Energy Technical Information

Glass in buildings provide many benefits and features including protection from the elements, allowing us to be part of the outside world, providing natural daylight and the ability to passively heat the home on colder days. However, when used as a clear single panel of window glass, it is less effective in controlling the indoor climate and promoting energy efficiency. In response the glass industry have developed solar control glass (tinted, low-E, reflective glass) and thermal control glass (low-E glass and IGU's).

The Australian government is also focused on the objective of reducing greenhouse gas emissions through the efficient use of energy in residential housing and commercial buildings. This has been proven by introduction and implementation of various codes and legislation. Energy efficient building measures have been in place for many years in North America and Europe.

This section shows how glass is used to mitigate the harsh effects of climate in which we live. It will however in most cases limit the discussion to glass only. Performance values shown are for glass only. Energy efficient window compliance should in most cases make reference to the total glazing system, meaning glass and window frame. Window fabricators should have accredited testing to prove the performance of their glazing systems to meet compliance requirements. Any information used from this publication should be referenced against tested product and building codes that are in existence.

ENERGY EFFICIENCY

The National Construction Code (NCC) for buildings has provisions that require the use of energy efficient windows and doors. This requires window fabricators to have their products tested and rated under WERS or the Windows Energy Rating Scheme which is compliant with the NCC.

ENERGY EFFICIENT WINDOWS

The type of climate has a major influence on window performance. To enable the correct selection of higher performing windows in different areas of Australia, WERS has split the country into three main zones, tropical, temperate and cold. See Diagram 1A.

For actual area/locality details on climate zones, refer to BCA.

- Cooling climate (tropical, subtropical and hot arid areas) – warmer climates where most of the energy used year round is to cool the building;
- Mixed climate (temperate) – in these areas heating and cooling represent approximately a 50/50 split of energy use;
- Heating climate (alpine and cool temperate) – colder climates where most of the energy used year round is in heating the building.

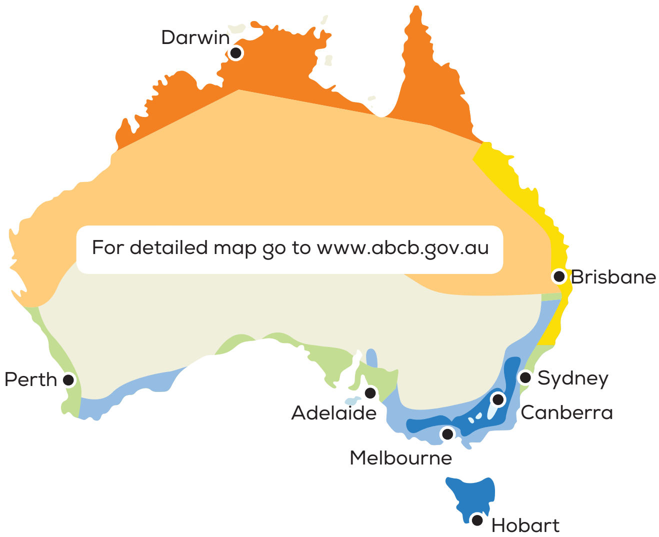
MEASURING WINDOW & GLASS PERFORMANCE

Performance is most commonly measured through the SHGC (Solar Heat Gain Co-efficient) and U-Value factor.

SHGC – SOLAR HEAT GAIN CO-EFFICIENT

Refers to the total amount of solar energy transmittance entering a building through the glazing as heat gain. This measure equates to the Sun's direct transmittance energy (T) plus the part of this energy absorbed by the glass and re-radiated inside (E) (See Diagram 1B). The lower the number the better. It's most commonly used in relation to the cooling of the building. For purposes of understanding the following information, the example we shall use is for 3mm Clear float glass. This glass has a SHGC value of 0.86.

DIAGRAM 1A: CLIMATE ZONES



Tropical (Emphasis on cooling)	Temperate (Cooling and heating)	Cold (Emphasis on heating)
Zone 1	Zone 4	Zone 6
Zone 2	Zone 5	Zone 7
Zone 3		Zone 8

THE SHGC CAN ALSO BE STATED IN THE FOLLOWING WAYS:

- 3mm clear lets in 86% of the Sun's total direct heat or;
- 3mm clear keeps out only 14% of the Sun's total direct heat.

