UK Guide to Green Walls

An introductory guide to designing and constructing green walls in the UK

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Introduction to Green or Living Walls

Green or living walls are essentially vertical (or near vertical) structures that are covered with vegetation. Historically this has been climbing plants naturally growing over walls and buildings. Modern techniques have now been developed that encourage and support the growth of different types of plants providing a more deliberate and controlled covering.

Patrick Blanc is arguably the founder of modern vertical gardening and is credited with capturing the public's imagination for green walls in the mid-1990s. Whilst the green roof is steadily gaining credibility as a green infrastructure (or 'greenfrastructure') solution to urban environmental challenges (Grant, 2003), until recently green walls have been overlooked as an obvious solution for urban greening. Roof space offers significant scope for greening in our cities but is dwarfed by the potential area available for urban greening on vertical walls and structures.

This introductory guide provides a basic understanding of green wall systems available in the UK, an overview of their main benefits and major issues to consider when designing or constructing a green wall. Example case studies are provided as a guide to potential applications and the likely costs.

Benefits of Green Walls

Benefits provided by green wall installations vary depending on their location and design, though most share common benefits. For simplicity those listed below have been grouped into environmental, human and building related aspects. Some cross-over does exist and often benefits are also categorised as Public and Private, i.e. those realised by only the building owners/tenants and others shared by the wider community (Dunnett & Kingsbury, 2010).

Environmental

Air purification & dust suppression

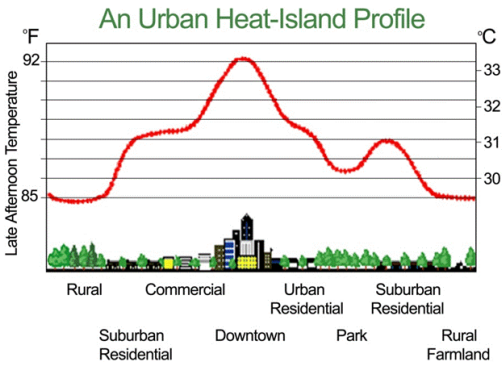
One of the biggest environmental issues currently facing the UK is the level of pollution in our cities. Green walls have the potential to address some of the problems. During the day plants extract carbon dioxide, carbon monoxide and many other toxins from the air during photosynthesis, resulting in significant reductions in CO2 levels in well vegetated urban areas (Nowak et al., 2006). Large areas of greenery can also help to suppress dust particles; improving air quality around construction sites and busy highways (Pugh et al., 2012). This can lead to a reduction in respiratory illness. There has been much focus in London recently on reducing PM10 particles to meet EU targets and avoid a substantial financial penalty (GLA, 2010).

Increased Biodiversity

By using selected plants a green wall can considerably increase the number and variety of insects and birds in a given area, helping to return a more sustainable ecosystem in urban environments (Brenneisen, 2003).

Reduced urban heat island effect

Urbanised areas have a higher average temperature than the surrounding countryside. Increasing vegetation in city hot spots, or urban canyons, provides cooling of trapped air and reduces reflected heat. Tests have shown temperature differences of up to 17°C between hard and vegetated surfaces in the same location (McPherson, 1994).



Storm water mitigation & rainwater harvesting

Increasing the coverage of vegetation can reduce the amount of storm water management required for a building (Dunnett & Clayden, 2007). This is especially useful in older urban areas where excess storm water is combined with wastewater systems. More advanced solutions can harvest excess rainwater for green wall irrigation, eliminating the need for a fresh water supply.

Building

Passive thermal performance

Coverage of vegetation over a building can dramatically reduce the need for additional cooling in summer. The vegetation also works as a blanket to reduce heat loss from a building in winter. These reductions lower the requirement for heating and air conditioning demands in a building. Studies have shown considerable energy savings (UK Government, 2009).

Building protection

Green walls help reduce UV damage to surfaces and can protect a building from wind, weather and temperature fluctuations, prolonging the life of the structure. These factors could, in fact, offset maintenance costs of green walls. In addition, many green wall systems have solid back panels that maintain rigidity, waterproofing and security; these can be used as cladding on buildings in place of traditional materials, thus offsetting the capital cost of an installation.

Green credentials

Green walls are visual indicators of sustainable design and can be a means of qualifying for additional eco-credits for sustainability assessment schemes and may help with planning applications.

Human

Aesthetics

Vegetated surfaces are generally considered aesthetically pleasing; they can provide a visual impact and focus for onlookers or can be used to obscure unsightly structures and spaces.

