European Timber Windows
&
Doors

PASSIVE HOUSE

Providers of Passivhaus building performance solutions

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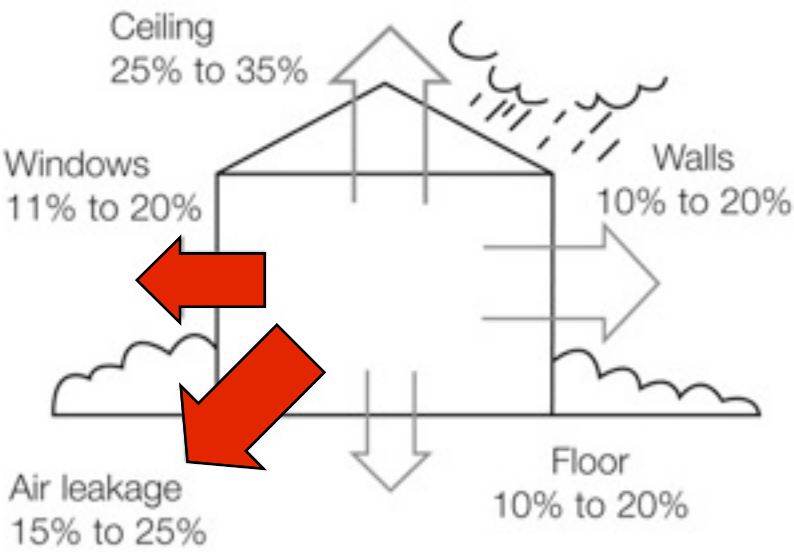
Building Thermal Performance Background

The Australian context:



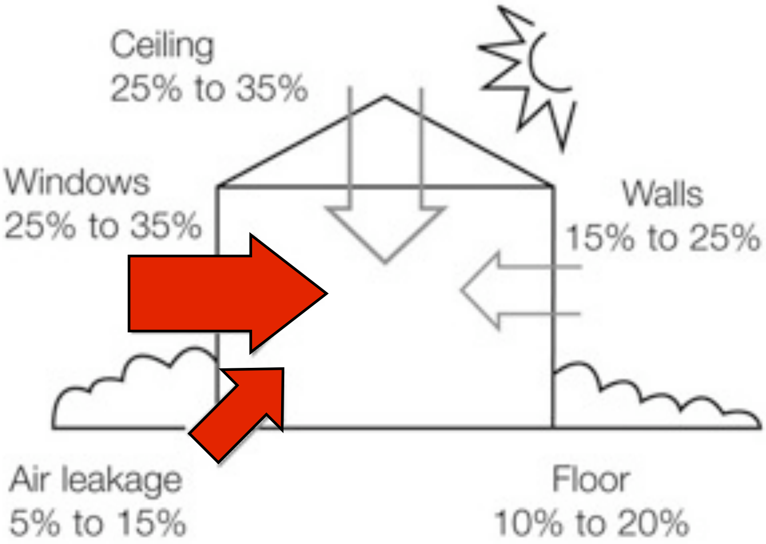


Figure 1 Winter Heat Losses & Summer Heat Gains in a typical uninsulated Australian home

The climatic conditions in Australia are such that to effectively improve the thermal performance of a home, a multi front approach is required by improving insulation (reflective for summer and bulk for winter performance), sealing air leakage points to minimise air infiltration, and significantly improve window (including glazing) performance.

Given the significant amounts of glazing in a typical Australian home, the performance of windows has a major impact on daylighting and thermal comfort.

The following section describes in detail our unique and technically robust, responses to significantly improving the window thermal performance and comfort of a building.

European Timber Windows

Windows are are often under specified in terms of thermal performance. In Australian homes they make up a significant portion of the building. Whilst the benefits of insulating a home are generally well understood, the requirements of a high performing window are very much less known.

