

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.



RYERSON UNIVERSITY, TORONTO,
ONTARIO

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.
- 1.5 m² (10.76 ft²) of uncut grass, produces enough oxygen per year to supply 1 human with their yearly oxygen intake requirement.

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 m² (10.76 ft²) of grass roof can remove between 0.2 kg of airborne particulates from the air every year.

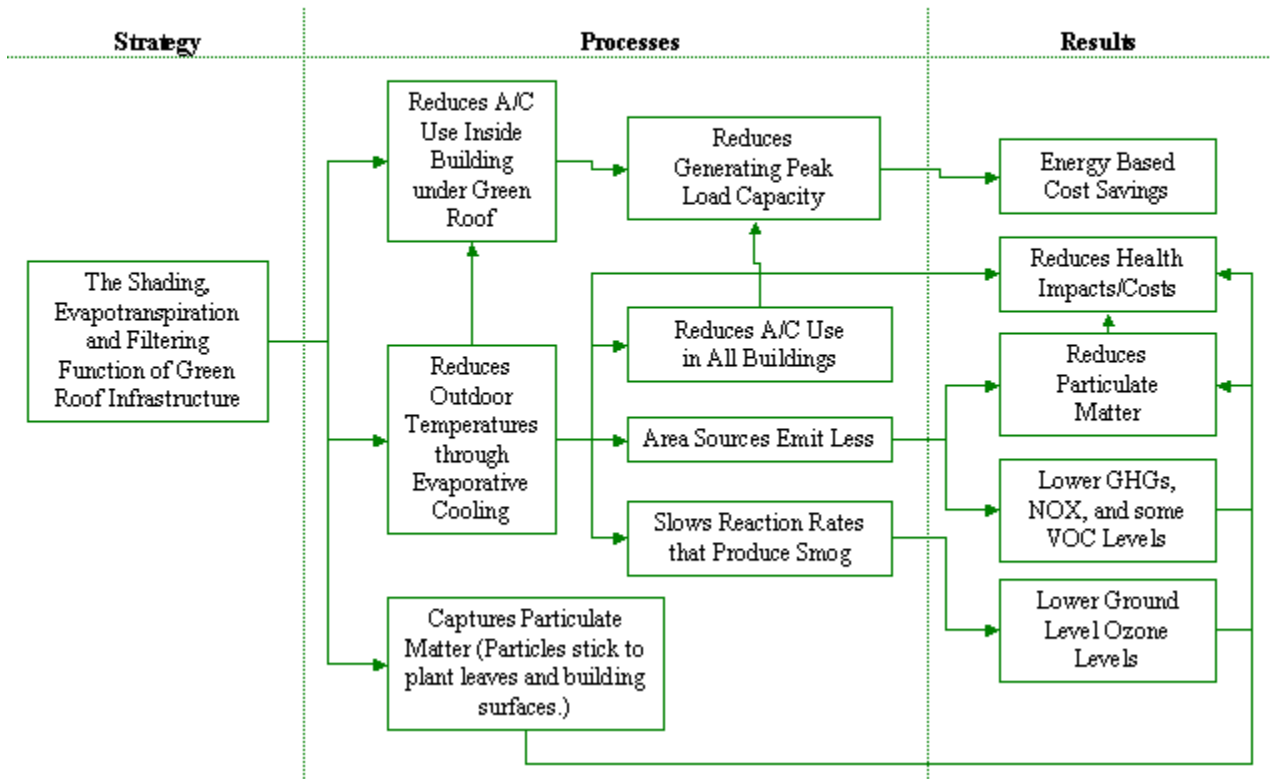
Temperature Regulation

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 m² (10.76 ft²) 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 & Urban Heat Island/Air Quality Benefits



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 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 (37.4 - 39.2 °F) cooler than the air outside, when outdoor temperatures range between 25-30 °C (77 - 86 °F).



Office green roof, Vienna, Austria

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 growing medium, green roofs retain 70-80% of the precipitation that falls on them; in winter they retain between 25-40%. For

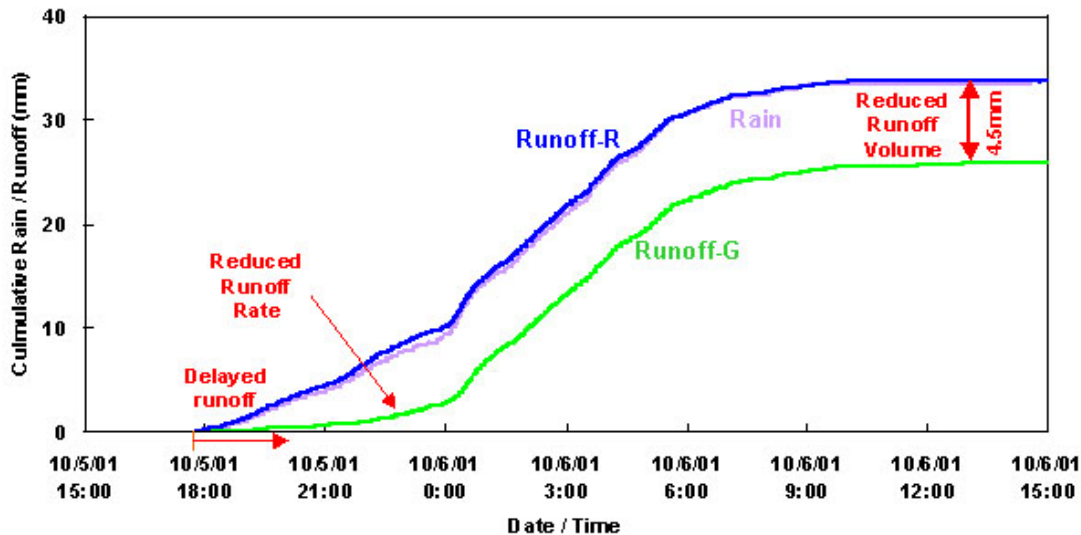
example, a grass roof with a 4-20 cm (1.6 - 7.9 inches) layer of growing medium can hold 10-15 cm (3.9 - 5.9 inches) of water.

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 Winter 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.