Green Public Procurement

Windows Technical Background Report

Windows, Glazed Doors and Skylights –

Report for the European Commission – DG Environment by AEA, Harwell, June 2010

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1 Introduction

1.1 Background

Following on from previous work in developing GPP criteria for ten product groups,[1] a further ten products and sub-products have been identified for the development of GPP purchasing criteria to add to the European Commission's GPP training Toolkit Module 3, which presents recommended GPP criteria for products and services. GPP is a voluntary instrument.

Windows have been identified as a product group for criteria development. Such a product group includes glazed doors and skylights, as well as windows. This report provides background information on the environmental impact of windows and outlines the key relevant European legislation affecting this product group. It then goes on to describe existing standards and ecolabels that cover this technology. Finally it outlines the rationale for the core and comprehensive environmental purchasing criteria that are being proposed for consultation.

This report accompanies the associated **Product Sheet** that contains the proposed purchasing criteria and ancillary information for green tender specifications and as such they should be read alongside one another.

The format for the purchasing recommendations comes in the form of two sets of criteria:

- The core criteria are those suitable for use by any contracting authority across the Member States and address the key environmental impacts. They are designed to be used with minimum additional verification effort or cost increases.
- The comprehensive criteria are for those who wish to purchase the best environmental products available on the market. These may require additional verification effort or a slight increase in cost compared to other products with the same functionality.

Within the core and comprehensive criteria, the guidance follows the various stages of a public procurement procedure and explains how best to integrate environmental criteria at each stage:

- Subject matter. It means the title of the tender, i.e. a short description of the product, works or service to be procured.
- Technical Specifications. Provide a clear, accurate and full description of the requirement and standard to which goods, works or services should conform. Description of the minimal technical specifications which all bids need to comply with. Set specific environmental criteria, including hurdles and levels that need to be met for specific products.
- Selection Criteria. It is based in the capacity / ability of the bidders to perform the contract. Assist in the identification of appropriate suppliers, for example to ensure adequately trained personnel or relevant environmental policies and procedures are in place.
- Award Criteria. The award criteria on the basis of which the contracting authority will compare the offers and base its award. Award criteria are not pass/fail criteria, meaning that offers of products that don't comply with the criteria may still be considered for the final decision, depending on their score on the other award criteria.
- Contract Performance Clause - Specify the conditions that must be met in the execution of the contract, for example as to how the goods or services are to be supplied, including information or instructions on the products to be provided by the supplier.

It should be noted that the contractor is bound by the existing legal framework.

Where the verification for the criteria states that other appropriate means of proof can be used, this could include a technical dossier from the manufacturer, a test report from a recognised body, or other relevant evidence. The contracting authority will have to satisfy itself on a case by case basis, from a technical/legal perspective, whether the submitted proof can be considered appropriate.

[1] http://www.ec.europa.eu/environment/gpp

2 Abbreviations and Definitions

BFRC	British Fenestration Rating Council
CPD	Construction Products Directive
EPBD	Energy Performance of Buildings Directive
EU	European Union
GPP	Green Public Procurement
IGU	Insulating Glass Unit
Low-E	Low Emissivity Coating
MS	Member States
NFRC	National (US) Fenestration Ratings Council
SHGC	Solar Heat Gain Coefficient
VOC	Volatile Organic Compound
WERs	Window Energy Ratings

Window: A glazed unit designed for a vertical installation in an external wall of a building to allow for views and natural day-lighting. May be fixed or operable.

Exterior Glazed Door: An entry or patio door system including door leaf, frame, and glazing where applicable.

Skylight: A glazed unit designed for a sloped or horizontal application in the roof of a building to allow for natural day-lighting. May be fixed or operable.

U-value: The *U-value* describes how well a building element conducts heat. The lower the value the better insulator a material is.

Methodologically, it measures the rate of heat transfer through a building element over a given area under standard conditions.

U is the inverse of R i.e. $U = 1/R$ where R describes how thermal insulation is achieved by retarding the flow of heat through the material itself. The higher the R-value, the greater the insulation.

Solar Gain: The heat gain in a building due entirely to the sun. Also know as solar heat gain, and passive solar gain.

g-value (Europe) or Solar Heat Gain Coefficient (SHGC, USA): a measure of how much heat from the external environment is transferred through a window into the interior of a building. Expressed as a value between 0 and 1; the lower the value the lower the solar gain.

L50 – air leakage factor. For good quality windows, air leakage makes little difference to energy performance, for poor quality windows that demonstrate air leaks, the impact is significant.

Conduction: Heat transfer through a solid material by contact of one molecule to the next. Heat flows from a higher-temperature area to a lower-temperature one.

Convection: A heat transfer process involving motion in a fluid (such as air) caused by the difference in density of the fluid and the action of gravity. Convection affects heat transfer from the glass surface to room air, and between two panes of glass.

Radiation: The transfer of heat through rays or waves. Radiative heat transfer can occur within a vacuum.

Condensation: The deposit of water vapour from the air on any cold surface whose temperature is below the dew point, such as a cold window glass or frame that is exposed to humid indoor air.

Building envelope: The barrier between conditioned and unconditioned space, including all walls, floors, roofs, doors and windows.

3 Definition, Scope and Background

For the purpose of these green public procurement criteria it is proposed to focus on windows in buildings. A window therefore would be defined as an opening in a wall or roof, with transparent material mounted in a fixed frame to admit day-light – i.e. encompassing all elements of the window in one unit and applying any performance criteria to this unit. Often it will be possible to open the window, through a sliding or hinged component of the frame to allow air to circulate. Such a definition would encompass skylights and exterior doors with a window(s) as a significant part of the construction, and from here on it should be assumed that 'window' or 'fenestration product' refers to all three categories.

This definition would exclude windows in transport vehicles, and it is recommended that windows with additional technology embedded in them – such as liquid crystals to allow the windows to transfer from clear to opaque, or internally heated windows, to be used in place of standard domestic heating arrangements, be defined as outside the scope of standard building windows.

The primary function of a window is to allow natural light into a space. In addition to this the loss of heat or cooled air through the window should be minimised. This has obvious economic benefits, but more recently this latter requirement has taken on additional importance due to the environmental implications. At an EU-25 level buildings are responsible for 20-35% of EU's energy use and the largest share of energy in buildings is used to heat the space.[2] In developed countries energy consumption in the residential sector accounts for between 20% and 30% of the total energy used (30% in the UK[3] for example while windows in dwellings alone account for 6% of the total UK energy consumption.[4]) Energy consumption, especially within the residential sector, is growing every year through increased use of air conditioning and heating systems.[5]

In addition windows must provide security as they are considered to be one of the weak security points in a building's envelope. Windows are also expected to be durable and economical with the least possible cost to prospective owners.[6]

Most window products are covered by the Construction Products Directive (see 6.2). Construction products covered by the CPD have to be CE marked. CE marking is accompanied by specific technical information about specific performance of these products.

3.1 The Window Market

In buildings, both residential and commercial, windows are a standard product with a well-established market. Traditionally a window comprised of a single piece of glass mounted in a timber frame. More recently multi-pane glazing has become common – double glazing throughout Europe and triple-glazing in Nordic countries. Some central European countries such as Germany and Austria are soon to introduce standards that will encourage the adoption of triple glazed windows. Double or triple glazing units are installed in new builds or as replacement glazing, due to the improved thermal characteristics. Multi-pane glazed units will be made from a variety of frame materials, will contain a range of cavity depths, and may have the cavity filled with an inert gas, all depending on the original specifications and the age of the windows. In general it can be expected that the more modern a window is the more likely it is to have a high standard of thermal efficiency. For further information see Section 3.2 on Technologies.

In residential buildings it is typical that each room will have at least one window, quite often more. However when commercial buildings are considered, it is often the case that the proportion of the building envelope that is glazed is far higher, in some buildings entire walls are made of glass. It should also be noted that business premises are considered to be less occupied than residential ones,

2 http://www.defra.gov.uk/environment/consumerprod/products/window.htm
3 Department of Trade and Industry, Digest of the United Kingdom Energy Statistics, HMSO, London, (1997)
4 Genuine High Performance: Timber and Aluminium Clad Windows and Doors, G. Menzies and T. Muncer.
5 Better Buildings Leaflet, European Commission, http://ec.europa.eu/energy/demand/legislation/doc/leaflet_better_buildings_en.pdf
6 Life Cycle of Window Materials – A Comparative Assessment, M. Asif, A. Davidson and T.Muneer.

due to the length of the working day and weekends, so heating and cooling may not be necessary 24 hours a day.

Over the last few decades attention has focused on developing 'green building methods', which often include measures to reduce energy use. To increase the efficiency of the building envelope, it is specified that high-efficiency windows as well as high levels of insulation in walls, ceilings, and floors be used. In addition passive solar building design can be implemented in low-energy homes. This involves the orientation of windows and walls and place awnings, porches, and trees such that the windows and roofs are shaded in the summer while allowing maximum solar gain in the winter. Effective window placement provides more natural light and lessens the need for electric lighting during the day. The glazing industry is responding to the requirements for more efficient glazing units, through improved standards and new technology.

3.2 Technologies

The use of glass in buildings, particularly commercial properties, has increased over the last few decades, and continues to do so.[7] Windows are composed of two basic sections: the glass used for the main body of the window, and the frame used to mount the glass and secure the structure into the building envelope.

The traditional variable for glass in windows is the thickness of the glass plane – the thicker it is the less heat is lost to the outside environment through conduction. It is relatively easy to change the chemical composition of the glass itself, for example, this is how tinting is achieved, while the use of low iron glass improves daylight transmission and can reduce solar heat gain through windows. The use of tinted glass is far more common in commercial glazing than in domestic.

The frame can be made from a wide range of materials, with common ones including aluminium, steel, wood, wood clad with aluminium, PVC-U and fibreglass, as well as composites using two or more of these materials together. The choice of material is often made on aesthetic and cost grounds, as well as suitability.

The simplest window is a single pane, which requires only the glass and frame. Introducing a second and third pane creates double and triple glazing respectively. Usually thermal spacers built as part of the frame separate the panes of glass. The windows are then known as insulating glass units (IGUs), and are now commonly installed in all types of window. The cavities created between the panes increase the thermal insulation properties of the window and decrease the level of noise transmitted.[8] However they also reduce the level of light transmission into the interior of a building and reduce solar heat gain. The optimum space between two panes of glass depends on what is used to fill the cavity. A smaller space than the optimum can lead to greater heat loss, while a larger one makes little difference to the level of thermal insulation. To create multi-pane windows a greater level of engineering is required in the frame. The design of the frame can have a significant impact on the thermal efficiency of the overall window unit. Installing thermally efficient glazing will have little effect, if the frame design allows significant amounts of heat exchange. It is important that thermal bridges are eliminated or minimised as far as possible in the frame, to improve the insulation properties of the unit as a whole.[9]

Both noise reduction and thermal insulation can be greatly improved by filling the cavities between the glass panes with an inert, low conductance gas. Traditionally dry air was used but more modern technologies use argon, xenon or krypton gas. This reduces the heat loss to the outside environment (i.e. the U-value, see Section 2 for a definition) by suppressing convection. When (dry) air or argon gas is used to fill the cavity the optimum gap between double-glazing panes is between 15 and 16mm, while if krypton gas is used to fill the cavity the optimum gap is around 10mm. Overall this creates a thicker window with substantially improved thermal insulation and noise reduction properties by reducing conduction and convection.