The optimal thermal performance and daylighting design of windows requires the careful consideration of their design, including frame material, weatherstrip sealing, glazing unit configuration, glass coatings, glass tinting, integration of blinds, etc. The heat loss and gain mechanisms involved in window thermal performance are complex:

Figure 2 Heat transfer mechanisms of windows

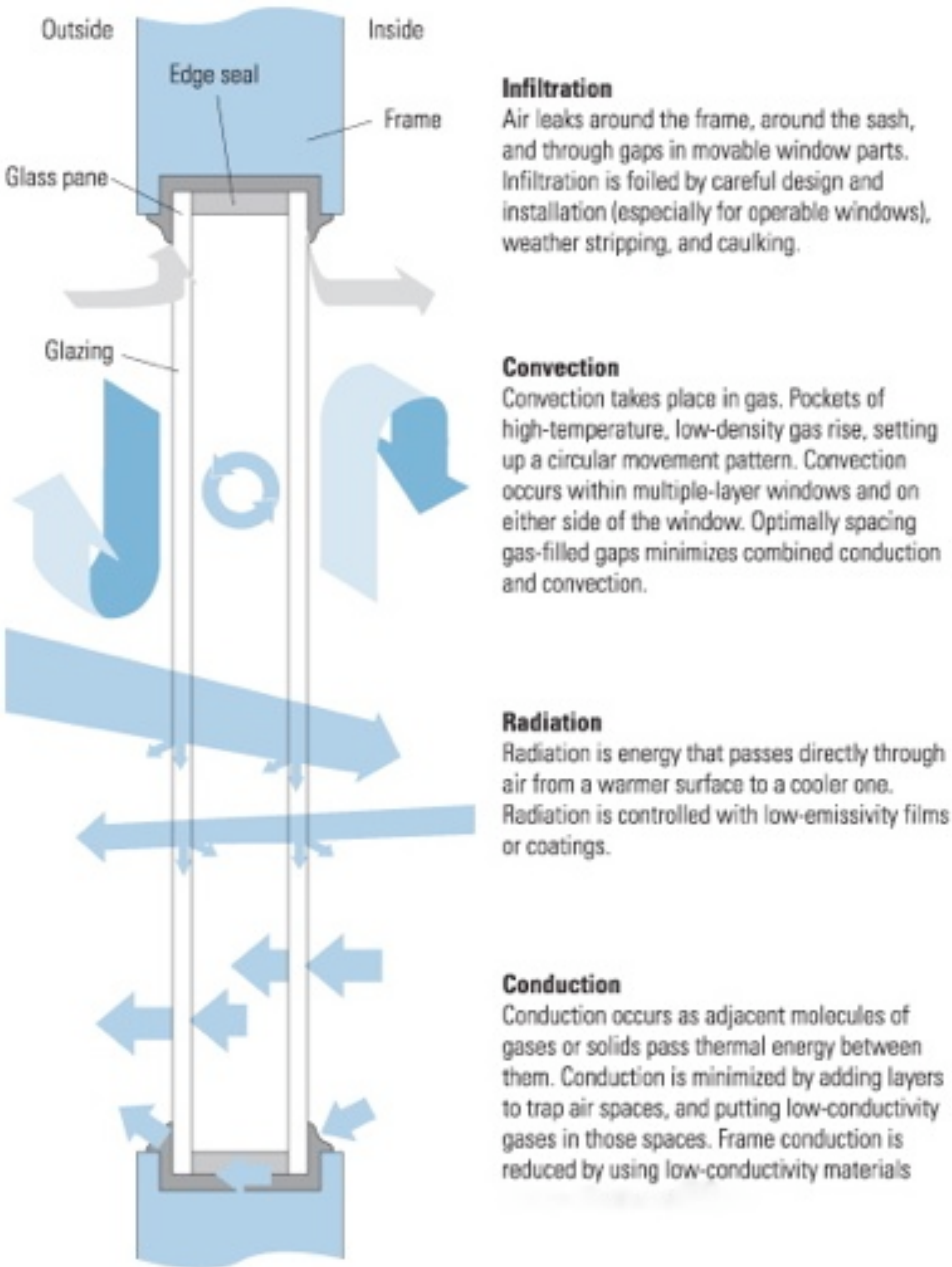


Table 1 below compares the thermal conductivity of several window materials.

