CE66

Windows for new and existing housing

energy saving trust™

Contents

Introduction

Double-glazed windows are now a standard item in any housing specification in the UK, having many advantages over single glazing. However, basic double glazing will no longer meet the minimum legal standards set down in the building regulations.

Around two million windows are installed every year in the UK in new build and as replacements in existing buildings: most only meet the minimum legal standard so the total potential energy savings from choosing higher performance products are substantial. While these savings are not as large as those achievable from, for example, cavity wall insulation, it is important to recognise that windows are replaced very infrequently, so the opportunity to install high performance glazing may not re-occur for a number of years. For this reason, it may be necessary to prioritise this when the occasion arises. It is much easier to alter the timing of other energy efficiency measures.

Home energy use is responsible for 27 per cent of UK carbon dioxide emissions which contribute to climate change. By following the Energy Saving Trust's best practice standards, new build and refurbished housing will be more energy efficient – reducing these emissions, saving energy and money as well as safeguarding the environment.

This guide is concerned with achieving best practice in terms of window specification and installed performance. Aimed at architects, specifiers, installers and others involved in specifying windows for new and refurbishment projects, it outlines some of the technical options available.

Measuring window performance

A window's energy performance has traditionally been stated in terms of its U-value. However, manufacturers may quote the U-value of the frame, the sealed unit or the whole window – the performance of different products may not be readily comparable. Whole window U-value calculations, while clearly more useful, are complex to determine because they must include the thermal performance of a number of components. These calculations must be calculated in accordance with international standards (BS EN ISO 10077-1 or EN ISO 10077-2), or measured in a 'hot box' test (to BS EN ISO 12567-1).

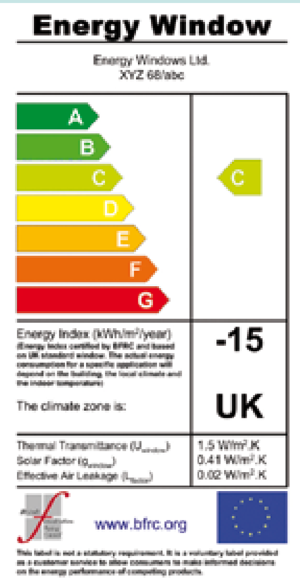
The U-value gives an indication of heat loss through a properly functioning window. However, poorly sealed opening casements and sashes will result in further losses. These may be small in new draught-stripped windows, especially compared to those in the ones being replaced, but they still need to be considered.

On the other hand, heat losses may be offset by solar gains. The exact contribution of this incident energy will depend on a number of factors, including location and orientation, the ratio of frame-to-glass area, and the properties of the glass itself. Because of these additional factors, the U-value is no longer the preferred measure of window performance. In its place is a European window energy rating system, known in the UK as the BFRC Rating.

This has been developed by the British Fenestration Rating Council (BFRC) and a number of European partners. Taking into account heat losses and solar gains, the BFRC Rating is a single number indicating the window's overall energy performance. To achieve a rating, a window installer must also have suitable quality management procedures in place to guarantee the performance of the installed product.

Similar windows may differ in the materials and components they are constructed from and the technologies they employ (window technologies are considered in more detail later in this document). As a result they can have quite different energy ratings (see Table 2). So assessing the true energy performance of a window is a highly complex process. The BFRC Rating system, though, offers a simple route to ensuring the selection of high performance windows.

A complete list of BFRC Rated windows is available at www.bfrc.org



Band	BFRC rating
A	0 or better
B	0 to -10
C	-10 to -20
D	-20 to -30
E	-30 to -50
F	-50 to -70
G	-70 or worse

The BFRC Rating

Developed in collaboration with European partners, the British Fenestration Rating Council system compares the overall energy performance of windows. It is based on the total annual energy flow (kWh/m^2/yr).

Most windows have a negative rating: this indicates a net heat loss over the year. However, a few very high performance products may be able to achieve a positive figure (indicating a net capture of heat).