A further technology that can be utilised to improve the properties of windows is the use of coatings applied to the inner surface of a glass pane, or laminates used between two sandwich panes. There

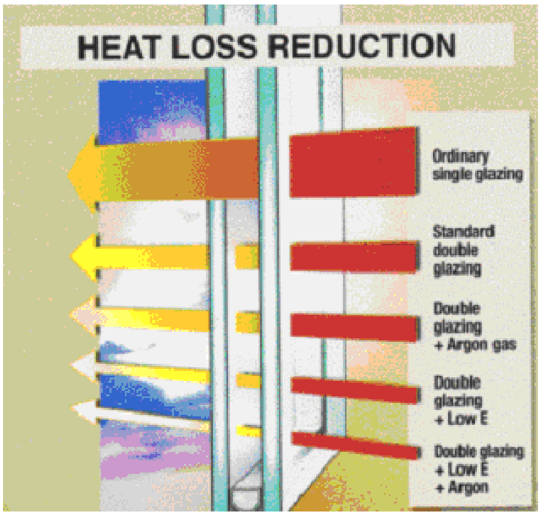
[7] Modern Built Environment KTN, http://www.bre.co.uk/page.jsp?id=873
[8] Insulating Glazing Units, S. L. Garvin.
[9] Efficient Windows, http://www.efficientwindows.org/gtypes.cfm

are many types of coatings available which can be used to reduce solar gain and glare or heat loss. While traditionally thicker glass was used in places where noise reduction or security was required, laminates sandwiched between two panes now provide greater noise reduction, and together with toughened glass provides improved security glass.[10]

Low-emissivity (Low-E) coatings are thin, virtually invisible, metal or metallic oxide layers deposited on a window. In double or triple glazing the main mechanism of heat transfer is thermal radiation from a warm pane of glass to a cooler pane. Coating a glass surface with a low-emissivity material and facing that coating into the gap between the glass layers blocks a significant amount of radiant heat transfer, thus lowering the total heat flow through the window, i.e. potentially significantly lowering the U-value. Particular Low-E coatings are designed for heating-dominated climates where the coatings reduce the amount of heat lost through the window to the outside environment, while still allowing natural light in. Alternative coatings exist to reduce solar gain in cooling-dominated climates, so minimising the amount of heat allowed through the glass from the outside environment, while still allowing the maximum amount of natural light to enter into the space.[11] This type of solar control glass can be specified for any situation where excessive solar heat gain is likely to be an issue, e.g. large facades, glass walkways, atria and conservatories. The potential CO_2 savings of using this type of glass optimally have been quantified by a TNO study.[12]

Use of multiple glass panes, together with well-designed frames and energy efficient coatings enables reductions in the energy use of the building the windows feature in and allows designers and builders to meet the requirements of current building regulations.

Figure 1 Increased thermal efficiency in window products.[13]



The above diagram illustrates the insulative properties of various types of glazing. For typical U-values for various types of glazing see Table 2 in Section 4.

[10] http://www.pilkington.com/applications/products2006/english/bybenefit/noisecontrol/optilamphon/default.htm
[11] Pilkington website, http://www.pilkington.com.
[12] Solar Control Glass for Greater Energy Efficiency: How policy-makers could save energy and significantly reduce CO_2 emissions to meet EU targets for 2020, http://www.glassforeurope.com/issues/building/EnergyAndEnvironment/Pages/solarprotectiveglazing.aspx
[13] Adapted diagram from North Canterbury Glass, www.northcanterburyglass.co.nz/technicalinfo.htm

4 Key Environmental Impacts

An important aspect of windows is their environmental impact – energy consumed by their manufacture, natural resources depletion occurring due to their manufacture, energy associated with their use phase, and then disposal impacts when they reach the end of their use phase.[14]

4.1 Materials

The materials commonly used in windows and external doors are glass, wood, plastic, aluminium and steel. All manufacturing requires extraction of raw materials at some stage, which will have impacts on land take, energy use and potential loss in biodiversity. Plastics and metals are often present, in addition to large obvious components, in many small applications such as beads, fittings and films or coatings. There will also be various chemical products used, such as wood preservatives and finishes, putty, glue, sealants and filler gases. Exterior doors will also contain insulation.

The material considerations and impacts for each of the main materials include:

- Glass
    - Glass is formed from four main ingredients: sand, soda ash, limestone, and additives such as iron for colour.[15] Although there is no shortage of these materials they do have to be quarried.
    - The raw materials are heated in blast furnaces at temperatures of over 1500^{o}C, an obvious consumption of energy, often from fossil fuel sources.
    - Glass process waste is routinely recycled, for example in the UK in 2003 approximately 70,000 tonnes of flat glass cullet were reprocessed, while an additional 60,000 tonnes were used for fibreglass insulation re-melt and 80,000 tonnes used in the container glass industry.[16] Glass can in theory be recycled many times, although this is dependent of collecting good quality recyclate and markets existing for this material.

- Frame material - Aluminium:
    - Aluminium is produced from its abundantly available ore, bauxite, which must be mined. Production requires a great deal of energy (between 170[17] - 225MJ/kg[18]) and generates significant amounts of pollution in the form of CO_2, SO_2, polyaromatic hydrocarbons (PAHs), fluorine and dust.
    - However, aluminium can be recycled repeatedly with virtually no deterioration in quality, requiring only 5% of the energy needed for primary production.[19]
    - Aluminium windows are light and durable due to the high strength to weight ration the material has, often made of hollow extruded components. Such properties allow for narrow frames, enabling a greater proportion of a window to be glazing.
    - Aluminium is highly heat conductive, so thermal breaks, usually made of a polyamide plastic, are incorporated into the frame to reduce direct conductivity. Reduced conductivity increases the temperature of the inside surface of the frame and reduces the potential for surface condensation and improves thermal performance.[20]

- Frame material - Steel
    - Steel is an alloy formed from iron ore and usually carbon in the form of coke. Although both materials are relatively common, they must be mined, and high temperature processes, blast furnace or electric arc furnace, are required to produce steel.

[14] In 2003 it was estimated that 195,000 tonnes of waste arose from the UK window sector. This is predicted to rise to 295,000 tonnes by 2020. www.defra.gov.uk/environment, priority products: windows.
[15] http://www.wasteonline.org.uk/resources/InformationSheets/Glass.htm
[16] Research into Waste glass, window and door frames from the demolition and replacement window industry, Hurley J, BRE, 2003.
[17] http://www.treehugger.com/files/2004/11/ecotip_glass_a.php
[18] Weir, G. and Muneer, T., Energy and Environmental Impact Analysis of Double-Glazed Windows, Energy Convers. Mgmt Vol. 39,No.3/4,pp. 243-256, 1998.
[19] Environmental Profile Report from the European Aluminium Association.
[20] John Carmody, Stephen Selkowitz, Dariush Arasteh and Lisa Heschong Residential Windows, first edition, 1996.

- Air emissions from the production process include CO, SOx, NOx, PM10 (particulate matter, dust), while other pollutants include wastewater contaminants, hazardous and solid wastes.
- Steel has a long durable lifetime, low thermal transmittance compared to other metallic materials,[21] is highly recyclable and recycling rates in general are good. However when mixed with other materials in a product recycling becomes more difficult, and the rate falls.[22,23]

- Frame material - Plastic
  - PVC (polyvinyl chloride) is the most commonly used plastic in windows - a synthetic material comprised of chlorine, carbon, and hydrogen and made from fossil fuels (43%) and rock salt (57%).[24] PVC-U stands for unplasticised PVC, the rigid plastic used.
  - Its advantages are that it requires very little maintenance, no painting for example, and lasts for a considerable length of time. A PVC frame is made of hollow profiles joined with heat. PVC windows can be made with metal reinforcements to increase the rigidity; this tends to increase its overall thermal conductivity.
  - The production of PVC is an energy-intensive process (70MJ/kg) and produces many toxic pollutant waste compounds such as dioxins, vinyl chloride and heavy metals. Emission of these waste compounds is tightly controlled by law and the wastes from current manufacturing processes are treated and disposed of. (Key legislation is the EU POPs regulation (EC 850/2004), as a signatory to the Stockholm Convention and the LR-TAP (Convention on Long Range Transboundary Air Pollution), and the Aarhus Protocol, part of LR-TAP.)
  - PVC waste may be recycled, incinerated and used for energy from waste or be disposed of to landfill. PVC is generally considered to be inert in landfill, although PVC additives may leach over time.[25] However if PVC is burned in an uncontrolled manner concern exists that dioxins will be released into the atmosphere.[26] Measures to prevent this are standard on modern approved incinerator sites, but due to the prevalence of PVC as a building material unregulated burning may occur through house and industrial fires, small scale refuse fires, or at landfill sites where fire breaks out. [27,28,29.]
  - The recycling of PVC is a challenging procedure. The separation of PVC-U from reinforcement materials (e.g. aluminium) is relatively easy with modern sorting systems.[30,31] In the recent past very little recycling was performed and most PVC was landfilled. This is changing as initiatives such as Vinyl2010 are focusing on end of life and recycling issues.[32] However, it is likely that the majority of the recycled PVC is down cycled into low-grade plastic products such as garden benches and sound barriers along highways. In addition old PVC frames may potentially contain lead, cadmium, organotins and other additives, which may further complicate the recycling process and the potential products the material can be recycled into.[33]
  - Vinyl2010 aims to recycle 200,000 tonnes of post consumer waste by 2010, although availability and collection of the waste is not taken by the industry as part of this commitment. This represents approximately 3% of PVC waste in Europe (based on 6 million tonnes of PVC consumed in 2008). With specific reference to rigid profiles (windows form approximately 30% of this category) 79,600 tonnes of 1.8 million tonnes were recycled in 2006, i.e. 4%. There are a number of certified recyclers in

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[21] Information from EUROFER, the European Confederation of Iron and Steel Industries.
[22] Information from the Steel Recycling Institute
[23] 2005 Minerals Handbook, http://minerals.usgs.gov/minerals/pubs/commodity/recycle/recycmyb05.pdf
[24] Information provided by Plastics Europe, during consultation phase.
[24] Information provided by Plastics Europe, during consultation phase.
[25] The behaviour of PVC in landfill, Final Report, Chapter 4, European Commission DGXI.E.3, 2000.
[26] Greenpeace comment, http://www.greenpeace.org/international/campaigns/toxics/polyvinyl-chloride/the-poison-plastic and Green Paper, Environmental Issues of PVC, 2000, http://ec.europa.eu/environment/waste/pvc/en.pdf
[27] EPA, 2005, USA, Human Health, Backyard Burning of Wastes, http://www.epa.gov/osw/nonhaz/municipal/backyard/health.htm.
[28] Estimating Releases and Prioritizing Sources in the Context of the Stockholm Convention: Dioxin Emission Factors for Forest Fires, Grassland and Moor Fires, Open Burning of Agricultural Residues, Open Burning of Domestic Waste, Landfill and Dump Fires, 2005, www.pops.int/documents/meetings/cop_2/followup/toolkit/submissions/IPEN%20Comments/Estimating%20Dioxin%20Releases%20English.pdf
[29] Dioxins, Euro Chlor, 2002
[30] British Plastic Federation, The Waste Management of Used Plastics at End of Life.
[31] M.Z. Rousseau Windows: Overview of Issues, Building Science Insight '88, "Window Performance and New Technology".
[32] Vinyl 2010 agreement, www.vinyl2010.org/ and Progress Report on 2008, http://www.vinyl2010.org/images/progress_report/2009/Vinyl2010-Progress%20Report%202009.pdf
[33] PVC-U or Timber. Which is best? Greenpeace leaflet, http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/5588.pdf

Europe, one example is Veka Umwelttchnik, connected to Veka a PVC systems manufacturer, who are able to process 50,000t of PVC window profiles a year.[34]
  - PVC is unaffected by saline or polluted air, but may be sensitive towards high temperature and ultraviolet radiation, which can break its molecular bonds and may result in embitterment and discoloration.[35,36] Such problems are less common today as PVC technology has improved.[37]

- Frame material - Wood
  - Wood is the traditional material to use for window frames, but has been largely superseded by PVC-U in recent decades. However, use of this material is still popular, partly due to aesthetic reasons, and to the perceived environmental sustainability of the product among other reasons.[38]
  - The production of wood in general has a low environmental impact. If the wood is sourced from a sustainably managed forest minimal impact will arise from harvesting and such material can be considered a renewable resource. If the wood is sourced from illegal or unsustainably managed sources, although still having a low impact in terms of production, it could have a hugely detrimental environmental impact through loss of habitat and potential changing land use.
  - Timber windows have to be maintained: oiled, painted or stained every few years. Wood preservatives are usually based on synthetic fossil fuel derived chemicals which can have local air quality impacts from the use of VOC solvents in the paints and staining / varnishing treatments, and potentially pollution implications from run-off, and disposal issues.
  - If well maintained, wood can have a long and durable life.
  - At end of life a wooden window frame itself is biodegradable, but the preservative treatments applied to it may contain chemicals that are toxic or harmful if released onto land or into water. In addition burning this treated wood, for example in incinerators, may release these substances into the air.[39]

- Window-filler - Gas
  - The gases most commonly used to fill the cavity between panes are xenon, argon, krypton, or air.
  - Argon, krypton and xenon are noble gases known for their inertness (lack of reactivity) and are present in the atmosphere in small amounts: 0.93% is argon, while only trace amounts of krypton and xenon exist in the earth's atmosphere.[40]
  - All three noble gases are produced industrially by the distillation of liquid air, and created as co-products to the main products of pure nitrogen and oxygen, both of which are used on a large industrial scale.[41] The noble gases all find their uses as co-products, and must therefore take their share of the considerable energy expended to produce them.
  - Due to the large amount of energy required to create liquid air in the first place, all three gases are expensive to produce and have a significant environmental cost. This said argon is by far the cheapest and cleanest to produce as the other two require considerably more processing and distillation.