Material	k-value (W/mK)
Aluminum	250
Steel	50
Glass	0.96
PVC	0.19
Hardwood	0.17
Softwood	0.12
Air (still layer)	0.024

Table 1 Thermal Conductivity of some window materials (Handbook of Chemical Engineering, Engineering Toolbox))

Aluminium is clearly a very poor insulator, being approximately 2000 times more thermally conductive than timber! On thermal performance alone, why would you choose an Aluminum window?

Even amongst timber, the softwoods such as Western Red Cedar and European Redwoods are 40% better thermally performing than the hardwoods such as Vic Ash. The performance gap widens even more when you consider that the sash of a standard Australian window is made of 40 mm thick hardwood and has less than half the insulative performance of a standard European window made of 68 mm thick European Redwood.

That's even before you get to consider the glass!

Nowadays PVC windows with their European profiles are often considered a high performance alternative. However, PVC as a polymer is more conductive than hardwood and even more than softwood. OK the air gaps within the profiles help, but rarely mentioned is the fact that PVC windows and door sections are steel reinforced to provide rigidity, and as steel is a conductor, the thermal performance drops dramatically.

PVC is never used alone. It is always mixed with heat stabilizers, lubricants, plasticizers, fillers, and other additives to make processing possible. PVC requires UV stabilisers for Sun protection. PVC material loses these stabilisers from the surface, so eventually loses protection.

The innovation in windows in Europe is all in timber, because it's so great in performance, and adaptable in manufacturing.

Typical window sash depths have increased from 56 mm to 68 mm and 78 mm (triple glazed) and are now headed beyond.

Obviously the glazing design and specification is also a very important consideration as detailed in Table 2 below (note R-value is the inverse of the U-value):

Glazing	U-value (W/m^2K)	R-value (m^2K/W)
Single Glazed	6	0.17
Double Glazed (std)	3	0.33
Double Glazed (improved)	2 - 3	0.33 - 0.5
Triple Glazed (std)	2	0.5
Double Glazed (high performance)	< 1.5	> 0.67
Triple Glazed (high performance)	< 1	> 1

Table 2 Heat Transfer Coefficient and Thermal Resistance of Glazing systems

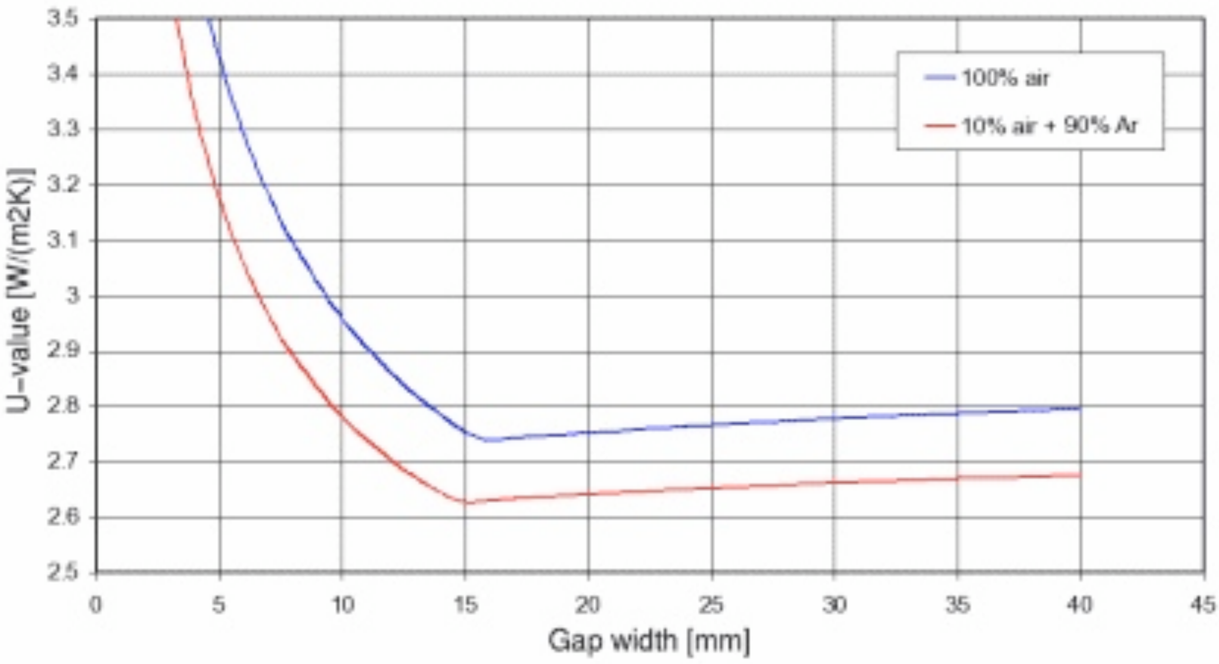
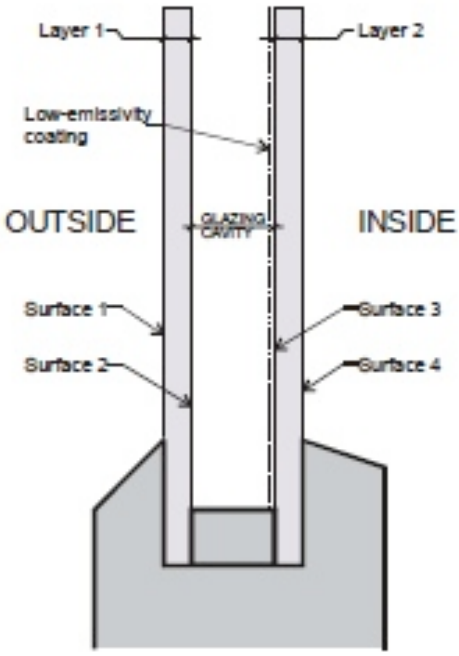


