glazing

overview

Windows and other glazed external surfaces have a major impact on the energy efficiency of the building envelope. If not designed correctly they can allow substantial unwanted heat transfer between the interior and the outdoors. If designed correctly, they will help maintain year-round comfort levels in your home.

Treadgold & Perkin

Windows also provide natural daylight, ventilation, noise control, security and allow views connecting interior and outdoor spaces.

Heat loss and gain in a well insulated home occurs mostly through the windows. In summer, each square metre of glass in direct sun can allow as much heat in as would be produced by a single bar radiator. In winter, losses from a window can be ten or more times the losses through the same area of insulated wall.

With good passive design windows can trap warmth in winter and repel summer heat. They admit cooling breezes and exclude cold winter winds. [See: Passive Solar Heating; Passive Cooling]

Choosing energy-efficient windows, positioning them well and passively shading them is a cost-effective investment that will keep your home comfortable, quiet and economical year round.

Savings on energy bills can quickly repay an initial extra investment in energy-efficient windows. Getting it wrong can turn your windows into an energy liability for the life of the building.

A well designed passive home with energy efficient windows requires no heating or cooling except in the most extreme climates. Even in extreme climates, it is possible to design a Zero Energy – Zero Bills house at little additional cost. [See: Housing project - Hockerton]

Sunpower Design

When replacing windows in an existing home, choose the best windows for your climate to reduce your energy bills, particularly in cold climates.

Selection of appropriate window frames and glazing is important for good passive design. Careful consideration of passive heating and cooling, orientation, shading, insulation and thermal mass are also vital.

GLAZING

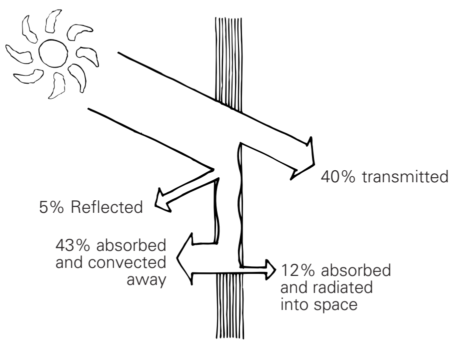
There are literally thousands of glass types to choose from. Choosing the right glass is a major factor in determining the energy efficiency of a window and will determine many other desirable properties such as light transmittance, noise control and security.

Glass products are generally classified as being either absorbent or reflective.

Solar radiation that is not reflected or absorbed is transmitted through the window.

Tinted or "toned" glass is the most common type of absorbent glass. Toned glass acts like sunglasses to reduce the solar radiation entering your home, which helps to keep it cool in summer.

Toned glass includes the basic tones (usually available in bronze, grey and green) and a range of "super tones" which provide even greater reductions in solar heat gain.



glazing

overview

Reflective glass has either a vacuum-deposited metal coating or a pyrolytic coating. Vacuum-deposited coatings are soft and must be glazed facing indoors. Pyrolytic coatings are hard and durable and can be glazed facing outdoors. Where glare may annoy neighbours, reflectivity should be kept below 15 to 20 percent.

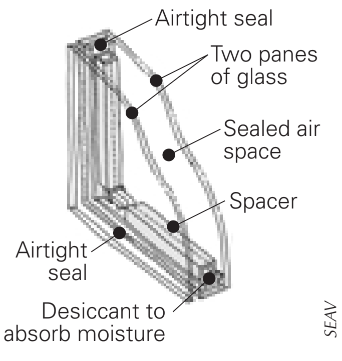
Spectrally selective glazing is commonly used for cooling climates or for westerly elevations where solar control and natural lighting are a priority. Spectrally selective glazing maximises light transmission while simultaneously reflecting unwanted solar radiation (UV and near infrared). Spectrally selective coatings can also have low emissivity.

Low emissivity (low-e) glass has a coating that allows short wavelength energy (daylight) from the sun to pass into the house but reduces the amount of the long wavelength energy (infrared heat) that can escape through the window. That is why this type of glass is often called a 'heat mirror'.

Polymers are used instead of glass in some applications, such as translucent glazing and skylights. Plastic glazings may also be included in composite laminates to improve impact resistance or within double glazing to improve insulation.

Single glazing offers little resistance to the passage of heat. The small amount of insulation that single glazing does provide is actually due to thin films of still air that exist next to the glass.

