

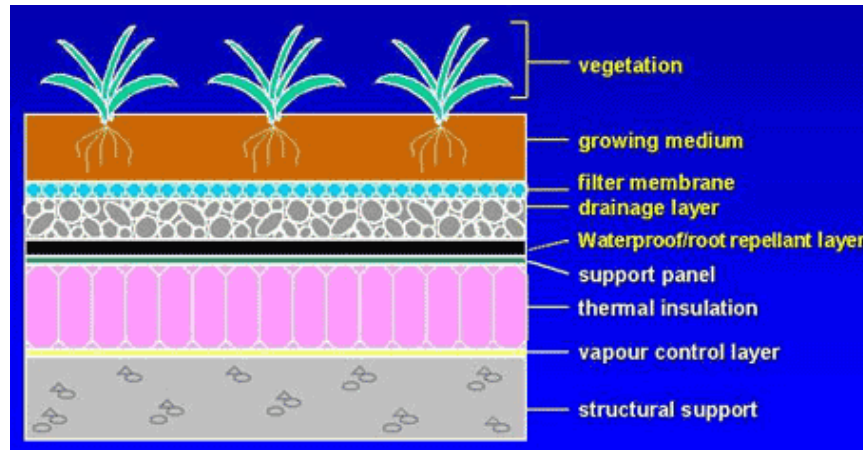
## About Green Roofs

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A green roof system is an extension of the existing roof which involves a high quality water proofing and root repellent system, a drainage system, filter cloth, a lightweight growing medium and plants.

Green roof systems may be modular, with drainage layers, filter cloth, growing media and plants already prepared in movable, interlocking grids, or, each component of the system may be installed separately. Green roof development involves the creation of "contained" green space on top of a human-made structure. This green space could be below, at or above grade, but in all cases the plants are not planted in the "ground". Green roofs can provide a wide range of public and private benefits.

**Principal Green Roof Technology Components**  
Source: National Research Council, Institute for Research in Construction



In North America, the benefits of green roof technologies are poorly understood and the market remains immature, despite the efforts of several industry leaders. In Europe however, these technologies have become very well established. This has been the direct result of government legislative and financial support, at both the state and municipal level. Such support recognizes the many tangible and intangible public benefits of green roofs. This support has led to the creation of a vibrant, multi-million dollar market for green roof products and services in Germany, France, Austria and Switzerland among others. In Germany for instance, the industry made 700 million DM in sales in 1997, up from 500 million DM in sales in 1994. The industry continues to experience growth with 13.5 million square metres of green roofs constructed in 2001, up from 9 million square metres built in 1994.

Green roof technologies not only provide the owners of buildings with a proven return on investment, but also represent opportunities for significant social, economic and environmental benefits, particularly in cities. Find out more about the private and public benefits of green roof technologies below.

## Frequently Asked Questions about Green Roofs

### Why a green roof?

There are generic private benefits for virtually all projects, benefits, specific to the design and type of green roof, and benefits/incentives relate to public policy, which have proven to be critical to developing the market in Europe:

### Private Benefits

*Please Note: while there are similarities among green roofs, each installation is unique. Hence, all technical performance details provided will vary by region, climate, building and green roof type and design. These figures are provided as generic examples only and should not be used for designing projects without expert advice and opinion.*

The following benefits can be achieved with virtually all green roof infrastructure systems.

#### Economic Benefits - cost savings opportunities for the building owner include:

Protection of roof membrane resulting in a longer material lifespan (it is estimated that green roofs will last up to twice as long as conventional roofs), resulting in decreased maintenance and savings in replacement costs;  
Savings on energy heating and cooling costs, depending on the size of the building, climate and type of green roof. Using a Micro Axxess Simulation model, Environment Canada found that a typical one storey building with a grass roof and 10 cm (3.9 inches) of growing medium would result in a 25% reduction in summer cooling needs. Field experiments by Karen Liu

in Ottawa Canada, found that a 6 inch extensive green roof reduced heat gains by 95% and heat losses by 26% compared to a reference roof.

#### **Sound Insulation**

Soil, plants and the trapped layer of air can be used to insulate for sound. Sound waves that are produced by machinery, traffic or airplanes can be absorbed, reflected or deflected. The substrate tends to block lower sound frequencies and the plants block higher frequencies.