The ratings are classified in bands A-G to make the system more consumer-friendly. In time, the BFRC Rating is expected to replace the U-value as the main UK method for specifying windows. More information on the BFRC Rating can be found at: www.bfrc.org

Energy Saving Trust standards

The Energy Saving Trust sets out performance standards for windows in new and existing housing. These are based mainly on the BFRC Rating bands. Note that the BFRC Rating does not apply to doors: these are still specified by U-value.

General specifications

The following specifications should be included, in addition to the BFRC Rating band or U-value (see Table 1):

- The frames should be of high quality and designed for the chosen glazing units.
- Glazing units should preferably be installed in a properly drained and ventilated frame. Solid bedding should only be used if windows are factory-glazed or in situations where a drained and vented system is impractical or unavailable.
- Units should comply with BS 6262, as described in the Glass and Glazing Federation manual (www.ggf.org.uk).
- Glazing units should be dual-sealed and certified in accordance with BS 5713:1979 (due to be replaced by EN 1279 in 2006).
- Site installation must ensure effective sealing round window and door frames (see Further reading).

New housing

There are three Energy Saving Trust performance standards for new housing and these are set at different levels. A 'whole house' approach is used to consider the overall carbon dioxide emissions. This allows specifiers to 'trade off' the performance of one construction element against others. Limits, or 'lowest acceptable standards' are set for the performance of building elements including walls, floors, doors and roofs and in many cases better performance will be required to meet the whole house requirements. The limiting values for windows and doors are set out in Table 1. Full details of these standards can be found on the Energy Saving Trust website at: www.est.org.uk/housingbuildings/standards

Table 1 Limiting performance standards for windows and doors

	Good practice	Best practice	Advanced
	BFRC Rating band		U-value (W/m^2K)
Windows	D	C	Metal frames 1.1 Other frames 0.8
	U-value (W/m^2K)		
Doors			
– solid	2.2	1.0	0.6
– half glazed	2.2	1.5	

Building regulations and existing homes

Where work is subject to building regulations[1,2,3,] agreement should be reached with the building control body prior to work being carried out. Alternatively, in England and Wales, a Fenestration Self-Assessment Scheme (FENSA) registered company (www.fensa.org.uk) can be used.

In England and Wales changes to the building regulations in April 2006 require replacement windows to have a BFRC Rating in band E, or a U-value of $2.0W/m^2K$, or a centre pane U-value of $1.2W/m^2K$. New windows in existing buildings (e.g. in extensions) must have a BFRC rating in band D, or a U-value of $1.8W/m^2K$ or a centre pane U-value of $1.2W/m^2K$.

There are no technical requirements for windows in existing homes in Northern Ireland but it is anticipated that changes in June 2006 will impose similar requirements to those in England and Wales.

In Scotland a U-value of either 2.0 or $1.8W/m^2K$ (depending on the main heating fuel for the building) is necessary.

Energy Saving Trust standards

Existing housing

For existing homes, the Energy Saving Trust specifications require a BFRC Rating in band C or better for windows, patio doors and French doors. For comparison, the legal minimum required by the building regulations in much of the UK is a band E rating (see box below).

Windows that do achieve a BFRC Rating in band C or better can also apply for 'energy saving recommended' certification. A full list of certified products is available at: www.est.org.uk/recommended

energy saving recommended
www.energysavingtrust.org.uk

Certification mark

External doors should be replaced with insulated solid doors (U-value less than 1.0W/m²K) or half-glazed insulated doors (U-value less than 1.5W/m²K).

Windows in historically sensitive buildings should only be replaced following consultation with the local authority's building conservation officer. If high performance windows cannot be used, other means of improving energy efficiency should be considered, such as greater use of insulation or more efficient heating.

Glazing performance

A window's thermal performance depends on a number of factors, including its design, the materials used and the combination of components. Table 2 gives the BFRC Rating and U-value for a number of window types.

