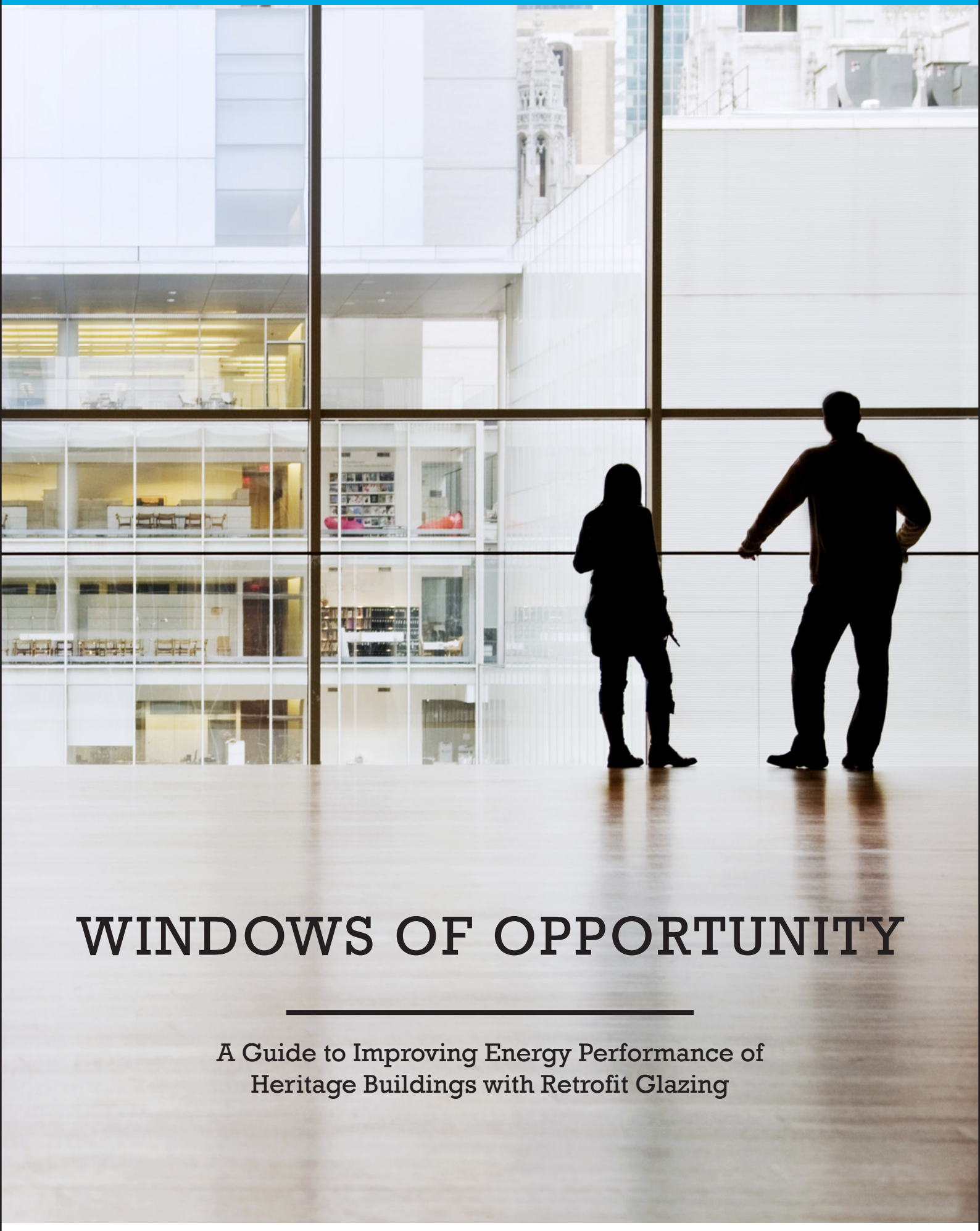


WINDOWS OF OPPORTUNITY

A Guide to Improving Energy Performance of Heritage Buildings with Retrofit Glazing

GLASSWORKS

Introduction

As heritage buildings become rarer and more sought after with time, the focus has shifted from replacing them to preserving their historical value. According to developer Dexus in 2018, heritage restoration and redevelopment projects are on the rise in Australia.[1] In an Allen Consulting Group report commissioned by the Heritage Chairs and Officials of Australia and New Zealand,[2] a further 5,000 sites are estimated to come under the protection of Australian heritage regulations by 2025.

