



SECTION  
**01**

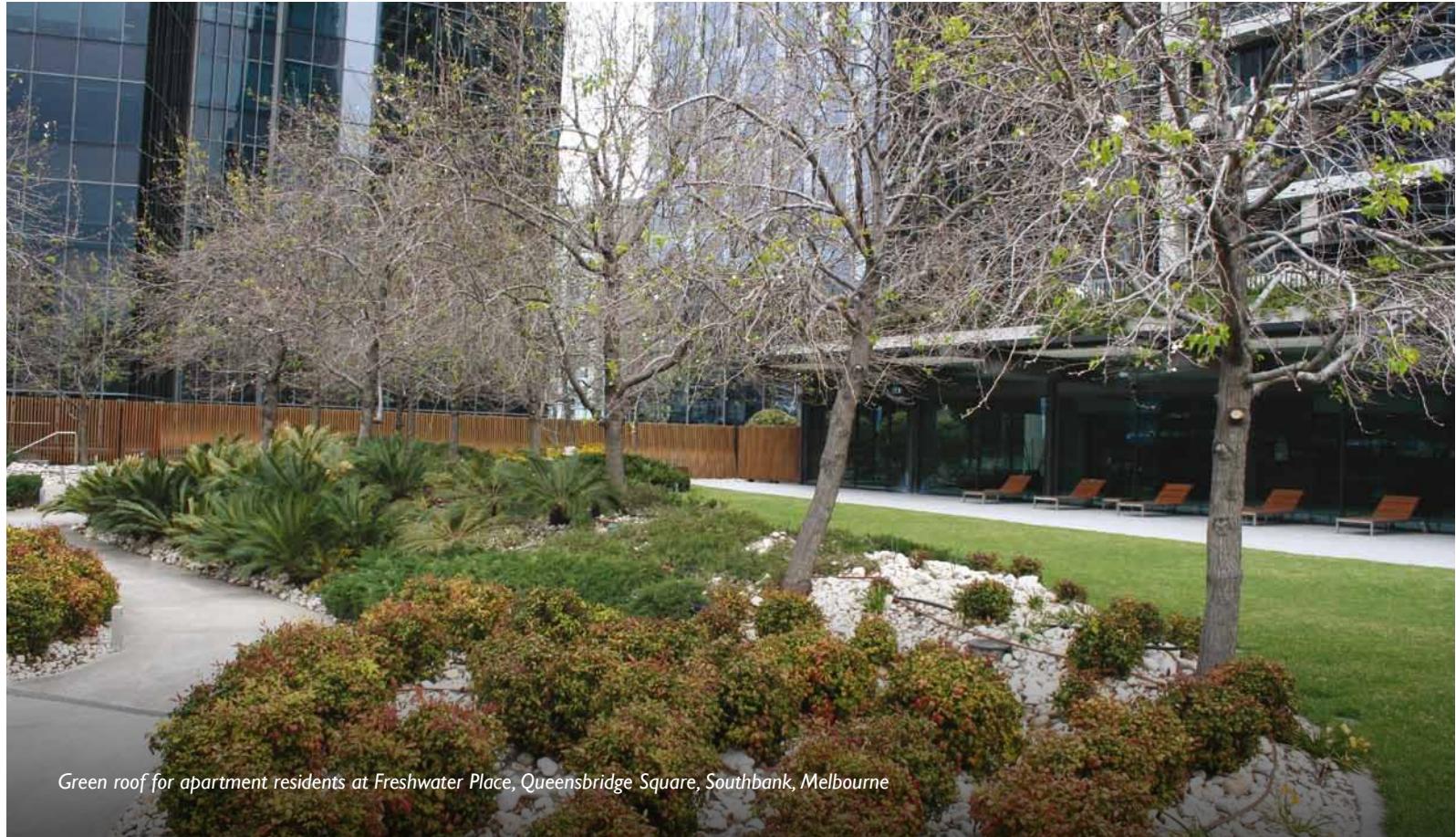
*Image: Fytogreen*

# An introduction to green roofs, walls and facades



**GROWING  
GREEN  
GUIDE**

*Image: ASPECT Studios*



*Green roof for apartment residents at Freshwater Place, Queensbridge Square, Southbank, Melbourne*



# INTRODUCTION

Green roofs, walls and facades are becoming more common in cities across the globe. Growing numbers of Australians are realising the potential of these living systems to improve the quality of their built environment to provide social, aesthetic, environmental and economic benefits.