It can be seen that changing the window specification may, in certain cases, improve the BFRC Rating without substantially improving the U-value. Indeed some specification changes which improve solar gain may actually detract from the U-value. This underlines the advantages of the BFRC Rating approach which considers the window as a system.

Table 2 BFRC Ratings and U-values for a range of window types

Frame type	Glass Layers	Glass type	Air gap (mm)	Gas fill	Spacer	BFRC Rating	Band	U-value
PVC-U (5 chamber)	3	2x low iron 1x hard coat	16 x 2	Argon	Warm edge hybrid	+4	A	1.3
PVC-U (5 chamber)	2	Soft coat	16	Argon	Silicone rubber	-8	B	1.4
PVC-U (3 chamber)	2	Soft coat	16	Argon	Silicone rubber	-13	C	1.5
Timber	2	Soft coat	16	Argon	Corrugated metal strip	-16	C	1.5
PVC-U (5 chamber)	2	Soft coat	16	Argon	Hard polyurethane	-18	C	1.5
Timber	2	Soft coat	16	Air	Silicone rubber	-22	D	1.6
PVC-U (5 chamber)	2	Soft coat	16	Argon	Aluminium	-23	D	1.6
Aluminium (23mm polyamide breaks)	2	Soft coat	16	Argon	Silicone rubber	-26	D	1.8
Timber	2	Hard coat	16	Air	Silicone rubber	-27	D	1.8
PVC-U (3 chamber)	2	Hard coat	16	Air	Aluminium	-38	E	2.0

Condensation

Double glazing reduces the risk of internal condensation: the temperature of the inner pane remains high enough to prevent moisture condensing on the surface. In conventional double-glazed units, enough heat still escapes to keep the external pane condensation-free as well. Any remaining condensation generally occurs at the edges of windows where the metal spacer acts as a thermal bridge.

In very high performance windows with improved U-values, less heat escapes and so the external pane temperature falls. Under particular weather conditions (generally damp weather followed by a sharp drop in temperature on clear, calm nights) dew can form on the external surface of the glazing unit. This is natural: it shows the window is functioning correctly. The microclimate has a particular influence here, so some windows may experience external condensation while others nearby do not.

Glazing technologies

Low emissivity coatings

A low emissivity (low-e) coating allows short wave radiation to pass through but inhibits the passage of long wave radiation. As a microscopically thin coating of metal or metal oxide on a pane of glass, it allows short wave solar radiation into the building. However, it effectively reflects long wave thermal radiation from the interior back into the room. The lower the emissivity, the less radiation is emitted from the window to the outside environment – and the better the U-value.

Low-e coatings are either hard or soft. Hard coatings are applied during the glass manufacturing process whereas soft coatings are applied later. The emissivity (ε_n) of the coating ranges from 0.15 to 0.20 for hard and 0.05 to 0.10 for soft coatings.

Low-e coatings are normally applied to surface 3 of a sealed unit (see Figure 1). They may have a slight tint which varies between suppliers, so glazed units from different sources may look slightly different. Careful records should be kept so that broken units can be replaced with identical products.

The coatings reduce the amount of light passing through the glass (transmittance), which in turn reduces solar gain. This does not affect the U-value of the window, but it does alter the BFRC Rating. So while soft coatings reduce heat loss more than hard ones, they also reduce heat gain. Devices are available which can detect the presence of a low-e coating in a sealed unit, although they cannot determine the type of coating.

For more information, see Post-construction testing – a professional's guide to testing housing for energy efficiency (CE128/GIR64).

Gas-filled units

Heat is transferred between the panes of a sealed unit by radiation and by convection. Replacing the air in the cavity with a more viscous, slow-moving gas minimises the convection currents and so reduces the overall transfer of heat. Argon is most commonly used, although krypton and even xenon can be employed, especially where the cavity width is limited. These gases are inert and non-toxic and so do not pose any risk to health or the environment in the event of a breakage.