A green roof with a 12 cm (4.7 inches) substrate layer can reduce sound by 40 decibels; a 20 cm (7.9 inches) substrate layer can reduce sound by 46-50 decibels.

**The following benefits may be achieved, depending on the type and design of the green roof system (i.e., accessible/inaccessible, intensive/extensive, integrated with other building systems or not).**

#### **Economic Benefits**

Potential to reduce the size of HVAC equipment on new or retrofitted buildings (capital and operational savings).

Potential to reduce the amount of standard insulation used.

Potential to incorporate cooling and/or water treatment functions.

Potential for local, regional, and national market exposure, depending on the uniqueness of the project.

Potential to reduce or eliminate roof drains.

Potential to meet regulatory requirements for stormwater management.

Potential to reduce community resistance to new developments.

#### **Amenity Space and Aesthetics**

Provision of amenity space for day care, meetings, and recreation;

Aesthetic appeal, increasing the value of the property and the marketability of the building as a whole, particularly for accessible green roofs. For example, American and British studies show that "good tree cover" adds between 6 to 15 per cent to the value of a home. Green roofs offer the same visual and environmental benefits.

Satisfying the aesthetic needs of people looking down upon the roof from adjacent buildings.

Potential to improve employee productivity.

#### **Food Production**

The Fairmount Waterfront Hotel in Vancouver used to grow herbs, flowers, and vegetables on its accessible roof, saving its kitchen an estimated \$30,000 a year in food costs.



**Herb Garden on Vancouver's Fairmount Waterfront Hotel (courtesy David Walker)**

**The following benefits may be achieved, depending on the type of public policy support for green roof installations in your area.**

Potential for faster approval process for new projects, as is the case in Chicago

Potential for reduced stormwater/wastewater charges from your municipality or utility.

- Potential to reduce the size of stormwater management ponds or cisterns, resulting in cost savings.
- Potential for grants related to energy efficiency and/or green roofs.
- Potential for density bonusing / larger floor area ratio.
- Potential to satisfy regulatory requirements for green roofs.
- Potential to score more than 7 credits under the US and Canadian Green Building Council LEED certification system.
- Potential for satisfying minimum parkland / green space set aside, requirements.
- Potential for greenhouse gas emissions trading credits, stemming from energy savings.

## Public Benefits

*Please note: All technical details provided will vary by region, building type and materials used. These figures are provided as generic examples only and **should not** be used for projects without **expert advice and opinion**.*

### Economic - Improved Air Quality - Temperature Regulation - Water - Social - Preservation of Habitat & Biodiversity - Local Food Production

#### Economic Benefits

##### Public policies that support green roof installations will create jobs for the following:

- Suppliers and manufacturers of roofing membranes and root repellent layers;
- Suppliers and manufacturers of drainage layers, landscaping cloth, curbs, irrigation systems and other specialty products;
- Suppliers and manufacturers of substrate, light-weight soils and amendments;
- Garden nurseries specializing in plants specifically for green roofs;
- Design and engineering professionals;
- Contractors and landscapers; and,
- Companies supplying maintenance contracts.

Although no exact figures exist, it is estimated that the roofing industry in Germany employs approximately 12,000 people, and if all flat roofs were to be greened, this figure would increase to approximately 100, 000.

##### Community cost savings opportunities include:

- Cost savings from increased stormwater retention and decreased need to expand or rebuild related infrastructure.
- Decreased cost of meeting greenhouse gas reductions and adapting to climate change by reducing the "Urban Heat Island Effect" and the need for interior building insulation.
- Decreased need for health care services from reductions in ground level ozone resulting from a reduction in the urban heat island.
- Increased worker productivity and creativity.
- Decreased need for health care services and medication due to the benefits of passive experiences with nature and vegetation.
- Extending the lifespan of landfill sites by reducing re-roofing material waste.
- Opportunities to recycle aggregate and compost.