As demonstrated here there are several different materials used to construct windows, each with their own set of impacts that must be taken into account when considering the overall environmental impact.

The area with the most flexibility over material use is frame construction as there are several different materials that can be used to construct window frames. Each of these materials has its advantages and disadvantages during processing, in use phase and disposal implications.

[34] Information supplied by Plastics for Europe.
[35] http://www.jlconline.com/jlc/archive/exteriors/vinyl_windows/page2.html
[36] Beckett, H.E. and J.A. Godfrey, "Windows." Crosby Lockwood Staples in association with RIBA Publications Ltd., London, 1974.
[37] Communication from EPPA during Consultation Phase.
[38] Window of Opportunity. The Environmental and Economic Benefits of Specifying Timber Window Frames, Thompson, C., (2005)
[39] http://www.sustainability-ed.org/support_materials/LCA%20windows.pdf
[40] Staff (2007). Xenon. *Columbia Electronic Encyclopedia*. Columbia University Press.
[41] Periodic Table of Elements: Argon – Ar, www.EnvironmentalChemistry.com

Many studies have been performed considering the various environmental impacts of these materials, with a wide range of conclusions drawn. Simply considering the material impacts is not sufficient, for example considering the environmental impacts of producing 1kg PVC versus 1kg wood versus 1kg of steel produces little relevant information. A more informative way is through using an LCA approach.

The material impacts within a specific application or product and over the duration of the products lifetime must be considered. Only then can a realistic and accurate assessment be made, as has been previously recognised by the EU, which stated:[42]

1) The LCA is the most innovative approach to understand the environmental impacts of a product during its life cycle;
2) The LCA approach allows the public administration to substitute product/services with alternative product/services having a lower environmental impact during the whole life cycle;
3) LCA is the only basic acknowledgment element that can directly influence GPP policy in a reasonable way.

When comprehensive LCAs are performed no single framing material is revealed as significantly environmentally better than another.[43] Different materials are appropriate for different situations and environments: for example wooden frames and the periodic maintenance they require will not be appropriate for high or inaccessible locations, while standard PVC frames will not be appropriate for very hot locations (although PVC-U can be specially formulated to be suitable for such locations).[44]

To this end it will be the responsibility of the purchasing authority to assess, in liaison with suppliers, what the most suitable materials is for the circumstances in which it is to be used.

Packaging

Definitions for packaging and specific types of packaging, including primary, secondary and tertiary are included in Article 3 of Directive 94/62/EC on packaging and packaging waste and can be summarised as:

- 'packaging` shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. 'Non-returnable` items used for the same purposes shall also be considered to constitute packaging.

As outlined in below, the Packaging Directive aims to ensure packaging waste is dealt with effectively and sets targets for Member States with regard to the recovery and recycling of packaging materials. These targets were revised by Directive 2004/12/EC and are summarised below, with full details available in Article 6 of the Directive.

- no later than 31 December 2008 60 % as a minimum by weight of packaging waste will be recovered or incinerated at waste incineration plants with energy recovery;
- no later than 31 December 2008 between 55 % as a minimum and 80 % as a maximum by weight of packaging waste will be recycled;
- no later than 31 December 2008 the following minimum recycling targets for materials contained in packaging waste will be attained:
  - (i) 60 % by weight for glass;
  - (ii) 60 % by weight for paper and board;
  - (iii) 50 % by weight for metals;
  - (iv) 22,5 % by weight for plastics, counting exclusively material that is recycled back into plastics;
  - (v) 15 % by weight for wood.

The relevance of packaging as a key environmental impact depends on factors such as product life time and the types of materials used.

[42] http://wwwa.vito.be/erscp2005/documents/papers/PAPER046.PDF
[43] Life Cycle Assessment of PVC and of Principle Competing Materials, 2004, Commissioned by the European Commission, http://ec.europa.eu/enterprise/sectors/chemicals/files/sustdev/pvc-final_report_lca_en.pdf
[44] http://ec.europa.eu/enterprise/chemicals/sustdev/pvc-extended_summary_lca.pdf

In the course of this study, consultation feedback suggests that using the same packaging criterion across different product groups is not an appropriate approach. In addition, for the majority of products in this study packaging is not a key issue, given their long life times, energy consumption during manufacturing and that some use energy in the use phase.

Commentators suggest that other factors also make this approach inappropriate, these are outlined below:

- The lack of a definitive evidence base to use when setting and justifying specific criteria.
- Focussing on a single parameter e.g. recycled content, may lead to sub-optimal environmental results. For example packaging with an increased recycled content may be less robust so more may be required to protect the goods whilst in transit.
- A fixed parameter value does not allow a flexible approach to the issue and may mean few suppliers can satisfy the requirement(s).

Consequently a packaging criterion is not included in the GPP specification. However, an explanatory note highlighting relevant issues that contracting authorities may wish to consider are included. Contracting authorities can determine for themselves the importance they wish to place on packaging and the particular issues that are relevant to them depending on their existing policies and practices.

4.2 In-use Phase

4.2.1 Energy

The primary function of a window, as stated previously, is to allow the transmission of natural light into a building, known as daylight transmission. While the above discussion of materials and manufacturing processes is important, by far the most significant environmental impact from a window occurs during the use phase. In order to allow daylight transmission into a building windows cover a significant proportion of a building's envelope. Windows generally have a poorer insulating performance than the wall they are set in and as such significantly affect the energy performance of that building. This impact of windows is estimated to exceed the impacts from framing production by one order of magnitude.[45] The climate of Europe varies considerably, and correspondingly the requirements people have of their buildings vary across Europe. In northern European climates preventing heat loss from within a building is the primary consideration for much of the year, while in southern climates conservation of cool internal temperatures is the main focus. Both of these thermal considerations can be achieved through the use of well constructed windows with appropriate glazing and use of technologies. However the glazing and technologies selected in the varying climates of Europe may be different, in order to achieve the most advantageous thermal situation for the occupants.

In both temperature scenarios double or even triple glazing is best, with an inert gas fill. The coatings and the tint of the glass can be varied such that minimum thermal transmittance occurs.[46]

The type of window included in a building envelope will have a considerable effect on the amount of heating and/or cooling required, so will influence the amount of energy consumed by the building. For example in Sweden 7% of total energy consumption is lost through windows.[47]

U-values can be used to measure the overall ability of a wall/roof/window to prevent heat loss, and were the original method used by many to compare various technologies, with the lower the U-value the better insulator the material is. U-values are an expression of the conduction, convection and thermal radiance that occur and move heat through a material or product. Some example U-values are listed in Table 1 to illustrate how insulating windows are compared to other building elements.

[45] EMPA, Materials Research and Technology, http://www.empa.ch/plugin/template/empa/*/32776/---/l=2
[46] http://www.pilkington.com/applications/products2006/english/byapplication/householders/roofLights/solarcontrol.htm
[47] R.E. Collins, G.M. Turner, A.C. Fischer-Cripps, J.-Z. Tang, T.M. Simko, C.J. Dey, D.A. Clugston, Q.-C. Zhang, J.D. Garrison, Vacuum glazing—A new component for insulating windows, Building and Environment 30 (4) (1995) 459–492.

Table 1 Typical U-value for new building components

Building Element	**Example good U-value** (W/(m²K)
External wall	0.03
Pitched roofs	0.16 – 0.20
Ground floors	0.22
Windows	1.80

As is clearly demonstrated by these numbers windows are the 'weak point' in the thermal properties of the building envelope. Table 2 shows how U-values for windows can be greatly improved through double-glazing and other technologies.

Table 2 Typical U-values for the various window types[48]

Type	**U-value** (W/m²K)
Single clear glass	5.4
Double glazing with 12mm air gap	2.8
Double glazing with 20 mm air gap and Low-E coating	1.7
Double glazing with 20 mm air gap and Low-E coating and argon fill	1.5
Triple glazing with 28mm depth overall	1.1
Triple glazing with 52mm overall depth, a Low-E coating and argon fill	0.75

Table 3 Example new building window U-values as required by Building Regulations for various European Countries, in 2005[49]

Country	**Limiting U-value in 2005** (W/m²K)	**Current Standard Practice**
Austria	1.9	Low-E double glazing and argon fill.
Belgium	3.5 (2.5 in Brussels Region)	Ordinary double glazing (Low-E double glazing in Brussels Region).
Finland	1.4	Triple (2 + 1), many with Low-E and argon fill.
Poland	2.6	Low-E double glazing.
Germany, Spain and many others	Volumetric: aggregate heat loss value for whole building envelope	

Although U-values were widely used as an indicator for the thermal efficiency of a window, many countries have already, or are planning to, move away from single building component heat loss values, and instead calculate losses for the whole building envelope in line with the Energy Performance of Buildings Directive discussed in Section 6. This is seen as a positive development as it works to ensure the building components are considered as part of the whole building, and this usually improves the overall energy efficiency performance of a building. While this is helpful for full building construction, it is less helpful for renovation or refurbishment, where many of the building elements will remain unchanged.

In addition to considering the U-value of a window, other key indicators are day light transmittance, solar heat gain and air leakage. Each of these aspects needs to be taken into account when designing an efficient window.

Day light transmittance is a measure of the amount of daylight that passes through a window and enters a room. Successfully achieving acceptable or high levels of daylight transmission will mean that minimal energy will be used for artificial lighting of the interior of the building. However, increasing amounts of glazing can mean that the level of daylight transmittance is decreased. Achieving an

[48] http://www.greenconsumerguide.com/commerciall.php?CLASSIFICATION=25&PARENT=19 and communication from Pilkington Group Ltd.
[49] Building Regulations for Windows in European Countries, Summary sheet from Pilkington.

optimum design of window can mean that the properties of thermal efficiency and day light transmittance must be balanced.

Solar heat gain (G-value) is a measure of how much heat from the external environment is transferred through a window into the interior of a building. Depending on the regional climate a building may benefit from the heating effects of solar radiation i.e. in a cool climate, or it may be beneficial to prevent this as would be the case in warmer climates. Table 4 gives some typical solar heat gain factors for a variety of window types and allows comparisons to be drawn between the technologies.

Table 4: A range of levels of window sophistication and their corresponding solar heat gain coefficients [50]

Glazing type	G-value / SHGC
Single glazed, clear	0.86
Single glazed, tinted (bronze or grey)	0.73
Double glazed, clear	0.76
Double glazed, tinted (bronze or grey)	0.62
Double glazed, high performance tint	0.48
Double glazed, high solar gain, low-E	0.71
Double glazed, moderate solar gain, low-E	0.53
Double glazed, low solar gain, low-E	0.39
Triple glazed, moderate solar gain, low-E	0.50
Triple glazed. Low solar gain, low-E	0.33

Air leakage or air infiltration is the amount of air that a window (or any other construction unit) allows to enter or leave a building. For good quality windows, air leakage is low and therefore makes little difference to energy performance, for poor quality windows that demonstrate air leaks, the impact is significant. The air leakage value is expressed as the L50 factor.

If the only parameter taken into account when designing windows was heat loss, the solution to make buildings warmer and more sustainable would be to use smaller windows – as was starting to occur in some building designs. This has obvious drawbacks: the primary function of windows is to provide good quality natural light for the occupants. Reduced window size will proportionally reduce this light delivery. Indeed poor light transmission can create gloomy interiors that are less pleasant to spend time in, and have been proven to affect both the mood of the occupant, and their ability to perform quality work. In addition the solar heat gain that windows can provide to a building can improve the overall energy efficiency of that building by contributing to the heating of the internal space.