It is generally recognised that the retention of heritage buildings also has environmental sustainability benefits. Restoring heritage buildings reduces the energy usage and waste associated with demolition, waste disposal and new construction, and conserves the embodied energy in existing buildings.[3] The concrete, stone and timber used in older buildings required less energy to produce and are inherently more insulating than the glass, steel and aluminium prevalent today.

Optimising the energy performance of heritage buildings through well-thought out design updates can contribute to broader sustainability objectives. A key area for improvement are windows – with many heritage buildings built before double glazing was even an option, many older structures feature single-glazed windows that let the rest of the building down in terms of energy efficiency.

In this white paper, we provide guidance on window retrofitting and glazing for heritage buildings to improve sustainability and energy performance.

Sustainability Factors in Older Buildings

Embodied Energy

"Embodied energy" refers to the energy used in the production of materials such as in mining, manufacturing and shipping. Traditional building materials, such as timber, concrete and brick, prevalent in older buildings have lower-scale embodied energy than modern materials such as glass, steel or aluminium.[4]

Thermal Mass

"Thermal mass" is the ability of a material to absorb and store heat energy.[5] High density traditional masonry materials like concrete, bricks and tiles are said to have high thermal mass.[6] Lightweight materials such as timber have low thermal mass.[7]

In summer, a high thermal mass building slows the transfer of external heat to keep the interior space naturally cooler. In cooler months, the high thermal mass building makes use of the winter sun and reradiates any escaping heat generated by internal heating systems back into the room.

Depending on the location and orientation of the building, thermal mass must be used appropriately and coupled with climate-appropriate passive design techniques.[3]

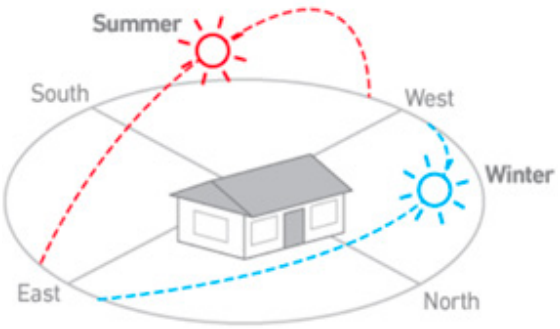
> "Optimising the energy performance of heritage buildings through well-thought out design updates can contribute to broader sustainability objectives."

Passive Heating and Cooling

Many heritage buildings have been "passively designed", which refers to the combination of building materials, orientation, sunlight, shade and ventilation that maintain thermal comfort inside a building with less reliance on artificial heating or cooling.[8]

Heritage Victoria has identified several measures that may improve passive thermal performance of a heritage building, including repairing damaged windows, doors and seals, unblocking boarded-over window openings, and removing introduced glazing over openable windows.[9] Orientation of windows in relation to the sun is also an important consideration when replacing or modernising older window systems.

The following diagram from Sustainability Victoria shows the way in which the sun rises and sets in summer versus winter and how performance is impacted by the orientation of certain windows. These should be taken into consideration for glass selection with the aim to optimise passive heating and cooling where necessary.



Key considerations for different orientations:

- **North elevated windows** receive direct sun in winter when the sun is low in the sky and little in summer when sun is high.
- **East and west facing windows** can also be a major source of heat gain during summer; east and north-east predominantly in the morning, while west and north-west more so in the afternoon.
- **South facing windows** more often than not receive very little direct sunlight in summer and virtually none in winter.