Health and wellbeing

Plants and greenery can provide uplifting and calming effects on people whilst having a positive impact on stress-related illnesses. Studies have shown that simply having a view of greenery increases workplace productivity and patient recovery rates in hospitals (Ulrich, 2002).

Noise reduction

Planted surfaces have low noise reflectivity and high absorption properties. Ambient noise is attenuated by green wall systems, improving conditions for building occupants and pedestrians (Kotzen & English, 2009).

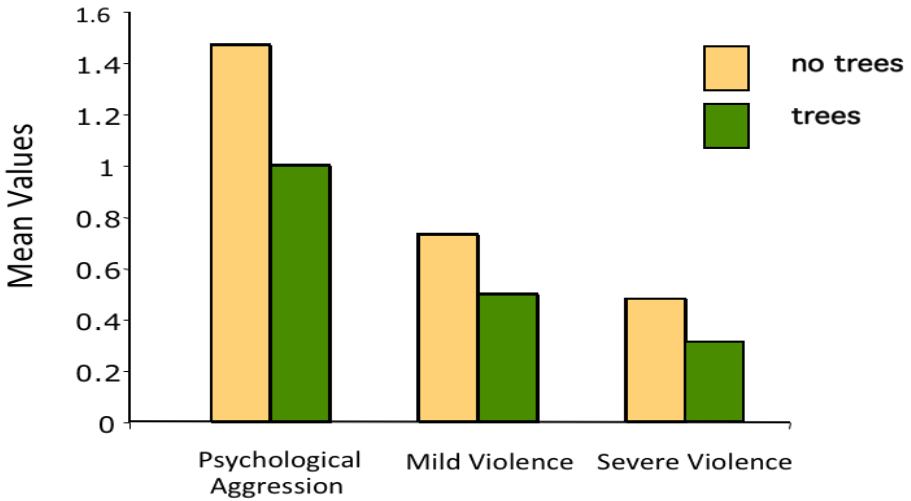
Food production

The introduction of vertical gardening techniques significantly increases available space for growing food in urban environments.

Behavioural improvements

Studies have shown a correlation between highly vegetated urban environments and a reduction of crime in the area, in particular reduced violent conduct (Kuo and Sullivan, 2001).

Aggressive Behaviour against a Partner
linked to increased mental fatigue in non-green living spaces



Kuo and Sullivan (2001)

Basic types of green wall

Climbing façades

The easiest way to introduce a green wall is to mimic Mother Nature and use simple climbing (or trailing) plants. Plants are established in the ground or in suitable troughs at the base of the wall to be covered. A framework is then attached to the wall for the plants to 'climb-up' to provide the wall with its green covering. In the wild this is often how such plants establish themselves by using other plants or naturally formed rocks as their 'climbing-frame'.

To aid the climbing process on buildings a number of systems exist including wire mesh frames, trellises and steel cables. The use of each frame is guided by the individual application, for example ivy plants grow easily and can attach themselves to walls and the side of building with minimal additional intervention. Often frames will be used to encourage the direction of growth or to support different species of plant growing on the wall.

Another easy way to introduce a living green cover on a wall is to plant on the top and allow growth to trail down. This is particularly effective in small enclosed areas (and even on internal walls).

Modular living walls

Though the systems used for this type of green wall are usually more sophisticated than for climbing façades, the final installation generally offers a more flexible solution in terms of aesthetics and functionality. The techniques are based around two main groups (though hybrid solutions do exist).

Hydroponic (soil-less)

This technique takes advantage of the fact that plants do not require soil to grow. Soil simply provides mechanic root support for the plant and it is only water (along with the minerals stored in the soil) that is required (in addition to light and carbon dioxide from the air).

Hydroponic systems are generally grown on pre-constructed panels prior to vertical installation using a specialist growing medium as root support. When ready the panels are transported to site and attached to a framework on the side of the wall/structure to be covered. Once installed plants will continue to grow and further cover the structure.

Substrate/soil-based

These systems typically use moulded troughs or containers that are built on or attached to existing walls (or similar structures). Planting is supported by soil-based substrates similar to those used in green roof installations; utilising a lightweight combination of recycled materials containing the right balance of nutrients with a free-draining medium.

The natural water retention properties of most substrates allow irrigation systems to be simple in design and construction, thus lowering installation and maintenance costs. However, an associated disadvantage of substrate-based systems is their weight relative to other solutions. Newer lightweight materials are increasingly becoming available to address this issue.