Like many other cities, Melbourne faces continued pressure from increasing urbanisation. Rapid population growth and urban development have transformed natural environments into areas of highly engineered infrastructure. Heat generation from cars, industry and commerce, coupled with the retention of the solar energy by buildings and paved surfaces, creates unnaturally warm city environments (known as urban heat islands). This can have negative effects on human health and wellbeing. The transition from the natural landscape to the built environment has also created large areas of impervious paved surfaces, creating problems such as loss of vegetation and habitat, increased surface run-off and flash flooding. Each of these issues is being exacerbated by an increasingly variable climate.

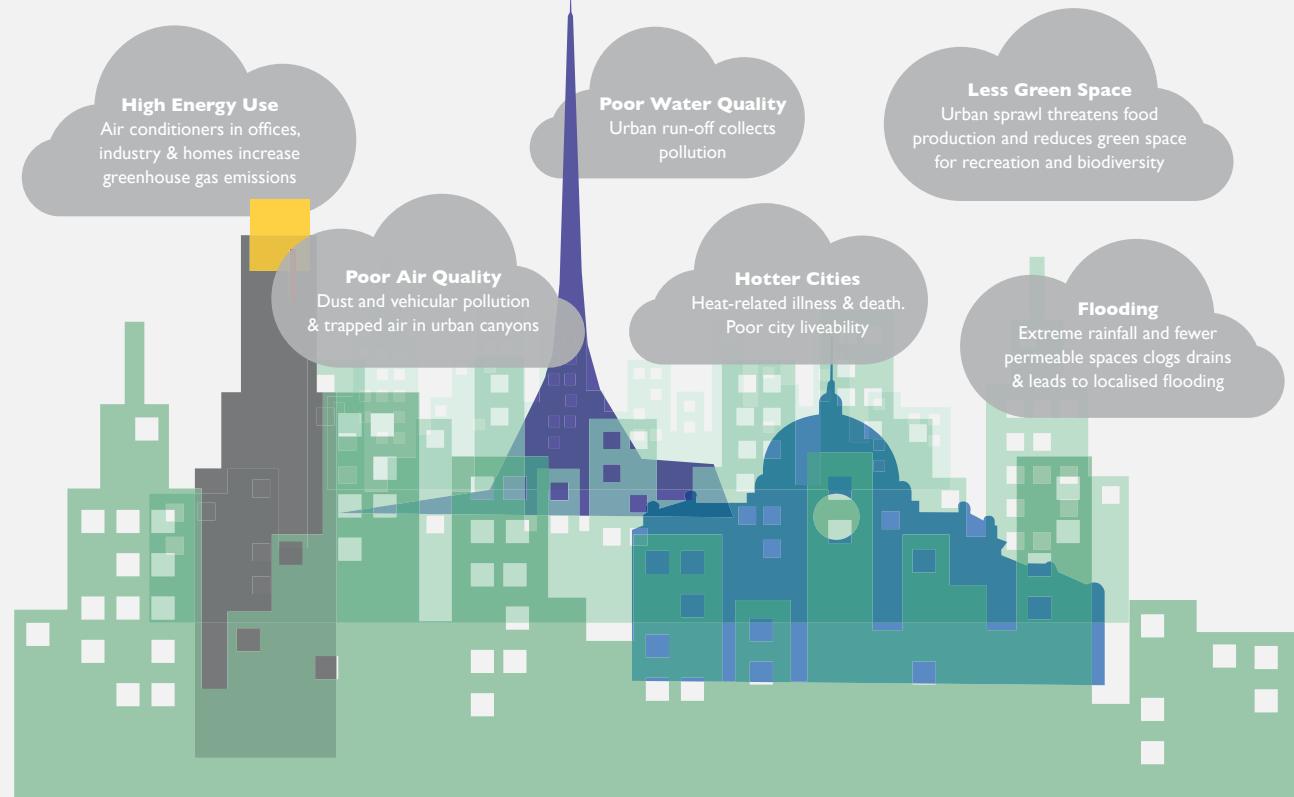
Collectively these issues present enormous environmental, economic and social challenges and require new ways of thinking to make our cities more liveable now, and into the future.

Many cities around the world recognise the importance of having green infrastructure; that is, natural landscape assets, including green spaces and water systems. Green infrastructure includes trees, parks, water sensitive urban design (such as wetlands and rain gardens) and green roofs, walls and facades.

Green roofs, walls and facades are appealing as a way of adding green infrastructure to a city because they can be included on new buildings or retrofitted onto existing buildings, and require little, if any, space at ground level. They are being used to compensate for the loss of urban greenery, and to provide localised cooling and aesthetic improvements in dense urban centres where there is insufficient space for other types of green infrastructure.

