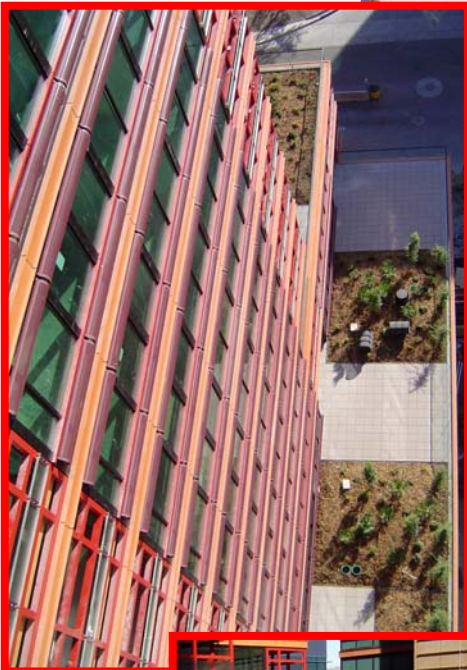


GREEN ROOFS WHITE PAPER
Prepared for the Phoenix Planning Commission
January 3, 2006



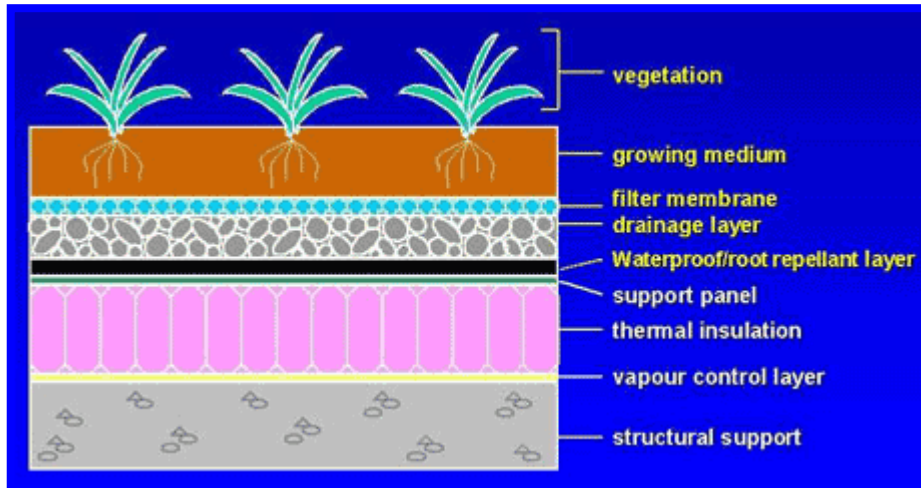
GREEN ROOF WHITE PAPER

INTRODUCTION:

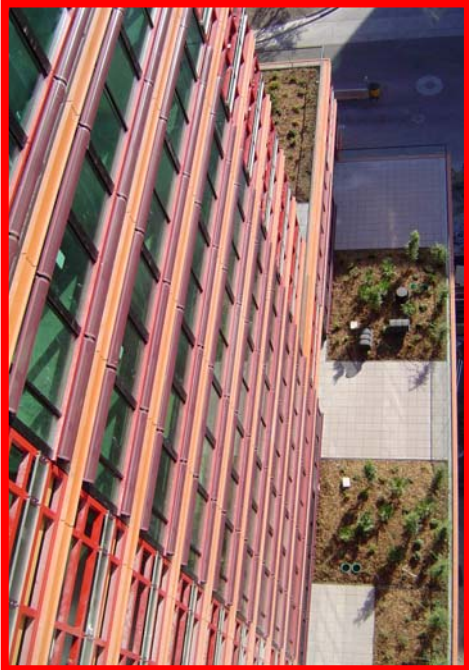
Green roof development is the creation of "contained" green space on top of a human-made structure. This green space could be below, at or above grade, but in all cases the plants are not planted in the "ground". A green roof system requires a high quality waterproofing and root repellent system, a drainage system, filter cloth, a lightweight growing medium, and plants.

Principal Green Roof Technology Components

Source: National Research Council, Institute for Research in Construction



Green roof technology is just beginning in the United States. In Europe however, these technologies are well established. This is due to government legislative and financial support. Such support recognizes both the tangible and intangible public benefits of green roofs and has led to the creation of a vibrant, multi-million dollar market for green roof products and services in Germany, France, Austria, and Switzerland. Green roofs can provide a wide range of public and private benefits.



**OPTIMA BILTMORE
TOWERS (24th St & Camelback)**

WHY DO IT?



Vancouver City Library, Vancouver, Canada Completion 2002

8,000 square feet

Private Benefits

1. 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.

A green roof with a 4.7 inch substrate layer can reduce sound by 40 decibels; a 7.9 inches substrate layer can reduce sound by 46-50 decibels.

2. Economic Benefits

Protection of roof membrane makes for a longer material lifespan (lasts twice long as conventional roofs)

Savings on energy heating and cooling costs, depending on the size of the building, climate, and type of green roof.

Potential to reduce the size of heating and air conditioning equipment.

Potential to reduce the amount of standard insulation used.