#### Improved Air Quality

##### Filtration of Airborne Particulates:

- A green roof will not only absorb heat, decreasing the tendency towards thermal air movement, but will also filter the air moving across it.
- 1 m<sup>2</sup> (10.76 ft<sup>2</sup>) of grass roof can remove between 0.2 kg of airborne particulates from the air every year.

##### Carbon Dioxide/Oxygen Exchange:

- Through the process of photosynthesis, plants convert carbon dioxide, water and sunlight/energy into oxygen and glucose.
- This cyclical process supplies animals and humans with oxygen and food.
- 1.5 m<sup>2</sup> (16.15 ft<sup>2</sup>) of uncut grass, produces enough oxygen per year to supply 1 human with their yearly oxygen intake requirement.

#### Temperature Regulation

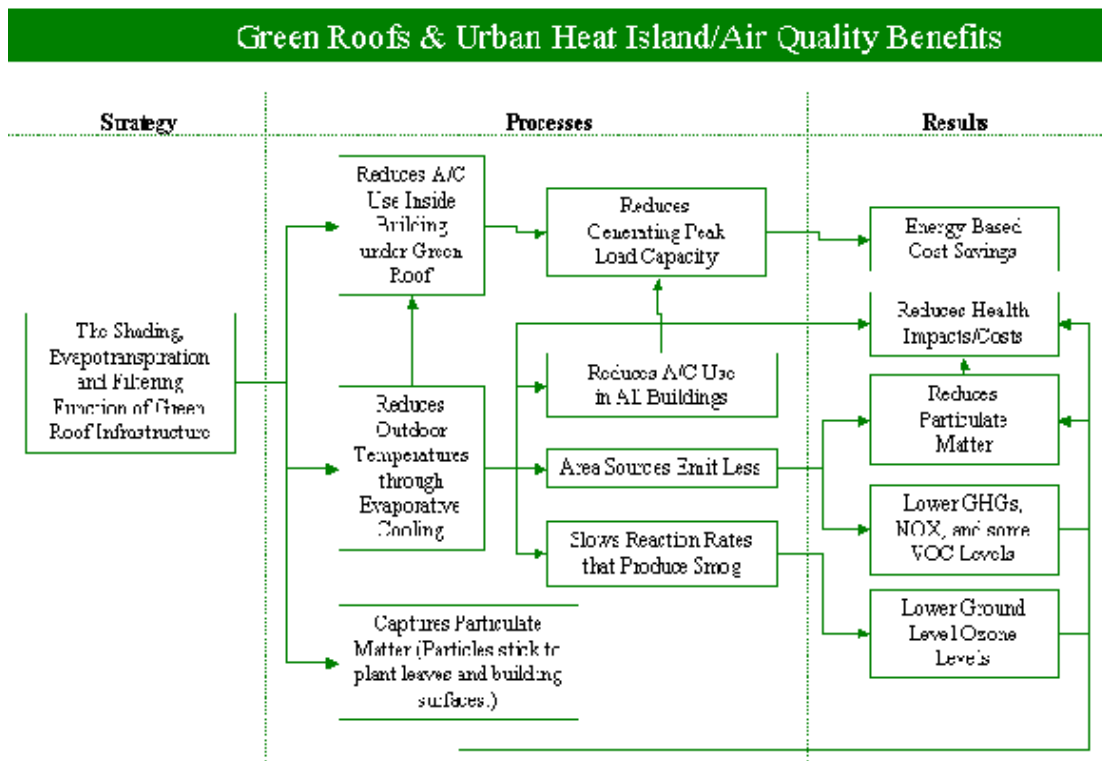
##### Moderation of the Urban Heat Island Effect:

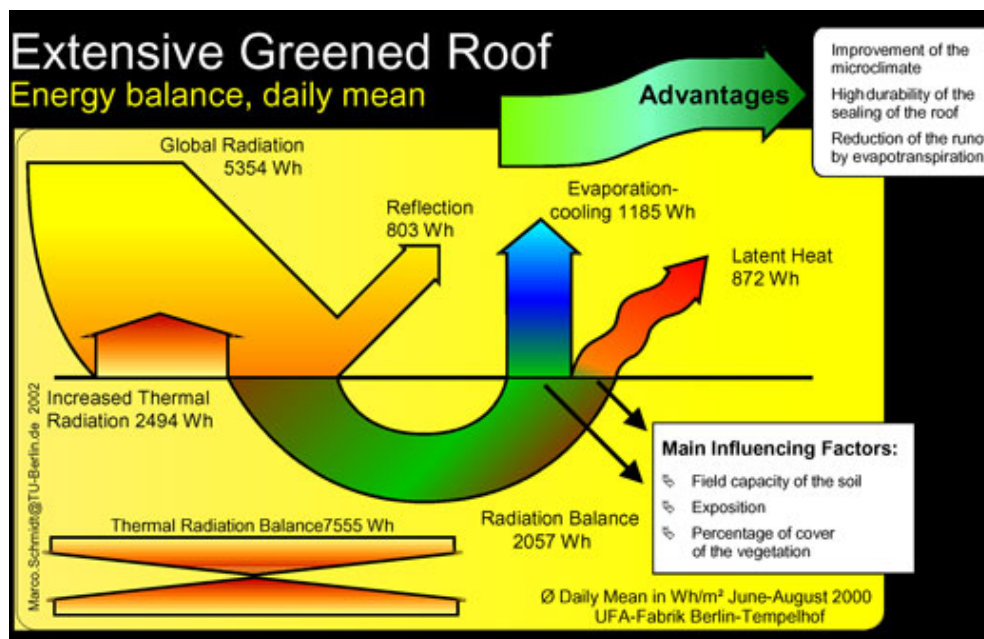
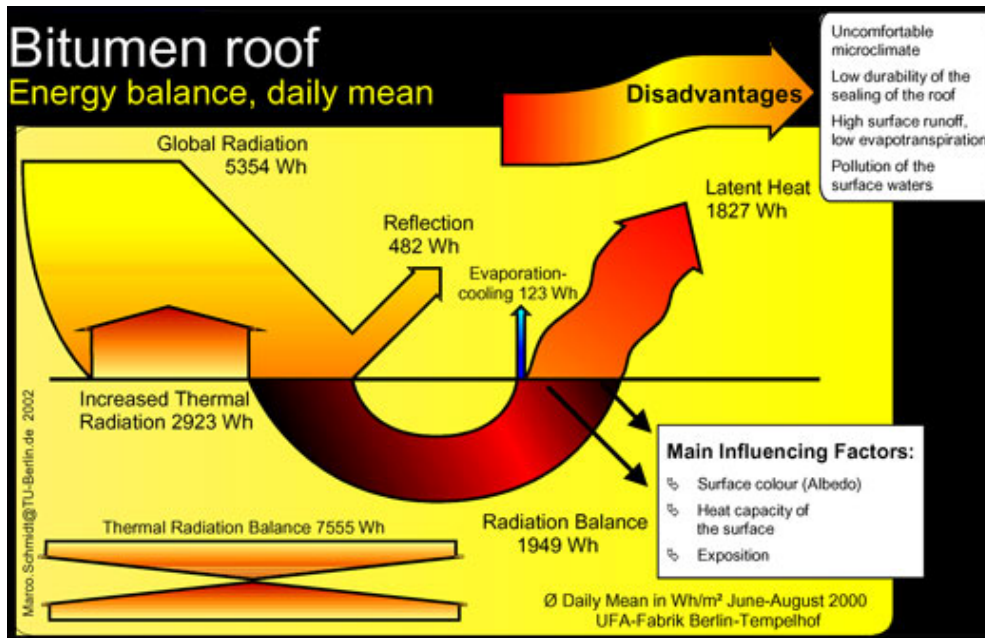
- Through the daily dew and evaporation cycle, plants on vertical and horizontal surfaces are able to cool cities during hot summer months. In the process of evapotranspiration, plants use heat energy from their surroundings (approximately 592 kcal per L of water) when evaporating water. One m<sup>2</sup> (10.76 ft<sup>2</sup>) of foliage can evaporate over 0.5 litres of water on a hot day and on an annual basis the same area can evaporate up to 700 litres of water.
- This process reduces the 'Urban Heat Island Effect' in the summer. The 'Urban Heat Island Effect' is the difference in

temperature between a city and the surrounding countryside. It is mainly due to the expanse of hard and reflective surfaces, such as roofs, which absorb solar radiation and re-radiate it as heat. Reduction of the 'Urban Heat Island Effect' will also reduce the distribution of dust and particulate matter throughout the city and the production of smog. This can play a role in reducing greenhouse gas emissions and adapting urban areas to a future climate with warmer summers.