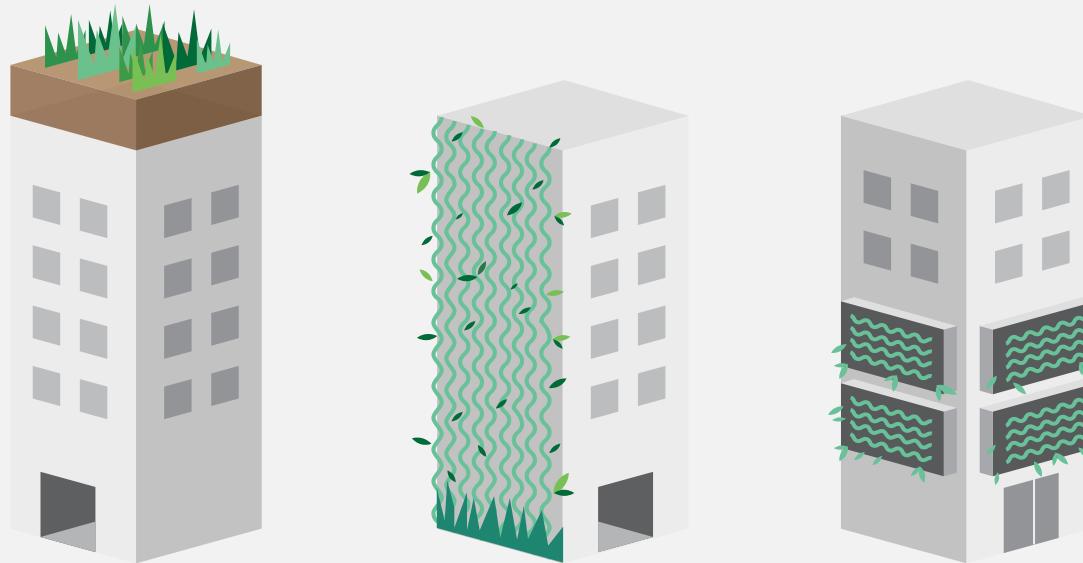
It is estimated that there are more than 50 green walls, more than 100 green roofs and hundreds of green facades across Melbourne. Yet there is limited Australian information about how to create and manage these types of green infrastructure. This guide provides technical advice on how to design, build and manage green roofs, walls and facades so they can provide multiple benefits over a long time span for building owners and the wider community.

**Figure 1. Pressure builds over our cities, with the transition from natural landscapes to hard infrastructure, an increasingly variable climate and a growing population**





**Figure 2. Vegetation can be added to a building as green roof, green wall or green facade**



## Definitions

### Green roof

A vegetated landscape built up from a series of layers that are installed on a roof surface as 'loose laid' or modular (that is, installed layer by layer on the roof or as pre-prepared layers in trays).

Green roofs are constructed for multiple reasons - as spaces for people to use, as architectural features, to add value to property or to achieve particular environmental benefits (for example, stormwater capture and retention, improved species diversity, insulation of a building against heat gain or loss).

Vegetation on green roofs is planted in a growing substrate (a specially designed soil substitution medium) that may range in depth from 50 mm to more than a metre, depending on the weight capacity of the building's roof and the aims of the design.

Green roofs have traditionally been categorised as 'extensive' or 'intensive'.

**Extensive green roofs** are lightweight with a shallow layer of growing substrate of less than 200 mm deep, requiring minimal maintenance. They generally have lower water requirements and use small, low-growing plant species, particularly succulents (see images 1 and 5 opposite). 'Ecoroofs' or 'brown roofs' are terms used to describe these extensive green roofs. Roofs that are designed and planted specifically to increase local plant diversity and provide habitat (food and shelter) for wildlife are known as 'biodiverse green roofs' (see image 3 opposite).

**Intensive green roofs** are generally heavier, with a deeper layer of growing substrate, and support a wider variety of plant types

(see image 2 opposite). Because they can support a heavier weight, they are readily accessed by people. Intensive green roofs need more irrigation and maintenance than extensive roofs, and are highly engineered landscapes, often built directly on structures with considerable weight load capacity, such as car parks. 'Roof gardens' or 'podium roofs' are terms also used to describe these types of green roofs. 'Roof garden' is used particularly for sites where less space is dedicated to the vegetation and growing substrate and more to hard infrastructure such as decking (see image 4 opposite).

