Alternative compliance route
Elemental Route Satisfied – Go To Installation Section B →	
A2: WHOLE BUILDING CARBON INDEX METHOD FOR OFFICES	
Is the whole building carbon index greater than the standard? (2.57)	Alternative compliance route
Does design meet the air leakage standard? (2.16)	None
Are all U-values no worse than values in table 2.6?	None
Whole Building Carbon Index Method Satisfied – Go To Installation Section B →	
A3: CARBON EMISSIONS CALCULATION METHOD	
Does calculation method satisfy criteria? (2.58)	Alternative compliance route
Does reference building satisfy the criteria in A above.	Alternative compliance route
Does calculation show that design emits less carbon than reference? (2.59)	None
Carbon Emissions Calculation Method Satisfied – Go To Installation Section B →	
B: INSTALLATION FOR ENERGY EFFICIENT CONSTRUCTION	
Have site procedures been applied to ensure insulation is secure and thermal bridging minimised? (3.1)	Infrared thermographic survey report showing insulation is reasonably continuous.
Does pressurisation test show building meets air leakage standard? (3.2)	Identify leaks, seal and re-test until standard is achieved.
Has an appropriate commissioning plan been produced, and a report signed off affirming that the services have been commissioned to that plan (3.5).	None.
Satisfactory installation has been achieved – Go to Energy Efficient Operation Section C →	
C: PROVIDING INFORMATION FOR ENERGY EFFICIENT OPERATION	
Has a "log-book" been prepared providing the user with the appropriate information in an accessible form? (4.1)	None
Has a metering strategy been developed to enable the user of the building (or separate tenancy) to calculate their energy performance and compare it with a benchmark? (4.2g)	None
For all systems serving office area > 200m^2, has a design Carbon Performance Index been calculated? (4.2h)	None
Satisfactory information has been provided. Building meets requirements.	

APPENDIX E

Determining U-values of windows, doors and rooflights in the Elemental Method

1. Within the Elemental Method of compliance it is permissible to have windows, doors or rooflights with U-values that exceed the standard Elemental U-values provided that the average U-value of all of the windows, doors and rooflights taken together does not exceed 2.2 W/m^2K. The following example illustrates how this can be done.

Example

2. A semi-detached house is to have a total window area of 16.9 m^2 (including frames) and a total door area of 3.8 m^2. It is proposed to use solid wooden doors with a U-value of 3.0 W/m^2K. In order to use the Elemental Method, the additional heat loss due to the use of solid timber doors must be compensated for by lower U-values in the windows and/or rooflights so that the average U-value of openings does not exceed 2.2 W/m^2K.

3. Windows with a U-value of 1.7 W/m^2K can be shown to achieve this requirement as shown in the following table and subsequent calculation.

Element	Area (m^2)	U-value (W/m^2K)	Rate of heat loss per degree (W/K)
Windows	16.9	1.7*	28.73
Doors	3.8	3.0	11.4
Rooflights	0.9	1.9*	1.71
Total	21.6		41.84

*these U-values correspond to double glazed windows or rooflights with a wood or PVC-U frame, with a 16 mm argon-filled space between the panes and a soft low-emissivity coating on the glass. Note that although the windows and rooflights have the same design the rooflight U-value is 0.2 W/m^2K higher than the window U-value.

This gives an average U-value of 41.84 ÷ 21.6, or 1.94 W/m^2K, which is below 2.2 W/m^2K. The windows, doors and rooflights therefore satisfy the requirements of the Elemental Method.

APPENDIX F

Examples of the use of the Target U-value method

1. For a new dwelling with a heating system based on a gas or oil boiler notified after this Approved Document comes into effect and using the simplified equation, the Target U-value is given by

$$U_{Target} = 0.28 + 0.463\frac{A_F}{A_T} + 0.04\frac{A_S - A_N}{A_T} + 0.005 \times (E - B)$$

where A_F is the total floor area, A_T is the total exposed surface area (including ground floor), A_S is the area of glazed openings (including frame) facing South (±30°) and A_N is the area (including frame) of glazed openings facing North (±30°). E is the boiler percentage efficiency and B is the Base Standard SEDBUK Efficiency, which is 75 for gas systems, 82 for LPG heating and 85 for oil systems.

2. For mains gas heating the Target U-value can be expressed as

$$U_{Target} =$$

$$0.28 + \frac{0.463 \times \text{Total floor area}}{\text{Total exposed surface area}} + \frac{0.04 \times (\text{South windows} - \text{North windows})}{\text{Total exposed surface area}} + 0.005 \times (\text{Boiler efficiency} - 75)$$

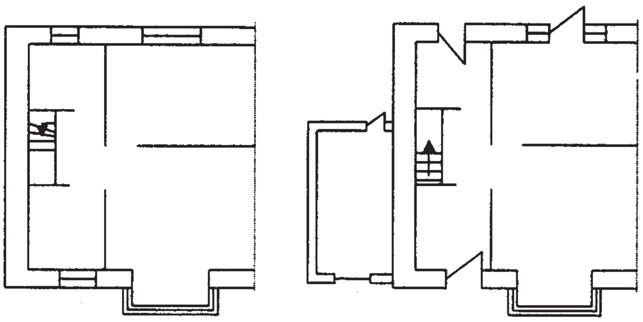
3. A dwelling can comply by the Target U-value method if the Target U-value is not less than the average U-value, where the average U-value is defined as the area-weighted average U-value of all exposed elements of the dwelling. Exposed elements here include walls, roofs, floors, windows and doors, including elements party to unheated spaces.

Example 1: A semi-detached dwelling

4. Consider the example in Figure F.1 which has details in the following table. It is proposed to adopt the Target U-value method with the U-value of the walls a little higher (i.e. worse) than would be required in the Elemental method. The walls are to have a U-value of 0.40 W/m^2K. The area of windows and doors is equal to 25% of the total internal floor area and the boiler efficiency is 75%. The total area of North-facing glazed openings is 8.82 m^2 and the total area of South-facing glazed openings is 10.88 m^2.