Performance Measures

When specifying window glazing, consider the performance of the solution using the below measures:

- **Solar Heat Gain Coefficient (SHGC)** measures the stopping power of the glass to let heat from the sun enter the building – the lower the number, the less solar heat is transmitted and the greater its shading ability.
- **Visible Light Transmittance (VLT)** measures the percentage of light coming into the building – the higher the percentage, the more natural light.
- **U-Value** measures the insulation factor of the glass and represents the rate of transfer of heat through the glass – the lower the number, the more insulating. The U-Value is particularly important for heating dominated environments.

Additional Features/Technologies

Additional features can be considered for glass units to improve performance. This includes:

- **Dynamic tint**, a PVB interlayer which adapts the SHGC and VLT based on the intensity or absence of the sun for constantly variable performance.
- **Easy-clean coating**, a patented invisible coating that uses the sun's UV rays to decompose organic matter and allow the rain to rinse it away with minimal streaks.

Glazing for Heritage Buildings

Glazing Options

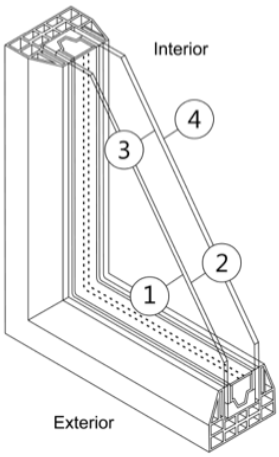
Inferior or old-fashioned glazing can compromise the thermal performance of a building. This is especially true for older glazing that has not benefited from the thermal enhancements of modern glass technology such as coated glass, laminated glass and double glazing.

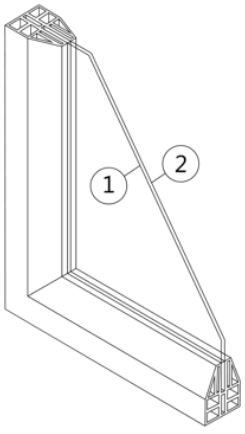
When replacing or modernising a heritage window system, it is advisable to combine it with a complementary high performing glass unit. Installing double-glazed windows (also referred to as Insulating Glass Units or "IGUs") is preferred if the maximum thickness of the window frame and sash allows for it. Incorporating a low-emissivity (Low-E) coating will further enhance performance.

Low-E coatings are used to minimise the amount of infrared and ultraviolet (UV) light that comes through glass. This keeps the heat primarily on the side the glass where it originates, without minimising the light that enters a building.

If the frames cannot be replaced or only allow for a maximum thickness of less than 14mm, single (or monolithic) glazing might be the only option available. However, there are new and advanced laminating or coating options available to improve thermal performance nonetheless.

The below diagrams show the typical IGU and monolithic construction and the surface numbers used to refer to coated surfaces.





Options for Insulating Glass Units

If the sash allows for a glass unit thickness of 14mm or above then an IGU is possible and recommended. Below are possible options worth considering when specifying IGUs.

Soft Coat Low-E IGUs
Soft coat Low-E IGUs have a coating that goes on the inside of the IGU and are the best performing solutions. According its structure, soft coat Low-E coated glass units may be classified as single silver Low-E glass, double silver Low-E glass and triple silver Low-E glass.

Triple silver Low-E coats (e.g. LoE³-366® and LoE³-340® by Glassworks) are the best performing in terms of solar control and insulation with high visible light transmission and energy efficiency. Double silver Low-E is also high performing with a lower shading coefficient than single silver Low-E glass. Single silver Low-E glass (e.g. Optitherm® by Glassworks) is widely used with leading solutions offering a VLT almost as high as clear glass but with a comparably lower SHGC and U-Value.

Hard Coat Low-E IGUs
Hard coat Low-E IGUs have a durable coating that can be exposed on room side or externally. Two solutions in this category are:

- **Room Side Low-E Pyrolytic coating** is the traditional hard coating, which can used in single or double-glazed units and available in a variety of tones.
- **Indium Tin Oxide (ITO) coating** is made of a composition of indium, tin and oxygen and can go on the inside or outside of the unit meaning it can be single or double glazed. LoE-i89® by Glassworks is the only glass of this kind. The main benefit of ITO-coated glass is a smoother, clearer surface without the haze. In an IGU, ITO-coated glass can be doubled up to become a double Low-E ultra-high performing unit and is ideal for cooler climates with some solar-controlling properties.

