**REPORT**

**Introduction**

Evaluating lifecycle costs is crucial when comparing cost of a green roof to a conventional roof since **green roof lifecycle costs** can be **lower for green roofs** than for conventional roofs, **even though** the **capital cost of green roofs is much higher**.

**Green Roof Capital Costs**

Green roof capital costs vary widely. Some of the biggest factors that influence green roof capital costs include, for example:

* Roof size: this will skew costs by at least a factor of three as green roof increases from a 1,000 sf roof to a 20,000 sf roof
* Location
* Availability of labor force experienced in green roof installation
* Ease of access for installation and maintenance
* Growing medium depth
* Whether or not additional structural support is needed
* Type of warranty

Based on local projects, extensive green roofs in Minnesota typically range from $10-$30 per square foot for the components above the waterproofing assembly and a simple irrigation system. These costs are consistent with costs noted in our literature review (e.g. TRCA 2007, Green Roofs for Healthy Cities 2005, Peck and Kuhn 2002). Intensive green roofs cost significantly more.

**Green Roof Maintenance Costs**

Green roof maintenance is crucial, especially in the first 5 years after establishment. Maintenance of the green roof for the first 5 years after installation is often included in a green roof installation contract.

Maintenance costs for extensive green roofs in Minnesota typically range from $0.10 to $1.00 per square foot per year after the first five years. Factors that affect maintenance costs include, for example, project size, level of maintenance needed, and proximity of the maintenance crew to the project site.

See task 6F for more on maintenance.

**Green Roof Lifecycle Cost-Benefit Analysis**

Evaluating lifecycle costs is crucial when comparing cost of a green roof to a conventional roof since **green roof lifecycle costs** can be **lower for green roofs** than for conventional roofs, **even though** the **capital cost of green roofs is much higher**.

Factors that generally have the biggest influence on green roof lifecycle costs are estimated roof lifespan and policy and financial incentives to install green roofs.

**Estimated Roof Lifespan**

While green roofs cost more up front than traditional roofs, they have the potential to increase the lifespan of the roofing membrane by protecting them from thermal stress from high temperatures and greatly reducing diurnal temperature fluctuations.

Green roofs and conventional roofs can vary greatly in cost, but in very general terms, installing a green roof **costs about twice as much** as a conventional roof. However, based on experience in Germany, where green roofs have been widely used since the 1970’s, green roofs are expected to **at least** **double the lifespan** of a comparable roof without greening (e.g. Porsche and Kohler 2003). If that is the case, two traditional roofs would need to be installed to equal the lifespan of one green roof.

**Policy and Financial Incentives to Install Green Roofs**

Local policy incentives to install green roofs, such as, for example, stormwater fee reductions, tax abatements, and direct financial incentives, can also render installation of a green roof financially attractive.

Miller et al (2010) compared the ROI of green roofs in 5 municipal regulatory environments and conclude “Local policy initiatives, however, can create direct incentives that result in positive [return on investment] ROI, and in some cases, first cost savings…Those cities that offer attractive polices for green roofs are often doing so in order to reduce the massive outlays that will be associated with infrastructure upgrades required to comply with the NPDES Part II (Clean Water Act) requirements. For these cities, the cost of incentives such as tax abatements and fee reductions are outweighed by the savings achievable by downsizing or delaying infrastructure improvements. This has been the largest driving factor behind the green roof phenomenon in Germany and the United States.”

**Methods to Evaluate Green Roof Lifecycle Costs and Benefits**

A number of different approaches have been taken to evaluate green roof lifecycle costs and benefits. Two examples are provided below.

1. **Comparing Costs and Benefits of a Green Roof to a Comparable Dark or Reflective Roof For a Certain Study Period**

The most common way to evaluate lifecycle costs and benefits of a green roof is to compare all the costs and benefits of the green roof over the duration of the study period, to all the costs and benefits of an alternative roof type(s), typically a comparable dark and/or reflective roofing membrane.