Figure F.1: **Layout of the dwelling**

Height to eaves = 5 m



First floor Ground floor

Table F1: **Data for Example 1**

Exposed element	Exposed surface area	U-value	Rate of heat loss per degree
wall	80.3	0.40	32.12
roof	44.4	0.20	8.88
ground floor	44.4	0.30	13.32
windows	18.4	2.2	40.48
doors	3.8	2.2	8.36
Total	191.3	–	103.16

5. In this case, therefore, the Target U-value is:

$$0.28 + \frac{0.463 \text{ x } 88.8}{191.3} + \frac{0.04 \text{ x } (10.88 - 8.82)}{191.3} = 0.495 \text{ W/m}^2\text{K}$$

The average U-value for the dwelling is given by the ratio of the two values:

$$\frac{\text{Total rate of heat loss per degree}}{\text{Total external surface area}}$$

6. These values are calculated in the above table, and in this case the average U-value is:

$$\frac{103.16}{191.3} = 0.539 \text{ W/m}^2\text{K}$$

7. Since the average U-value is more than the target U-value the proposed design does not meet the requirements and modifications must be made to the design. The proposed average U-value could be reduced or the Target U-value increased (or both).

8. A number of ways of modifying the proposed design in order to comply with the Target U-value Method are described below:

Using a higher performance heating system

9. If the boiler efficiency is 85% instead of 75% the Target U-value will increase by 0.005 × (85 – 75), or by 0.050 W/m^{2}K. This is sufficient to raise the Target U-value above the average U-value.

$$U_{Target} = 0.28 + 0.463 \times \frac{88.8}{191.3} + 0.04 \times \frac{(10.88 - 8.82)}{191.3}\ 0.005 \times (85 - 75)$$

$$= 0.545\ W/m^2K$$

Reducing the U-value of the roof and the ground floor

10. If the U-value of the roof is reduced from the standard elemental U-value of 0.20 W/m^{2}K to 0.15 W/m^{2}K the average U-value will be reduced by [44.4 × (0.20 – 0.15) / 191.3], or by 0.011 W/m^{2}K. Taken on its own this measure is not sufficient to reduce the average U-value below the Target U-value. If the U-value of the ground floor is also reduced from the standard Elemental U-value of 0.30 W/m^{2}K to 0.15 W/m^{2}K, the average U-value will fall by a further [44.4 × (0.30 – 0.15) / 191.3], or by a further 0.035 W/m^{2}K. Applying both reductions together will reduce the U-value by 0.046 W/m^{2}K which will satisfy the Target U-value requirement.

Average U-value = 0.539 W/m^{2}K – 0.046 W/m^{2}K = 0.495 W/m^{2}K

Reducing the total area of the windows and doors

11. If the total area of windows and doors is reduced from 25% of the floor area to 19% of the floor area the average U-value will be reduced by (6% of 88.8) × (2.2 – 0.40) / 191.3, or 0.050 W/m^{2}K, which is sufficient to reduce the average U-value to below the Target U-value.

Average U-value = 0.539 – 0.050 = 0.489 W/m^{2}K

Using insulated doors and reducing the area of windows and doors

12. If doors with a U-value of 1.2 W/m^{2}K are used instead of 2.2 W/m^{2}K the average U-value will fall by (2.2 – 1.2) × 3.8 / 191.3, or 0.020 W/m^{2}K. This is not sufficient on its own to reduce the average U-value to below the Target U-value. If, however, the total window area is reduced by 20% then the average U-value will fall by an additional amount equal to (20% of 18.4) × (2.2 – 0.40)/191.3 = 0.035 W/m^{2}K. The dwelling now satisfies the Target U-value Method.

Average U-value = 0.539 – 0.020 – 0.035 W/m^{2}K = 0.484 W/m^{2}K

Improving the thermal resistance of the windows

13. Using windows with a U-value of 1.7 W/m^{2}K (double-glazed windows with a 16 mm argon-filled space between panes, with a soft low-emissivity coating and wood or PVC-U frames) instead of 2.2 W/m^{2}K will reduce the average U-value by [(2.2 – 1.7) × 18.4/ 191.3], or 0.048 W/m^{2}K. This is sufficient to reduce the average U-value to below the Target U-value. Reducing the window U-value to 1.7 W/m^{2}K is therefore sufficient to achieve compliance.

Average U-value = 0.539 – 0.048 = 0.491 W/m^{2}K

Example 2: A detached dwelling

14. Consider the example in Figure F.2 which has details as given in the following table. It is proposed to adopt the Target U-value approach with the walls having a U-value of 0.40 W/m^{2}K. To compensate for this the floor U-value is reduced to 0.15 W/m^{2}K, the roof U-value is reduced to 0.15 W/m^{2}K and the window U-value is reduced to 1.7 W/m^{2}K.

Figure F.2: **Layout of the dwelling**

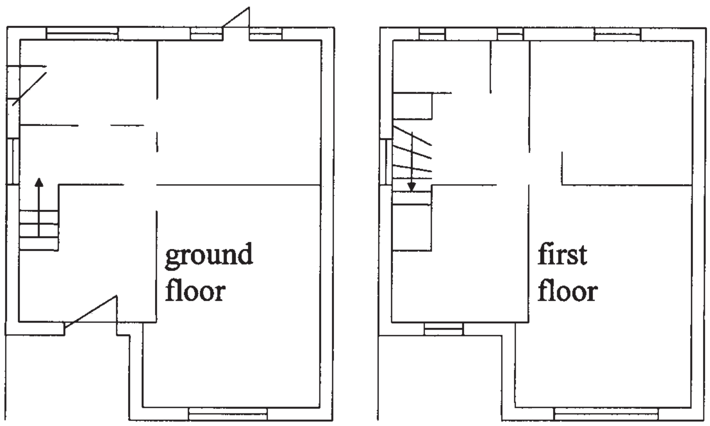


Table F.2: **Data for Example 2**

Exposed element	Exposed surface area	U-value	Rate of heat loss per degree
wall	123.0	0.40	49.2
roof	52.0	0.15	7.8
ground floor	52.0	0.15	7.8
windows & doors*	26.0	1.7	44.2
totals	253.0		109.0

*this includes 7.02 m^2 of North facing glazing and 8.91 m^2 of South facing glazing

15. The Target U-value, is then

$$U_{Target} = 0.28 + \frac{(0.463 \times 104.0)}{253.0} + \frac{0.04 \times (8.91 - 7.02)}{191.3} + 0.56 \times (75 - 75)$$

which is equal to 0.47 W/m^2K.