Figure 3 U-value of double glazed unit vs air gap width

With “ improved” double glazing, the spacer gap of the double glazed unit is increased (16 mm is optimal) as it has a significant impact on the thermal performance of the glazing.

The addition of inert gas such as Argon (Ar) also improves the thermal performance of the double glazing unit. However, the Argon dissipates over the lifetime of the glazing unit.



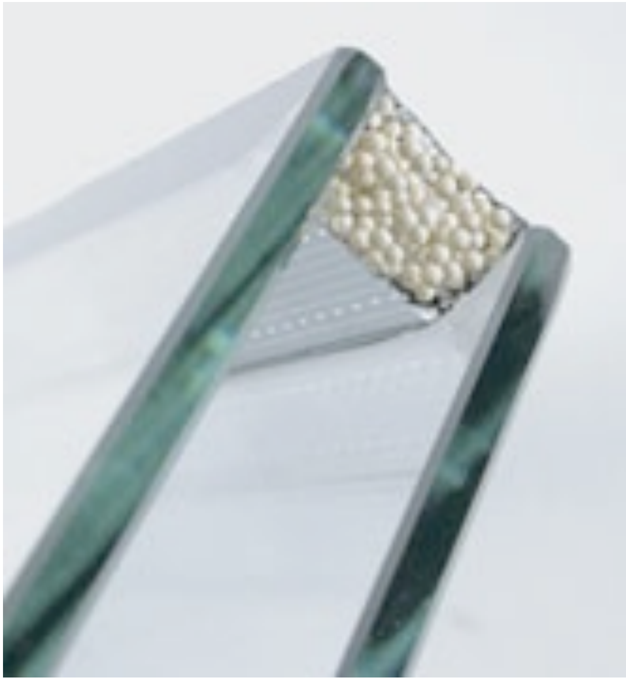


Figure 4 Specification of double glazing   *Figure 5 Insulating spacer of a double glazed unit*

With “performance” double glazing, the addition of a metal oxide (clear) layer on the inner side(s) of the glass also has a significant impact, particularly in summer with east and west facing windows and unshaded northern windows.