Until quite recently, extensive green roofs were usually designed as lightweight installations that were not publicly accessible, while intensive green roofs were designed as amenity spaces for people. The boundaries between these types of roofs are now less distinct, and terms such as 'semi-intensive' or 'semi-extensive' are used to describe roofs that show elements of these major categories.

The [International Green Roofs Association](#) and other international green roof industry organisations use these distinct roof classifications. However, in this guide, green roofs are described in terms of their particular characteristics, such as depth of growing substrate. The authors of the guide consider that as each green roof is unique and may incorporate a mix of design elements, strict classification of types is no longer as helpful or relevant as it once was. Around the world, designers and their clients, and those who install and maintain green roofs, are exploring a range of creative solutions.



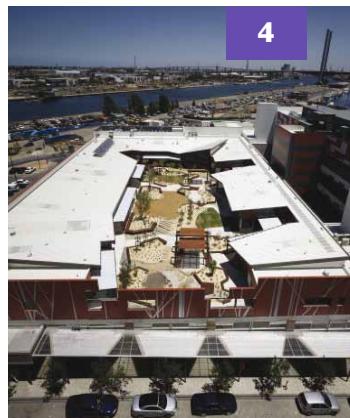
1



2



3



4



5

**1** Council House 2 in Melbourne has a non-irrigated, non-trafficable green roof comprised of modular trays

**2** The demonstration green roof at The University of Melbourne, Burnley campus, is an accessible roof used by staff and students. It demonstrates different irrigation regimes, growing substrates and plant species

**3** A small-scale green roof at a public amenity block in Healesville, designed as an architectural feature and for biodiversity - it includes indigenous species with the intent to create habitat. Image: Fytogreen

**4** Lady Gowrie Child Care Centre, Docklands, is a roof garden designed for use and play. Image: City of Melbourne

**5** The Venny, Kensington is a non accessible, light weight green roof with solar panels. Image: Andrew Wutke



## Green wall

A green wall is comprised of plants grown in supported vertical systems that are generally attached to an internal or external wall, although in some cases can be freestanding. Like many green roofs, green walls incorporate vegetation, growing medium, irrigation and drainage into a single system. Green walls differ from green facades in that they incorporate multiple 'containerised' plantings to create the vegetation cover rather than being reliant on fewer numbers of plants that climb and spread to provide cover. They are also known as '*living walls*', '*bio-walls*' or '*vertical gardens*'.

Green walls provide an attractive design feature, but also add to building insulation by direct shading of the wall surface. They create cooler microclimates and improve local air quality, and provide the possibility of growing plants in locations that would not normally support vegetation. A wide range of plants is used on green walls, usually herbaceous, though some small shrubs can also be suitable.

The provision of adequate light is an important consideration, particularly when planning an interior green wall, where artificial lighting may be necessary (see image 1 below).

Many different proprietary green wall systems are available. Some are hydroponic and others use a growing substrate. Green wall structures vary from modular systems to sheet or board-based structures with felt pockets to contain and support plant life. All green walls require irrigation, often inclusive of fertiliser (fertigation). Fertigation solution can be re-used, but requires careful monitoring and management to ensure nutrients do not build up over multiple recirculations to damaging levels.

A well-designed green wall system will fulfil both design and functional aims by providing growing conditions suitable for the selected species, have a long lifespan, require minimal component replacement, and have achievable demands for maintenance.



1



2



3



4

**1** Artificial lighting is an important element for this internal green wall in the foyer of Telstra's Melbourne headquarters. Image: Fytogreen

**2** Victoria's Environmental Protection Authority has a green wall outside its head office in Carlton, signalling their interest in sustainability and a visible cue to the building's 6 star Green Star rating

**3** Illura Apartments in West Melbourne have four green walls facing north-east, which helps to shade the wall surface in summer. Image: Fytogreen

**4** The internal green wall is a design feature in the foyer of The Gauge, Docklands. Source: PAD Creations



## Green facade

A green facade is created by growing climbing plants up and across the facade of a building, either from plants grown in garden beds at its base, or by container planting installed at different levels across the building (see image 4 below).