16. The average U-value for the dwelling is given by the following ratio:

$$\frac{\text{Total rate of heat loss per degree}}{\text{Total external surface area}}$$

17. For this example, therefore, the average U-value is

$$\frac{109.0}{253.0} = 0.43\ W/m^2K$$

18. Since the average U-value is less than the Target U-value, the proposed design meets the Regulations.

APPENDIX G

Example SAP Ratings and Carbon Indexes

Note: These examples use fabric insulation specifications that would meet the standards given in the Elemental Method.

EXAMPLE 1: TWO BEDROOM MID-TERRACE HOUSE

Diagram G1: **Plans of two bedroom mid-terraced house**

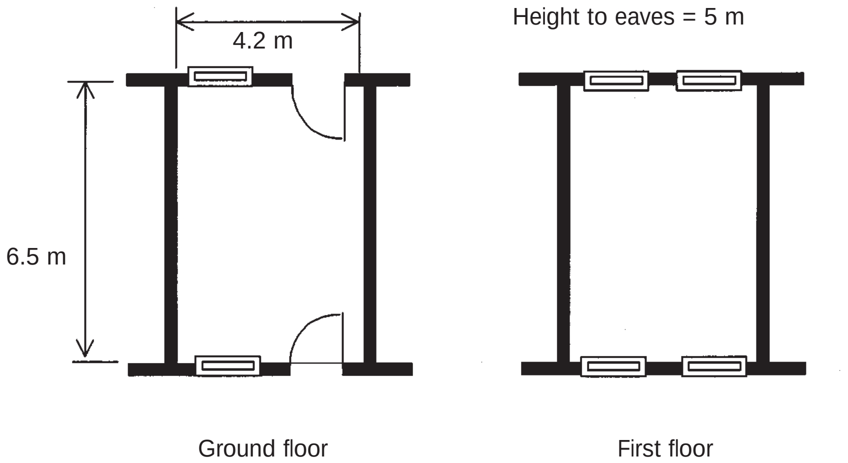


Table G1: **Data for the two bedroom mid-terrace house with electric storage heaters**

Element	Description	Area	U-value
Wall	Brick/cavity/dense block with 130 mm blown fibre cavity insulation	30.3	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	27.3	0.16
Ground floor	Suspended timber, 115 mm insulation	27.3	0.25
Windows and doors	Double glazed, low-E wooden frame	13.7	2.0
Heating	Central heating with conventional gas boiler (efficiency 78%)		

SAP rating = 91

Carbon Index = 8.2

EXAMPLE 2: THREE BEDROOM SEMI-DETACHED HOUSE

Table G2: **Data for the three bedroom semi-detached house with gas boiler**

Element	Description	Area	U-value
Wall	Brick/cavity/dense block with 130 mm blown fibre cavity insulation	72.5	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	40	0.16

EXAMPLE 3: THREE BEDROOM SEMI-DETACHED HOUSE

Diagram G3 **Plans of three bedroom semi-detached house**

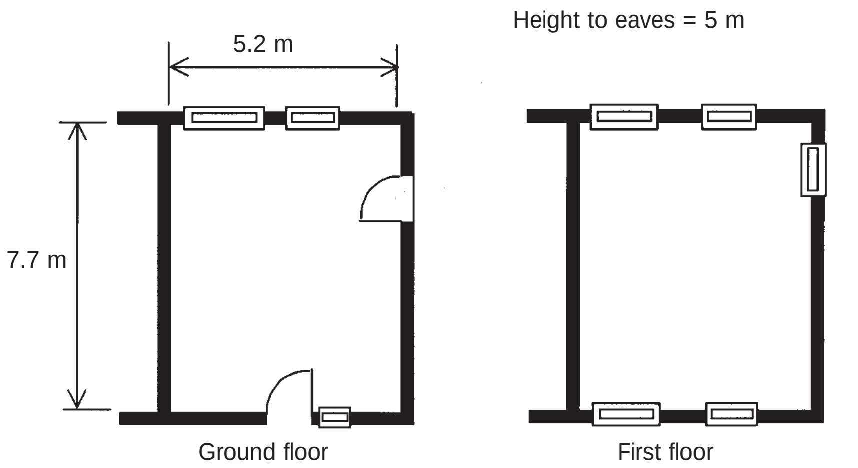


Table G3: **Data for three bedroom semi-detached house with condensing gas boiler**

Element	**Description**	**Area**	**U-value**	
Wall	Brick/cavity/dense block with 130 mm blown fibre cavity insulation	72.5	0.30	
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	40	0.16	
Ground floor	Solid concrete, 60 mm insulation	40	0.25	
Windows and doors	Double glazed, low-E, PVC-U frame	20.0	2.0	
Heating	Central heating with condensing boiler (efficiency 85%)		**LPG**	**Natural Gas**
		SAP rating =	**72**	**99**
		CI =	**7.4**	**8.3**

EXAMPLE 4: FOUR BEDROOM DETACHED HOUSE

Diagram G4: **Plans of four bedroom detached house**

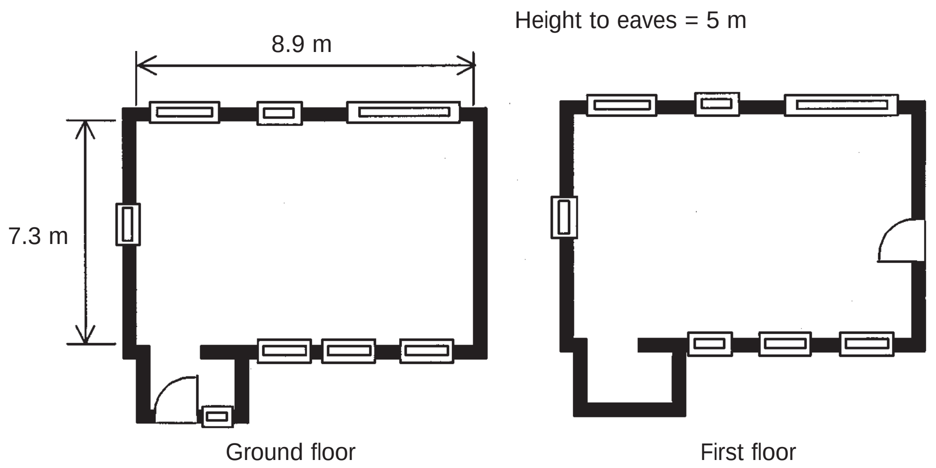


Table G4: **Data for the four bedroom detached house with gas condensing boiler**