There are a number of different systems available supporting many applications and budgets. Most garden centres will supply soil-based systems for vertical allotments and domestic green wall installations. A range of more sophisticated solutions exist for larger commercial green wall applications, together with a variety of irrigation solutions to suit each situation.

What will your green wall provide?

The first thing to consider with a green wall is the main function of the installation. It is likely that more than one benefit will be gained from an installation but the main reason (or reasons) for selecting a green wall will drive all other selection factors.

Aesthetics or feature wall

A popular reason to install a green wall is to make a visual statement or impact on onlookers. Though all green walls have some aesthetic appeal, a feature wall will be designed with visual appearance paramount. Typically costs are not a driving factor and plants are selected for their appearance and diversity in colour, shape or even scent.

Biodiversity

Walls designed to bring biodiversity into the local environment will need to support a variety of plant species. Research from green roof installations suggests that the mix of plants is more important than their origin, i.e. native plants are not essential (Dunnett & Kingsbury, 2010). In some cases it may be important to select a type of plant that specifically attracts a particular bird or insect species to meet design objectives.

Urban farming

Access is a major factor for a green wall intended for growing produce. The need to tend and harvest plants may restrict the height or size of the wall. A vertical allotment needs to allow easy, cost-effective access for the growers on a regular basis.

Dust suppression and air quality improvement

If improvements in air quality are a desired benefit from a green wall, plant species should be selected for their ability to capture dust or toxins. Longevity and robustness of the plants are also likely to be important if the location of the wall is in a particular harsh environment, for example next to a busy road or a construction site. Often a cost-effective green wall is important in these situations, especially when aesthetic impact is not the main objective. With the correct selection of plants indoor walls can be particularly useful at cleaning air inside buildings (Wolverton, 1997).

Thermal insulation, building cladding and noise reduction

When selected as cladding, the physical construction of the green wall system needs to be adequate to provide the necessary building protection in addition to providing support for vegetation. In these situations there is a need to evaluate the impact of green wall loadings on the strength of the building. When thermal properties are being considered the thickness of substrate and type of plants used may also influence design choices.

Key factors in green wall design and installation

Plant selection

Plant selection will depend on a number of related factors. A key driver will be the location of the green wall with regard to temperature, light levels and exposure to the elements. The function of the wall will also determine the plants required. High impact feature walls typically require plants with abundant foliage and brightly coloured flowers. Walls designed to improve air quality should be planted with species that absorb dust and toxins.

Light levels (sun or shade) will influence the selection of plants able to cope with specific conditions. Indoor walls may require additional artificial light to support plant growth. Though not essential it can also be beneficial to select plants that require similar levels of irrigation to reduce the complexity of the irrigation system required.

Expectations for overall aesthetics, the speed of coverage and initial growth need to be considered. Some systems (especially façades) may require several years' growth before achieving the desired visual impact.

Irrigation

A reliable watering system is essential for a successful long-term installation. Walls have failed in the past due to inadequate irrigation solutions. The complexity required will vary from basic timer controlled dripper lines to computer controlled systems with automatic moisture monitoring, leakage detection and pressure regulation. Green façades generally use climbers that grow from the ground or in containers. Location will determine level of irrigation required and any additional nutrient supply. Plants will typically be hardy and robust species able to support their growth with minimal intervention so will generally only require a relatively simple irrigation system.

Modular living wall techniques require more reliable irrigation and generally demand a fairly sophisticated automated solution which will depend on temperature, exposure and plant-type. Vegetation used will also determine the level of nutrients required and how frequently these need to be applied.

In the UK many plants become dormant during the winter and it may be necessary to reduce or even shut-down irrigation systems in some situations. It is important to monitor and adjust irrigation levels regularly on all installations.

The amount of water required to support vertical growing systems has prompted much debate. The quantity required is often less than used to support more conventional ground-based growing. Green walls require between 0.5 - 1.5 litres per sq.m. per day. The table below shows a comparison between a 10 sq.m. green wall and other common water usages (South Staffs Water, 2010).