The gas is normally inserted via an inlet port and vent in the spacer bar, or by using special corner pieces. Correct specification of the sealed units is important in order to reduce the risk of failure (and subsequent gas loss), and to maintain energy efficient performance.

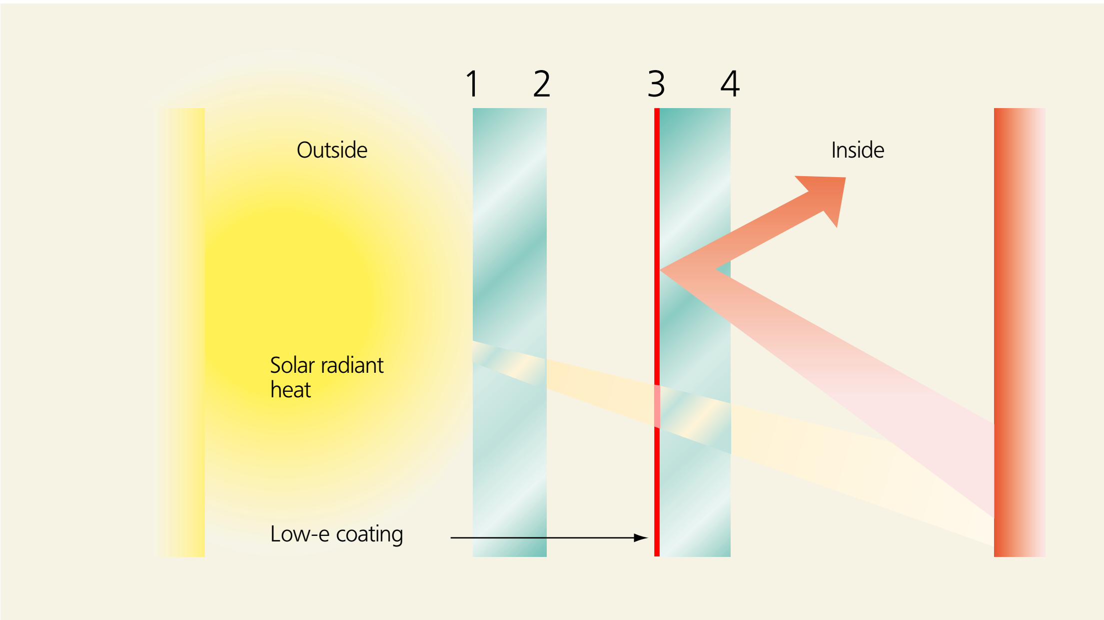


Figure 1 The low-e coating on Surface 3 reflects longer wavelength radiation back into the room, reducing heat loss

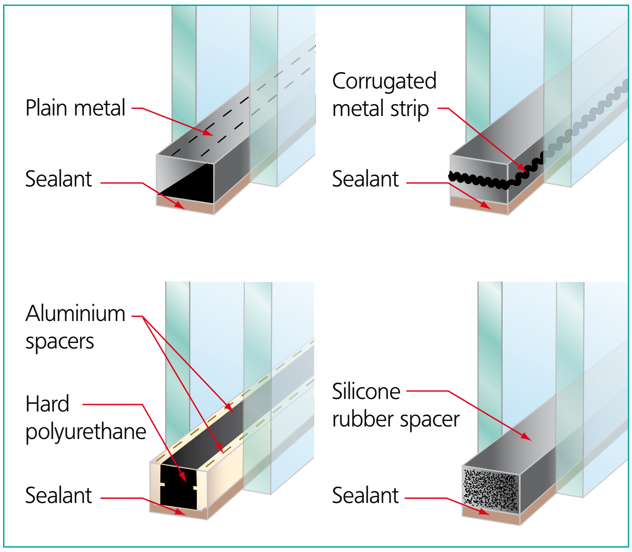


Figure 2 Conventional plain metal and 'warm edge' insulating spacer bars

Figure 3 Section through a composite window
(image courtesy of Rationel Windows)