Element	**Description**	**Area**	**U-value**
Wall	Brick/partial cavity fill/medium density block with insulated plasterboard	116.5	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	50	0.16
Ground floor	Suspended timber, 150 mm insulation	50	0.25
Windows and doors	Double glazed, low-E, wood frame	25	2.2
Heating	Central heating with gas condensing boiler (efficiency 89%)		

SAP rating = 100

CI = 8.2

EXAMPLE 5: TWO BEDROOM BUNGALOW

Diagram G5: **Plans of two bedroom bungalow**

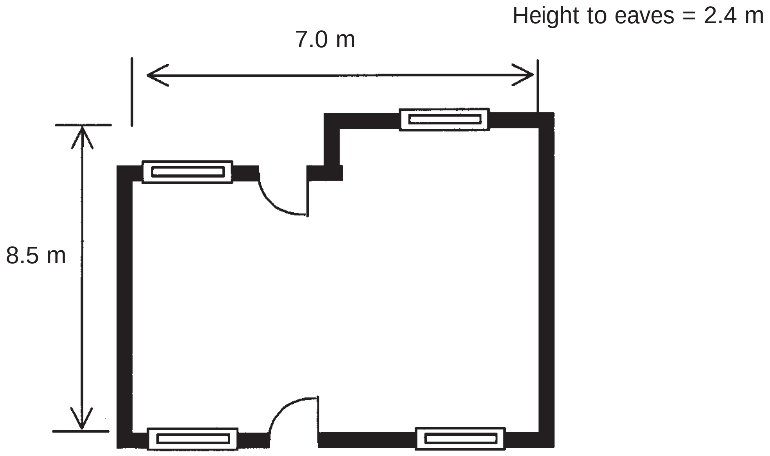


Table G5: **Data for the two bedroom bungalow with gas boiler**

Element	**Description**	**Area**	**U-value**
Wall	Brick/partial cavity fill/medium density block with insulated plasterboard	64.2	0.30
Roof	Pitched roof, 100 mm insulation between joists, 160 mm on top	56.7	0.16
Ground floor	Concrete suspended beam and medium density block, 70 mm insulation	56.7	0.25
Windows and doors	Double glazed, low-E, PVC-U frame	14.2	2.0
Heating	Central heating with gas condensing boiler (efficiency 87%)		

SAP rating = 92

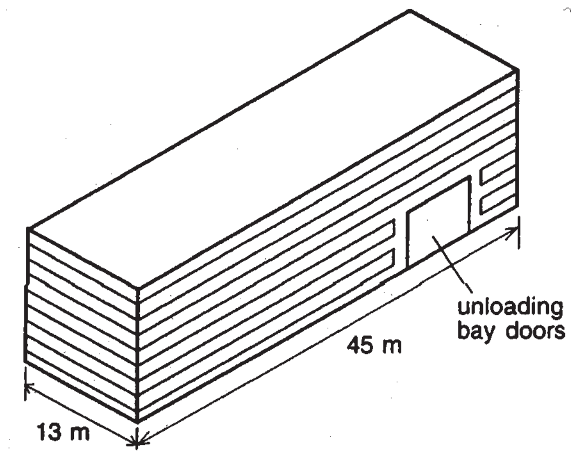
CI = 8.2

APPENDIX H

Example trade-off calculation for buildings other than dwellings

1. This is an example of the procedure described in paragraphs 2.13 and 2.14 of the draft Approved Document.

2. A detached, four storey office building 45 m x 13 m in plan and height 15 m is to be constructed with glazing occupying 52% of the external wall area, using windows with a measured U-value of 2.0 W/m^2K. No roof light glazing is proposed. The remaining exposed walls and the roof are to have U-values of 0.35 W/m^2K and 0.20 W/m^2K respectively, with the ground floor being insulated with 17.5 mm expanded polystyrene with thermal resistance of all-over floor insulation 0.5 m^2KW, giving a U-value of 0.29 W/m^2K (Appendix C).



Proposed building

Step 1: Calculate the areas of each element:

	(m^2)
area of roof (45 x 13)	= 585
area of elevations (45 + 45 + 13 + 13) x 15	= 1740
area of windows (48% of 1740 m^2)	= 835
area of personnel doors	= 14
area of vehicle unloading bay doors	= 27
area of exposed wall (1740 – 835 – 14 – 27)	= 864
area of floor (45 x 13)	= 585

Step 2: The rate of heat loss from the proposed building is calculated as follows:

Element	Area (m^2)	U-value (W/m^2K)	Rate of heat loss (W/K)
Roof	585	0.20	117.0
Exposed walls	864	0.35	259.2
Windows	835	2.0	167.0
Personnel doors	14	2.0	28.0
Vehicle loading bay doors	27	0.70	18.9
Ground floor	585	0.29	117.0
Total rate of heat loss			**2210.1**

Notional building

3. The area of openings in the proposed building is more than the basic allowance in Table 2.2 in the Approved Document. So the basic area allowance of 40% of the wall area plus 20% of the roof area should be assumed for the notional building.