Another way to describe how the SHGC is used is in terms of energy consumption in watts/m2.

For example the sun's direct energy typically radiates on a hot day 785 watts and 6mm Sunergy® Green has a SHGC of 0.41. If you multiply 785 watts x 0.41 (SHGC) you get 322 watts per m2 radiated into the building. In this example the Sunergy® glass is reducing the sun's direct energy into the building by 59%.

U-VALUE

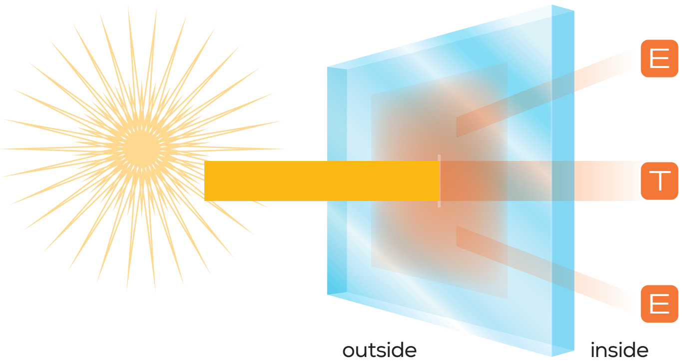
Refers to the measure of heat transfer by method of **re-radiation, conduction** and **convection** (See Diagram 1C). The Sun's direct energy transmission through the glass is not the only way in which heat is transferred through the glazing. Heat also flows naturally from warm air/bodies to cold air/bodies. This heat flow is in the form of long wave (infrared) energy. On warm days the Sun's direct heat on an object (called short wave infrared – what we feel as sunlight heat on our bodies) causes it to absorb and re-radiate this heat in the form of a low-energy heat (long wave infrared radiation). U-value is used to measure this type of non-solar heat transfer. On cold winter days/ night time, U-value is measuring the amount of heat loss from inside the home, for example, from a heater. It is not to be confused with measuring the Sun's direct energy transmission on the glass as measured by SHGC. U-value and SHGC are both important when considering energy costs and comfort. However, each measure may have more weight in different climates.

DIAGRAM 1B: SHGC FORMULA

SHGC = Sun's direct transmission energy **(T)**

\+ Re-radiated heat **(E)**

= SHGC



U-value is measured in watts per square metre per degree Celsius (Wm2K) difference. The amount of heat energy transferred as measured by the U-value can be calculated by taking for example 4mm clear float with a U-value of 5.9w/m2oC and multiplying the difference between outdoor and indoor temperature (32oC outside and 24oC inside = 8oC) › 5.9 x 8oC = 47watts per m2 heat transferred between the outside and inside. The lower the U-value the better the thermal insulation properties of the glazing system. The U-value is progressively reduced by adding more than one pane of glass (IGU's) which reduces the effect of conduction and convection and a low-E coating which reduces the effect of re-radiation.

Table 1A shows insulation comparisons between glass and other building materials. The lower the number the better the insulation. The U-value is the reciprocal of the "R" value and either can be calculated from the other e.g. U = 1/R or R = 1/U.

U and R values are variable and dependent upon climatic conditions. That means that the transmittance of heat through a glazing system changes. Therefore glass transmits heat at varying rates depending upon the prevailing climatic condition. When comparing glazing systems based upon U-value, it is important that the climatic conditions used to model all the systems are the same.