[50] Carmody, J., Selkowitz, S., Arasteh, D. & Heschong, L., Residential Windows: A Guide to New Technologies and Energy Performance, W. W. Norton, New York, 2000, http://naturalfrequency.com/articles/thermalsolargains

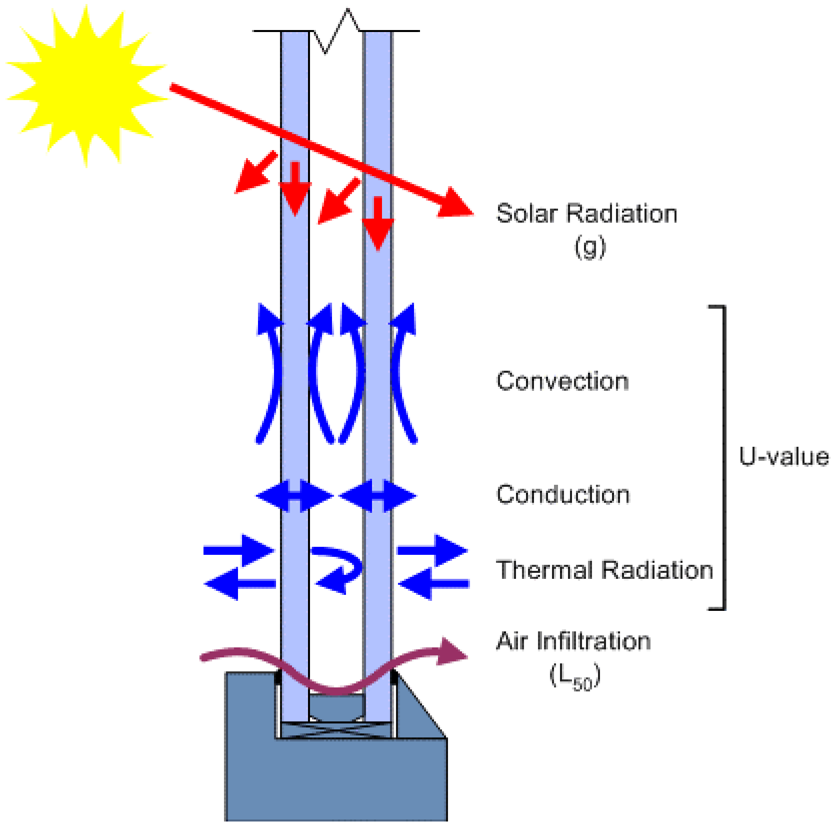


Figure 2 The energy flows for a double glazed window.

4.2.2 Maintenance

During the lifetime of a window some maintenance will be required, irrespective of the materials used to construct it. Appropriate maintenance will help the window realise its full lifetime, while a lack of maintenance may reduce the lifetime of the window.

Cleaning and removing debris will be the minimum required. If timber has been used as the framing material, regular painting of the exterior wood will be required, whether with oil, preservative or paint. Maintenance therefore has a significant cost implication during the lifetime of the product.

It is often the case the intended lifespan of an IGU is significantly longer than that of the glazing element of the window. In such cases replacement of the glazing component can be achieved at significantly lower cost than replacement of the whole window, extending the lifetime of the whole unit.

4.2.3 Indoor Air Quality

The installation of windows into a building has implications for the internal air quality of the building. Any treatments that have been used on the materials or VOCs that are released from the materials themselves will be present in the indoor air. Although it is likely that such indoor air pollution will dissipate within a short period of time, this is still a concern in the short term, and in situations where people are sensitive to such chemicals.

4.3 End of Life

When a glazed unit reaches its end of useful life, either through a replacement unit being inserted or the building demolished, significant proportions of window, door and skylight waste are created. The quantities relating to replacement units are often well known, for example in the UK in 2003 it was identified that 6.7 million window units were replaced, leading 190,000 tonnes of waste including:

- 90,000 tonnes of glass waste
- 74,000 tonnes timber waste.

Estimations up until 2013 predict the amount of waste to be:

- 160,000 tonnes of glass waste
- 6,200 tonnes of timber waste
- 89,000 tonnes of PVC-U waste.

However the quantities of waste generated through the demolition process are often not recorded. It is thought that in the UK for example around 266,000 tonnes of waste flat glass are created per annum, while amounts of timber and PVC-U are unknown. It is likely that a significant proportion of aluminium frames are recycled due to the value this material has at end of life. An investigation by Delft University of Technology identified that aluminium collection rates from a range of commercial and residential buildings (9 buildings in total) in six European Countries were found to be 92 % or higher.[51]

There are few records of glazed units being removed to be recycled before the general demolition of a house. However the introduction of the Vinyl2010 commitment in Europe has raised the profile of recycling PVC-U, with developments such as the first PVC framed window to be made from recycled first generation PVC, currently installed in a social housing project in Manchester, UK.[52]

The volumes of flat glass wastes are expected to increase in future years as whole glass facades are replaced or demolished.

Waste from such replacement or demolition activities is regularly sent to landfill, or via a waste segregation plant where superficial segregation is performed such as the stripping of metals.[53]

Thus windows must be a balance of priorities:

1. Good physical properties
    a. Low U-values created by using double or triple glazing, low emissivity coatings and an inert gas fill.
    b. Appropriate solar gain and air tightness values.
    c. Appropriate values of daylight transmittance.

2. Environmental burden
    a. Natural resource depletion
    b. Energy consumption during material manufacture
        Both of which will have more significant impacts for double glazing than for single glazing, and for triple glazing versus double glazing
    c. Energy consumed during window construction
    d. Disposal.

When considering purchasing windows, all the above issues must be taken into consideration against the back-drop of local and regional climate, local geography, and in the case of GPP, regional and national legislation.

[51] Comment from European Aluminium Association during consultation phase, and report from Delft University of Technology, http://www.alufuture.org/affg/pdf/TUDelftBrochure2004.pdf
[52] Epwin Group website, news August 2009, http://epwin.co.uk/pages/news/august_09.html
[53] MTP Briefing note BNWS02: Domestic window systems – window waste management.

5 Cost Considerations

Windows are a major component of most buildings, certainly of those used as homes or work places. The use of windows, especially in commercial properties is increasing due to a combination of improved strength and thermal properties, and due to changing fashions. The cost of windows is a considerable part of any build budget, so as a product they must be durable and economical.

Once a building is completed and moves into the use phase, the energy efficiency of the windows becomes a primary concern, as discussed in Section 4.2.1. If refurbishment is being undertaken it is likely that the energy efficiency of the windows will be improved, while the majority, if not all, of the remaining building envelope remains the same.

The payback period for windows will depend on whether their installation is into a new build or a refurbishment. As many older properties do not satisfy the same high level building standards as new builds today, greater energy savings will be afforded through installing highly thermally efficient windows. This will reduce the payback period as energy bills will be reduced by a greater degree. This demonstrates that all stages, initial cost, running costs and the anticipated life expectancy will have an impact on the cost effectiveness of a window product.

In most buildings windows will have a shorter service life than that expected for the life of the building as a whole. It is therefore likely the windows will need replacing several times over the life of the building. On a day-to-day basis windows experience environmental conditions that cause gradual degradation – the weather. The rate of degradation will depend on factors such as geometric position, construction details, composition, porosity, and adherence of corrosion products, environmental pollution, humidity, sun exposure and temperature variations. It must also be considered that the service life of windows not only concerns technical performance, but aesthetic concerns and fashions.

Estimating the average expected lifetime of windows is challenging and depends on many factors including local climatic conditions, use and maintenance. Consequently there are a number of conflicting estimations for window lifetimes. A report by BRE for the British Plastics Federation predicted the service life of PVC, and also assessed timber, steel and aluminium in the context of LCA calculations: [54,55]

- At least 35 years for PVC-U windows,
- 40 years for steel, kiln dried timber and aluminium.

Guidelines issued by the German Ministry of Buildings in 2001 for sustainable buildings, gave the following expected lifetimes for window materials:[56]

- Soft Wood-Windows – 30-50 years
- Plastic Windows – 40-60 years
- Hard Wood-Aluminium Windows 40-60 years
- Galvanised Steel 40-60 years
- Glazing – 20-30 years.

A report by the UK's Waste and Resources Action Plan (WRAP)[57] also provides an overview of typical life expectancies and replacement rates for common glazing types and frame materials (see Table 5). This shows that windows are typically replaced before the end of their actual service life, possibly due to technical progress, financial incentives to replace old windows or changing tastes.

[54] Report by BRE for British Plastic Federation, http://www.pauljervis.net/filemgmt_data/files/BRE%20Service%20Life%20PVC-U%20Windows%20Executive%20Summary.pdf
[55] Information provided by the Council for Aluminium in Buildings during the consultation phase.
[56] Leitfaden Nachhaltiges Bauen, Bundesamt für Bauwesen und Raumordnung, Januar 2001, Guidelines for Sustainable Construction, Federal Office for Building and Regional Planning, January 2001.
[57] Sjogren Leong, M. (2004). Increasing the Collection and Recycling of Post Consumer Domestic Window Waste. WRAP Research Report. Tabulated data from BNWS01: Domestic window systems – industry, product and market overview.

Table 5 Common domestic window frame and glazing life expectancy and replacement periods

Frame type	Average life expectancy (years)	Typical replacement period (years)
Softwood timber frames	8 – 10	7 – 8
Hardwood timber frames	20 – 35	10 – 15
Steel frames	40 – 60	30 – 40
Aluminium frames	20 – 35	Glazing (10 – 15)
Polyester powder coated aluminium frames	20 – 40	Glazing (10 – 15)
PVC-U	20 – 25	10 – 20

It should be noted that the replacement periods for the glazing section of aluminium windows is included in the table above as this was the format of the original reference – not to single out aluminium windows. Some standards, such as BS 7543: 2003 require a design life of 30 years, and figures provided by European sector associations state that the expected service life for an IGU (Insulating Glass Unit) could be 20 years or more, while the window itself could have a service life at least double that of the IGU.

The more technically advanced a window is the greater the cost at the point of purchase. Technical advances that will increase the cost of a window include using double or triple glazing, using a noble gas (e.g. argon) to fill the cavity between panes rather than dry air, using low-E coatings or noise reducing laminated glass and using frames with minimised thermal bridges. In terms of cost savings achieved through using more thermally efficient windows in a building, there is a balance to be achieved between technologically advanced windows and cost at point of purchase.

The current general advice is that the installation of double glazed units is cost effective and will provide significant environmental benefits compared to single pane glazing in temperate climates – it can be expected to halve the heat lost through a window.[58] Installing triple glazed windows will generate cost and environmental savings, with the additional cost of the glazing sections of the windows usually between 20-40% more than double glazing.[59] The installation of such windows may not be economically beneficial overall, unless extreme cold or hot weather is the norm for significant periods each year, or there is considerable noise pollution in which case the interior environment can be further improved by its use. However, the benefits delivered by triple glazing, even in temperate climates, are not insignificant and a number of European countries are proposing their widespread introduction, Sweden for example already stipulates them, Germany and Austria are soon to introduce standards that will encourage the adoption of them, and such windows are already standard in many demonstration low carbon homes. The ultra-low energy PassivHaus standard requires triple glazed windows with a U-value of no more than 0.8 W/m²K. To achieve a window with such a low U-value it is necessary to use triple glazing and to insulate the frame itself, as well as using more expensive manufacturing techniques, for example the gas krypton tends to be used, instead of argon.

New technologies, such as vacuum sealed units which have not been covered here due to their current very limited availability, may in the future offer increased benefits. However, the primary considerations will continue to be the local climate and use patterns, which need to be taken into account when deciding which level, and type, of glazing is most appropriate for a building.

[58] Energy Saving Trust Advice, www.energysavingtrust.org.uk
[59] Information taken from http://www.glaziersregister.com/About_Double_Glazing.php and comments from Eurowindow

6 Relevant EU Legislation and Policy

This section details EU legislation that is relevant to thermal insulation, which is important for setting the framework in which standards and labels have been developed. Contracting authorities should also be aware of any additional local, regional or national legislation pertinent to their situation with respect to a particular product or service.