Double-glazing offers much better insulation. It comprises two panes of glass with a sealed space between. The space is filled with air or an inert gas with better insulating properties than glass.



The best thermal performance for air-filled units occurs when the space between the panes is about 12 mm. If the double glazing is also to be used for noise reduction, a wider gap may be appropriate with some trade-off in thermal performance. See Noise Control on page 6.

For best performance, solar control glass should be used for the outer pane and low emissivity glass for the inner pane. The solar control glass prevents unwanted solar radiation entering, while the low emissivity glass reduces heat loss from inside. The low e glass also blocks heat radiated from the outer pane of glass when it heats up.

A low cost alternative to conventional double-glazing is to use a thin, flexible, transparent polyethylene membrane in place of the inner pane of glass. The membrane is attached to the window frame using a high quality, transparent tape and shrunk taut using a hairdryer.

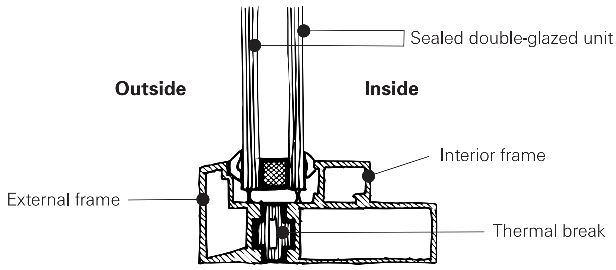
This system can provide performance similar to that of plain, clear double-glazing at a much lower cost. It can be applied to almost any glazed fixture that has a frame.

FRAMES

After the glazing, frames have the greatest impact on window energy performance.

Aluminium window frames are light, strong, durable and easily extruded into complex shapes, but aluminium is a good conductor of heat and can decrease the insulating value of a window by 20 to 30 percent. Aluminium frames (especially dark coloured ones) in full sun can become hot to touch and cause discomfort to people close by. A large amount of energy is also used (and greenhouse gas emitted) in making aluminium. Aluminium windows can be recycled at the end of their lifespan to reduce this impact.

Some manufacturers may be able to provide aluminium frames made from recycled material, which greatly reduces the energy used during manufacture.



A thermal break is often used to reduce the heat conduction of aluminium frames. A thermal break splits the frame components into exterior and interior pieces using a less conductive material to join them.

Timber is a good insulator but requires more maintenance than aluminium. Timber frames swell and shrink in response to changes in temperature and humidity. They therefore require larger tolerances, which can result in gaps unless special draught sealing is provided.

Timber absorbs greenhouse gases as it grows and retains them until it is burnt or decays. It is important to check that the timber used is from sustainably managed forests.

uPVC (plastic) frames are relatively new in Australia. Their insulating properties are similar to timber but they require less maintenance.

Fibre-reinforced polyester (FRP) frames are used overseas and are the most thermally efficient framing materials available.

Composite frames are also available. These frames commonly use thin aluminium on the outer sections with either a timber or uPVC inner section.

Composite frames are often called 'thermally improved frames'. They insulate about twice as well as standard aluminium frames but they are more expensive.

THE WINDOW ENERGY RATING SCHEME (WERS)

WERS can assist you in choosing the most energy-efficient windows. [See: How to use WERS]

WERS rates the energy performance of residential windows.

27 generic types of windows are given an energy star rating according to their heating and cooling performance.

Star ratings take into account the effect of both the window and the frame. WERS will help you to determine whether heating, cooling or both are more important in your climate.

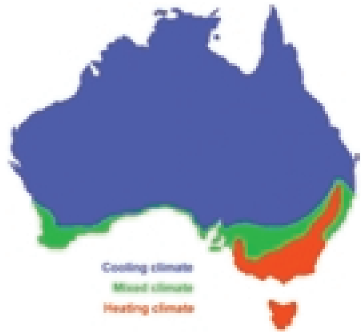
WERS rated windows carry a sticker, a certificate and marketing material that show the star ratings for heating and cooling performance plus other useful information. Look for the WERS label when selecting a window and choose the window with the highest star rating appropriate for your application and budget. Talk to the manufacturer or retailer to identify key requirements for your home.

CLIMATE CONSIDERATIONS

The energy performance of windows is heavily influenced by climate.

Australia can be divided into three climate types to assist in window design and selection.