The ‘E’ in low-E refers to emissivity. Emissivity is a measure of a material’s ability to radiate energy. A material with ‘low’ emissivity absorbs and radiates infrared energy poorly which is the key factor in reducing heat transfer. The lower the emissivity of a coating the better the glass performs in reducing heat transfer.

A basic understanding of how low-E glass works, involves a closer look at the sun’s energy and the solar spectrum:

The sun’s energy can be divided into different components such as (1) ultraviolet light; (2) visible light; (3) infrared energy.

High levels of ULTRAVIOLET LIGHT can be harmful to humans and damage and fade furnishings. The desire is to exclude all of this component.

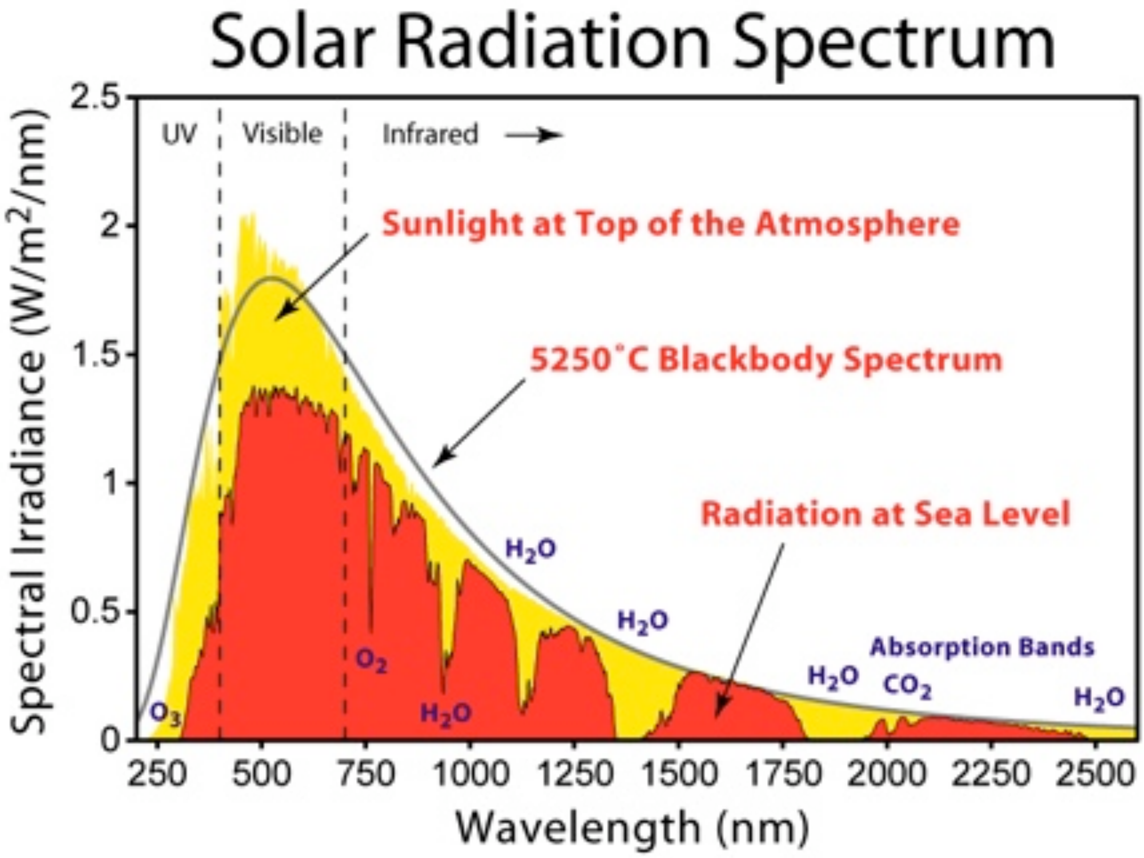


Figure 6 Solar Radiation Spectrum

VISIBLE LIGHT is the desirable component giving us natural daylight, the cheapest source of lighting available (of course we may want to control glare).

The INFRARED ENERGY component may be both desirable and undesirable. It is desirable when we seek sunshine and warmth for personal comfort and to naturally heat a room's interior (passive solar heat gain/heating). It is undesirable when it becomes discomforting, where the room becomes hot and strains are placed on people and air-conditioning systems.