6.1 Construction Products Directive (CPD) 89/106/EEC

The Construction Products Directive (CPD) is aimed at creating a single market for construction products, through the use of CE Marking. It defines the Essential Requirements of construction works (buildings, civil engineering works) which indirectly determines the requirements for construction products (in function of the works design and the climatic and geological conditions in the place where the construction works are situated).

Construction products must declare their performance for mechanical strength and stability, fire safety, health and environment effects, safety of use, sound nuisance and energy economy if EU or national regulatory requirements exist. Under the Directive, the Commission may give a mandate to standardisation organisations such as CEN to develop standards in consultation with industry. A list of the adopted standards can be found on the European Commission's website[60], and ones specific to windows in 'Other Standards' and for component parts in 'Appendix 1'. Where harmonised standards are not available, existing national standards apply.

In relation to insulation, the harmonised European product standards developed under the CPD introduced a specific approach on how thermal conductivity of a building is measured and declared This change makes each component of a building's envelope important in achieving an energy efficient building.[61] It should be noted also that Directive 93/68/EEC[62] amended the CPD 89/106/EEC on the approximation of laws, regulations and administrative provisions of the Member States relating to Construction Products.

The Commission has adopted a proposal to replace Council Directive 89/106/EEC by a Regulation (CPR) with the aim to better define the objectives of Community legislation and make its implementation easier.[63] It now includes a specific extra essential requirement related to the sustainable use of natural resources, stating that:

"The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and ensure the following:

(a) Recyclability of the construction works, their materials and parts after demolition.
(b) Durability of the construction works.
(c) Use of environmentally compatible raw and secondary materials in the construction works."

6.1.1 CEN TC 350

Based on mandate 350 European technical standards are currently under development in CEN and will provide a methodology for the voluntary delivery of environmental information for construction products, in a similar way to an environmental product declaration (EPD). It will provide information to allow purchasers to compare the technical and environmental performance of products.

The European standardisation approach is based on a lifecycle assessment methodology covering production (mandatory), construction, use (including maintenance) and end of life stages (all optional). The standardisation work will also consider social and economic aspects of sustainability.

[60] http://ec.europa.eu/enterprise/newapproach/standardization/harmstds/reflist/construc.html
[61] TIMSA Brief: New European Legislation and lambda 90/90.
[62] OJ L 220, 30.8.1993, p. 1–22 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0068:EN:HTML
[63] http://ec.europa.eu/enterprise/construction/index_en.htm

The following diagram demonstrates the various stages considered.

Product			Construction		Use					End of life			
Raw materials supply	Transport	Manufacturing	Transport	Construction/ installation	Use	Maintenance	Repair	Replacement	Refurbishment	Deconstruction/ demolition	Transport	Reuse/recycling	Disposal

Within these stages the following environmental indicators are being developed:

1. Life Cycle Impact Assessment (LCIA) emission indicators (output):
   - Climate change
   - Destruction of the stratospheric ozone layer
   - Acidification of land and water resources
   - Eutrophication
   - Formation of ground level ozone

2. Resource use indicators (input):
   - Use of non-renewable materials
   - Use of renewable materials
   - Use of secondary materials
   - Use of non-renewable primary energy
   - Use of renewable primary energy
   - Use of freshwater resources

3. Waste indicators
   - Construction and demolition waste to recycling
   - Construction and demolition waste to energy recovery
   - Non-hazardous waste to disposal
   - Hazardous waste to disposal
   - Radioactive waste to disposal

CEN TC 350 is working on a standardised voluntary approach across Europe for the delivery of environmental information on construction products, and to assess the environmental performance of building products and new and existing buildings. It will specify what information should be declared on the labels of construction products, however, the declarations will not specify benchmarks or standards that products should aspire to, which will be done by other instruments like GPP. Until the CEN TC 350 work is complete the EU GPP criteria have been developed using the current evidence base available that is provided by the existing ecolabels.

The following timetable for CEN 350 has been provided by EURIMA:

WI	Standard	Title of standard	Comment
	prEN 15643-2	Sustainability of construction works- Framework for Environmental Performance	**Enquiry September 2008**
WI 350002	EN	Sustainability of construction works – Assessment of environmental performance of buildings – Calculation methods	**Enquiry Nov 08**
WI 350003	EN	Sustainability of construction works - Assessment of environmental performance of buildings - Use of the EPD	**Enquiry June 09**
WI 350004	prEN 15804	Sustainability of construction works - Assessment of environmental performance of buildings- Product category rules	**Enquiry September 2008**

WI 350005	EN	Sustainability of construction works – Environmental product declarations Communications format	**Enquiry January 2009**
WI 350006	TR	Sustainability of construction works – Environmental product declarations – Methodology and data for generic data	**Vote January 2009**

ISO standards exist for determining life cycle impacts. The interested reader is guided towards EN ISO 14040: 2006, EN ISO 14044: 2006, EN ISO 14025: 2005 and EN ISO 21930:2007 for further details.

6.1.2 CEN TC 351

Mandate 351 was established in 2005 under the framework of the Construction Products Directive (89/106/EEC - CPD with the title "Construction products: Assessment of release of dangerous substances". It deals with the emission of dangerous substances from construction products, that may have harmful impacts on human health and the environment (Essential Requirements 3 (ER3) of the CPD). Horizontal standardised assessment methods for harmonised approaches relating to dangerous substances are developed under the CPD and relates to emissions to indoor air and release to soil, surface water and ground water. These horizontal assessment methods will be used in product specific harmonised European standards under the framework of the CPD. Technical reports for CEN 351 were due in April 2009.[64] By January 2010, despite a number of documents having been reviewed, no TC 351 documents were approved for enquiry/ formal vote.[65]

6.2 The Energy Performance of Buildings Directive (EPBD) 2010/31/EU

This Directive[66] is a recast of Directive 2002/91/EC and is concerned with promoting energy efficiency in buildings across Europe using cost effective measures, whilst at the same time harmonising standards across Europe to those of the more ambitious Member States. The original Directive has been recast for the purposes of clarity in light of previous amendments and further substantive amendments to be made.

It is widely recognised as important to tackle the construction sector as energy use in buildings, for space heating, cooling and lighting accounts for around 40 % of total energy use in Europe.

This Directive centres around four key strands:

- Providing a methodology framework for calculating the energy performance of buildings, taking into account local climatic conditions;
- Applying energy performance requirements to both new buildings and existing building stock;
- Providing a certification scheme for all buildings together with;
- Regular assessments of any heating and cooling equipment installed.

The recast Directive ensures that all new buildings must comply with high energy-performance standards as well as generating a significant proportion of their own energy through renewables after 2020. The intention is that the public sector will lead the way through using buildings with "nearly zero" energy standards two years earlier, from January 2019. However the definition of "nearly zero" was left vague, and this will allow member states to define their own standards.

Buildings with a useful floor area over 500m^2 that are occupied by public authorities and frequently visited by the public will be required to display the energy performance certificate in a prominent place, where one has been issued. The 500m^2 threshold will be lowered to 250m^2 on 9 July 2015.

[64] http://www2.nen.nl/cmsprod/groups/public/documents/bestand/249543.pdf
[65] http://www.normapme.com/docs/expertsmeeting/presentations/experts/
[66] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF

The provision for existing buildings states that where major renovations are carried out these must increase energy-savings if doing so is “technically, functionally and economically feasible”. In addition Member States will have to develop national plans that encourage owners to install smart meters, heat pumps and heating and cooling systems using renewables energy sources, as well as listing incentives from technical assistance and subsidies to low-interest loans by mid-2011 for the transition to near zero-energy buildings.

6.3 Directive on Packaging and Packaging Waste 94/62/EC and the Directive amending Directive 94/62/EC on packaging and packaging waste 2004/12/EC

The EC Packaging Directive[67] seeks to reduce the impact of packaging and packaging waste on the environment by introducing recovery and recycling targets for packaging waste, and by encouraging minimisation and reuse of packaging.[68] A scheme of symbols, currently voluntary, has been prepared through Commission Decision 97/129/EC[69]. These can be used by manufacturers on their packaging so that different materials can be identified to assist end-of-life recycling.

The Packaging Directive (94/62/EC) was amended in 2004 by Directive 2004/12/EC[70]. This amendment included a number a key revisions. These included further clarification regarding the definition of packaging, amendments to the provisions relating to prevention and revised targets for the recovery and recycling of packaging materials.

6.4 Waste Framework Directive, 2008/98/EC

The revised Waste Framework Directive was signed on behalf of the European Parliament and the Council on 19 November 2008[71]. The revised Directive replaces the existing Waste Framework Directive (2006/12/EC), the Hazardous Waste Directive and the Waste Oil Directive. These Directives will all be repealed in December 2010, once the requirements of the revised Waste Framework Directive have been transposed by Member States into national legislation.

The revised Waste Framework Directive sets the basic concepts and definitions related to waste management and lays down waste management principles such as the "polluter pays principle" and the "waste hierarchy". In relation to construction waste recycling targets of 70% are to be achieved by 2020:

“b) by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material … shall be increased to a minimum of 70% by weight”

It also provides clarification regarding the definition of waste and other concepts such as recycling and recovery.

6.5 Landfill Directive 1999/31/EC

This Directive aims to encourage waste minimisation and increased levels of recycling and recovery of waste and thus reduce the negative effects of landfilling on the environment.[72]

[67] OJ L 365, 31.12.1994, p. 10–23 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31994L0062:EN:HTML
[68] http://www.defra.gov.uk/environment/waste/topics/packaging/index.htm
[69] OJ L 050, 20.02.1997 P. 28 – 31, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31997D0129:EN:HTML
[70] OJ L 47, 18.2.2004, p. 26–32, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:047:0026:0031:EN:PDF
[71] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0003:EN:PDF
[72] OJ L 182 , 16.07.1999 P.1–19 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999L0031:EN:HTML

6.6 Energy End-use Efficiency and Energy Services Directive 2006/32/EC

The aim of this Directive[73] is to improve energy efficiency, manage demand and reduce energy consumption across Europe. Member States will be required to save at least an additional 1% of their final energy consumption each year from 2008 for nine years. Within these targets are savings targets for the public sector of 1.5%[74] as it is expected that a particular contribution will have to be made by this sector, a large part of which will be as a result of public procurement.

6.7 REACH Regulation EC 1907/2006

The REACH Regulation[75] came into force on 1st June 2007 and deals with the Registration, Evaluation, Authorisation and restriction of Chemical substances. It provides an improved and streamlined legislative framework for chemicals in the EU, with the aim of improving protection of human health and the environment and enhancing competitiveness of the chemicals industry in Europe.

REACH places the responsibility for assessing and managing the risks posed by chemicals and providing safety information to users in industry instead of public authorities, promotes competition across the internal market and encourages innovation.

Manufactures are required to register the details of the properties of their chemical substances on a central database**,** which is run by the European Chemicals Agency in Helsinki. The Regulation also requires the most dangerous chemicals to be progressively replaced as suitable alternatives develop.

6.8 Directive establishing a framework for the setting of Ecodesign Requirements for Energy-related Products 2009/125/EC

The original Directive (2005/32/EC) on the ecodesign of energy using products was adopted in July 2005 and focused on energy using products. This Directive has subsequently been repealed by Directive 2009/125/EC[76], which is a recast and increases the scope from energy using product to energy related products.

It provides clear EU wide rules for ecodesign, aimed at avoiding disparities in regulation amongst individual Member States, which could impede the free movement of products within the internal market.

The Ecodesign Directive does not in itself set binding requirements for specific products, however it does define conditions and criteria for setting, through subsequent implementing measures, minimum requirements regarding environmentally relevant product characteristics and allows them to be improved quickly and efficiently.

The framework provided by the Directive aims to encourage manufacturers to develop products where they have taken into account the environmental impact of the product throughout its entire life cycle.

Regulations setting binding requirements for specific product groups are gradually been developed, and would only be set for those energy related products which meet certain criteria, for example, key environmental impact and volume of trade across the internal market and only if there is clear potential for improvement of a product. Under the Ecodesign Directive, self-regulation, including voluntary

[73] OJ L 114, 27.4.2006, p. 64–85 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0085:EN:PDF
[74] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/03/1687&format=HTML&aged=0&language=EN&guiLanguage=en
[75] OJ L 396, 30.12.2006, p. 1–849 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:396:0001:0849:EN:PDF
[76] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF

agreements offered as unilateral commitments by the industry can, under certain conditions, be recognised as a valid alternative to implementing measures.