Heating (or alpine and cool temperate) climates are colder climates where most energy is used to heat the home. These climates exist in Tasmania and the southeast corner of mainland Australia, extending along the Great Dividing Range to the north. In these climates windows should be designed to keep heat inside. [See: Glazing – Cool Temperate]



Courtesy of WERS

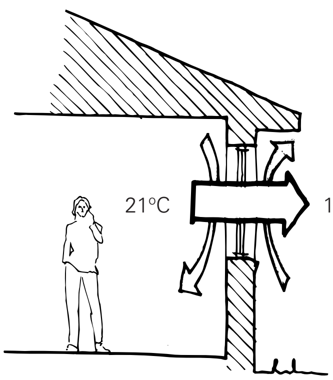
Cooling (or tropical, subtropical and hot arid) climates are warmer climates where most energy is used to cool the home. Geographically, most of Australia has a cooling climate. In these climates windows should be designed to keep the heat outside. [See: Glazing – Hot Humid]

Mixed (or temperate) climates use energy for heating in winter and cooling in summer. Existing mainly in the southwest of Australia, along the southern coastline and across much of NSW, the goal in these climates is to keep heat in during winter and out during summer. [See: Glazing – Temperate]

About 70 percent of Australia's population lives in "heating" or "mixed" climates. In such climates, more advanced windows return a net energy benefit over a whole year, regardless of which direction they face. It is possible for an advanced window's energy gains to exceed its losses, even if it faces south.

PASSIVE DESIGN CONSIDERATIONS

Selection of windows is an important element of passive design. Glass is a good conductor of heat and also allows radiant heat to pass through freely. When there is a temperature difference between inside and outside, heat is lost or gained through the window frame and glazing. While this can be used to your advantage with careful passive design, it is a big liability if overlooked.



U-value (or insulating value) is a measure of how easily heat is transferred through a particular window assembly. U-values have been chosen by WERS to describe the performance of windows.

The lower the U value the better the performance.

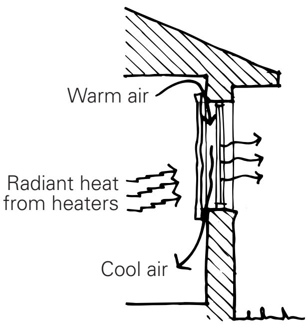
Double glazing and/or specially treated glass will lower the U-value.

R values are used to describe similar insulating properties in all other building materials. The higher the R value – the better the performance. To convert U values to R values, divide the U value into 1 (ie. R value = 1 / U value).

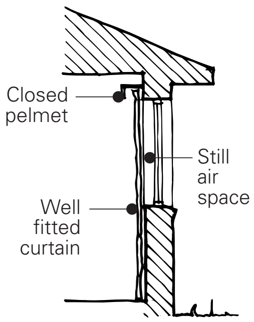
In heating and mixed climates it is important to have a low U-value (ie. a high resistance to heat flow) so that heat is retained inside the house. A low U-value can also be important in cooling climates to keep heat from flowing into the house, especially when there is a significant difference between the indoor and outdoor temperatures.

The U-value of a window can be found at the bottom of the WERS rating label.

HEAT LOSS THROUGH WINDOWS



Poorly fitted curtain allows warm air to contact the cold glass



Well fitted curtain with closed pelmet creates a still air space between the glass and curtain

Internal insulation on windows can substantially reduce heat loss in winter. Closely woven curtains and sealed pelmet boxes are the most effective. Curtains can also provide extra summer protection, especially if they have reflective linings.

A snug fit on both sides of the window and boxed pelmets or solid strips at the top of the curtain will stop warm air from moving behind the curtain and cooling down when contacting the cold glass.

Tightly fitting Roman type blinds and insulated shutters may also be effective as long as they form a sealed air space next to the window. There are many other ways to reduce heat loss through glazing.

