A Glass Roof for a Passive House
Specifying Glass Roof Systems for Thermal Efficiency, Natural Ventilation and Smoke Control
Introduction

Good building design plays a critical role in regulating temperatures within an indoor space and reducing our reliance on mechanical heating and cooling. With an increased awareness of the cost and environmental impacts of energy use, designers and specifiers are looking for design solutions that can provide thermal performance without compromising on aesthetics. A well-designed glass roof has these advantages, but too often an uninformed choice in glass roof design or a lack awareness of options in the market leads to systems that have low thermal performance or other costly issues such as poor condensation management.

In particular, operable glass roof systems are often overlooked in Australia due to cost and the lack of proven systems, but their benefits are undeniable. A well-designed operable glass roof provides a sophisticated solution for natural lighting, natural ventilation, thermal efficiency, and premium aesthetics, all of which contribute to healthier and greener buildings. They can also be integrated into a building’s smoke control strategy, maximising the return on investment.

Good glass roof design delivers exceptional insulation, ventilation, and weathertightness. These characteristics are in line with Passive House design principles that ensure a building delivers very high performance, ultra-low energy use and maximum comfort over its lifetime. In this white paper, we look at some issues with current glass roof systems and the key design elements that make a glass roof the ideal choice for energy efficient, sustainable buildings.

“Dedicated glass roof systems include secondary water drainage channels, and some have internal ventilation designed to remove moisture that forms inside the profiles”
Glass roofs allow a designer to introduce daylight into a building that would otherwise not be possible but incorrect product selection can result in unsatisfactory outcomes. Specifiers are taking profiles designed for vertical facades (where water runs down the glass) and using these to produce an ad hoc glass roof solution unaware of the unintended consequences of such an approach. Vertical glazing is not designed to be aligned horizontally, with no drainage or internal ventilation, so there may be areas in which the glass roof system will not perform as expected, such as in managing moisture and condensation.

Condensation refers to the process by which a gas or vapour changes into a liquid. If the temperature of glass falls below what is known as the “dew point” temperature for a given relative humidity of the surrounding air, atmospheric water vapour condenses into water droplets on the surface. This typically occurs when single glazing is used for air-conditioned spaces instead of other glass configurations with less heat conductivity. Similarly, a non-thermally broken frame can be made cooler from the outside temperature, so when warmer indoor air comes into contact with the frame, there is potential for condensation to form on the frame’s surface, which is a common issue with indoor swimming pool areas.

A glass roof system that does not manage moisture sufficiently, whether by preventing condensation and/or draining away liquid that enters via the primary seals, can cause several problems. Moisture, whether it is standing rainwater, humidity or condensation, can encourage mould and bacterial growth, which can reduce indoor air quality and cause deterioration in the building structure. Over time, moisture can compromise the building’s structural integrity, which can impact airtightness, insulation, and thermal performance. Within the roof system itself, condensation can degrade the aluminium profiles and cause deterioration of the Insulated Glazing Unit (IGU).

In addition, specifiers are cautious of operable glass roofs due to concerns regarding thermal performance and water ingress. A well-designed glass roof system, paired with high performance glazing, can combine thermal performance with an effective means of natural ventilation while achieving excellent resistance to water penetration.

Current Glass Roof Systems

Benefits of Well-Designed Glass Roofs

The selection of low performing components, incorrect glazing, limited functionality or simply a lack of awareness of the design options available has several drawbacks that can prove costly. So why should you consider a glass roof system for your next project?

Thermal efficiency. If specified correctly, glass roofs without thermal bridges can deliver excellent thermal performance and low U-Values that help reduce the load on mechanical heating and cooling systems. This results in ongoing energy savings over time.

Natural light. A well-designed glass roof allows natural light into an indoor space thus reducing the dependence on artificial lighting during the day. Paired with design solutions for heat gain control, natural light can increase occupant comfort and happiness, and create a healthier, more welcoming space. Studies have shown that office workers in a work environment with more natural light experience a better quality of life, and improved productivity.