6.9 The CLP Regulation (EC) No 1272/2008

The Regulation of 16 December 2008[77] on classification, labelling and packaging of substances and mixtures entered into force on 20 January 2009 and will ultimately replace the current rules on classification, labelling and packaging of substances (Directive 67/548/EEC) and preparations (Directive 1999/45/EC). Substance classification and labelling must all be consistent with the new rules by 1 December 2010 and for mixtures 1 June 2015.

The Regulation aims to ensure a high level of protection of human health and the environment, as well as the free movement of chemical substances, mixtures and certain specific articles, whilst enhancing competitiveness and innovation. This should be achieved by ensuring that the same hazards will be described and labelled in the same way all around the world.

6.10 Directive on the indication by labelling and standard product information of the consumption of energy and other resources by energy related products 2010/30/EU

This Directive[78] is a recast of the original Energy Labelling Directive (92/75/EEC). The recast has been undertaken to clarify the Directive in light of the number of changes, and further changes that have been made to the original directive.

Directive 92/75/EEC was only applicable to household appliances. The recast Directive (2010/30/EU) aims to improve the overall environmental performance of products and to help consumers buy more eco-friendly products, through its application to 'energy related products', including construction products, that have a significant direct or indirect impact on the consumption of energy.

This extension of the scope to energy related products could reinforce potential synergies between existing legislation, and in particular Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy related products.

The recast Directive for the labelling of energy related products forms part of the broader legal framework to bring about energy savings and environmental gains.

6.11 Future Legislation

In 2008 a proposal for a Regulation of the European Parliament and of the Council laying down the obligations of operators who place timber products on the market (COM2008/0644 final-COD2008/0198)[79] was put forward. This has become known as the proposed EU Due Diligence Regulation.

To minimise the risks of placing illegally harvested timber and timber products on the market, the proposal outlined requirements for the due diligence system, which included the following:

- Measures to track timber and timber products
- Ensure information regarding compliance with applicable legislation is available

[77] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:en:PDF
[78] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0001:0012:EN:PDF
[79] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0644:FIN:EN:PDF

- Require operators to show prudence, judgement and positive action when considering the legality of timber entering their supply chains.

The Regulation is still in the process of being finalised and progress can be followed through the European Parliament website[80].

Once the EU "due diligence" regulation is in operation, wood placed on the EU market and which has thus been subject to a due diligence system will also be deemed to be legal, unless a specific challenge arises under which its bona fides are unproven. In the future this will be useful for the verification of green public procurement criteria relating to timber.

[80] http://www.europarl.europa.eu/oeil/file.jsp?id=5704232

7 Existing Ecolabels and Standards for Windows

7.1 Ecolabels and Standards

There are various sets of Ecolabel criteria currently available for windows: the Nordic Swan, the New Zealand, Canada and Australia's energy rating ecolabels, the Korean Ecolabel, the Taiwan GreenMark, the UK Energy Saving Recommended Logo and the US and Canadian Energy Star systems are some examples. The different ecolabels have varying scope, for example some include skylights, others don't, or they may be concerned with regional climates and what constructions are most suitable, rather than a generic set of criteria. Despite this many of these ecolabels are examples of best practice and represent good quality work and performance. Summaries of the criteria used by these standards are outlined below.

7.1.1 Nordic Swan Ecolabel

One of the most comprehensive Ecolabels for windows is the Nordic Swan system.[81] This is a voluntary certification system that covers Denmark, Finland, Iceland, Norway and Sweden. It is designed to provide a guide for fixed and opening windows and window-doors, and exterior doors forming the boundary between free and heated areas.

Like several of the other Ecolabels, the Nordic Swan places definitions on the thermal efficiency of the window, but it goes further and places restrictions on chemical use, wood and wood preservatives, sorting waste, and plastic additives. Such restrictions apply to subcontractors as well as main contractors. Thus this ecolabel is a multi-attribute certificate. It is also a pass or fail label, where most others discussed in this document use a scale to rank products.

The main aspects of the Nordic Swan Ecolabel are:

- Heat transfer (U-value): The U-value must be 1.3 W/m^{2}K or lower, for a 12 x 12 m window, for the whole window including the frame. An exterior door must have a U-value of 1.0 W/m^{2}K or lower and air-tightness of at least 600 Pa.

- Solar energy transmittance (G-value): must be 52±2% or more, measured perpendicular to the glass (so incoming solar energy heats the building).

- Daylight Transmittance: The daylight transmittance must be 63±2% or higher, i.e. the window must not be considered as daylight shielding.

- Air permeability: A window must fulfil Class 4 of EN 12207 for air permeability under negative and positive pressure.

- Material restrictions:
    - 70% of the solid wood in exterior doors must come from certified sustainable forests.
    - Halogenated plastics are not permitted, neither are plastics containing additives of lead, cadmium, chlorinated/brominated paraffins, organic tin compounds, phthalates or polybrominated diphenyl ethers.
    - Exterior doors must not contain chemical products classified as carcinogenic, toxic to reproduction, causing inheritable damage, toxic or sensitising by inhalation in accordance with regulations in force in any Nordic country and/or EU classification system 1999/45/EC.
    - Plastic casement and frame parts heavier than 50g must be visibly labelled for recycling in accordance with ISO 11469.

[81] Ecolabelling of Windows and Exterior Doors, Criteria document, 12 December 2001 – 30 June 2009, Version 2.4 and http://www.svanen.nu

- Filler gases that contribute to the greenhouse effect, with a Global Warming Potential (GWP) greater than 5 *over a period of 100 years* may not be used in the insulating units. (Inert gases such as argon and krypton have a GWP lower than 5).
- Chemical products (paint, adhesive, sealants, putty) in the finished window/exterior door must contain no more than 2 % of substances classified as environmentally hazardous according to EC Directive 67/548/EEC3. For wood preservative this rises to 3 % as defined by 67/548/EEC4.
- Significant (and specified) sections must be made of heartwood, all exposed wooden sections must be treated with wood preservatives in accordance with the Nordic Wood Preservation Council's (NTR) class B, or be metal-covered.

- Other
  - The manufacturer of the window/exterior door must provide a 10 year warranty.
  - The manufacturer must provide maintenance recommendations, which must satisfy relevant product certification requirements. The manufacturer must also have documented procedures and instructions for quality and environmental assurance.
  - The manufacturer and subcontractors must separate the different types of production waste. Furthermore, a plan for separating waste at source must be drawn up, describing how the waste is dealt with, e.g. recycling, landfill and incineration. If the waste is environmentally hazardous this must be stated.
  - Included with delivery must be written instructions for handling the window/exterior door, for installation, protection, maintenance and G- and U-values.

All of these requirements must be verified by documentation. There is a great deal more detail provided within the Nordic Swan Criteria Document; this is a simplified summary only.[82]

7.1.2 WERs in the UK

In the UK the British Fenestration Ratings Council (BFRC) established the Window Energy Rating system (WERs) to assess the thermal efficiency of windows of a standard size (1.48m by 1.23m) allowing comparison of products against one another under identical conditions.[83, 84] The WERs were developed with EU funding, with the input of many Member States and are the British implementation of WERs. The intention is to assist consumers to quickly understand the energy efficiency differences between products, to allow legislators to ensure that fitted windows meet the legal requirements, and to enable energy agencies to give support to the more energy efficient products.

The use of WERs as an alternative to U-values as a criterion for compliance gives a more accurate indicator of the energy performance of a window because they take a range of factors into account including thermal transmittance, useful solar heat gain and air tightness. Ultimately this provides a method to link window performance to other thermal assessment systems, and as such has become widely recognised throughout the building industry in the UK, and has become a recognised component of building regulations.

The measure allows comparison between different products but it does not provide the actual energy efficiency for specific products when installed. The actual energy consumption for a specific product in a specific site will depend on the location, the building parameters such as insulation and occupancy, the building geometry and orientation, the local climate and the indoor temperature set by the occupants.

The WERs assess the whole window, so covers the frame material, the frame design, the glass type and all the other components that make up the window. The rating is carried out by computer simulation of the product to European Standards and the use of climate data and building models. This generates a single value that can then be used to compare the energy performance of a window simply and quickly.

The BFRC system uses three measures of energy efficiency. These are:

[82] http://www.svanen.nu/Default.aspx?tabName=CriteriaDetailEng&menuItemID=7056&pgr=62
[83] BFRC Guidance Notes, BFRC Ratings Calculations.
[84] BFRC Guidance Notes, BFRC Rating and Energy Saving Recommended.

- Thermal transmittance (U-value): measuring how well a product prevents heat escaping.
- Solar Factor (G-value): This measures how well a product blocks heat caused by sunlight. The Solar Factor is expressed as a number between 0 and 1. A lower Solar Factor means less heat gain.
- Air Leakage (L50 value): For good quality windows, air leakage makes little difference to energy performance, for leaky windows, the impact is significant.

The BFRC Rating is calculated from the simple formula:

Rating = 218.6 x G-value – 68.5 (U-value + L50)

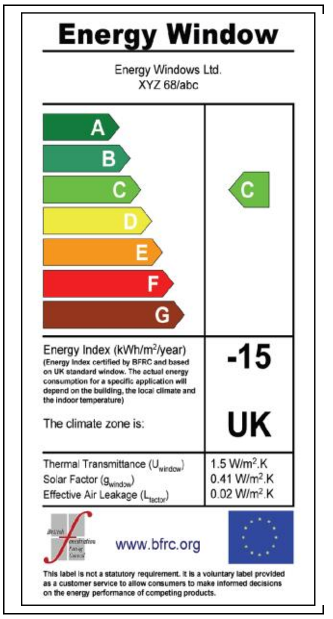
The computer simulation is run, and the number produced is converted into an A to G rating system, as shown in Table 6. Thus an A-rated window is more energy efficient than a G-rated window, as demonstrated by the summary table below.

Table 6 BFRC Rating System

BFRC Rating Scale	BFRC Rating (kWh/m^2/year)
A	0 or greater
B	-10 to < 0
C	-20 to < -10
D	-30 to < -20
E	-50 to < -30
F	-70 to < -50
G	Less than –70

This is then converted into a diagram similar to the EU Energy Label for energy using products to represent the values, an example is shown below in Figure 3.

Figure 3 BFRC Rating Scale and Label



The UK building regulations Part L (for England and Wales) make use of this classification scheme by stating the minimum level for replacement domestic windows is band E while for windows in new domestic extensions, the minimum requirement is band D. In Scotland the matter is discussed in Technical Handbook, Section 6 concerning the energy use of dwellings.[85]

[85] Scottish Building Standards, Technical Handbook, Section 6, http://www.sbsa.gov.uk/tech_handbooks/th_pdf_2008/domestic/chapters/Section_6_Domestic_2008.pdf

Manufacturers that produce windows that achieve a grade C or above are eligible to apply to the Energy Saving Trust's (EST) endorsement scheme for approval to use the logo and to be listed on the energy saving recommended database.[86] This mark is endorsed by the UK government, widely recognised by consumers and is well respected as indicating which products are energy saving, and to what degree.[87]

Furthermore the EST has produced a series of Best Practice guides for windows in new dwellings which use BFRC ratings as the measure of window performance: Good Practice is achieved by the use of D rated windows and Best Practice via the use of C rated windows. Whilst not mandatory, these guides will be used increasingly in any UK government-funded construction (e.g. social housing).[88]

At the same time the UK's Department for Environment, Food and Rural Affairs (Defra) "Quick Wins" procurement specification used in Sustainable Public Procurement specified that using a window of C rating was good practice (84 % of rated windows at BFRC), while best practice was achieved by using B rated windows (44 % of rated windows on BFRC). In both cases the other life cycle impacts, such as frame materials used (timber, plastic, metal) should be considered.[89]

The BFRC are working to extend the rating system to glazed doors, patio, French and Juliette doors[90] in 2009, with the stipulation that the doors should contain a minimum 25 % glazing surface area to qualify to be included in the rating system. (Windows typically contain 70 % glazed surface area.[91])

7.1.3 New Zealand and Australia

New Zealand and Australia both have a window efficiency rating system, WERS. In New Zealand the scale runs from five stars which is the highest rating to one star, the lowest. The WERS assessment covers performance on winter heating, summer cooling, and prevention of fading.[92] The Australia WERS is a ten star rating, again the more stars the better the energy performance of the window, and considers both commercial and residential windows and skylights.[93] Both systems divide the country into climate zones and consider each of these separately.