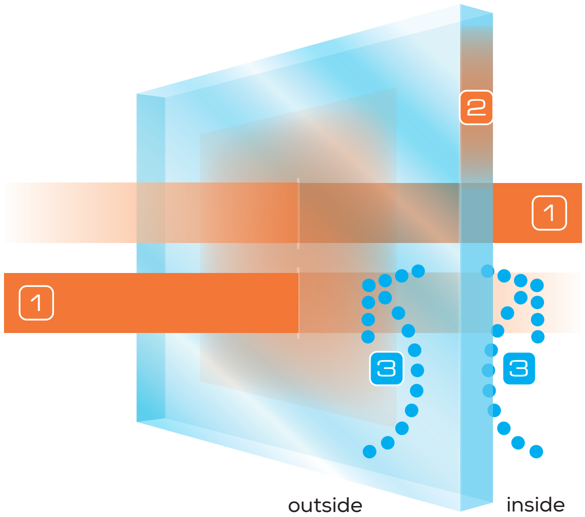
WHICH MEASUREMENT IS MORE RELEVANT?

Conduction, convection and re-radiation are measured by the U-value whilst direct transmittance energy from the Sun is measured by the SHGC. Why use both measures? Are one of these measures more relevant than the other in different climates?

In general terms where homes are artificially cooled or heated in any climate, glass with a lower U-value will reduce energy costs. However, for warm climates when we combine the SHGC and U-value into one total heat gain number (relative heat gain), it is the control of the Sun's direct intensity on an unshaded glazing as measured by the SHGC which becomes more relevant. The Sun's direct heat (measured by SHGC) controls a much larger percentage of the total heat gain when compared to other heat flows (as measured by U-value). For warm climate unshaded windows, control of the Sun's direct energy with a glass that has a lower SHGC is the first important step in design. As previously mentioned, a lower U-value will further assist in heat gain reduction and lower energy costs.

DIAGRAM 1C: U-VALUE

- U-value (summer and winter conditions);
- Measures thermal or non-solar heat flow occurring through conduction, convection and re-radiation.



1 Re-radiation.

2 Conduction.

3 Convection.

IMPROVING WINDOW ENERGY EFFICIENCY

LOW-E COATED GLASS

Consists of a microscopically thin, virtually invisible coating applied to the glass which provides additional solar and thermal control over ordinary non coated glass. Though primarily designed for IGU's, LowE glass is used in single glazed windows.

IGU'S

Insulated glass units (IGU's) are a significantly more energy efficient glazing system than single glazed windows. The still air and additional

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TABLE 1A: INSULATION COMPARISONS U-VALUE W/M²K

Single glazing	5.60–6.20
Single low-E coating	3.60–4.20
Standard IGU	2.40–2.70
Low-E IGU	1.90–2.10
Low-E/argon gas IGU	1.30–2.00
Low-E/triple/argon gas IGU	0.80
Wall insulated*	0.50–1.00
Ceiling/roof insulated*	0.25–0.33

* Average recommended insulation levels (converted from R-value) for Australian homes.

glass pane in the IGU reduce the effects of heat transfer through conduction, convection and radiation. However a degree of solar control is still required and in many circumstances in Australia where windows are exposed to direct solar energy, a tinted and/or low-E glass should be used in combination to reduce this heat gain.

WINDOW LOCATION/BUILDING ORIENTATION

For windows positioned on easterly and westerly elevations, controlling overheating is most important. A combination of low-E and IGU's with lower SHGC's are most effective. For heating and mixed climates, windows positioned on northern elevations allow for the Sun's direct energy to passively or naturally heat the interior. In combination with low-E coated and/or IGU's, the heat generated can be trapped or re-radiated back into the room which in turn reduces heating costs.

SHADING DEVICES

Eaves and external shading devices can also be used in reducing the adverse effects of direct heat gain particularly on east and west facing facades. External devices should be adjustable to allow for different climate conditions. Internal blinds or curtains are less effective as the heat has already penetrated the room. A thermal assessment should be carried out on the glazing to determine risk of thermal breakage when using these devices.

VENTILATION

The use of windows in a room that create a breezeway or air draft can reduce the effects of heat gain. This is of particular use where the room or building is not air-conditioned.

AIR-CONDITIONING VENTS

Air from these vents should be directed away from the window. Air blowing on or close to the glass surface will create a greater convection of hot air into the room.