Natural ventilation. Modern glass roof systems can be designed to include operable vents or flaps that add ventilation through the roof. Natural ventilation is an essential component of a sustainable building as it increases air circulation, cycling out stale air and CO₂, provides a form of passive cooling, manages humidity and condensation, and can remove aerosols from indoor spaces. The improvement in indoor air quality has corresponding health benefits. An American study demonstrated that employees working in environments with improved ventilation performed 61% better on cognitive tasks. In another study, ventilation rates were found to match academic performance; as ventilation rates increased so did the proportion of students passing standardised tests.

Fire safety. Operable glass roofs can incorporate smoke vents to provide smoke relief in the event of a fire. During a fire, sensors can trigger the smoke control panels to open the vents allowing smoke to escape.

Aesthetics. Glass roofs can deliver a contemporary, clean look both from the outside and within that is sought after in both new and heritage projects. Sky views can make interiors feel more open, and controlled natural light can accentuate indoor designs and colours, which helps to increase the positive ambience within an indoor space.
Regulatory Requirements

Designing a high performing glass roof system that delivers the benefits discussed above starts with understanding the applicable regulatory requirements. The National Construction Code (NCC) Volume 1 includes requirements for weathertightness (Section F), energy efficiency and thermal performance (Section J), and fire resistance/safety (Section C), all of which impact glass roof design.

There are also several Australian Standards relevant to glass roof systems, such as AS1288-2006 Glass in Buildings—Selection and Installation, but there are no Standards specifically on the subject. The most commonly-used glazing standard does not cover glass roofs; AS2047-2014 Windows and External Glazed Doors applies to windows to a specified vertical angle and does not cover roofs. Similarly, AS4285-2019 Rooflights covers a “factory-manufactured assembly to permit natural light transmission” and thus is not applicable to glass roofs constructed onsite.

High Performance Glass Roofs

Critical Design Elements

In Australia, it is possible to specify high performing glass roofs and achieve superior thermal efficiency (up to Passive House certification), resistance to water penetration, and can include operable vents for natural ventilation and/or smoke relief. Specifiers can nominate systems that meet EN and ISO standards, which gives confidence that the system has been tested and certified for water penetration, air leakage and other factors similarly covered in AS2047. Certification under recognised sustainable product certification schemes, such as Passive House (discussed below), also indicates that the system meets a high standard of performance.

When designing operable glass roofs for use as part of a buildings smoke control solution, AS 2427-2004 Smoke/Heat Release Vents is applicable but, at the time of writing, the National Association of Testing Authorities has listed no facilities certified to undertake testing under this Standard. Alternatively, it is possible to nominate smoke relief systems that are tested and certified under ISO 21927/EN 12101 Smoke and Heat Control Systems.
Sustainable Building Product Certification – Passive House

Passive House is a voluntary standard for energy efficiency in a building. Compliance with Passive House ensures that a design delivers high performance and comfort over the lifetime of the building. The key principles of Passive House are:

- Airtightness.
- Thermal insulation.
- Mechanical ventilation heat recovery.
- High performance windows.
- Thermal bridge free construction.

Advanced product design with these characteristics are typical in buildings that achieve the Passive House standard. Products that are Passive House Certified have been tested to uniform criteria to deliver excellent quality regarding energy efficiency. For example, glazing certified under the Passive House standard will deliver optimum solar gains and thermal performance values. Some leading glass roof systems also carry this certification. Certified building products will be typically environmentally friendly, and/or accompanied by a life cycle assessment and environmental product declaration.

Design Considerations

Stability and safety. Glass roof systems should be tested for watertightness, air permeability and resistance to wind load. Consider the appropriate profile to support the intended spans, which will be either self-supporting or using secondary structural framing. Integration of wide ventilated glazing rebates to distribute the load (glass weight) over a wider area and to protect the IGU edge from exposure to moisture is recommended.

Thermal performance. What is the U-Value of the whole system? The answer to this is dependent on the overall system design and the glazing selected. U-value should be calculated on the dimensions of the actual unit, rather than a standard unit.