7.1.4 Korea

The Korean Ecolabel as applied to windows sets voluntary standards for the use of chemical substances during the production process, for example limits on the amounts of lead, cadmium and mercury in the product (50, 0.5 and 0.5 mg/kg respectively) as well as banning the use of organotin compounds (such as tributyltin and triphenyltin), lead compounds and cadmium compounds.

In terms of energy efficiency, the windows must meet the requirements of 'high-efficient energy equipment technology' as described by law, and must be soundproof to the standard given by the industry. [94]

7.1.5 China and Hong Kong

China has developed an ecolabel that applies to energy saving plastic windows and doors. The specification covers a range of aspects, from ensuring the windows attain the requisite levels of water

[86] http://www.energysavingtrust.org.uk/
[87] http://www.energysavingtrust.org.uk/energy_saving_products/about_energy_saving_recommended_products
[88] Energy Saving Trust, www.est.org.uk/myhome
[89] http://www.sustainable-development.gov.uk/what/priority/consumption-production/quickWins/glazing.htm and http://www.sustainable-development.gov.uk/what/priority/consumption-production/quickWins/glazing.htm
[90] Patio doors: Double width, full height, single glass pane per door, opening through a hinged or sliding mechanism. French door: a door with multiple windows set into it along the full length of the door. Juliette doors: Inward opening full height doors with a metal grille immediately outside, providing a minuscule balcony.
[91] Verbal information from BFRC.
[92] Window Association of New Zealand, http://www.wanz.org.nz/
[93] Windows Energy Rating Scheme, http://www.wers.net/.
[94] EL250. Windows [EL250-2003/1/2003-200], http://www.koeco.or.kr/eng/business/business01_01.asp?search=1_1

and air tightness, to pollution control during manufacture to the thermal insulation properties of the windows.[95]

The Hong Kong Green Label Scheme is an independent, not-for-profit voluntary scheme established in 2000 which uses LCA to identify and then recommend products, including windows that are environmentally preferable.[96]

7.1.6 Canada

Canada uses an energy rating system for windows called the Energy Star system, looking at the overall performance of the product by considering solar heat gains, heat loss through frames, spacers and glass and air leakage heat loss.[97] A value is established in watts per square metre, which is either positive or negative, depending on heat gain or loss during the heating season versus a standard window. Again, the country is divided into climate zones which are treated as separate cases for the establishment of best practice energy performance.

7.1.7 U.S.A.

In the USA the Energy Star Programme has been applied to windows and covers residential windows, doors and skylights within one Ecolabel.[98] Qualification for this scheme is based on the U-value and G-value of each component taken together and incorporating their relative values. The scheme also takes into account the differing requirements of the various regions of the USA, shown in Table 7 with the required U and G-values altering accordingly. For example homes in Florida, in the southern region, need windows that have a cooling effect on the house, where as homes in Washington State, in the northern region, require windows that retain heat.

Table 7 Windows and door values awarded the Energy Star Programme certification.

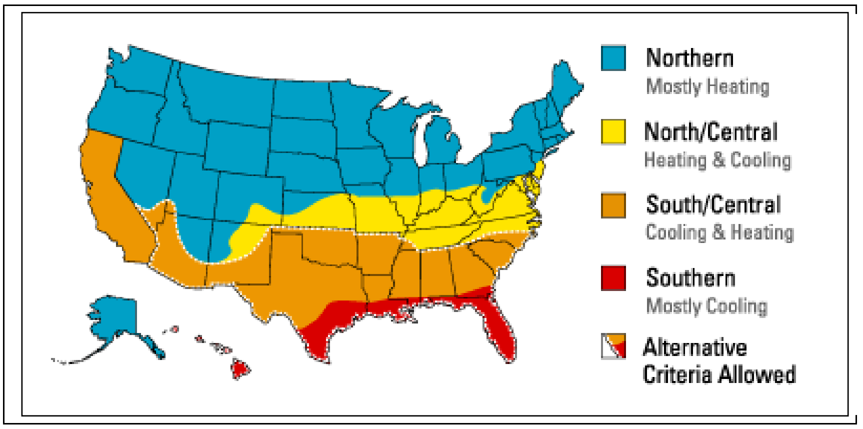
Climate Zone	U-Value*	Equivalent European U-Value***	G-value **
Northern	≤ 0.35	1.99	Any
North/Central	≤ 0.40	2.27	≤ 0.55
South/Central	≤ 0.40	2.27	≤ 0.40
Southern	≤ 0.65	3.69	≤ 0.40

Table 8 Skylight values awarded the Energy Star Programme certification.

Climate Zone	U-Factor 2001 an 2004 NFRC rated at 20ºC****	Equivalent European U-Value***	G-value **
Northern	≤ 0.60	3.41	Any
North/Central	≤ 0.60	3.41	≤ 0.40
South/Central	≤ 0.60	3.41	≤ 0.40
Southern	≤ 0.75	4.26	≤ 0.40

[95] Technical Requirement for Environmental Products, The Certifiable Technical Requirement for Environmental Labeling Products, Energy Saving Doors and Windows HBC 14-2002.
[96] Hong Kong Green Label Scheme, Product Environmental Criteria for Windows (GL-008-004). http://www.greencouncil.org/eng/greenlabel/cert.asp
[97] http://www.oee.nrcan.gc.ca/energystar/english/consumers/window.cfm?attr=4
[98] Energy Star, Programme Requirements for Residential Windows, Doors and Skylights – Version 4, 14th May 2007.
*U-value: The rate of non-solar heat loss or gain through a material or assembly. Expressed here in units of Btu/h·ft^{2}ºF.
** G-value / Solar Heat Gain Coefficient (SHGC): The fraction of solar radiation admitted through a window, door, or skylight. Expressed as a value between 0 and 1.
*** Multiply American U-value by 5.68 to give European U-value in W/m2·ºK.
****U-value qualification criteria based on 2001 and 2004 NFRC simulation and certification procedures that rate skylights at a 20-degree angle. Although reported U-value is higher than RES97 rated products, energy performance at the Energy Star minimum qualifying level is equivalent. Previous NFRC certification using the 1997 NFRC procedures for residential windows rated skylights as a 90-degree angle. Skylights rated under this procedure ceased to be placed on the market from 1st April 2008.

Figure 4 Different climatic regions in the USA[98]



7.2 Other Standards

There are many other standards and specifications for windows throughout the world. Many countries have building specifications which are becoming increasingly focused on building sustainability, and specify either window standards, or thermal standards for the building envelope.

Some very recent examples of developments in the construction sector include the British government recently announcing new resource efficiency targets to be met by construction firms by 2012: the landfilling of construction, demolition and excavation waste must be halved.[99] The strategy promotes green public procurement, design and innovation, and also EU priorities. Meanwhile, the global standardisation body ISO has set a new sustainability standard for the building construction sector, ISO 15392:2008 which covers the general principles to be followed for sustainable construction, however it does not include levels or benchmarks that can serve as a basis for sustainability claims;[100]

> *"ISO 15392 is based on the concept of sustainable development as it applies to buildings and other construction works, from "the cradle to the grave". [sic]*
>
> *The foundations elaborated [sic] form the basis for a suite of standards intended to address specific issues and aspects of sustainability. They are applicable to buildings and other construction works individually and collectively, as well as to building materials, products, services and processes."*

ISO TC163 is developing a standard to assess energy performance of windows that will take into account energy losses, energy gains and a differentiation between windows with and without shutters, currently known as ISO/CD 18292.

Many European trade associations have their own standards and labels that their members must adhere to, to remain as members. Again, only a couple of examples have been provided as there are many examples. The Dutch Association of Metal Windows and Facades (VMRG) have a label for their association members' aluminium and steel window products - called the "VMRG-Keurmerk" (Quality Mark).[101] Similarly the Dutch Association of PVC facade elements industry (VKG) has a label called the "VKG Keurmerk".[102] Both place a high value on informing the consumer about the products and guaranteeing quality, safety and durability.

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[99] ENDS Europe DAILY 2562, 12/06/08, http://nds.coi.gov.uk/environment/fullDetail.asp?ReleaseID=370253&NewsAreaID=2&NavigatedFromDepartment=True and http://www.berr.gov.uk/files/file46535.pdf

[100] International Organisation for Standardisation, Ref 1131, http://www.iso.org/iso/pressrelease.htm?refid=Ref1131

[101] http://www.vmrg.nl/paginas/english/

[102] http://www.vkgkozijn.nl/page.php?id=54

There are also many European glazing standards, which when met allow the CE mark to be applied to component parts and products and therefore allow for their sale in the EU market. The main one is EN 14351-1: Harmonised technical specification for windows and doors which incorporates a U-value as discussed in Section 6.[103] In addition criteria for air permeability (EN 12207:1999) and the correlating test method (EN 1026:2000), water tightness (EN 12208:1999 and test method EN 1027:2000), resistance to wind load (EN 12210:1999) and the thermal performance of windows and doors (EN ISO 12567-1:2000) exist, as do specifications and requirements for timber and wood-based materials in external windows, doors and frames (EN 14220:2006). EN 12608 covers the requirements for PVC-U profiles for windows and doors. Many specifications for window hardware (fittings, hinges, etc) are also available. Meanwhile PVC-U heat resistance requirements are covered in EN 479:1995 together with the relevant test method EN 478:1995.

There are two ISO standards that are directly applicable to fenestration products. EN ISO 10077 Parts 1 (1:2006) and 2 (2:2003), is used throughout Europe and considers the thermal transmittance of windows and frames for inwards opening windows.[104] Meanwhile ISO 15099 is another standard for windows and that has been adopted outside of Europe in places like the United States of America and Canada. However it conflicts with European standards such as EN 673 and 410.

[103] European Committee for Standardisation, and http://standards.mackido.com/en/en5.html
[104] Advice from BFRC. http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40360, http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=30300

8 Conclusion & Summary

Windows (including glazed doors and skylights) play a key role in sustainable buildings. Although windows are essential components of buildings and improve the quality of life for those inside, significant amounts of energy are lost through them. As such the main issue to be addressed is the thermal efficiency of a window. In northern climates this is required to minimise heat loss from space heating while conversely in southern climates this will likely work to reduce the amount of heat gained from the sun and therefore reduce the load on any air conditioning systems.

In order to minimise energy loss careful consideration must be given by any purchasing authority to:

- Local climatic considerations – which way a window may face, whether the area is shaded, etc.
- Regional climatic considerations – the prevailing weather conditions and whether the predominant climate control inside will be heating or cooling.
- The choice of materials used to construct the windows.
- The level of sophistication of the window, and whether environmental payback will be achieved.

Once the thermal performance of the window has been considered, other impacts from windows include the manufacturing and end of life stages. Here it is important to monitor and reduce the burden on the environment from the energy used and natural resources consumed in the construction of windows, and the subsequent waste management at end of life by allowing for greater and better recycling possibilities through ecodesign. It is therefore appropriate that these kinds of issues are addressed in the core and comprehensive criteria.

In addition to the recommended core and comprehensive technical specifications (which are criteria that have to be met by all products offered for purchase), award criteria are proposed where applicable. These are additional criteria on which the contracting authority will base its award decision. Award criteria are not pass/fall criteria, meaning that offers of products that don't comply with the criteria may still be held for the final decision, depending on their score on the other award criteria, including the price. To stimulate further market uptake of ever improved environmental products, award criteria should be considered depending on the specific circumstances of each case.

Windows are just one element of the overall energy performance of buildings. A wider holistic approach forms the basis of the EPBD (Energy Performance of Buildings Directive). Its implementation by the Members States and the integration of the different aspects will be key to improving the overall energy performance of buildings in the future. The recommended GPP criteria for windows and the development of GPP criteria for other construction elements such as insulation and climate control will provide key information to public contracting authorities.