Activity	*Litres used*
Irrigation of green wall - 10 sq.m	5 - 15 per day
Allotment, flower bed or garden lawn - 10 sq.m	10 - 20 per day
Flushing the toilet	8 per flush
Power shower	80 per 5 mins
Washing machine	65 - 85 per load
Dishwasher	42 per cycle

Maintenance

The maintenance of a green wall is a key factor in its success and needs to be seriously considered at the start of any project. Often a controversial subject the long term maintenance of a wall can become the most expensive and labour intensive element. Green walls are living organisms and as such require adequate support and nurturing to survive. With many solutions this can be minimal but must suit the application, the technique used and the plants involved.

The level of maintenance will include need for plant pruning, feeding and replacement. Some systems will also need monitoring to ensure structural elements remain secure and do not deteriorate, e.g. correct tension in wire-rope systems. To maximise the longevity of a green wall it is important to highlight costs and requirements early. Clients must be made aware of their responsibilities to ensure long term project success.

Access

In addition to the obvious height challenges, there can often be a number of access issues when installing and subsequently maintaining green walls. Ease of access to the structure may even dictate the type of system chosen. In general it is far better to plan green wall installations during the original design of buildings, rather than rely on retrofitting afterwards.

Green façades generally only require access to the base of the wall, especially once growth has been established and initial coverage achieved, though it is likely some periodic pruning will still be required. Other systems require regular access to the complete structure for maintenance and monitoring. Often staging, platforms or even abseiling experts are required to provide safe and effective access for maintenance tasks.

Services

The provision of services such as power and water are essential to many green wall systems and it is important to ensure these can be supplied within the scope of the project's budget.

Policies, standards and incentives

Increasingly councils and planning authorities are looking at encouraging the inclusion of greenfrastructure in new developments and many Local Development Framework (LDF) policies are being modified to reflect these changes. Though no standards or certification processes are currently in place for green wall installations, there is a movement amongst industry experts to address this gap through the development of a trade association for green wall providers.

In the meantime the most common specifications adopted in the UK for sustainable buildings is the BREEAM environmental assessment method and rating system for buildings (www.breeam.org). Though no green wall specific measures or ratings are currently in effect, the ratings system can be applied to green walls in two main areas (BRE, 2011):

1. The materials used in construction of green wall system.
2. Improvements in biodiversity offered by the new/addition of plant species in the area.

Example Green Wall Installations in the UK

Transport for London (TfL) – Edgware Road Underground Station, London

Type: Modular living wall system Area: 200 sq.m Cost: £120,000

Description

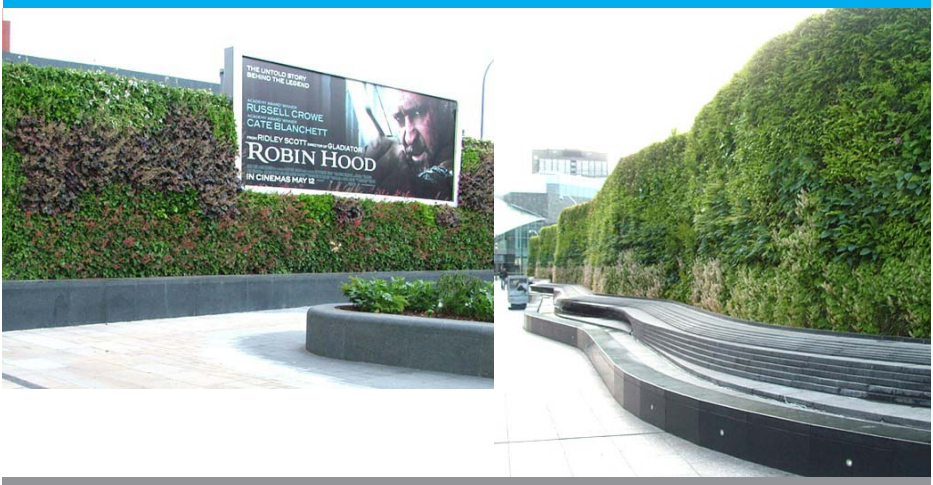
Transport for London commissioned this green wall to counter air pollution on the corner of Edgware and Marylebone Roads, funded by the government's Clean Air Fund. Fifteen species of plants have been chosen (with a mixture of evergreen and perennial) and their performance is being monitored by researchers from Imperial College. Species were chosen with smaller leaf shapes and 'hairy' textures because these are known to be good air filters.

The plants are grown vertically in a modular hydroponic system that is designed for low water use and low maintenance. These are planted in a peat-free substrate supported by a structure incorporating an Ecosheet waterproof backing that is made in the UK from recycled materials. Initially plants in the wall include Munsted lavender, geraniums, lamb's ears, heuchera and veronica.