Green roofs can play a role in reducing the urban heat island (UHI), augmenting the existing vegetation, but the precise amount of coverage is still uncertain. Dr. Brad Bass in collaboration with a modelling group at the University of British Columbia under the direction of Dr. Roland Stull, ran a mesoscale atmospheric simulation for the City of Toronto with green roofs. The city's vegetation reduced the UHI by up to 1 degree C over approximately 1/4 of the City. Using a green roof coverage of 50%, this cooling was extended to approximately 1/3 of the City and increased the maximum cooling to 2 degrees C. Although the green roof coverage was high, Dr. Bass estimated that only 6% of the roofs were fully irrigated as the model decreased irrigation to those parts of the city that were not fully urbanized, decreasing it to zero in totally natural areas of the city. This suggests that the actual green roof coverage to obtain these results could be much smaller than 50% although the exact requirement is difficult to determine due to a number of uncertainties that emerged in this modelling exercise.

The arrows in this diagram illustrate the nature of how green roofs reduce the urban heat island and improve air quality. For more information, see the Spring 2001 issue of the **Green Roof Infrastructure Monitor**.





Building

The above images demonstrate the effect of a green roof on local heating - note the difference in energy radiated via evaporation-cooling vs. latent heat between the two scenarios. (Used by permission of author: Marco Schmidt)

#### Insulation:

Historically, green roofs have been used to insulate buildings. Shading the external surface of the building envelope has been shown to be more effective than internal insulation.

Green roofs insulate buildings by preventing heat from moving through the roof. Their insulation properties can be maximized by using a growing medium with a low soil density and a high moisture content and by choosing plants with a high leaf area index (i.e. the bigger the leaves, the better). This could play a role in reducing greenhouse gas emissions and adapting urban areas to a future climate with greater incidences of drought and extreme heat.

#### Industrial Cooling:

The Possman Cider Cooling and Storage Facility in Frankfurt, Germany yielded a 2-3 year payoff of their green roof system through savings in heating and cooling costs, as well as in equipment costs, since additional cooling towers had become unnecessary.

#### Creation of Microclimates:

A green roof will have a noticeable impact on the heat gain and loss of a building, as well as the humidity, air quality and reflected heat in the surrounding neighbourhood. In conjunction with other green installations, green roofs can play a role in altering the climate of the city as a whole.

On a summer day, the temperature of a gravel roof can increase by as much as 25 °C (77 °F), to between 60-80 °C (140 - 176 F). Covered with grass, the temperature of that roof would not rise above 25 °C (77 °F), thus resulting in energy cost savings.

20 cm (7.9 inches) of substrate with a 20-40 cm (7.9 - 15.7 inches) layer of thick grass has the combined insulation value of 15 cm (5.9 inches) of mineral wool.

Rooms under a green roof are at least 3 - 4 °C (5.4 - 7.2°F) cooler than the air outside, when outdoor temperatures range between 25-30 °C (77 - 86 °F).

## Water

### Stormwater Retention:

Water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation.

In summer, depending on the plants and depth of growing medium, green roofs retain 70-90% of the precipitation that falls on them; in winter they retain between 25-40%. For example, a grass roof with a 4-20 cm (1.6 - 7.9 inches) layer of growing medium can hold 10-15 cm (3.9 - 5.9 inches) of water.

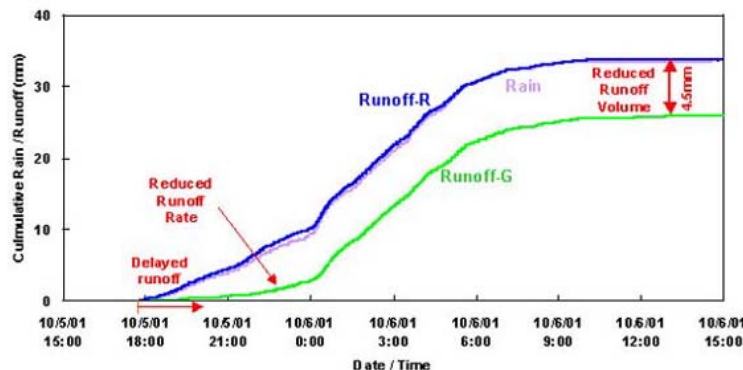
### Water Filtration:

Green roofs not only retain the rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off.