Reflecting the level of importance of windows in a sustainable future for buildings are the number of ecolabels and standards available currently to encourage purchasers to make informed and more sustainable choices. Many countries have their own standards and ecolabels and taking all the current advice into account is practically impossible.

Currently none of the existing standards and ecolabels cover all climatic regions of Europe, so a pre-existing single ecolabel should not be used as a basis to identify the thermal efficiency requirements of GPP criteria. An advanced method for an all-encompassing energy efficiency assessment for Europe would be the wider uptake of a scheme like the British Fenestration ratings Scheme that incorporates U, L50, G-values, as well as incorporating the daylight transmittance values. Climate zones would need to be set, and for each zone constants would need to be established and agreed that can be used within the methodology. Currently such a climate model for windows has not been developed, and to do so was outside the scope of this work.

The method adopted here for assessing the thermal efficiency of the product depends on the ambition level defined in national legislation, or where relevant national regulations are absent, the national regulations from other, appropriate, countries in Europe. The core criteria recommend that the procurement professional aim for at least a 20% improvement on existing thermal efficiency national standard demands, while improvements for the G, L50 and daylight transmittance values must be defined according to local requirements and present a good level of improvement on national requirements. The comprehensive criteria recommend that an improvement of 30% is achieved, and an ‘excellent level of improvement’ sought.

Criteria used for the material impacts of the materials used to construct the windows and the waste implications of the products have been developed from the range of Type 1 Ecolabels discussed in this report.

9 Proposal for core and comprehensive criteria

It is proposed to set core and comprehensive criteria for Windows. The proposed GPP criteria are designed to reflect the key environmental risks. This approach is summarised in the following table:

Key Environmental Impacts	GPP Approach
• Impact of the energy used to heat/cool the building LOST through the window during its use lifetime. • Environmental impact of the materials used to construct the window. • Impact of waste, including packaging and end of life waste.	• Promote the purchase of thermally efficient glazing. • Promote use of frames with higher thermal efficiency and lower impacts (using LCA). • Promote the use of appropriate glazing - consideration of climatic conditions in inform the decision making process. • Promote effective maintenance of windows to extend useful life. • Promote end of life management e.g. take back schemes / re-use / recycling. • Promote products designed to be easily dismantled and recycled. • Promote use of recycled materials. • Promote environmentally sound materials

Please note that the order of impacts does not necessarily translate to the order of their importance.

As outlined in Section 7, there are many ecolabels created for windows, many of which cover a slightly different range of products, and have varying criteria. By far the most significant environmental impact a window, glazed door or skylight has is the loss of energy through it during its use period, estimated to be an order of magnitude (ten times) greater than the energy required to manufacture the windows, and the greatest benefit that a purchasing authority could generate is to minimise this energy loss. This applies both to heat loss to the outside, and therefore more demand on heating systems, in colder climates and concomitantly to heat gain to the building's interior and hence greater need for cooling energy, in warmer climates.

To address this it is proposed that a system based on the thermal efficiency of the window and guided by the ambition level defined in national legislation be used. Where relevant national regulations are absent, the national regulations from other, appropriate, countries in Europe should be used as the basis.

The energy efficiency core criteria have been developed to aim for at least a 20% improvement on existing thermal efficiency national standards, while improvements for the G, L50 and daylight transmittance values must be defined according to local requirements and present a good level of improvement on national requirements.

The energy efficiency comprehensive criteria recommend that an improvement of 30% is achieved, and an 'excellent level of improvement' sought.

Criteria used for the material impacts, at both core and comprehensive level, and the waste implications of window have been developed from the range of Type 1 Ecolabels discussed in this report.

Full details of the proposed purchasing criteria are provided in the associated Product Sheet for this product group.

10 Relevant EU legislation and information sources

10.1 EU Legislation

- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0106:EN:HTML

- Directive on indication by labelling and standard product information of the consumption of energy and other resources by energy related products 2010/30/EU
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0001:0012:EN:PDF

- Energy Performance of Buildings Directive (EPBD) 2010/31/EU
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF

- Council Directive 94/62/EC to reduce packaging and packaging waste.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31994L0062:EN:HTML

- Commission Decision (97/129/EC) of 28 January 1997 establishing the identification system for packaging materials pursuant to European Parliament and Council Directive 94/62/EC on packaging and waste packaging
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31997D0129:EN:HTML

- Directive amending Directive 94/62/EC on packaging and packaging waste 2004/12/EC
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:047:0026:0031:EN:PDF

- Waste Framework Directive 2008/98/EC
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:EN:PDF

- Landfill Directive 1999/31/EC
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999L0031:EN:HTML

- Council Directive 2006/32/EC which focuses on end users of energy.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:01:EN:HTML

- REACH Regulation 1907/2006 ensuring the Registration, Evaluation, Authorisation and Restriction of Chemical substances.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:396:0001:0849:EN:PDF

- The CLP Regulation (EC) No 1272/2008. The Regulation of 16 December 2008 on classification, labelling and packaging of substances and mixtures
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:en:PDF

- Council Directive 93/68/EEC amending many Directives including 89/106/EEC (construction products).
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0068:EN:HTML

- Directive establishing a framework for the setting of Ecodesign Requirements for Energy-related Products 2009/125/EC:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF

10.2 Ecolabels and Standards

- Window Efficiency Rating System (WERS), Window Association of New Zealand
  www.wanz.org.nz

- Window Energy Rating System (WERS), Australia
  www.wers.net

- Energy Star, Canada, Office of Energy Efficiency
  http://www.oee.nrcan.gc.ca/energystar/english/consumers/window.cfm?attr=4

- Korean Ecolabel
  EL250 2003/1/2003-200
  http://www.koeco.or.kr/eng/business/business01_01.asp?search=1_1

- Chinese Ecolabel, China Eco-labelling Centre
  Technical Requirement for Environmental Products, The Certifiable Technical Requirement for Environmental Labeling Products, Energy Saving Doors and Windows HBC 14-2002.

- Hong Kong Green Label Scheme
  Product Environmental Criteria for Windows GL-008-004
  http://www.greencouncil.org/eng/greenlabel/cert.asp

- Energy Star, Programme Requirements for Residential Windows, Doors and Skylights – Version 4, 14th May 2007.
  http://www.energystar.gov/index.cfm?c=manuf_res.pt_windows

- BFRC energy performance label and ratings calculations
  http://www.bfrc.org/

- Nordic Swan
  Ecolabelling of Windows and Exterior Doors, Criteria Document, covering the period 12 December 2004 – 30 June 2009.
  http://www.svanen.nu/

- International Organisation for Standardisation
  Ref 1131
  http://www.iso.org/iso/pressrelease.htm?refid=Ref1131
  http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40360
  http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=30300

- European Committee for Standardisation
  www.cen.en/cenorm/homepage.htm

- VMRG Keurmerk
  Dutch Association of Metal Windows and Facades (VMRG)
  http://www.vmrg.nl/paginas/english/

- VKG Keurmerk
  Dutch Association of PVC façade elements industry
  http://www.vkgkozijn.nl/page.php?id=54

10.3 Studies and Other Sources of Information

- European Commission, Environment, Green Public Procurement
  http://www.ec.europa.eu/environment/gpp

- Eurima, European Insulation Manufacturers Association
  http://www.eurima.org/index.php?page=u-values-in-europe

- Ecotecho, Spanish advise centre for small scale installations
  http://www.sips-spain.com/english/page3/page13/page13.html

- DEFRA, British Government Department for Food and Rural Affairs
  http://www.defra.gov.uk/environment/consumerprod/products/window.htm

- Department of Trade and Industry, Digest of the United Kingdom Energy Statistics, HMSO, London, (1997).

- Genuine High Performance: Timber and Aluminium Clad Windows and Doors, G. Menzies and T. Muncer.

- Better Buildings Leaflet, European Commission,
  http://ec.europa.eu/energy/demand/legislation/doc/leaflet_better_buildings_en.pdf

- Life Cycle of Window Materials – A Comparative Assessment, M. Asif, A. Davidson and T.Muncer.

- Life Cycle Assessment of PVC and of Principal Competing Materials, Commissioned the European Commission, July 2004,
  http://ec.europa.eu/enterprise/sectors/chemicals/files/sustdev/pvc-final_report_lca_en.pdf

- Modern Built Environment KTN
  http://www.bre.co.uk/page.jsp?id=873

- Insulating Glazing Units, S. L. Garvin.

- US Efficient Windows Collaboration
  http://www.efficientwindows.org/

- Pilkington, Flat Glass Manufacturers
  http://www.pilkington.com.
  http://www.pilkington.com/applications/products2006/english/byapplication/householders/roofLights/solarcontrol.htm

- North Canterbury Glass
  www.northcanterburyglass.co.nz/technicalinfo.htm

- Waste Online
  http://www.wasteonline.org.uk/resources/InformationSheets/Glass.htm

- Eco-advise website
  http://www.treehugger.com/files/2004/11/ecotip_glass_a.php

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- The Ecology of Building Materials, Bjorn Berge, Architectural Press, 2001.

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- The embodied energy of a standard house – then and now, Embodied Energy – the current state of play, J A Alcorn and P J Haslam, Deakin University, 28-29 November 1996.

- British Plastic Federation
  The Waste Management of Used Plastics at End of Life.

- Windows: Overview of Issues, M.Z. Rousseau, Building Science Insight '88, "Window Performance and New Technology".

- Journal of Light Construction- Online
http://www.jlconline.com/jlc/archive/exteriors/vinyl_windows/page2.html

- "Windows", Beckett, H.E. and J.A. Godfrey, Crosby Lockwood Staples in association with RIBA Publications Ltd., London, 1974.

- Steel Recycling Institute
http://recycle-steel.org/

- 2005 Minerals Handbook
http://minerals.usgs.gov/minerals/pubs/commodity/recycle/recycmyb05.pdf

- Staff (2007). Xenon. *Columbia Electronic Encyclopedia*. Columbia University Press.

- Periodic Table of Elements: Argon – Ar
www.EnvironmentalChemistry.com

- Vacuum glazing—A new component for insulating windows, R.E. Collins, G.M. Turner, A.C. Fischer-Cripps, J.-Z. Tang, T.M. Simko, C.J. Dey, D.A. Clugston, Q.-C. Zhang, J.D. Garrison, Building and Environment 30 (4) (1995) 459–492.

- Green Consumer Guide
http://www.greenconsumerguide.com/commerciall.php?CLASSIFICATION=25&PARENT=19

- Housing Zone
http://www.housingzone.com/article/CA6423674.html

- Energy Saving Trust
www.energysavingtrust.org.uk

- Glazier's Register
http://www.glaziersregister.com/About_Double_Glazing.php

- Verbal advise from the British Fenestration Ratings Council.

- TIMSA Brief: New European Legislation and lambda 90/90.

- FENSA -
http://www.fensa.co.uk/

- Ends Europe DAILY 2562, 12/06/08,
http://nds.coi.gov.uk/environment/fullDetail.asp?ReleaseID=370253&NewsAreaID=2&NavigatedFromDepartment=True and http://www.berr.gov.uk/files/file46535.pdf

Appendix 1: Technical Standards

The CEN Technical Committee's harmonised European standards generate that are relevant for windows and their components include:

hEN 572-9 – Glass in building. Basic soda lime silicate glass products. Evaluation of conformity/Product standard
EN 1096-4 – Glass in building. Coated glass. Evaluation of conformity/Product standard
EN 1748-1-2 - Glass in building. Special basic products. Borosilicate glasses - Part 1-2: Evaluation of conformity/Product standard
EN 1748-2-2 - Glass in building. Special basic products. Glass ceramics - Part 2-2: Evaluation of conformity/Product standard
EN 1863-2 - Glass in building. Heat strengthened soda lime silicate glass. Evaluation of conformity. Product standard
EN 14179-2 - Glass in building - Heat soaked thermally toughened soda lime silicate safety glass. Evaluation of conformity/Product standard
EN 14321-2 - Glass in building - Heat soaked thermally toughened soda lime silicate safety glass - Part 2: Evaluation of conformity/Product standard
EN 14351-1 - Windows and doors. Product standard, performance characteristics. Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics
EN14449 - Glass in building. Laminated glass and laminated safety glass. Evaluation of conformity/product standard