INTERNAL CURTAINS/DRAPES

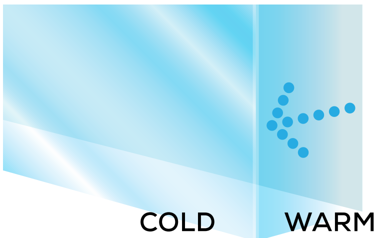
These can be of benefit during cold night time conditions. Tight fitting heavy drapes and pelmets around the window can assist in keeping the warmth in.

BASIC PRINCIPLES OF HEAT TRANSFER THROUGH GLASS

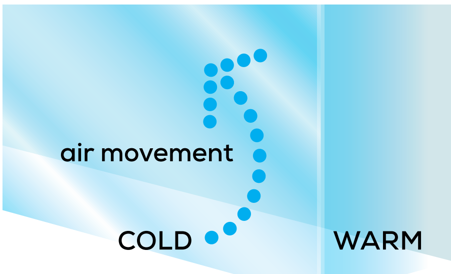
The basic principle of heat transfer is that heat will always move through the glazing to the colder side. Summer heat will migrate towards the colder interior and winter warmth will migrate to the colder outside environment.

Heat is transferred through the glazing by three methods:

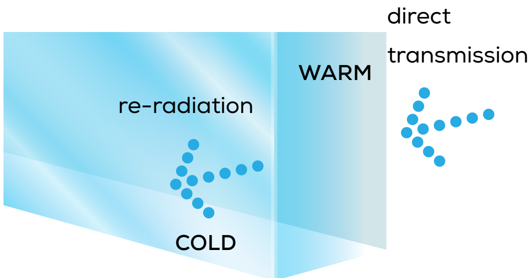
Conduction Is the process where heat travels through a solid material or like a frying pan heating up.



Convection is the transfer of heat by the movement of air across a surface or similar to hot air from a hair dryer.



Radiation heat transfer makes reference to both direct transmission and re-radiation. Direct transmission is the heat we feel on our bodies when we are next to a sunny window. Re-radiation occurs when the glass absorbs this short wave radiation and re-radiates it to the interior or exterior.



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GLARE REDUCTION

Reducing annoying glare can be achieved through controlling the amount of daylight that passes through the glass. Though it should also be noted that glare is subject to individual perception. Some situations may require other methods to control glare such as external barriers, blinds, ceramic fritted patterns or matrixes on the glass itself or removing the cause of the glare.

To assist in reducing glare, the glazing industry looks at the Visible Light Transmittance % (VLT) measurement. The higher this number the brighter the interior will be and possibly the greater level of glare. Typically 3mm clear has a high VLT of 90% which means that it lets through 90% of daylight. An adverse effect of restricting the level of interior light in a room is increased artificial lighting. This results in increased costs and less of the benefits of natural daylighting. As a general guide, glass products with a VLT of around 70% or lower will aid in the reduction of glare.

CONDENSATION

Water from condensation build up and resultant water run-off can damage window frame/sills and seep into walls and adjoining areas. Condensation will form when the moisture in the air condenses out on surfaces that are cooler than the 'dew' point. Insulated walls, ceilings and floors provide better thermal barriers than windows. Window surfaces being colder than other surfaces in a room are more prone to condensation build up. Condensation can also occur on the outside of windows in hot humid climates where the inside room temperature (through air-conditioning) is lower than the outside temperature. If the area is subject to condensation, IGU's are the best method to help reduce the likelihood of it occurring. IGU's provide a thermal barrier between the inside and the outside. The lower the U-value of the unit the better.

UV AND FADING PROTECTION

There is no guarantee that furnishings or objects can be completely protected from fading. Though ultraviolet light is a significant contributor to fading, it can also be visible light and infrared radiation (heat) that cause fading and damage. Choosing glass products restricting UV transmission, visible light and infrared radiation will assist in the reduction of fading. For example, the polyvinyl butyral (PVB) interlayer in laminated glass screens 99% of UV light. But supplying a product in clear laminated would still not stop lessen damage from heat. A better option to control heat damage is by adding a tinted interlayer instead and a low-E coated glass to the laminated glass make-up.