Step 3: Calculate the areas of each element:

	(m^2)
area of roof lights (20% of 585 m^2)	= 117
area of roof (45 x 13) -117	= 468
area of elevations (45 + 45 + 13 + 13) x 15	= 1740
area of windows and personnel doors (40% of 1740 m^2)	= 696
area of vehicle unloading bay doors	= 27
area of exposed wall (1740 – 696 – 27)	= 1017
area of floor (45 x 13)	= 585

Step 4: Calculate the rate of heat loss from the notional building as follows:

Element	Area (m^2)	U-value (W/m^2K)	Rate of heat loss (W/K)
Roof lights	117	2.0	234.0
Roof	468	0.25	117.0
Exposed walls	1017	0.30	305.1
Windows and personnel doors	696	2.0	1392.0
Vehicle loading bay doors	27	0.7	18.9
Ground floor	585	0.25	146.25
Total rate of heat loss			**2213.25**

4. The rate of heat loss from the proposed building is less than that from the notional building and therefore the requirements of the Regulations are satisfied.

APPENDIX J

Examples of meeting the lighting requirements

General lighting in office, industrial and storage buildings

COMPLIANCE BY SELECTION OF LAMP AND LUMINAIRE TYPES

1. The performance standard for the electric lighting system in these building types depends on the efficiencies of both the lamp/ballast combination and the luminaire. The recommendation in paragraph 2.37 is met if both

   (a) the installed lighting capacity in circuit Watts comprises lighting fittings incorporating lamps of the type shown in Table J1

Table J1: **Types of high efficiency lamps for non-daylit areas of offices, industrial and storage buildings**

Light source	Types
High pressure Sodium	All ratings above 70W
Metal halide	All ratings above 70W
Tubular fluorescent	All 26mm diameter (T8) lamps and 16mm diameter (T5) lamps rated above 11W, provided with low-loss or high frequency control gear. 38mm diameter (T12) Linear fluorescent lamps 2400mm in length
Compact fluorescent	All ratings above 26 W

and

(b) all the luminaires have a light output ratio of at least 0.6.

2. A maximum of 500 W of installed lighting in the building is exempt from the above requirement (paragraph 2.40). Otherwise, if the use of other types of lighting or less efficient luminaires is planned, a calculation of the average initial luminaire efficacy (paragraph 2.38) is required.

EXAMPLE 1: CALCULATION OF AVERAGE LUMINAIRE EFFICACY

3. A small industrial unit is being constructed incorporating production, storage and office areas. Lighting in the production area (which is non-daylit) is to be controlled by staged time switching to coincide with shift patterns. The storage area is anticipated to be occasionally visited, and is to be controlled by local absence detection, where a sensor switches the lighting off if no one is present, but switching on is done manually. The office areas are daylit; the furthest luminaire is less than 6 metres from the window wall, which is 30% glazed with clear low emissivity double glazing. Lighting control in this area is by localised infra red switch. Lighting control in the non-daylit corridor, toilet and foyer areas is by full occupancy sensing with automatic on and off.

4. The lighting controls therefore meet the standards in paragraph 2.47 (for the office and storage areas) and 2.48 (for the production and circulation areas) of the Approved Document.

5. The table below shows a schedule of the light sources proposed, together with a calculation of the overall average luminaire efficacy. It incorporates the luminaire control factor, which allows for the reduced energy use due to lighting in daylit and rarely occupied spaces. The storage areas are occasionally visited and incorporate absence detection, so have a luminaire control factor of 0.8.

6. The daylit office areas with local manual switching also have a luminaire control factor of 0.8. Note that if the office areas had tinted glazing, of transmittance 0.33, the equivalent area of glazing of transmittance 0.7 would need to be calculated. This is 30% x 0.33/0.7 = 14% of the window wall area. As this area is less than 20% of the window wall, the office areas would not count as daylit if this type of glazing were used.

Table J2: Calculation of average luminaire efficacy for Example 1

Position	Number	Description	Circuit Watts per fitting	Lamp lumen output λ (lumens) per fitting	Luminaire light output ratio LOR	Luminaire control factor CL	Total corrected luminaire output (B x E x F ÷ G) (lumens)	Total circuit Watts (B x D)
A	B	C	D	E	F	G	H	I
Production	16	250W high bay metal halide	271	17000	0.8	1	217600	4336
Offices	12	4 x 18W fluorescent with Al Cat 2 louvre and high frequency control gear	73	4600	0.57	0.8	39330	876
Storage	16	58W fluorescent with Al louvre and mains frequency control gear	70	4600	0.6	0.8	55200	1120
Circulation, toilets and foyer	30	24W compact fluorescent mains frequency downlights	32	1800	0.4	1	21600	960
						Totals	333730	7292

7. From the table, the total corrected lumen output of all the lamps in the installation is 333,730 lumens and the total circuit Watts of the installation is 7292 Watts. Therefore the average luminaire efficacy is 333,730/ 7292 = 45.8 lumens/Watt. As this is greater than 40 lumens/Watt, the proposed lighting scheme meets the requirements of the Regulations. Note that up to 500 W of any form of lighting, including lamps in luminaires for which light output ratios are unavailable, could also be installed in the building according to paragraph 2.40 in the Approved Document.

General lighting in other building types

EXAMPLE 2: CALCULATION TO SHOW AVERAGE CIRCUIT EFFICACY IS NOT LESS THAN 50 LUMENS/WATT

8. A lighting scheme is proposed for a new public house comprising a mixture of concealed perimeter lighting using high frequency fluorescent fittings and supplementary tungsten lamps in the dining area. Lights in the dining and lounge areas are to be switched locally from behind the bar. Lighting to kitchens and toilets is to be switched locally.

9. The table below shows a schedule of the light sources proposed together with the calculation of the overall average circuit efficacy.

Table J3: **Calculation of average circuit efficacy for Example 2**

Position A	Number B	Description C	Circuit Watts per fitting D	Lumen output per lamp E	Total circuit Watts) (B x D) F	Total lamp lumen output (B x E) G
Over tables	20	60 W tungsten	60	710	1200	14,200
Concealed perimeter and bar lighting	24	32 W T8 fluorescent high frequency ballast	36	3300	864	79,200
Toilets and circulation	6	18 W compact fluorescent with mains frequency ballast	23	1200	138	7,200
Kitchens	6	50 W, 1500 T8 fluorescent with high frequency ballast	56	5200	336	31,200
				Totals:	2538	131,800

10. From the table, the total lumen output of the lamps in the installation is 131,800 lumens and the total circuit Watts of the installation is 2538 Watts. Therefore, the average circuit efficacy is: 131,800/2538 = 51.9 lumens/Watt. The proposed lighting scheme therefore meets the requirements of the Regulations.