> "Inferior or old-fashioned glazing can compromise the thermal performance of a building."

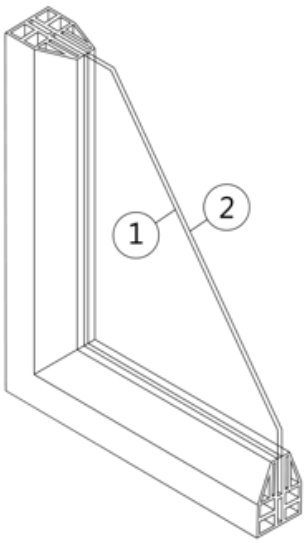
Options for Monolithic Glazing

If the building is restricted to slimmer profile windows, such as heritage type timber frames, then monolithic glazing might be the only option. Some options worth considering are discussed below.

Hard Coat Low-E Mono
Hard coat Low-E mono have a coating that can be exposed, allowing for monolithic glazing.

Options include:

- **Room Side Low-E Pyrolytic coatings**, which are the traditional hard coatings for mono low-E coated glass units and available in a variety of thicknesses and tones.
- As mentioned above, **ITO coatings** can also be single glazed and boast superior clarity without the haze. It represents the highest performing hard-coated mono option.



Standard or Custom Laminates
Laminates range from 6.38 to 13.5mm and incorporate two layers of glass with special interlayer(s). Options include:

- **Low-E coated laminate** a range of off-the-shelf laminates with a Low-E coating for increased comfort and is typically available in a variety of colours.
- **Dynamic laminated glass**, such as Glassworks' Suntuitive® MonoLite is a custom laminate which incorporates an adaptable interlayer that causes the glass to self-tint based on the intensity of the sun and returns to its clearest state in the absence of direct sunlight for constantly variable and hence optimised SHGC and VLT figures. To further reduce the U-Value, a high performing hard coat Low-E coating is recommended on the room side.

Swapping Out Existing Window Units

When electing to swap out existing single-glazed windows for a laminate or IGU with better performance, many heritage buildings are limited by the existing framing system, which may be able to be upgraded to a modern system only with a thinner profile permitted than a new build.

Considering these limitations, here are some possible ways to improve your window performance for retrofits:

Maximum width	Swap out	Swap for	Gained benefit
<8mm	**4 or 6mm clear glass**	**Mono Low-E** 6mm LoE-i89 ITO	*Low-E lowers infrared energy and heat transfer from the outside in and inside out.* Reduce heat gain by approximately 12% compared to 6mm clear glass.
	4 or 6mm grey class	**Low-E coated laminate** 6.38mm ComfortPlus Grey	*The benefits of Low-E and noise control.* Reduce solar heat gain by approximately 15% and U-Value by over 35% for improved insulation compared with 6mm grey glass.
<10mm	**6 or 8mm grey glass**	**Mono dynamic laminate** 9.5mm Suntuitive MonoLite	*Variable VLT and SHGC.* Increase VLT by approximately 22% on a cold day compared with 6mm grey glass. Reduce SHGC by over 50% on a hot day compared with 6mm grey glass and by over 65% compared with 8mm clear glass.
<12mm	**8mm or 10mm clear glass**	**Low-E coated laminate** 10.38mm ComfortPlus Clear	*The benefits of Low-E and noise control.* Reduce solar heat gain by approximately 15% and U-Value by over 35% for improved insulation compared with 8mm clear glass.
	8mm or 10mm grey glass	**Mono dynamic laminate** 11.5mm Suntuitive MonoLite	*Variable VLT and SHGC.* Increase VLT by approximately 22% on a cold day compared with 8mm grey glass. Reduce SHGC by over 50% on a hot day compared with 8mm grey glass and by over 65% compared with 8mm clear glass.
>14mm	**Any thickness clear mono glass or IGU**	**Clear double Low-E IGU** 4mm LoE^{3}-366 6mm Argon 4mm LoE-i89$^{(4)}$*	*Balances clarity with insulation and solar control.* Reduce the U-Value by over 50% and SHGC by over 60% compared with 14mm clear IGU.
	Any thickness tinted mono glass or IGU	**Dark double Low-E IGU** 4mm LoE^{3}-340 6mm Argon 4mm LoE-i89$^{(4)}$*	*Ultimate solar control and insulation.* Reduce the U-Value by over 50% and SHGC by over 60% compared with 14mm grey IGU.
	Any thickness tinted mono glass or IGU	**Mono dynamic laminate** 12.5 Suntuitive Monolite	*Variable VLT and SHGC.* Increase VLT by approximately 22% on a cold day compared with 8mm grey glass. Reduce SHGC by over 50% on a hot day compared with 10mm grey glass.