Potential to incorporate cooling and/or water treatment functions.

Potential to reduce or eliminate roof drains.

Potential to meet regulatory requirements for stormwater management.

3. Amenity Space and Aesthetics

Amenity space for day care, meetings, and recreation;

Aesthetic appeal, increasing the value of the property/marketability of building.

Satisfies the aesthetic needs of people looking down on the roof from adjacent buildings.

4. Food Production

Grow herbs, flowers, and vegetables on roof, saving food costs.

5. Benefits from public policy support for green roof installations in your area.

Potential for expedited approval process for new projects.

Potential for reduced stormwater/wastewater charges.

Potential to reduce the size of stormwater management facilities.

Potential for grants related to energy efficiency and/or green roofs.

Potential for density bonusing / larger floor area ratio.

Building Potential to score more than seven credits under the US and Canadian Green Council LEED certification system.

Potential for satisfying minimum parkland / green space set aside, requirements.

Public Benefits

1. Economic Benefits: Public policies that support green roof installations will create jobs for the following:

Suppliers, manufacturers of roofing materials, irrigation systems, and other specialty products;

Garden nurseries specializing in plants specifically for green roofs;

Increase jobs for design and engineering professionals; contractors and landscapers;

Increase the number of companies supplying maintenance contracts.

2. 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.

Extending the lifespan of landfill sites by reducing re-roofing material waste.

Opportunities to recycle aggregate and compost.

3. 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.

Approximately 10.76 ft of grass roof can remove between 0.2 kg of airborne particulates from the air every year.

Principal Green Roof Technology Components

Source: National Research Council, Institute for Research in Construction



4. 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.

Approximately 16.15 cu. Ft. of uncut grass produces enough oxygen per year to supply 1 human with their yearly oxygen intake requirement.

5. 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 Liter of water) when evaporating water. One m² (10.76 ft²) of foliage can evaporate over 0.5 liters of water on a hot day and on an annual basis the same area can evaporate up to 700 liters 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.

6. 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.

7. 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 neighborhood. 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 77 °F, to between 140 - 176 F. Covered with grass, the temperature of that roof would not rise above 77 °F, thus resulting in energy cost savings.

Approximately 7.9 inches of substrate with a 7.9 - 15.7 inches layer of thick grass has the combined insulation value of 5.9 inches of mineral wool.

Rooms under a green roof are at least 5.4 - 7.2°F cooler than the air outside, when outdoor temperatures range between 77 - 86 °F.

8. Water

Stormwater Retention:

Water is stored by the soil and then taken up by the plants and returned to the atmosphere through transpiration and evaporation.

between 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 25-40%. For example, a grass roof with a 1.6 - 7.9 inch layer of growing medium can hold 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 delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

Social Benefits

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

2. **Health & Horticultural Therapy:**

Psychological studies have shown that the restorative effect of a natural view holds people's attention and diverts their awareness away from themselves and 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, colors 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.

3. Improved Safety:

A garden on the roof is often considered safer than a garden at grade because access is often restricted to building tenants or employees.

4. Recreation:

Green roofs can help to address the lack of green space in 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.



Modular Green Roof System Low lying shrubs

5. 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 neighbors in a relaxed setting.



6. 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 rare Sonoran Desert plants.

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.

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.

7. 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 \$9-\$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.

REGULATION RATIONALE:

A good way to regulate is to either require a LEEDS certification or provide incentives to the developer to get LEEDS certified. LEEDS certification requires building code standards for green roofs. In fact, green roofs can facilitate a significant improvement in the LEED™ rating of a building, contributing as many as 15 credits under the system, depending on the design and level of integration with other building systems. In some instances, green roofs may not contribute directly to achieving points under the system, but they do contribute to earning LEED™ credits when used with other sustainable building elements. 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

CONCERNS:

Measurable Success

It is very difficult to determine the measurable success of a green roof because it requires a commitment to documentation of energy costs, stormwater retention savings, and other benefit gains that are difficult to quantify. The larger the building, the quicker the capture of savings from the benefits cited above.

Plant Selection for extreme arid climate:

Phoenix, Arizona has an extremely harsh climate. The best green roofs have broad leaf trees and lush green shrubs and grasses. These plant varieties would not be able to adapt to the harsh conditions found in the southwest desert. In addition, native plants are fragile and often have symbiotic relationships with other plant and animal species. The restrictive conditions found on rooftop gardens make plant selection especially difficult. Only the hardiest varieties can be used and even then, they must be very carefully placed within the landscape.

CONCLUSION

Green roofs are new to the United States but have been used in Europe for many years. For the many benefits they provide, they are inexpensive. They provide economic benefits to the property owner and health, environmental and economic benefits to the general public. Unfortunately, it is difficult to measure the exact amount of benefit. Some benefits are intangible and cannot be documented; in other cases, it is difficult to get managers to document all the factors and costs needed to substantiate benefit.

Much of the information regarding the care and maintenance of green roofs was obtained in Europe where climates are very different from the desert southwest. Additional work, documentation, and research with southwest plant species are needed. This research is currently being conducted and the results will be used in new development incorporating the green roof concept.