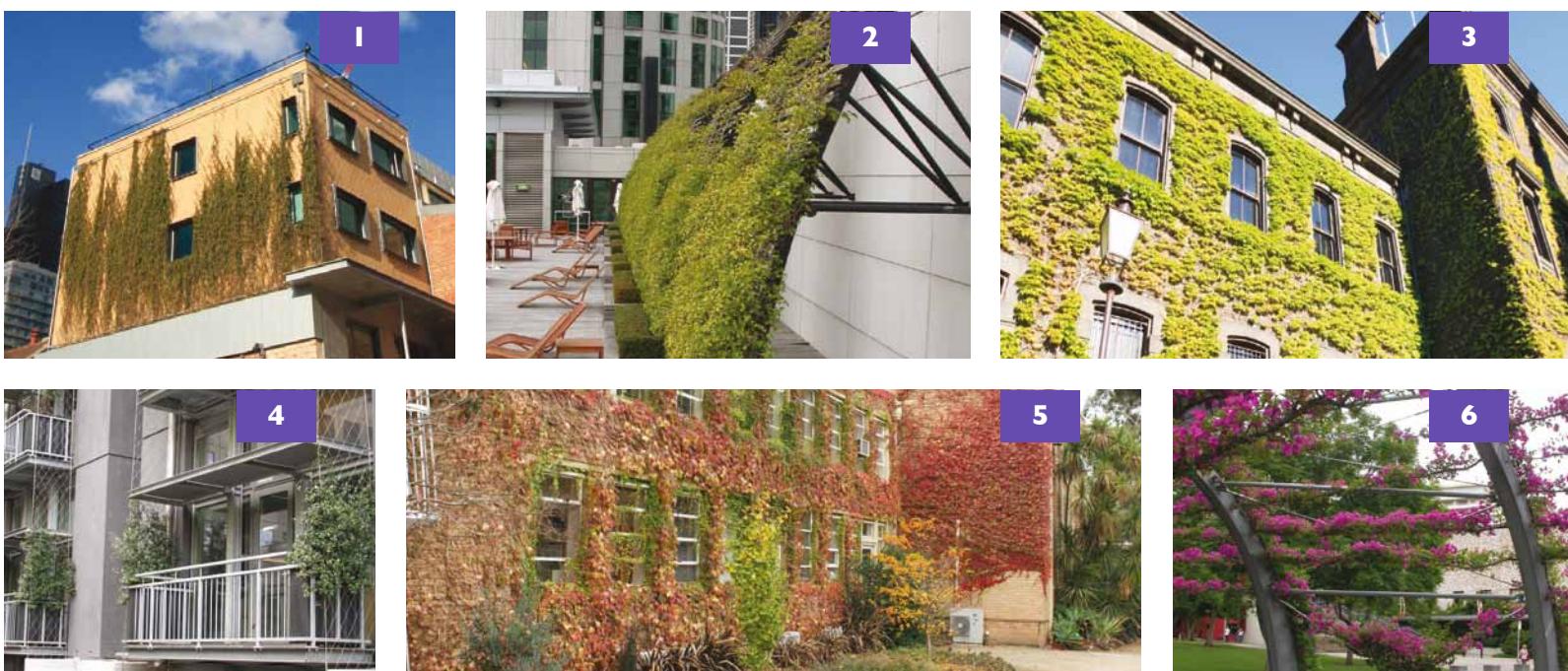
Climbing plants can attach directly to the surface of a building (see images 3 and 5 below), or they can be supported on a structure independent of the building (see images 1, 2, 4 and 6). The use of climbers that anchor themselves to a structure by twining stems or twining tendrils enables a green facade to be installed in front of solid walls or some other structure, to create a partition, privacy screen or sunshade. The degree of density of the facade coverage can be managed to suit the required function. For example, a facade designed to shade a building wall would ideally have greater foliage density than a screen installed near a window that is designed to allow at least partial views to the environment beyond the facade.

Green facades are often installed because they provide an attractive look to a building wall, or they may be used to block out a view, or to provide shade for a building. Green facades can create a cooler microclimate immediately adjacent to a building, primarily through direct shading of the building facade, but also from cooling from plant foliage (transpiration of water through the leaves), and evaporative loss of water from the growing medium. All climbing plants will provide some retention of stormwater,

shading of the building, protection of its surface, and capture of airborne particulate matter and volatile gaseous pollutants. These benefits will be greater for evergreen species that retain foliage cover year-round.

For multi-level facades (see image 4 below), particularly at height, wind can create significant problems for plant attachment. In these settings, twining climbers are preferred over plants that adhere directly to the building facade as the twining stems attach strongly around vertical and horizontal supports. Foliage may still be stripped under extreme wind conditions, so foliage type and size should be matched to the level of exposure and likely wind strengths at the site. In general, the higher the planting on a building, the more extreme the growing conditions are likely to be. Other factors of importance in multi-level facade design include planter box design (volume, substrate, drainage), maintenance access and irrigation system design.