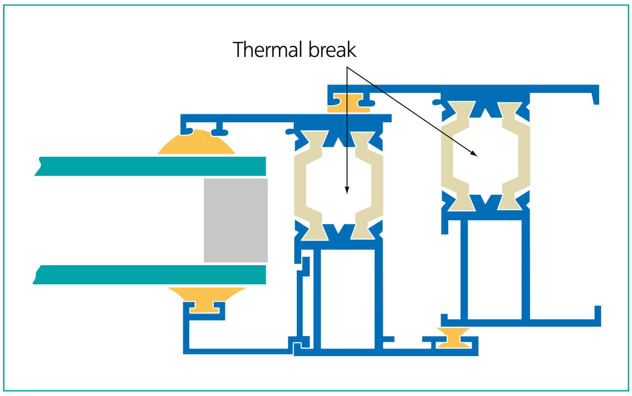


Figure 4 Section of metal window showing thermal breaks.

Insulating spacer bars

The panes of glass in a sealed unit are separated by a spacer bar which is normally made of aluminium. However, its high conductivity creates a thermal bridge around the edge of the unit. This results in greater heat loss and makes the area more prone to condensation, which can encourage mould growth. Stainless steel spacer bars have a lower conductivity than aluminium (17W/mK as opposed to 230W/mK), but while this is an improvement, the term 'insulating spacer bar' should only be used to refer to spacers that have reduced (or even zero) metal content. These are sometimes referred to as 'warm edge'.

Low-iron glass

Sand, the basic material of glass, contains iron as an impurity; this contributes to the green tinge in standard clear float glass which is particularly noticeable in thicker sheets. Removing this iron produces practically colourless glass with high light transmittance. This low-iron glass is an obvious choice for atriums, skylights, doors and entranceways, display cases and storefronts. Its very high solar transmittance (typically 90 per cent compared to 85 per cent for normal 'clear' float) increases solar gain. This benefit becomes more marked with multiple-paned units where it is used in the outer pane, low-e glass being used for the inner pane.

Frame design

The energy performance of the frame can also be improved. Significant advances have been made over recent years and more are possible.

PVC-U: thinner frame sections or 'profiles' increase the proportion of glass in the overall window space, allowing greater solar gain. Many manufacturers now produce profiles with four or five internal chambers which provide slightly better thermal performance than conventional three-chamber designs. A few fill some of the chambers with insulating foam, although this option is not yet generally available.

Timber: improvements in technology have led to greater sectional stability and less movement in use, reducing draughts. New preservation treatments and paints are extending working life and reducing maintenance costs. Composite windows (a timber frame with an aluminium or plastic protective layer on all external surfaces) are more widely available: the coverings reduce the need for maintenance still further (Figure 3).

Metal: manufacturers of both aluminium and steel windows have increased the size and performance of the 'thermal breaks' which reduce the heat flow across the metal window sections (Figure 4).

Embodied energy

There is a growing urgency to reduce the environmental impacts of human activities. Energy efficiency initiatives over the last 40 years have reduced the energy consumption of buildings considerably, but action to minimize the impact from construction materials has been relatively slow. There are two key elements to the energy use of a building. Energy used by occupants to run the building during its lifespan – known as operational energy; and energy used during the manufacture, maintenance and replacement of the components that constitute the building during its lifespan. This is known as embodied energy.

In older buildings operational energy has traditionally represented the major impact. As the energy efficiency standards of modern buildings have been raised the importance of embodied energy has increased. Where the selection of products and materials directly affect the operational energy, the most efficient option should be selected. For those looking to maximise environmental benefit, or where products are very similar in terms of operational performance, then embodied energy aspects should also be taken into consideration.

Windows and doors typically contribute between 5-10 per cent of the embodied energy of a building. Although using double glazing increases the embodied energy of a building, the savings in energy from the improved insulation double glazing provides outweigh this additional impact within a year or so of installation.