Heat loss through various glass treatments

Unprotected single glazing	100%
Vertical or ventian blinds	100%
Unlined drapes or Holland blinds, no pelmet	92%
Heavy lined drapes, no pelmet	87%
Unlined drapes or Holland blinds, pelmets	79%
Double glazing	69%
Heavy lined drapes, pelmet	63%
Double glazing with low-e coating	57%
25mm Polystyrene shutters, good airseal	50%
Double glazing, heavy drapes, pelmets	47%

Heat loss through various window frames

Single glazed industry typical aluminium	100%
Singe glazed thermally improved aluminium	87%
Single glazed timber or P.V.C	82%
Double glazed industry typical aluminium	72%
Double glazed thermally Improved aluminium	60%
Double glazed timber or P.V.C	54%

HEAT GAIN THROUGH WINDOWS

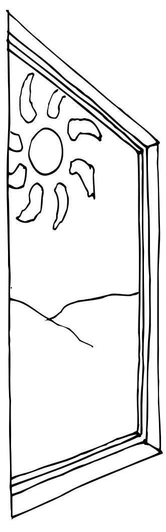
In summer, external shading (eaves, overhangs, pergolas or sun blinds) can reduce the outside temperature and reduce heat flow through the window. [See: Shading]

The main role of external shading is to prevent direct or indirect solar radiation from passing through the windows.

The solar heat gain coefficient or shading coefficient of the window glazing is a measure of the control of heat gain.

In mixed and cooling climates or for westerly orientations, windows with a low solar heat gain coefficient are desirable.

Solar heat gain can help create a warm home in winter but in summer it is desirable to minimise solar heat gain. Solar heat gain can be controlled through appropriate orientation and shading and/or appropriate glazing decisions. [See: Orientation; Shading]



Heat gain through various various glass treatments

Unshaded single glazed window	100%
Double glazing	90%
Internal vertical blinds/open weave drapes	76%
Internal venetian blinds	55 – 85%
Internal holland blinds	55 – 65%
Tinted glass	*A 40 – 65%
Solar control film/reflective glass	*B 20 – 60%
Trees-full shade to light shade	20 - 60%
1.0 m Eaves over north wall	30%
External roller shutter	25 – 35%
External awning	25 – 35%
2m pergola over north wall with deciduous vines or shade cloth	20%
Outside metal blind or miniature louves parallel and close to window	15 – 20%

*A Effectiveness is reduced as the colour darkens.
*B Solar film, tinted glass and reflective glass of varying effectiveness is available. They significantly reduce light levels all year round

THERMAL MASS

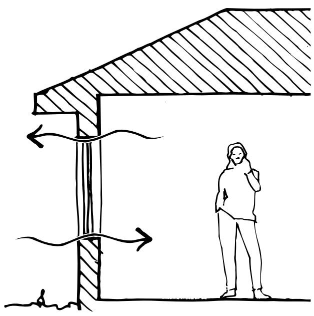
Interaction between heat loss and heat gain through windows and the thermal mass of the building should be considered. [See: Thermal Mass; Passive Solar Heating; Passive Cooling]

High mass buildings require adequate north facing window areas to take full advantage of passive heating and cooling.

Low mass buildings need windows with low U-values to minimise heat loss at night and on cloudy days, and to reduce heat flow into the building in hot weather. A low solar heat gain coefficient and shading also help to reduce summer heat gain.

Where passive design principles are compromised because of site or design restrictions, the use of energy-efficient windows is an essential alternative method for achieving thermal comfort and energy efficiency.

AIR-TIGHTNESS



Air infiltration through cracks in the window assembly is a key means of energy transfer.

The thermal performance of windows and doors is lowered if they are not airtight.

Heat loss and gain occur by air infiltration through cracks in the window assembly.

Well-made frames and seals around opening sashes are an important feature.

Sealing between the wall and window frame at installation is equally important.

Infiltration is measured in terms of the amount of air that passes through a unit area of window under given pressure conditions.

Air infiltration for a particular window can be found at the bottom of the WERS rating label. The lower this number the better.

LIGHT TRANSMITTANCE

Good window design and location maximises natural lighting. Bright, naturally lit homes promote health and well-being and reduce the need for electric lighting.

Natural light provides good colour rendition and skin tones and is preferred by most indoor plants.

The visible transmittance (VT) of a window is a measure of the amount of visible light transmitted through the glass. The VT for a particular window can be found at the bottom of the WERS rating label.

Choose glass that generally has a VT of at least 0.5 (50 percent) to preserve natural lighting. All of the generic window types in WERS meet this requirement.

A high VT is generally desirable to maximise daylight and view but this must be balanced against the need to control solar gain and glare in hot climates.

Windows with special multi layer films are available that can maximise VT while reducing solar gain.

Diffuse lighting (as opposed to direct sunlight) is generally the best for providing good uniform illumination over a room and avoiding glare.