The distinction between green walls and green facades is not always clear. As the design and use of plants on vertical surfaces expands, systems become harder to define. For instance, a 'hybrid living wall' system has been created in Adelaide that uses both green wall and green facade technologies. This blurring of definitions is akin to the already acknowledged difficulties in classifying green roof types, where new designs merge what were previously considered different categories.



**1** A wire mesh structure supports this green facade at the RMIT University City campus **2** Green facades are used as a screen to cover a bland wall on the green roof at Crown Casino, Southbank **3** This climbing plant attaches directly to the facade of Victoria Barracks, St Kilda Road, Melbourne **4** Twining plants are used to create a multi-level green facade at Council House 2 in Melbourne. Planter boxes located on each balcony allow the facade to extend to the full height of the building **5** Deciduous climbing species provide an attractive feature in autumn at the University of Melbourne's Burnley campus **6** A climbing plant (with a scrambling habit) is used on this free-standing green facade in Brisbane, Queensland



# Benefits of green roofs, walls & facades

There is a range of benefits, outlined below, that can potentially be provided by green roofs, walls and facades. Some provide benefits to the public at large and some only benefit the building owner or occupants. It is important to recognise that the following benefits are only realised if the roof, wall or facade is planned and

constructed well and has the supporting management required to sustain it. Section 3 of this guide discusses the importance of design in realising the intended outcomes from any project. Section 2 provides the research evidence for these benefits.

## **Increased property value and other benefits for building owners**

Building owners and developers are increasingly installing green roofs, walls or facades to add a point of difference, increase commercial returns, provide visual appeal and turn a building into a local landmark. Most building owners in Melbourne ignore the potential of large, leasable spaces on rooftops that can be transformed into versatile recreation, amenity or productive facilities, or commercial spaces for bars, restaurants or cafés.

While the construction of a green roof, wall or facade can be independent from the rest of a building project, involving specialists early in the construction timeline will help to minimise risks associated with design development. Importantly, early design discussions will help ensure that the roof, wall or facade can be planned and incorporated in other building aspects such as drainage, irrigation, lighting and weight loading.

Green roofs can lengthen the lifespan of a traditional roof surface. They protect a roof's waterproof membrane from solar radiation and add insulating materials (vegetation, substrate and other layers) to reduce severe temperature fluctuations on the roof surface.

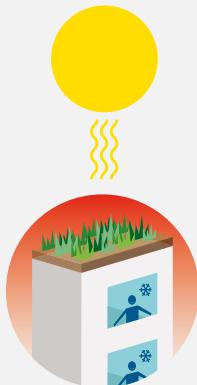


## **Stormwater management**

Green roofs absorb and retain rainwater and can be used to manage stormwater run-off in urban environments. They can also filter particulates and pollutants. Stormwater run-off can be reduced or slowed because it is stored in the substrate, used by or stored in the foliage, stems and roots of plants, and also evaporates directly from the substrate. Additional water storage capacity in green roof systems can be provided through incorporation of a water retentive layer or drainage layer at the base of the green roof.

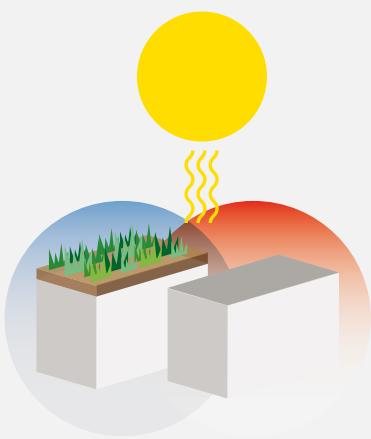
Several factors influence the extent to which a green roof can reduce the volume of water run-off into the stormwater system, including depth and properties of the growing substrate, type of drainage layer used and roof slope. Plants and drainage systems are important considerations in the design of a green roof for stormwater management. Details on research supporting stormwater management are provided in Section 2.





### Improved thermal performance

A significant benefit of green roofs, walls and facades is the potential for reducing building heating and cooling requirements. Green walls and facades can reduce heat gain in summer by directly shading the building surface. Green roofs reduce heat transfer through the roof and ambient temperatures on the roof surface, improving the performance of heating, ventilation and air conditioning (HVAC) systems. While there is great potential to cool buildings, research data and the results of modelling studies vary greatly in relation to the extent of the difference in temperature and the energy savings that are predicted for buildings with green roofs versus conventional roofs (see Section 2).



### Cooling a city – urban heat island effect

Hard surfaces in urban environments, such as concrete, brick, glass, asphalt and roofing, have a high thermal mass, collecting the sun's heat during the day and re-radiating it slowly back into the atmosphere. This contributes to a rise in ambient temperature in cities, creating large, stable masses of hot air (urban heat islands), especially during periods of calm, still weather.