Irrigation and maintenance

Plants are drip-fed twice a day by a remote controlled irrigation system. The system logs all water timings and provides the ability to view and alter settings remotely. Site visits are carried out two to three times per year to maintain plants and pumps. SMS text alerts provide instant warnings of any major problems.

Westfield Shopping Centre – Shepherd's Bush, London



Type: Modular living wall system Area: 1,275 sq.m. Cost: Unknown

Description

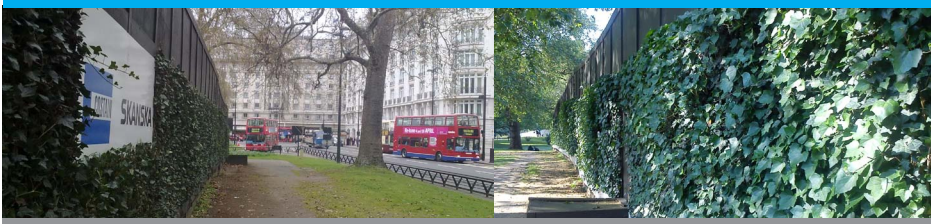
Aimed at mitigating the shopping centre's auditory and visual impact on local residents, the living wall provides aesthetic and ecological benefits to the retail complex. In addition the wall contributes to air filtration, noise reduction and cooling in hot weather.

A modular-cellular system using 0.5m x 0.5m pre-planted panels is used to facilitate speed of construction and provide practicality for maintenance. Plant species vary depending on the exposure of each wall. North facing walls use predominantly native woodland plants, primarily ferns with seasonal interest added with species such as bergenias, snowdrops and anemones. On southern faces, sun-loving species such as red fescue, sedum, honeysuckle and vinca are used.

Irrigation and maintenance

Irrigation provided by emitter line with water collection chambers controlled by electronic control system. Maintenance visits provided monthly to monitor and adjust the irrigation according to season, calibrate plant feeder, provide any insect control and remove any weed growth. Pruning is carried out consistent with time of year.

Crossrail, Transport for London (TfL) – Park Lane, London



Type: Climbing façade system Area: 300 sq.m. Cost: £30,000

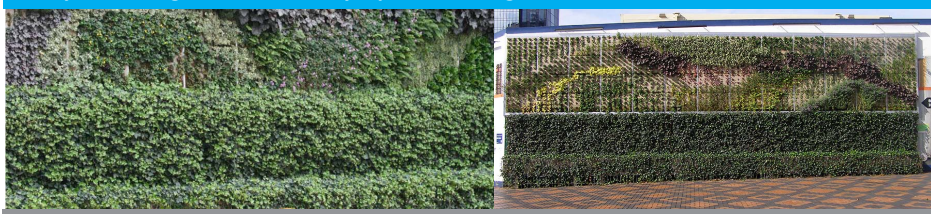
Description

To minimise the impact of construction, Crossrail commissioned this project to enhance the appearance and reduce noise and dust pollution around their site in Park Lane. Ivy screens were used as a quick and effective solution for covering the site hoarding. Future growth of the ivy will continue up over the wooden hoarding providing a full 3m high 'hedge' around the Crossrail site.

Irrigation and maintenance

Drip irrigation line with basic battery operated timer. Site visit every two months to monitor and adjust the irrigation, provide any insect control and prune the screens.

Library of Birmingham – Centenary Square, Birmingham



Type: Climbing façade & modular living wall systems Area: 100 sq.m. Cost: unknown

Description

While the construction work continues on the new Library of Birmingham, a living wall has been installed in Centenary Square to conceal the site and add environmental sustainability to the construction process. The lower part of the 5m hoarding is covered using ivy screens which are robust enough to prevent vandalism. The top of the hoarding uses a modular system which allows a variety of plants to enhance the visual impact.

Irrigation and maintenance

Drip irrigation line with computer-controller. Site visit every two months to monitor and adjust the irrigation, provide any insect control and prune the plants.

Summary

It may be some time before all new urban construction projects incorporate green walls commonly in their design, but with so many bare and available walls in our cities the potential to benefit from vertical greening solutions is significant.

The combination of skills required to design, install and maintain systems is challenging and requires input from a number of industry disciplines, e.g. architecture, horticulture and construction. It is important to ensure that any new installation addresses all the factors and, in particular, sets expectations correctly with regard to initial cost and impact on the environment, as well as potential future effort and costs required to maintain the system.

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