Skylights are an excellent way to provide natural day lighting for a room, particularly in cooling climates where shading and other passive design elements can reduce light transmittance through windows. Conventional skylights can let in too much heat and light, but new designs (such as angular-selective skylights) can be a very efficient way to light a room.

A Skylight Energy Rating Scheme (SERS) has been developed in Australia, similar to WERS and is being used by some manufacturers. Check the SERS rating before selecting a skylight to install. [See: How to Use WERS]

VENTILATION

Providing ventilation is an important function of windows. The ventilation depends on physical characteristics such as the placement of the windows, the opening size and the frame type.

Cross ventilation is about five times as effective as single-sided ventilation at encouraging air movement through the house. Positioning windows to provide cross ventilation is the most effective way to provide ventilation. However, it is important to balance the need for ventilation in summer against air leakage and winter heat loss.

Choose the best opening style to achieve ventilation appropriate for your climate.

Openable, hinged windows provide ventilation through the full window area.

Louvre windows allow 100 percent opening area. They cannot be easily double glazed and are less airtight. They are most useful in cooling climates where air conditioning is not used and should be avoided in heating and mixed climates – especially where exposed to high winds.

Sliding windows can only open to half the window area.

Double hung windows allow restricted opening area but can be very useful in allowing hot air to escape at the top of the room or cool air to enter at the bottom.

Fixed glass panels provide no ventilation and can be problematic in very hot and very cold climates.

NOISE CONTROL

Sealing cracks and gaps around the window, and elsewhere in the building, is probably the most effective way to control noise, though appropriate windows and glass can assist with noise control.

Standard single glazed windows are poor barriers against noise. Sealed double glazing reduces transmission of medium to high frequencies such as the human voice.

To reduce low frequency noise such as traffic noise, thicker glass, preferably double-glazed with a large air gap in between the panes (100 mm or more) is most effective. Note that such large gaps allow convection to occur between the panes and reduce insulating properties.

Thick laminated glass is also effective in reducing noise transmission but offers little in the way of thermal performance. [See: Noise]

FADING

Exposure to sunlight causes many modern interior furnishings to fade. The wavelengths most responsible for fading are the ultraviolet, violet and blue wavelengths.

Appropriate glazing will block some of these wavelengths and reduce fading although it will not prevent it completely.

Fabric Fading Transmittance is a measure of the extent to which a window transmits those wavelengths of light that cause fading. It can be found at the bottom of the WERS rating label. The lower this number, the lower the potential for fading.

CONDENSATION

The interior and exterior glass surfaces of energy efficient windows are closer to the adjacent air temperature, reducing condensation and the build-up of unsightly and unhealthy mould and fungus on windows.

Less efficient windows create greater differences between room temperature and glass surface temperature, facilitating the formation of condensation.

Most double glazed units are sealed, with a desiccant in the perforated spacer bar to eliminate condensation.

Open windows can also promote condensation and mould growth when warm, moist air meets colder air inside or outside the house.

LIFECYCLE COSTING

Windows are one of the major cost items in your home at construction.

The cost of windows and the cost of heating and cooling your home are closely related. Generally, the more you spend on good quality windows the less you will pay in heating and cooling bills.

An initial investment in energy-efficient windows can greatly reduce your annual heating and cooling bill. Energy-efficient windows also reduce the peak heating and cooling load, which can reduce the size of an air-conditioning system by 30 percent, leading to further cost savings.

THE REAL COSTS

The additional loan repayments for purchase of energy efficient windows at time of construction or renovation are usually less than the additional energy bills resulting from inefficient windows.

PROPERTY VALUES

Homes with higher energy ratings are already fetching premium prices in many areas (eg. the ACT). This trend will continue as energy costs rise and environmental problems associated with energy consumption manifest.

Minimum Energy Performance Codes for the Building Code of Australia; WERS and other State and Local Council specific regulatory measures are likely to accelerate awareness of and demand for energy efficient housing.

ADDITIONAL KEY REFERENCES

WERS website, www.wers.net

Australian Window Association, www.awa.org.au

Efficient Windows Collaborative, www.efficientwindows.org

Carmody J, Selkowitz S, Arasteh D K and Heschong L (2000). Residential Windows, 2nd Edition. W W Norton & Co. ISBN 0-393-73053-0. (Available through the Australian Window Association, info@awa.org.au).

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