Temperatures can be reduced by covering a roof or wall with a layer of vegetation that shades building materials which would otherwise absorb heat. Evapotranspiration provides cooling effects, as water is evaporated from the soil and plants and plants transpire by taking water in through roots and releasing it through leaves. Energy from the sun that would otherwise heat the roof or wall surface and increase ambient air temperatures is instead used in the evapotranspiration process, resulting in latent heat loss that lowers surrounding air temperatures. When green wall and facade plants are grown on a support system that leaves a gap between the wall and the planting, hot air moves up by convection through the space between the wall and the vegetation, providing passive cooling.

A city-wide strategy to implement green roofs, walls and facades could help mitigate some of the negative consequences of urban heat islands, and consideration should be given to appropriate plant selection and substrate depth to maximise cooling potential.



### Creation & preservation of habitat & ecological biodiversity

Green roofs can contribute to and enhance biodiversity by providing new urban habitats and specific habitats for rare or important species of plants or animals. Green roofs can also provide a link or corridor across urban 'ecological deserts' and assist in migration of invertebrates and birds. Designing for biodiversity requires consideration early in concept development with regard to plant species, food sources, habitat values, access points and building heights.



## Aesthetics, open space and urban food production



The liveability of cities is increasingly dependent on the availability of and access to green open space. Green roofs, walls and facades can increase amenity and provide opportunities for food production, recreation, relaxation or commercial ventures.

In dense, rapidly growing urban areas, the contribution of green roofs, walls and facades to overall green space should not be underestimated. In inner-city areas especially, most space is occupied by buildings and related infrastructure and the opportunities for new parks and gardens is extremely limited. Green roofs, walls and facades can be used for multi-level greenery designs that connect with ground level green spaces.

## Cleaning the air



Green roofs, walls and facades can contribute to the removal of gaseous pollutants from the air, although their effectiveness varies with plant species and area of cover. Plants with a high foliage density or with textured leaf surfaces that trap small particles also assist in removing particulate pollution, through dry deposition on the foliage or through rain wash. On a larger scale, green roofs, walls and facades can help to reduce overall environmental heat gain (re-radiation of heat from building materials with high thermal mass), in turn improving air quality as less photochemical pollutants are produced at lower air temperatures.

In interior environments, plants have been shown to have a significant capacity to reduce volatile organic compounds from the air. Carpets and other soft furnishings and office equipment are common sources of these gaseous pollutants; inclusion of vegetation, such as a green wall, can help to improve the air quality of the indoor environment.

## Next Steps

Read the frequently asked questions and the rest of the guide to understand the details of green roof, wall or facade systems, or seek advice from a professional in the industry to learn more about approaches that may be suitable to achieve particular identified aims for your site.

[Section 2](#) details some evidence of the benefits of green roofs, walls and facades. In [Section 3](#), technical advice is provided on how to design, construct and maintain green roofs, walls and facades. Finally, [Section 4](#) provides detailed case studies of a selection of Victorian green roof, wall and facade projects to give practical examples of design, construction and maintenance.

# FREQUENTLY ASKED QUESTIONS

## **Do green roofs work on new and old buildings?**

Yes. Green roofs can be fitted to a range of roof types. A new building can be constructed to accommodate the weight loading necessary for a green roof. Some existing buildings will have the capacity to support a green roof, or additional structural support can be retrofitted to support the required increase in loading. A structural engineer must be engaged to clarify details of building structure and weight loading capacity.

## **Can I green any building?**

Most building surfaces have the potential for greening. Challenging sites such as those in deep shade or with low weight-loading capacity, and tall buildings or sites with limited access, require specialist engineering, design and technical input.

## **Can a tile roof be greened?**

Yes, but it requires design expertise and specialised systems that are not yet widely available in Australia.

## **Is irrigation necessary for a green roof, wall or facade?**

All green walls and most green facades and roofs, require irrigation. It is possible to install a green roof with no irrigation, but this will limit the range of plants that can be used successfully and the potential benefits of the roof (such as summer cooling or aesthetically pleasing views of leafy plants). Some green facades grown in garden bed settings may not need irrigation.

## **Can I have a green roof on a slope?**

Yes, but steeper slopes present a challenge, and require specialised design solutions, including drainage boards and systems to help hold substrates and plants in place.