11. If 100 W tungsten lamps were used in the dining area instead of the 60 W lamps actually proposed, the average circuit efficacy would drop to 43.4 lumens/W, which is unsatisfactory. If, however, 11 W compact fluorescent lamps, which have a similar light output to 60 W tungsten lamps, were used in the dining area, the average circuit efficacy would be 83.2 lumens/W.

EXAMPLE 3: SHOWING AT LEAST 95% OF LIGHTING SYSTEM CAPACITY COMPRISES HIGH EFFICACY LAMPS

12. A new hall and changing rooms are to be added to an existing community centre. The proposed lighting scheme incorporates lamps that are listed in Table 2.8 in the Approved Document except for some low voltage tungsten halogen downlighters which are to be installed in the entrance area with local controls. A check therefore has to be made to show that the low voltage tungsten halogen lamps comprise less than 5% of the overall installed capacity of the lighting installation.

Main hall

13. Twenty wall mounted uplighters with 250 W high pressure Sodium lamps are to provide general lighting needs. The uplighters are to be mounted 7 m above the floor. On plan, the furthest light is 20.5 m from its switch, which is less than three times the height of the light above the floor. It is also proposed to provide twenty 18 W compact fluorescent lights as an additional system enabling instant background lighting whenever needed.

Changing rooms, corridors and entrance

14. Ten 58 W, high frequency fluorescent light fittings are to be provided in the changing rooms and controlled by occupancy detectors. Six more 58 W fluorescent light fittings are to be located in the corridors and the entrance areas and switched locally. Additionally, in the entrance area there are to be the six 50 W tungsten halogen downlighters noted above.

Calculation

15. A schedule of light fittings is prepared as shown in Table J4:

Table J4: **Calculation for Example 3**

Position	Number	Description of light source	Circuit Watts per lamp	Total circuit Watts
Main hall	20	250 W SON	286 W	5720
Main hall	20	18 W compact fluorescent	23 W	460
Entrance, changing rooms and corridors	16	58 W HF fluorescent	64 W	1024
Entrance	6	50 W low voltage tungsten halogen	55 W	330
			Total =	7534 W

16. The percentage of circuit Watts consumed by lamps not listed in Table 2.8 is (330 x 100)/7534 = 4.4%. Therefore, more than 95% of the installed lighting capacity, in circuit Watts, is from light sources listed in Table 2.8. The switching arrangements comply with paragraph 2.48. The proposed lighting scheme therefore meets the requirements of the Regulations.

APPENDIX K

Performance assessment methods for office buildings

Assessing the contribution to carbon emissions due to building services design and operation

1. The efficiencies of buildings, and of the services systems that produce the indoor conditions required by occupants, can be assessed and compared provided a consistent system is used to describe the buildings and their energy use.

2. Applying such a consistent approach in the office building sector has allowed energy consumption benchmarks to be developed with which the performance of existing buildings, or the likely performance of new designs, can be compared. The benchmarks result from a number of surveys of operational buildings, and are included in DETR's Energy Consumption Guide 19 "Energy use in offices" (ECON 19).

PERFORMANCE BENCHMARKS

3. The information contained in ECON 19 provides benchmarks for the energy consumed by ACMV, heating and lighting services, together with benchmark information describing the hours of use of the equipment. Benchmarks also describe the energy consumed by the additional equipment necessary to support use of the building for typical office activities. The benchmarks refer to office buildings described as representing 'typical' and 'good practice' for the sector.

> Paragraphs 1 to 9 are intended to show the interrelation between design assessment, performance benchmarks and performance assessment, and how the information needed to support them might be improved by new provisions in ADL.

DESIGN ASSESSMENT

4. The annual energy likely to be consumed by a particular service can be estimated as the product of the total installed input power rating of the plant installed to provide the service and the annual hours of use of that plant at the equivalent of full load. The annual hours of use can be considered to be the result of combining a benchmark value for the 'typical' hours of use of the service with a management factor that acts to reduce or increase this value. The management factor is a number related to the provisions that have been included that have the potential to help the occupier control and manage the use of the plant.

5. The Carbon Performance Index (CPI) is a technique for assessing the likely performance of building services systems using this design information. It uses benchmarks consistent with ECON19 and is intended to estimate the potential for efficient operation of building services systems using information available at the design or construction stage.

PERFORMANCE ASSESSMENT

6. The inclusion of meters (Section 4.1.2) improves the confidence with which occupiers may assess their buildings' performance by estimating the energy consumed by servicing plant and the additional equipment required for the full operation of the building.

7. A technique of estimating operational energy consumption, and comparing the achieved performance of buildings with the ECON19 benchmarks, has been developed to assess the achieved performance of office buildings. This method is described in CIBSE Technical Memoranda TM22 "Energy Assessment and Reporting Methodology: Office Assessment Method".

8. A means of comparing the design of services with benchmarks of installed load and energy use is described the CIBSE Guide volume "Energy Efficiency in Buildings".

9. The results of ongoing performance assessment could be used to provide valuable information from which to maintain and improve performance benchmarks, and hence the CPI method, and to inform the design process.

The carbon performance index (CPI)

THE CPI FOR MECHANICAL VENTILATION – $CPI_{(MV)}$

10. The assessment is based on the calculation of a Carbon Performance Index using the following relationship:

$$CPI_{(MV)} = \frac{MV}{(PD \times HD \times CD \times FD_A)}$$

Where the value of the factor MV = 800 has been set so that the design is considered to represent acceptable practice where the result of the calculation is 100 or greater.