The Athena Institute, supported by Tremco, has developed the **Greensave Calculator** (insert hyperlink to calculator on GHRC website, http://www.greenroofs.org/index.php/component/content/article/20-system-notices/237-living-architecture-toolbox) for Green Roofs for Healthy Cities, to “compare roofing alternatives over a specific time period to determine which has the lowest life-cycle cost. It is excellent for determining whether higher initial costs are justified by reducing such future costs as operating, maintenance, repair or replacement costs and/or producing additional benefits, such as energy savings.”

Based on user-defined input on costs, benefits, and other relevant financial investment information, the calculator compares lifecycle costs, simple payback period, and internal rate of return on investment of up to 3 roofing scenarios.

Cost input includes capital, maintenance, replacement costs, and lifespan. Benefit input includes information needed to determine stormwater savings, energy savings, HVAC downsizing capital savings, development fee reduction, UHI effect mitigation capital cost savings, annual increase in revenue due to productivity and health, and increased property value. Many of these benefits will not be relevant to all projects, and the user only enter input for those applicable to the project evaluated. Additional annual costs and benefits that are not included in the calculator can also be entered manually. Other relevant financial investment information includes, for example, inflation rate, and applicable discount rate.

1. **Comparing Costs and Benefits of a Green Roof to a Comparable Dark or Reflective Roof PLUS an at Grade BMP to treat stormwater that would otherwise be treated on the green roof**

Another way to evaluate green roof return on investment is to compare the lifecycle cost of a green roof to the lifecycle cost of a comparable non-greened roof PLUS another BMP that would be used instead of the green roof to meet stormwater regulations, such as, for example, pervious pavement or a raingarden. Green roof related policy and incentives and cost of land are especially significant influences on such analyses.

Example green roof lifecycle cost-benefit analysis calculations can be found, for example, in:

* Carter, Timothy, and Andrew Keeler. 2008. Life-Cycle cost–benefit Analysis of Extensive Vegetated Roof Systems. Journal of environmental management 87:350-363.
* David Evans and Associates, Inc. and ECONorthwest. 2008. Cost Benefit Evaluation Of Ecoroofs. Prepared for: City of Portland Bureau of Environmental Services Sustainable Stormwater Group.
* Miller, C., Weeks, K, Bass, B. Berghage, R. Berg, S. 2010. Stormwater Policy As A Green Roof (Dis)Incentive For Retail Developers. Cities Alive 8th Annual Green roof &Wall Conference, Vancouver, November 30-December 03, 2010.
* Porsche, U. and M. Kohler. 2003. “Life Cycle Costs of Green Roofs: A Comparison of Germany, USA, and Brazil.” Presented at the World Climate and Energy Event. December 1-5, Rio de Janeiro, Brazil.
* Toronto and Region Conservation. An Economic Analysis of Green Roofs: Evaluating the Costs and Savings to Building Owners in Toronto and Surrounding Regions. Sustainable Technologies Evaluation Program. July. Retrieved September 26, 2007, from http://www.sustainabletechnologies.ca/Portals/\_Rainbow/Documents/GR\_Econ\_Full%20document.pdf

Depending on the approach to the lifecycle cost analysis and project specifics, some of the above found green roofs to have the lowest lifecycle costs, while others found the traditional roof to have the lowest lifecycle costs, and still others found them to have comparable lifecycle costs.

In those cases when the green roof lifecycle costs are lower than those of a traditional green roof, the payback period is often (but not always) significantly more than 5 years, which is the maximum payback period acceptable to many developers. But for long-term property owners, green roofs can make financial sense depending on project conditions and local stormwater policy and green roof incentives. And under some local policies, payback for green roofs can even come close to 5 years.

Miller et al (2010), for example, compared payback for a green roof compared to a traditional roof with pervious pavement to meet stormwater regulations, as well as to a traditional roof with a raingarden to meet stormwater regulations in five different municipal regulatory environments, represented by five major metropolitan areas. While the green roof never pays back for itself in one of the cities studied, it paid back for itself in just 6 years compared to a traditional green roof with a raingarden in Minneapolis!

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