### Temporal Delay of Stormwater Runoff and Reduced Runoff Volume:

Green roofs reduce the amount of stormwater runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

Source: National Research Council's Institute for Research in Construction



The graph above records the cumulative rainfall and runoff from the Green Roof and the Reference Roof during a 34mm (1.3 inches) rain event over a 15h period in October 2001. The green roof delayed runoff and reduced the runoff rate and volume. For more details on this research conducted by the National Research Council's Institute for Research in Construction, see the article on page 7 of the Fall 2002 issue of the **Green Roof Infrastructure Monitor**.

## Social Benefits

### Aesthetics:

Urban greening has long been promoted as an easy and effective strategy for beautifying the built environment and increasing investment opportunity.

### Health & Horticultural Therapy:

Psychological studies have shown that the restorative effect of a natural view holds the viewers' attention, diverts their awareness away from themselves and from worrisome thoughts thereby improving health.

People living in high-density developments are known to be less susceptible to illness if they have a balcony or terrace garden. This is partly due to the additional oxygen, air filtration and humidity control supplied by plants but also from the therapeutic benefits that result from caring for plants. The variety of sounds, smells, colours and movement provided by plants, although not quantifiable, can add significantly to human health and well being.

Patients in the same hospital, recovering from the same operation, were studied as to the restorative effects of views onto a landscaped courtyard versus a brick wall. The patients with the green view had shorter post-operative stays, took

fewer moderate and stronger painkillers and had fewer negative evaluation comments from the nurses.



A green roof by **Garland** on a nursing home

#### **Improved Safety:**

A garden on the roof is often considered safer than a garden at grade. For example, because access to the roof is often restricted to building tenants or employees, there is less likelihood of assault or vandalism.

#### **Recreation:**

Green roofs can help to address the lack of green space in many urban areas. Studies show that leisure activities in natural settings such as gardens and parks, are important for helping people cope with stress and in meeting other non-stress-related needs.



Corporate Golf Course Green Roof

#### **Community Building:**

The creation of shared gardens, like the rooftop garden on top of the Mary Lambert-Swale housing project in Toronto, allows residents to feel ownership of their building and meet neighbours in a relaxed setting.

#### **Preservation of Habitat & Biodiversity**

##### **Habitat:**

Rooftop habitats can play one of two roles: a 'stepping stone' habitat connecting natural isolated habitat pockets with each other, or an 'island' habitat remaining isolated from other habitats at grade.

Green roofs can be specifically designed to mimic endangered ecosystems/habitats, including the prairie grasslands of the midwest US, the rocky alvars of Manitoulin Island and the Great Lakes Region in Canada.

The Toronto City Hall Demonstration Project features a black oak prairie ecosystem and native plant butterfly plot.

**Flora & Fauna:**

Green roofs designed for minimal maintenance are very protected and can become home to plants easily damaged by walking and to birds that nest on the ground. Since the soil on these green roofs is also less likely to be disturbed, it becomes a safer habitat for insects, and the deeper the soil the more diversity the roof can support.

In Germany, for instance, research has shown that green roofs can support anywhere from 10 to 40 different insect species and have even been found to harbour nesting bird species.

The Toronto City Hall Demonstration Project features two urban agriculture plots that are growing a variety of annuals and perennials.

**Local Food Production**

Green roofs can provide new opportunities for urban agriculture. There are many benefits to growing and distributing food locally including:

- Support of the local economy in growing, processing and distributing;
- Increased access to food by everyone;
- Fresher produce;
- Decreased travel time to market and related environmental costs; and
- Control of soil, fertilizer and pesticides.