The infrared part of the spectrum (or what we feel as heat) consists of varying wavelengths. Short wave infrared heat energy is absorbed in the interior of the building by carpets, curtains, furniture, walls etc., and is changed into long wave infrared heat. Objects outside the building also absorb short wave energy and are changed into long wave heat energy.

Low-E glass selectively allows specific portions of the sun's energy or the 'desirable' wavelength components to be transmitted. When combined with spectrally selective tinted glass, low-E glass offers the ideal glazing solutions of low ultraviolet and high visible light transmittance, low shading co-efficient or solar gain and high insulation or 'U'- values. This translates to a greater control of the internal environment, greater occupant comfort and lower heating and cooling costs.

Ideally for warm climates where summer heat reduction is a priority, a low emissivity coating should be on surface (2) for maximum performance. The coating on surface (2) minimises heat gain because it reduces heat build up in the air gap and heat transfer to the interior. This coating should always be directly applied to a tinted glass as a soft coat application. The coating in this situation works in conjunction with the tinted glass to reduce heat gain. In these situations the substrate glass should be heat strengthened or toughened to avoid thermal breakage. In cold climates where retention of heat is a priority, the low-E coating of panel clear glazed surface (3) is recommended. In these situations we are relying on the effects of passive solar heat gain to naturally heat the building's interior and the low-E coating to reflect any of the re-radiated heat back into the room. The shading coefficient can also be improved by up to 25% with the coating on surfaces (2), (3).

For the combination of high performance low-E glass can be specified on either outboard or inboard glass with coatings on both surface(2) or (3), with a tinted glass as the outer pane.

Another variation, spectrally selective low-E glass also block long wave radiation, but they have another important function. The multiple layers of silver in the coating allow the glass to selectively transmit and reject certain wavelengths of solar radiation. Spectrally selective low-E coatings are designed to maximize the transmission of visible light and to reduce transmission of longer wavelength heat in the near-infrared spectrum. In summary, low-E glass reduces heat loss, and spectrally selective low-E glass reduces heat loss and heat gain.

In an insulated glass unit (IGU) or double glazed unit, various grades of laminated glass can be used to improve acoustic performance.

Specifying window glazing is very important, quite complex and must be fully considered for optimal thermal performance. The orientation of the window, it's external shading or screening have significant impact on the thermal performance of the building. Preferably modeled with thermal computer software programs such as AccuRate or the Lawerence Berkley Laboratory Window 6.3, to enable the most favourable specification for the desired building performance.

Figures 7, 8 & 9 below depict insulated double glazed units, and highlight at least one surface of low emissivity coating or tinted glass for improved thermal performance. In addition, tinting of the outer-pane is also very effective in reducing summer heat gain:

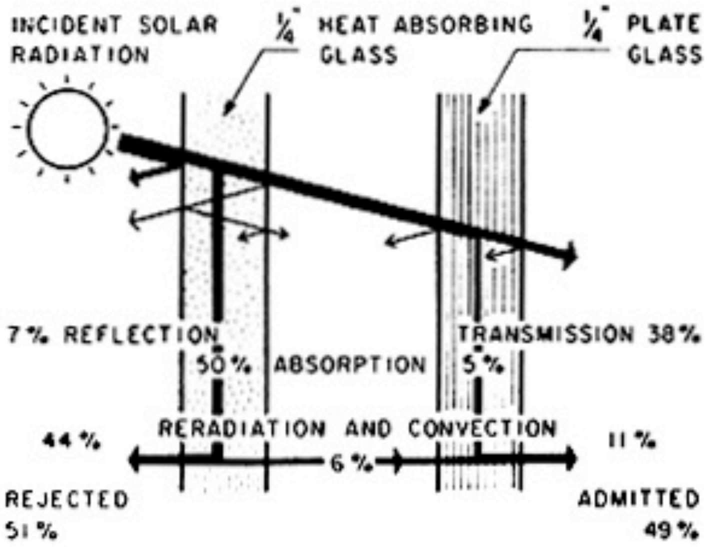


Figure 7 Double glazing configured for summer performance, solar passive winter

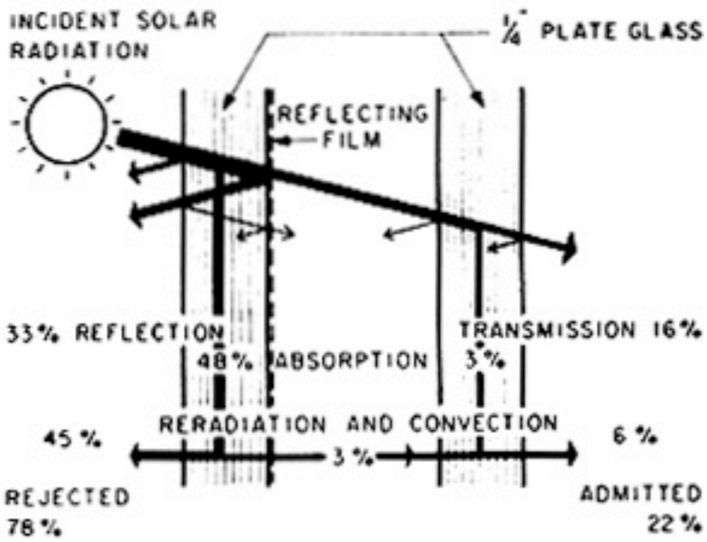


Figure 8 Double glazing configured for summer performance

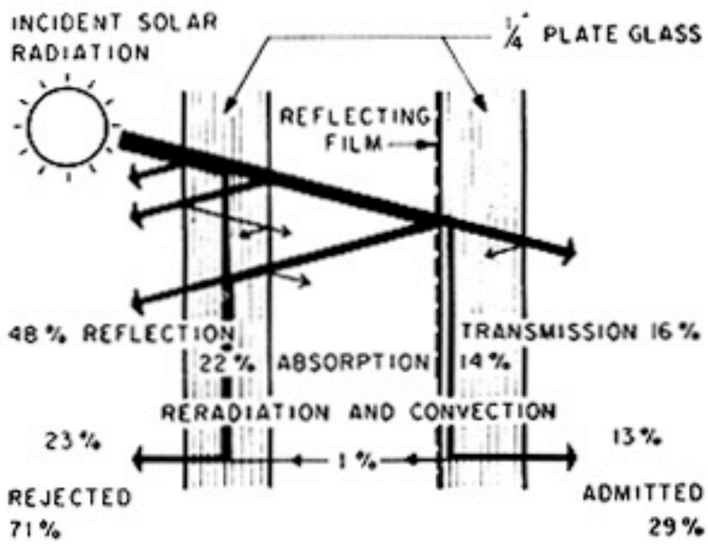


Figure 9 Double glazing configured for winter performance

Also important is the full perimeter sealing of the window sash:

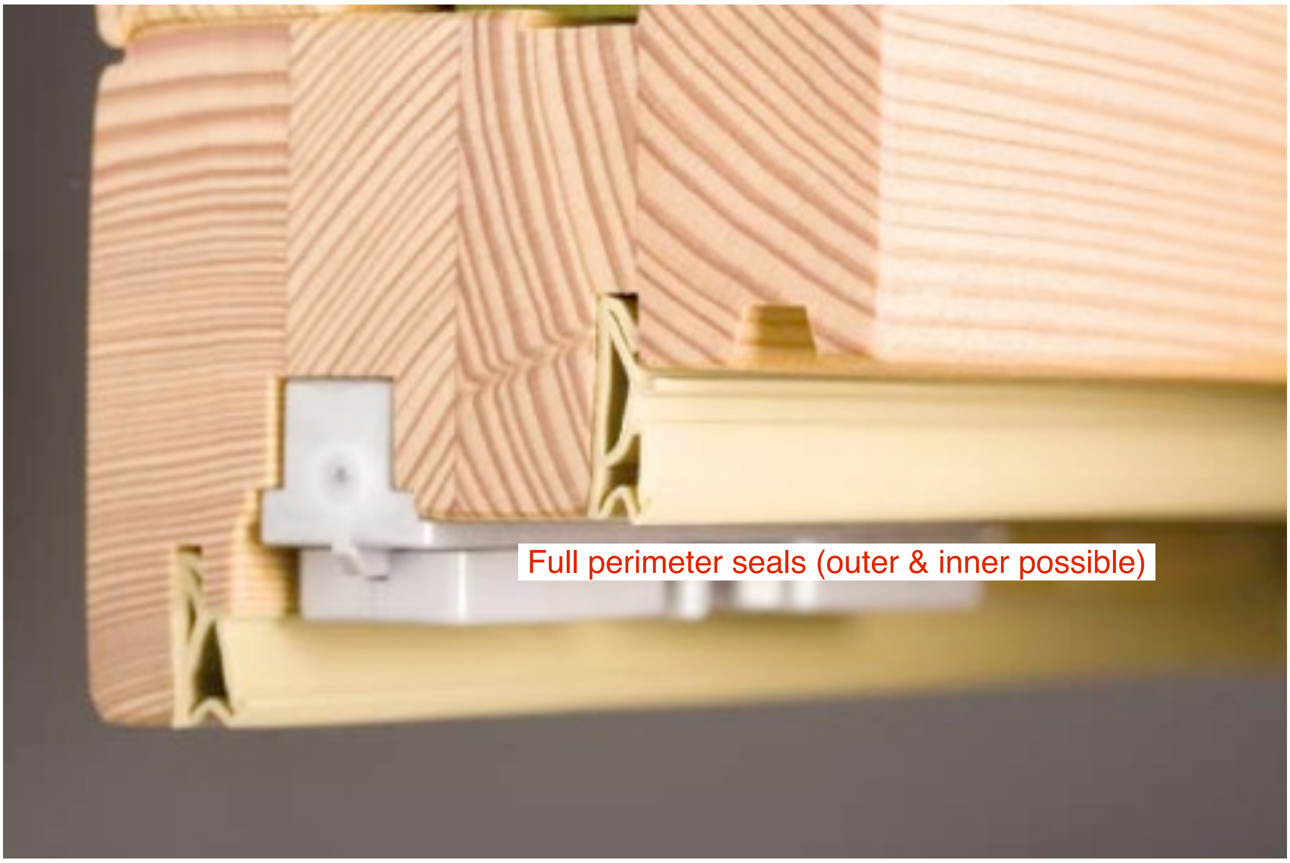


Figure 10 Full perimeter seals

Plus the use of a (European standard) and a multipoint locking system to ensure that the seal is fully activated for closure:

Figure 11 European standard multipoint active locking systems

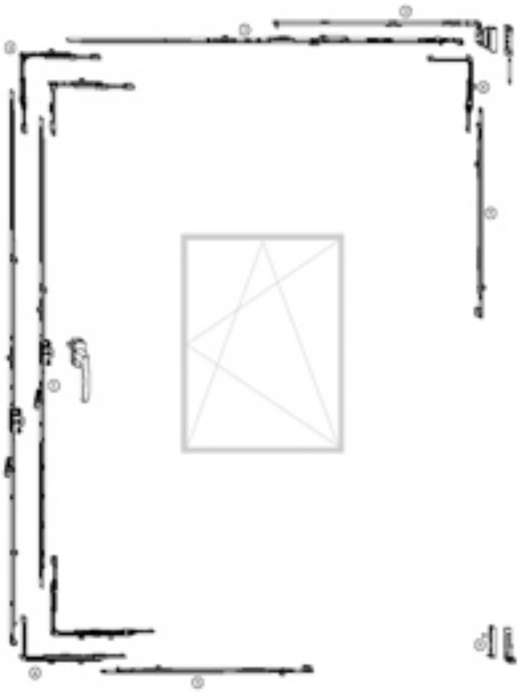


Figure12 European Timber Windows, Doors & Façades manufactured in Australia by Passive House Pty Ltd