11. For a system installed to provide mechanical ventilation, the factors PD, HD, CD and FD_A are as defined below:

PD is the total installed capacity (sum of the input kW ratings) of the fans installed to provide mechanical ventilation divided by the relevant treated area (square metres)

HD is the typical annual equivalent hours of full load operation, and is taken as 3700 hours per year

CD is the conversion factor relating the emissions of carbon to the fuel used (electricity) i.e. 0.139 kgC/kWh. (See Table 2.5 in the Approved Document)

FD_A is a factor which depends on the provisions that are made to control and manage the installed air distribution plant and which could act to improve the annual efficiency of the plant above that of the typical installation, or to reduce the effective annual hours of use. (See Table K1)

The CPI for air conditioning – $CPI_{(ACMV)}$

12. The assessment is based on the calculation of a CPI using the following relationship:

$$CPI_{(ACMV)} = \frac{ACMV}{(PD \times HD \times CD \times FD_C) + (PR \times HR \times CR \times FR)}$$

13. The value of the factor ACMV = 1200 has been set so that the design is considered to represent acceptable practice where the result of the calculation is 100 or greater.

14. For the distribution system transferring cooled medium to the conditioned spaces, the factors PD, HD, CD and FD_C are as defined below:

PD is the total installed capacity (sum of the input kW ratings) of the fans and pumps installed to distribute air and/or cooled media around the building divided by the relevant treated area (square metres)

HD is the typical annual equivalent hours of full load operation, and is taken as 3700 hours per year

CD is the conversion factor relating the emissions of carbon to the fuel used (electricity) i.e. 0.139 kgC/kWh. (See Table 2.5 in the Approved Document)

FD_C is a factor which depends on the provisions that are made to control and manage the installed cooling distribution plant and which could act to improve the annual efficiency of the plant above that of the typical installation, or to reduce the effective annual hours of use. (See Table K2)

15. For the refrigeration system, the factors PR, HR, CR and FR are as defined below:

PR is the total installed capacity (sum of the input kW ratings) of the plant installed to provide the cooling or refrigeration function divided by the relevant treated area (square metres)

HR is the typical annual equivalent hours of full load operation of the refrigeration plant, and is taken as 1000 hours per year

CR is the conversion factor relating the emissions of Carbon to the fuel used, here most frequently electricity, sometimes gas, in kgC/kWh. (See Table 2.5 in the Approved Document)

FR is a factor which depends on the provisions that are made to control and manage the installed refrigeration plant and which could act to improve the annual efficiency of the plant above that of the typical installation, or to reduce the effective annual hours of use. (See Table K3 below)

Plant control and management factors

16. Tables K1, K2 and K3 below itemise a number of control and management features which could act to improve the annual efficiency of the relevant plant above that of the typical installation, or to reduce the effective annual hours of use. Values to be associated with each feature are obtained from column A, B or C as appropriate and the resultant factor is obtained by multiplying together all of the individual values obtained. Values are selected from columns A, B and C of the table depending on the extent to which facilities for monitoring and reporting are provided, as follows:

Column C No monitoring provided

Column B Provision of energy metering of plant and/or metering of plant hours run, and/or monitoring of internal temperatures in zones

Column A Provision as B above, plus the ability to draw attention to 'out of range' values

Table K1: **To obtain factor (FD_A) for the air distribution system**

	Values		
Plant management features	**A**	**B**	**C**
a. Operation in mixed mode with natural ventilation	0.85	0.9	0.95
b. Controls which restrict the hours of operation of distribution system	0.9	0.93	0.95
c. Efficient means of controlling air flow rate	0.75	0.85	0.95
Column product (FD)			

17. The plant management features for Table K1 are more fully described below:

a. Mixed mode operation available as a result of including sufficient openable windows to provide the required internal environment from natural ventilation when outdoor conditions permit. This may only apply where the perimeter zone exceeds 80% of the treated floor area.

b. Control capable of limiting plant operation to occupancy hours with the exceptions noted below in which operation outside the hours of occupancy forms a necessary part of the efficient use of the system:

for control of condensation,

for optimum start/stop control, or

as part of a 'night cooling' strategy.

c. Air flow rate controlled by a variable motor speed control which efficiently reduces input power at reduced output; variable pitch fan blades. (Damper, throttle or inlet guide vane controls do not attract this factor).

Table K2: To obtain factor (FD_C) for the cooling distribution system

	Values		
Plant management features	**A**	**B**	**C**
a. Operation in mixed mode with natural ventilation	0.85	0.9	0.95
b. Controls which restrict the hours of operation of distribution system	0.9	0.93	0.95
c. Efficient means of controlling air flow rate	0.75	0.85	0.95
Column product (FD)			

18. The plant management features for Table K2 are more fully described below:

a. Mixed mode operation available as a result of including sufficient openable windows to provide the required internal environment from natural ventilation when outdoor conditions permit. This may only apply where the perimeter zone exceeds 80% of the treated floor area. This factor is credited only where interlocks are provided to inhibit the air conditioning supply in zones with opened windows.

b. and c. are as described in Table K1 above for mechanical ventilation.

Table K3: To obtain factor (FR) for the refrigeration plant

	Values		
Plant management features	**A**	**B**	**C**
a. Free cooling from cooling tower	0.9	0.93	0.95
b. Variation of fresh air using economy cycle or mixed mode operation	0.85	0.9	0.95
c. Controls to restrict hours of operation	0.85	0.9	0.95
d. Controls to prevent simultaneous heating and cooling in the same zone	0.9	0.93	0.95
e. Efficient control of plant capacity, including modular plant	0.9	0.93	0.95
f. Partial ice thermal storage	1.8	1.86	1.9
g. Full ice thermal storage	0.9	0.93	0.95
Column product (FR)			

19. The plant management features for Table K3 are more fully described below:

a. Systems that permit cooling to be obtained without the operation of the refrigeration equipment when conditions allow.(eg, ‘strainer cycle’™; ‘thermosyphon’™.)

b. Systems that incorporate an economy cycle in which the fresh air and recirculated air mix is controlled by dampers, or where mixed mode operation is available as defined in Table K2.

c. Controls that are capable of limiting plant operation to the hours of occupancy of the building, with the exceptions noted below in which operation outside the hours of occupancy forms a necessary part of the efficient use of the system:

for control of condensation,

for optimum start/stop control, or

as part of a strategy to pre-cool the building overnight using outside air.

d. Controls that include an interlock or dead band capable of precluding simultaneous heating and cooling in the same zone.

e. Refrigeration plant capacity controlled on-line by means that reduce input power in proportion to cooling demand and maintain good part load efficiencies (eg. Modular plant with sequence controls; variable speed compressor). (Hot gas bypass control does not attract this factor).

f. Partial ice storage in which the chiller is intended to operate continuously, charging the store overnight and supplementing its output during occupancy.

g. Full ice storage in which the chiller operates only to recharge the thermal store overnight and outside occupancy hours.