Further reading

BR390 The Green Guide to Housing Specification, Anderson and Howard, BRE, 2000 Life Cycle Assessment of PVC and of principal competing materials. Commissioned by the European Commission, April 2004.

Case study – Piper Windows

Window energy ratings are driving up standards and making industry more responsive to customers as Piper Windows showed when they first looked to use ratings.

Following the launch of BFRC Ratings the Energy Saving Trust provided a speaker at events organised by the window industry. One such event run by Network Veka was attended by one of Piper's customers – acting on behalf of a London Borough. Keen to improve the energy efficiency of the products installed in his stock he approached Piper to see what standard they could achieve.

Piper were already aware that a window with a BFRC Rating in band C was practical but they had not looked beyond this. Only by using the window energy rating system could they see the true impact of possible changes in components and a combination that would result in band B was soon identified.

Encouraged by their client to go further, Piper worked with technical staff at Veka to look to different specifications, including product options they had not used before, to see if they could reach band A.

It became clear that a triple glazed window would be required. Multiple layers of low-e glass improved heat loss but reduced affected solar gains – the answer was to combine the thermal performance of low-e with the exceptional clarity of low iron glass. This was combined with warm edge spacers and argon fill to create a high performance sealed unit. By limiting the two air gaps to 16mm they were able to take advantage from the economies of using one of their standard profiles.

As the first window with a rating in band A the product is creating a great deal of interest and is being launched via Piper's commercial and retail divisions. Piper and their profile supplier Veka have learnt the benefits of using window energy ratings to improve their products. However, of equal importance they realise the benefits it offers in working with professional specifiers and are looking to increase the use of window energy ratings across their range so gaining an advantage over their competitors.

Further reading and references

Publications

Glass and Glazing Federation Technical Manual, GGF (www.ggf.org.uk).

Code of practice for the survey and installation of windows and external doors (available from the trade associations listed below).

References

1 Building Regulations 2000, Approved Document L1A Conservation of Fuel and Power – Work in new dwellings (2006 edition) and Approved Document L1B – Work in existing dwellings (2006 edition).

2 Building Regulations (Northern Ireland) 1994, are detailed in Technical Booklet F, Conservation of fuel and power (December 1998) (due for revision June 2006).

3 Section 6: Energy, of the Domestic Technical Handbook on possible ways of complying with the Building (Scotland) Regulations 2004.

Relevant organisations and websites

Trade associations

British Plastics Federation
Tel: 020 7457 5037 www.bpf.co.uk

British Woodworking Federation
Tel: 020 7608 5050 www.bwf.org.uk

Council for Aluminium in Building
Tel: 01453 828851 www.c-a-b.org.uk

Glass and Glazing Federation
Tel: 020 7403 7177 www.ggf.org.uk

Steel Window Association
Tel: 020 7637 3571 www.steel-window-association.co.uk

Other bodies

British Fenestration Rating Council
Tel: 08700 278 494 www.bfrc.org

Building Research Establishment
Tel: 01923 664000 www.bre.co.uk

FENSA
Tel: 0870 780 2028 www.fensa.org.uk

Further reading

The Energy Saving Trust sets energy efficiency standards that go beyond building regulations for use in the design, construction and refurbishment of homes. These standards provide an integrated package of measures covering fabric, ventilation, heating, lighting and hot water systems for all aspects of new build and renovation. Free resources including best practice guides, training seminars, technical advice and online tools, are available to help meet these standards.

The following publications may also be of interest:

- Domestic energy efficiency primer (CE101/GPG171)
- Effective use of insulation in dwellings (CE23)
- Energy efficient refurbishment of existing housing (CE83/GPG155)
- Post-construction testing – a professional's guide to testing housing for energy efficiency (CE128/GIR64)

To obtain these publications or for more information, call 0845 120 7799, email bestpractice@est.org.uk or visit www.est.org.uk/housingbuildings

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