**What do I need to know about my building before I initiate a green roof installation?**

You will need to know the slope, the structural loading capacity, and existing materials of the roof, as well as the nature of any drainage systems, waterproofing, and electrical and water supply in place. You should also consider who would have access to it, who will do maintenance, and what kind of sun and wind exposure the roof gets.

For a deeper insight into green roofs and green roofs design, look for one of our ***Green Roof Design 101 - Introductory Courses*** in a city near you.

**What kinds of landscape design should I use and what plants can I grow on my roof?**

Plant selection depends on a variety of factors, including climate, type and depth of growing medium, loading capacity, height and slope of the roof, maintenance expectations, and the presence or absence of an irrigation system. A landscape architect would be able to advise you on suitable plants and design of the plantings. See the landscape contacts below.

**How much does a green roof cost?**

The cost of a green roof varies considerably depending on the type and factors such as the depth of growing medium, selected plants, size of installation, use of irrigation, and whether they are to be accessible or inaccessible - intensive, semi-extensive or extensive. Intensive green roofs typically require greater investment but confer the benefits of accessibility. An installed extensive green roof with root repellent/waterproof membranes may be installed for \$10-\$24 US per square foot. While green roofs typically require a greater initial investment, it is important to keep in mind that they can extend the life of the roof membrane and reduce the heating and cooling costs of your building. Speak to a qualified green roof professional about the range of costs and benefits for different green roof systems and designs. Search green roof professionals in our online member database.

**How can I purchase a green roof system for my home or building?**

You should contact green roof manufacturers directly and speak to a sales representative. Corporate Member websites can be found in our **Members** section.



Green Roof System  
Hamilton Building in Portland, OR



Green Roof System  
Mountain Equipment Co-op  
in Toronto, ON



Modular Green Roof System  
Low lying shrubs

### Who can design and install a green roof?

Landscape architects and contractors frequently design green roofs and can install the living components (i.e., growing medium and plants).

Because green roof systems include materials not found on conventional roofs, we recommend that you choose a qualified roofing contractor with experience in green roof installation to install the non-living components (e.g., vapour barrier, waterproof membrane). Contractors can be found in our **Corporate Members** section.

You can also contact a roofing consultant, who will assess your roofing design needs, ensure quality control and recommend a suitable green roof system.

### How many LEED<sup>™</sup> credits can I receive?

Green roofs can facilitate a significant improvement in the LEED<sup>™</sup> rating of a building, contributing as many as 15 credits under the system, depending on design and level of integration with other building systems. In some instances, while green roofs may not contribute directly to achieving points under the system, they contribute to earning LEED<sup>™</sup> credits when used with other sustainable building elements. For example, green roofs can earn direct credits under the following:

- Reduced Site Disturbance, Protect or Restore Open Space
- Landscape Design That Reduces Urban Heat Islands, Roof Storm Water Management
- Water Efficient Landscaping
- Innovative Wastewater Technologies
- Innovation in Design

*(the above is an excerpt from [Green Roofs and Maximizing Credits under the LEED<sup>™</sup> Green Building System](#), by Richard Kula in [The Green Roof Infrastructure Monitor](#), Spring 2005)*

### Where can I learn more about green roofs?

For general information on green roofs, please check out the rest of our website and [The Green Roof Infrastructure Monitor](#). More information can also be found on some of [Our Members](#) websites.

For a deeper insight into green roofs and green roofs design, look for one of our [Green Roof Design 101 - Introductory Courses](#) in a city near you.

### What sort of research is being done on green roofs?

A considerable amount of research on the public and private benefits of green roof infrastructure in different climate zones, different built environments, and at different scales needs to be conducted in order to forge a new industry through the development of supportive public policy.

One of [Green Roofs for Healthy Cities](#) important goals is to encourage that research through activities like the [GRHC Research Committee](#).

### What sort of Policy and Funding support is available for green roofs?

Green Roofs for Healthy Cities is working with local partners in a number of cities to develop cost effective direct and indirect financial support for green roof implementation that meets local/regional needs.

One of the ways that we try to encourage the development of local markets for Green Building is by running [Green Roof Symposia](#) in various cities. For more information on this initiative, please contact [Jennifer Sprout](#).

Contact your local or county government for possible incentives.

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