Example CPI calculations

EXAMPLE CALCULATION FOR AN OFFICE PROPOSAL INCLUDING AIR CONDITIONING

20. In this example it is intended to include an air conditioning system in a new office building. The relevant details from the proposal are that:

a. The total area to be treated by the system is $3000m^2$.

b. Cooling will be provided by two speed-controlled electrically powered compressors, with a total rated input power of 150kW.

c. The refrigeration compressor energy consumption will be metered.

d. The fans used to distribute cooled air to treated spaces have a total rated input power of 35kW.

e. The fan energy consumption will be metered.

f. A time clock control is to be provided so that the operation of the cooling system (refrigeration and air distribution) may be restricted to occupancy hours.

g. Windows in treated areas will be openable so that natural ventilation may be used, and the cooling system turned off, when required.

h. The CPI calculation for air conditioning is:

$$CPI_{(ACMV)} = \frac{1200}{(PD \times HD \times CD \times FD_C) + (PR \times HR \times CR \times FR)}$$

21. The factors for the cooling distribution system are:

PD is the total installed capacity (sum of the input kW ratings) of the fans divided by the relevant treated area (square metres)

= 0.0117 (35/3000)

HD = 3700 hours per year

CD is the carbon conversion factor for electricity, in kgC/kWh. (Table 2.5 in the Approved Document)

= 0.139

FD_C = 0.84, determined from Table K2 as follows:

As the major plant will be metered, factors from Column B of the Table are used.

The Factor for including the opportunity for natural ventilation (mixed mode operation) = 0.9

The Factor for including provision to restrict the hours of use of the system (time control) = 0.93

The Column product (FD_C) = 0.84 (0.9 x 0.93)

22. The factors for the refrigeration system are:

PR = the total installed capacity (sum of the input kW ratings) of the refrigeration plant divided by the treated area (square metres)

= 0.05 (150/3000)

HR = 1000 hours per year

CR = the carbon conversion factor for electricity, in kgC/kWh. (Table 2.5)

= 0.139

FR = 0.75, determined from Table K3 as follows:

As the major plant will be metered, factors from Column B of the Table are used.

The Factor for including the opportunity for natural ventilation (mixed mode operation) = 0.9

The Factor for including provision to restrict the hours of use of the system (time control) = 0.9

The Factor for providing efficient means of controlling plant capacity = 0.93

The Column product (FR) = 0.75 (0.9 x 0.9 x 0.93)

23. The CPI calculation is then:

$$CPI_{(ACMV)} = \frac{1200}{(0.0117 \times 3700 \times 0.139 \times 0.84) + (0.05 \times 1000 \times 0.139 \times 0.75)}$$

$$= 114$$

24. The proposal achieves a calculated index of 114, which is better than the required target CPI of 100 and would therefore be acceptable.

The index of 114 indicates that, under similar patterns of occupancy and use, the system proposed would be likely to cause about 10% less carbon emission than would be caused by the use of air conditioning in the typical air conditioned office building defined in ECON 19.

EXAMPLE CALCULATION FOR A PROPOSAL TO INCREASE THE AREA TREATED BY AN OFFICE MECHANICAL VENTILATION SYSTEM

25. In this example it is intended to increase the area treated by an existing office mechanical ventilation system. The relevant details from the proposal are that:

The total area to be treated by the system is to be increased from $3200m^2$ to $3800m^2$.

The total input power rating of the fans is to be unchanged at 72kW.

The fan will be metered, where previously it was not.

An existing time clock control provision for the system is to be kept.

26. The CPI calculation for mechanical ventilation is:

$$CPI_{(MV)} = \frac{800}{(PD \times HD \times CD \times FD_A)}$$

27. In this proposal, for the existing air distribution system:

PD is the total installed capacity (sum of the input kW ratings) of the fans divided by the relevant treated area (square metres)

= 0.0225 (72/3200)

HD = 3700 hours per year

CD is the carbon conversion factor for electricity, in kgC/kWh. (Table 2.5)

= 0.139

FD_A = 0.95, determined from Table K1 as follows:

As the plant is not metered, factors from Column C of the Table are used.

The Factor for including provision to restrict the hours of use of the system (time control) = 0.95

The Column product (FD_A) = 0.95

28. The CPI calculation is then:

$$CPI_{(MV)} = \frac{820}{(0.025 \times 3700 \times 0.0139 \times 0.95)} = 73$$

29. Since this calculated value of 73 for the existing system is lower than 90, the proposals for altering the system would need to improve the value by at least 10.

30. In this proposal, for the extended air distribution system:

PD is the total installed capacity (sum of the input kW ratings) of the fans divided by the relevant treated area (square metres)

= 0.01895 (72/3800)

HD = 3700 hours per year

CD is the carbon conversion factor for electricity, in kgC/kWh. (Table 2.5)

= 0.139

FD_A = 0.93, determined from Table K1 as follows:

As plant will now be metered, factors from Column B of the Table are used, then:

The factor for including provision to restrict the hours of use of the system (time control) = 0.93

The column product (FD_A) = 0.93

31. The CPI calculation is then:

$$CPI_{(MV)} = \frac{820}{(0.01895 \times 3700 \times 0.0139 \times 0.93)} = 89$$

This alteration achieves more than a 10 point improvement in the calculated CPI (Previous value = 73; value after alteration = 89; improvement = 16) and would therefore be acceptable.

The index of 89 indicates that, under similar patterns of occupancy and use, the system proposed would be likely to cause about 10% greater carbon emission than would have resulted from the use of mechanical ventilation as inferred from the typical air conditioned office building defined in ECON 19.