Thermal breaks. The construction of the frame can greatly affect the energy efficiency of the glass roof system. Frames made out of heat conductive material, such as aluminium, act as a thermal bridge. This can be mitigated by specifying a thermally broken frame, which includes a material of low thermal conductivity inside the frame (e.g. polyamide) to significantly reduce levels of heat transfer from inside to outside the building and vice versa.

Automation. Automation refers to the “remote” operation of the ventilation flap via electric actuator, which can be connected to a building management system or simple wall switch via appropriate controls hardware. The incorporation of sensors can add additional functionality and convenience – for example, weather sensors can be used to automatically close vents or flaps during rain. Integration with other mechanical systems also has its advantages, such as the ability to disable or enable air conditioning depending on whether the roof is in an open or closed state. It is also possible to utilise operable glass roofs for smoke relief where they interface with the building’s fire system and operate according to ISO 21927.

Resistance to water penetration. Leading systems can achieve resistance to water penetration ratings greater than 1000Pa.

Secondary management. Condensation build up is one of the main pitfalls of taking a vertical facade system and installing it horizontally as a glass roof. A system that was designed to fulfil its function as a vertical facade will lack the design elements necessary to effectively manage moisture and condensation which tend to pool on a flat surface. Dedicated glass roof systems include secondary water drainage channels, and some have internal ventilation designed to remove moisture that can form inside the profiles. Thermally-efficient designs can overcome internal and external temperature differentials (of up to 20 degrees) to prevent condensation build-up in the first instance.

Glass selection. Glass roofs with single glazing are prone to condensation as the glass is not insulated from the outside temperature, creating a temperature differential when an air-conditioned space is warmed up or cooled down. The increased stringency in thermal performance in Section J of the NCC also make single glazing less likely to achieve compliance. Designers and specifiers should select the appropriate glass make-up according to AS1170 and AS1288 to comply with the project’s thermal requirements. The use of IGUs – glass units made of two or three glass panels designed to minimise conducted heat loss through the unit – makes it possible to achieve Uw values of <2.0, right up to Passive House levels. Integration of internal or external blinds may also be considered to control heat gain and natural light.

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Based in Sydney, Melbourne, Brisbane, and Auckland, EBSA Pty Ltd is a leading Australian supplier of operable glass roofs, window automation and architectural glass louvres. Driven by a strong focus on sustainability, EBSA offers the latest in operable facade technology to deliver systems that make buildings breathe.

EBSA's wide range of products and unrivalled expertise allow them to design, install and maintain the most sustainable solution for any project. The company has extensive experience in operable facades delivering many of Australia's most energy efficient and sustainable projects.

**Lamilux PR60**

EBSA have partnered with Lamilux to offer the PR60, an advanced Passive House Certified glass roof system with limitless design potential. Efficient ventilation, controlled water runoff and condensate draining are built-in to the aesthetically-pleasing design, enabling energy efficient daylighting for a wide range of commercial applications such as shopping centres, sports halls and aquatic centres.

The design incorporates a stable, fully thermally separated structure with controlled water and condensate drainage through overlapping EPDM secondary drainage system. Operable ventilation flaps can be incorporated for natural ventilation, light, and natural smoke exhaust (certified to EN12101). Providing exceptional thermal performance, PR60 may be utilised as part of Passive House certified solutions and has been quality tested to EN and ISO standards.

**Lamilux FE Skylight Range**

The FE Skylight is a Passive House Certified skylight that comes in both standard and custom sizes in eight different glazing configurations. They have been designed without any thermal bridges to offer the highest level of thermal performance enabling daylight and ventilation without compromising energy efficiency.

A patented structural ribbing uses the heat energy of the air within the room below the base for the glazing. This increases the surface temperature in the aluminium frame which results in a flawless isothermal line and minimises the risk of condensation. This solution is available in fixed or operable models with manual or automated operation and a range of custom sizes.
References


All information provided correct as of June 2021