Green Roofs:

A Sustainable Technology

Sustainability and the Built Environment

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What is a Green Roof?

The sustainable technology I choose to research is Green Roofs. Also referred to as eco-roofs, living roofs, or garden roofs, this technology incorporates the planting of permanent landscape onto building roof tops.

The use of vegetation on roofs has origins dating as far back as the *Hanging Gardens* of Babylon and in the design of Viking homes. The modern use of Green Roof technology has been well established in Germany since the 1960s, successfully implemented on top of schools, office buildings, shopping centers and retail stores.

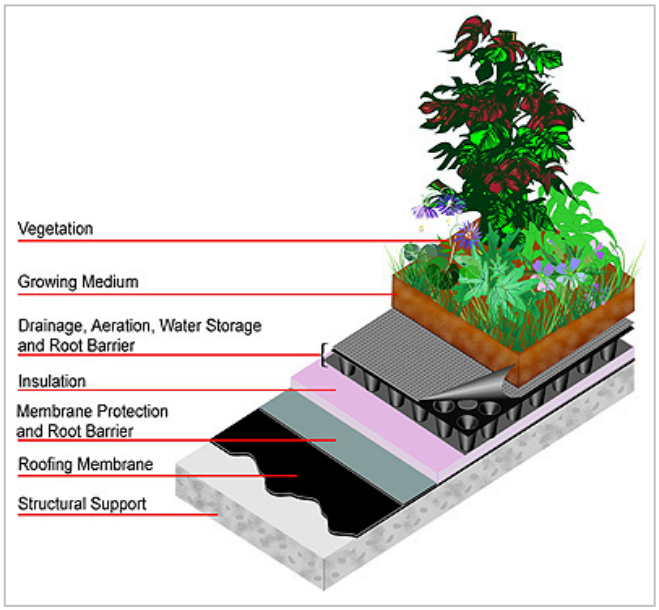
The oldest Green Roof in the United States is on top of the Rockefeller Center in New York. Although the Rockefeller roof top garden was built in 1930, interest in Green Roof technology has only occurred within the last 15 years. Currently, Chicago, Portland and New York are the leaders in implementing Green Roof technology in the United States.

How does it work?

A Green Roof is the sum of more than just plants. *Figure A* shows a Green Roof cross section. A key component to successful Green Roof implementation is the waterproof membrane that protects the roof from excess moisture. Similarly, a growing medium that provides proper drainage and aeration is essential.

Classification of Green Roofs can be divided into two main categories – extensive and intensive. Extensive Green Roofs, the more common of the two categories, employs a shallow growing medium of five inches or less. The plants chosen for extensive roofs usually include succulents and moss. The design of extensive Green Roofs is geared towards low maintenance and limited irrigation. At most, maintenance occurs one to two times a year with limited access to the roof.

Figure A: Green Roof Cross Section



Source: American Wick Drain Corporation

Intensive Green Roofs make up the second category. Intensive roofs use hardier plants that require a growing medium of at least 6-12 inches. Roofs in this category can serve the multiple

functions such as providing an outdoor garden space for food production. Inherently, this type of Green Roof requires more active maintenance with regular watering, fertilization, and pruning. Likewise, intensive Green Roofs require more structural support than extensive roofs due to heavier weight loads. Finally, if the intent of an intensive Green Roof is to provide public access than additional design features for safety must be considered.

Installation of Green Roofs occurs in one of two ways. First, plants and soil are hauled onto a roof where planting occurs directly on top of the waterproof membrane. The second option involves prefabricated squares with growing medium and plants already sprouted. The squares are hoisted, usually by crane or conveyer belt, onto a roof. Using the prefabricated squares is an attractive alternative as blocks can be easily removed if a leak or another maintenance issue should occur.

Benefits & Considerations

Green Roofs providing numerous benefits such as energy efficiency, storm water management, filtration of pollution and community amenities. As a buffer, vegetation acts to protect a roof from extremes in heat, cold, wind and rain. Compared to standard roofs, a Green Roof can double the life of a roof from 15 years to 30 years. This technology keeps internal building temperatures more evenly regulated by slowing heat gain and loss – resulting in energy savings for the building occupants.

Plants, by naturally convert sunlight to chlorophyll and water into cooling mist, negate the heat island effect caused by an abundance of concrete and asphalt surfaces in urban areas.

Likewise, Green Roofs are an effective tool in storm water management by reducing the temperature, slowing flow rate, and decreasing the amount of water run-off into local water systems. Plants also act as a filter, removing pollutants in storm water and from smog – converting carbon dioxide into oxygen.

In another interesting application, the Frankfurt Airport in Germany has installed Green Roofs to buffer noise generated from air traffic.

Not only do Green Roofs provide environmental benefits, this technology also provides added amenity to urban areas. A Green Roof transforms an underutilized area into an opportunity for an outdoor park space, a place for food production or a public gathering space. In highly urbanized areas Green Roofs add aesthetic pleasure, and correspondingly - added property value.

Along with the many benefits of Green Roof technology, implementation of a successful Green Roof depends on several factors including the type of Green Roof (extensive or intensive) you wish to use and where you plan to implement this technology.