## **How much water do you need?**

There is no one answer, as calculating the water needed to sustain a green roof, wall or facade depends on climate and environmental influences, the design and type of system used, and on the substrate and vegetation characteristics. Explore alternative sources of water for use in irrigation, such as harvested and recycled water, to minimise reliance on potable water. Many green walls rely heavily on irrigation and it is essential to establish that supply can meet demand.

## **Will plants ‘overtake’ the roof or wall?**

Vegetation maintenance on a green roof is important and should be factored in during the design phase of the project. Selection of less vigorous plants (species with low biomass) or those that do not seed freely will help reduce maintenance requirements. Green walls can be designed to have an air gap between the back of the system and the wall, to provide air pruning of roots. Green facades will require pruning to manage size and maintain effective cover.

## **How much do green roofs, walls and facades cost?**

Costs will vary significantly between sites and projects. The case studies in this guide indicate costs for a range of projects of varying complexity for comparative purposes. The key factors that influence costs are the size of the roof, wall or facade; the design and type of materials used in the roof (for example, structural reinforcement, volume of growing substrate and components used in the mix, plants, system components, hard surfaces and furniture, etc.); requirements for access; and the requirements for ongoing maintenance (including inputs for irrigation, weeding, pruning, fertiliser).

Green wall technologies offer notable variation in costs, with relatively cheap domestic green wall products suited to small-scale DIY (do-it-yourself) applications, through to large and small-scale custom-designed commercial systems. Each presents a different level of refinement and security for long-term success.

## **Will the green roof leak and cause problems?**

Any roof has the potential to leak. Well-constructed green roofs, walls and facades will not leak or cause other structural damage to the building. Correct installation of waterproofing is essential on roofs and some walls, and leak detection systems can minimise risks on green roofs. Waterproofing membranes can actually last much longer under green roofs because they are protected from damage by the elements by overlying layers.

# FREQUENTLY ASKED QUESTIONS

## **What is the typical lifespan of a green roof, wall or facade?**

The lifespan is directly related to the quality of the design, construction and maintenance, and in particular, the longevity of the system components. Some green roofs in Europe have been in place for more than 75 years and are still performing strongly. There are many examples of direct façade greening in Melbourne that have lasted for decades. The projected lifespan of green wall and facade technologies that are more recent entries into the market are less well understood.

## **Will construction of a green roof, wall or facade cause delays in the construction of my building?**

Although a green roof, wall or facade should be considered an integral component of a building, its construction can usually be done independently from the rest of the build, so it poses little risk in causing delays. It is very important to include the installation specialists in early design discussions and associated construction project timelines to establish the most efficient construction timetable and ensure that drainage, irrigation and lighting are designed to include the green roof, wall or facade.

## **Can I have solar panels on a green roof?**

Yes. There are examples of green roofs in Melbourne and other parts of the world where green roofs have solar panels installed above them.

## **How much pruning will be needed if I grow a green facade?**

Pruning is usually required once or twice a year, although this will depend on the vigour of the plant species and the growing conditions. Annual pruning is important to control growth and keep vegetation away from building fixtures (lighting, heating or cooling equipment, drains).

## **Could I just paint my roof white to achieve summer cooling?**

Increasing roof reflectance through a 'white roof' is one way of reducing heat gain through the roof. However, a white roof will not capture and retain stormwater, provide aesthetic benefits or increase biodiversity values. Paint eventually degrades and requires maintenance. Most white roofs cannot help insulate the building in the winter months and will therefore only improve the building's energy efficiency in the heat but not the cold. A green roof can help a building's energy efficiency year round.

## **How do I know if my building has the capacity for a green roof?**

An architect, engineer and green roof provider are needed to ascertain that a green roof can be installed on a new building. To retrofit a green roof on an older building, consultation with an architect and/or structural engineer is necessary to determine the load-bearing capacity of the structure. Consult with green roof, wall or facade providers to discuss design ideas and solutions for the site.

## **Are green roofs, walls and facades environmentally sustainable?**

Design of the system is paramount to how well it contributes to broad sustainability goals, such as pollutant filtration, thermal insulation, providing habitat or localised cooling. By considering how you design, operate and maintain your system you can also ensure that the materials and practices used are environmentally sustainable now, and in the long term. This process is called 'life-cycle analysis'. Recycled waste products could be used (from the building materials to substrate materials) or local products sourced rather than imported materials to reduce the energy used in these components. Some systems may require more water than others, but if that water is sourced from harvested stormwater or recycled water, it may be more sustainable than a low water-using system that uses potable water. Considered application of fertiliser is required to ensure there is no negative effect from polluted run-off from the site. Management of weeds and pests in the vegetation through a maintenance regime will also contribute to overall sustainability outcomes.