*Double Low-E is for further enhanced U-Value as low as 1.5 (or 1.11 if the thickness allows for a larger Argon gap of 12mm) however specifying 4mm clear on surface 4 still produces a good U-Value of 1.9 (or 1.35 with a larger Argon gap of 12mm).

Comparisons are an approximate guide made using LBNL Window 7.6 based on NFRC 100 environmental conditions.

Glassworks

Glassworks is an Australian-owned glass processing operation that utilises the best technology and machinery from around the world to provide innovative, customised glass solutions to the Asia Pacific region with over 90 percent of all materials sourced locally.

Committed to innovation in design and glass that contributes to a buildings' overall sustainability performance, the company's main areas of focus are performance driven glass and decorative glass with processing capabilities such as laminating, toughening and customisation.

The Glassworks range of energy-saving glass includes:

- **LoE³-366® + Neat®** is the highest performing energy-saving glass on the Australian market. LoE³-366 delivers the ideal balance of solar control and high visibility and is ideal for commercial and residential windows.
- **LoE³-340® + Neat®** solar control Low-E blocks the sun but not the light, producing a SHGC figure of 0.18, the lowest of any stocked glass in Australia and is perfect for commercial buildings seeking green ratings.
- **LoE-i89® + Neat®** is a single-glazed Low-E product that reflects escaping heat back into the room, making it the ideal glass solution all year round, especially during the colder months. LoE–i89 can be glazed monolithic or combined with a high performing hard coat on surface 4 of an IGU for ultimate performance.
- **Optitherm®** is an ultra-clear, insulating hard coat Low-E glass that is ideal for residential applications, achieving an exceptional VLT of 78% while maintaining a low SHGC of 0.63 and a U-Value of 1.3.
- **Suntuitive®** is Australia's first truly Solar Responsive Thermochromic adaptive glazing film, a type of dynamic glass that uses the suns own energy to self-tint according to the buildings' needs throughout the day and across the seasons. This innovative technology can be incorporated in an IGU or a monolithic laminate version and offers constantly variable SHGC and VLT as needed to optimise natural light and naturally control temperature and glare.

Neat® easy-clean coating technology - a titanium dioxide layer of Neat reacts chemically with the sun's UV rays and causes organic materials that are on the glass to decompose so that they are easily washed away.

REFERENCES

1 Stewart, Claire. "Why heritage building transformations are on the rise." Dexus. https://www.dexus.com/prism/why-heritage-building-transformations-are-on-the-rise (accessed 11 June 2020).

2 Allen Consulting Group. "Valuing the priceless: the value of historic heritage in Australia." Office of Environment & Heritage. https://www.environment.nsw.gov.au/Heritage/research/papers.htm#priceless (accessed 11 June 2020).

3 Heritage Victoria. "Heritage Buildings and Sustainability." Heritage Victoria. https://www.heritage.vic.gov.au/__data/assets/pdf_file/0018/61533/Sustainability_Heritage_tech_-leaflet.pdf (accessed 11 June 2020).

4 Ibid.

5 Australian Government. "Thermal mass." YourHome. https://www.yourhome.gov.au/passive-design/thermal-mass (accessed 11 June 2020).

6 Ibid.

7 Ibid.

8 Australian Government. "Passive design." YourHome. https://www.yourhome.gov.au/passive-design (accessed 11 June 2020).

9 Above n 3.

All information provided correct as of June 2020

GLASSWORKS