The same Green Roof design used in Chicago may not successfully translate to a roof in Sacramento. Local microclimate factors should be considered when evaluating choices in plant species and watering needs. A Sacramento Green Roof would do well with plants that are drought resistant in the summer or which die off in the summer and easily decompose to provide nutrients for winter plants. Given Sacramento's hot summer temperatures, a companion technology such as a water catchment system could provide needed watering during heat spells.

Intensive Green Roofs add considerable more weight to roofs; thus requiring additional structural support and added costs. If the intent is to allow public access to a roof top garden then safety features need to be designed into the roof.

Generally, Green Roofs are more expensive than standard roofs. The following chart from the City of Portland estimates the construction of a new Green Roof to be $1-6 more per square foot than construction of a standard roof. Although energy efficiency will offset operational costs, some builders may not be able to get past the initial capital costs.

	Conventional Roof	Green Roof
New Construction (including structural support)	$3-9/sq ft	$10-15/sq ft
Re-roofing	$5-50/sq ft	$15-50/sq ft
Although Green Roofs initially cost more than conventional roofs, they are competitive on a life-cycle basis because of reduced maintenance and replacement cost. Source: Bureau of Environmental Services estimates based on City of Portland demonstration projects, and information obtained from roof contractors.		

Not all roofs are suitable for Green Roof technology. While a flat roof provides the greatest opportunity for energy efficiency, a roof with a minimum pitch of 10%-20% slope is preferred to encourage proper drainage. Slopes greater than 40% will require additional anchors for plants which may slide under their own weight.

Local Examples

Currently, examples of Green Roofs do not exist (or are not well documented) in the local Sacramento area. Some of my research mentioned Pacific Telephone and Telegraph (PT&T), a predecessor to Pacific Bell, who in 1962 built a half acre extensive Green Roof to maintain a constant, humidified indoor environment to protect the sensitive computer equipment.

Several Green Roof projects have begun to sprout in the San Francisco Bay Area. Among the oldest applications is the GAP headquarters building in San Bruno, built in 1997. The City of San Francisco is utilizing Green Roofs on several public projects like the new California Academy of Sciences to be

completed in 2008, the replacement of Laguna Honda Hospital and Moscone West convention center. San Francisco is also making strides to implement Green Roofs in affordable housing developments like North Beach Place which features a Green Roof as an outdoor community gathering area.

One of the main barriers to building Green Roofs in Sacramento is that the technology has not yet been adopted by the city. Jurisdictions with active Green Roof programs share the following characteristics: adoption of green building techniques to building and zoning codes; a demonstrative Green Roof project (usually on a municipal or large commercial building); and developer incentives to encourage local Green Roof Implementation.

Incentives

One of the first steps in popularizing Green Roofs is for a jurisdiction to acknowledge Green Roofs as a viable development option. Most jurisdictions that have adopted Green Roofs do so for storm water management and to promote energy efficiency. Some cities, like Cambridge, Massachusetts, Chicago and Los Angeles, are using Green Roofs as a strategy for climate protection.

Germany, the leader in modern Green Roof implementation, charges a 100% utility fee for owners of conventional roofs. Developers using a Green Roof are eligible for fees assessed at 50-80% of the utility fee. The fees are used to cover construction, maintenance and replacement costs for stormwater management facilities.

Additional, Germany also allows developers to build Green Roofs as mitigation for providing open space at a ratio of 50-70%.Other techniques in Germany include establishing zoning districts that require Green Roofs to be installed on flat roofs. Munich has included Green Roofs in its building ordinance and offers subsidies for the capital cost of installing a Green Roof.

Tokyo, Japan requires any new construction projects larger than 10,000 square feet to provide 20% of roof surfaces to be developed as a green space. In Portland, buildings that are 500 square feet of impervious surface are required to reduce storm water pollution and flow rates. Portland has targeted Green Roofs as an acceptable measure.

Portland also offers a Floor Area Ratio (FAR) bonus, allowing a developer three extra square feet per square foot of Green Roof that covers a minimum of 60% of the roof.

Other incentives being employed are:

- Faster approval/construction permitting process
- Loans or grants for capital costs

- Reduced storm water/wastewater system development charges
- Reduce stormwater/wastewater usage fees
- Reduced size of stormwater management ponds or cisterns
- Grants rewarding energy efficiency or economic and environmental objectives
- Density bonus/ larger floor area ratio
- Satisfy minimum parkland / green space requirements
- Greenhouse gas emissions trading credits

Development of incentive programs has encouraged a growing interest in Green Roof technology. This technology provides numerous energy saving, storm water management, climate control, and community benefits. Sacramento's favorable weather and agricultural history makes it an ideal candidate for Green Roofs to flourish and could benefit immensely from the ground work set by other jurisdictions.

Sources:

Cover photos left to right are of the Sechelt Justice Building in British Columbia, Canada. Bottom photo is of North Beach Place in San Francisco. Courtesy of www.verdirsystems.com and http://www.greenroofs.org

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