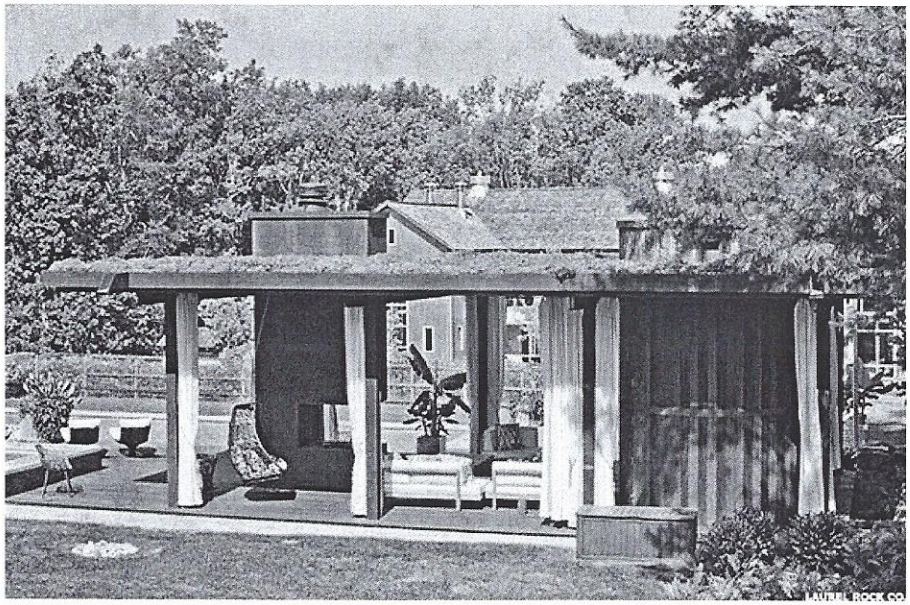
What a Green Roof Costs You on the Way to Saving Everything

Planting a garden on your roof provides insulation in the winter and cooling in the summer, saves money and the Earth and might just keep you healthy as well.

By Mia Taylor
May 22, 2015 7:00 AM EDT



NEW YORK (MainStreet) — Maybe Bilbo Baggins was onto something, living in a house built into a hillside, its roof covered in grass and flowers.

In *The Hobbit* and *Lord of the Rings*, Bilbo was one of many Hobbits living in homes that today would be viewed as cutting-edge eco-friendly.

A recent, visually stunning article in *Dwell*, the trendy, forward-thinking home publication, was dedicated to this very topic — the increasing number of homeowners around the country and world who are building or redesigning homes to include a living roof, literally planting a garden on a roof whether with succulents, grass or some other combination of local plants.

Green roofs are not entirely new. That's essentially what the ancient Hanging Gardens of Babylon were.

But in today's world of global warming, dwindling natural resources and increasing utility costs, a green roof has taken on a new and increasingly popular appeal for businesses and homeowners from Massachusetts to California and beyond. A green roof comes with numerous benefits for the property owner and community at large.

"If designed and maintained properly, a green roof can save you money," says Breeze Glazer, sustainable design director for the New York firm **Perkins + Will**. "The savings comes from reduced utility costs and even reduced [roof] maintenance over time. But the green roof has to be properly installed and inspected from time to time."

Growing plants on your roof provides insulation in the winter and a cooling effect in the summer, Glazer explains, saving money on air conditioning and heating.

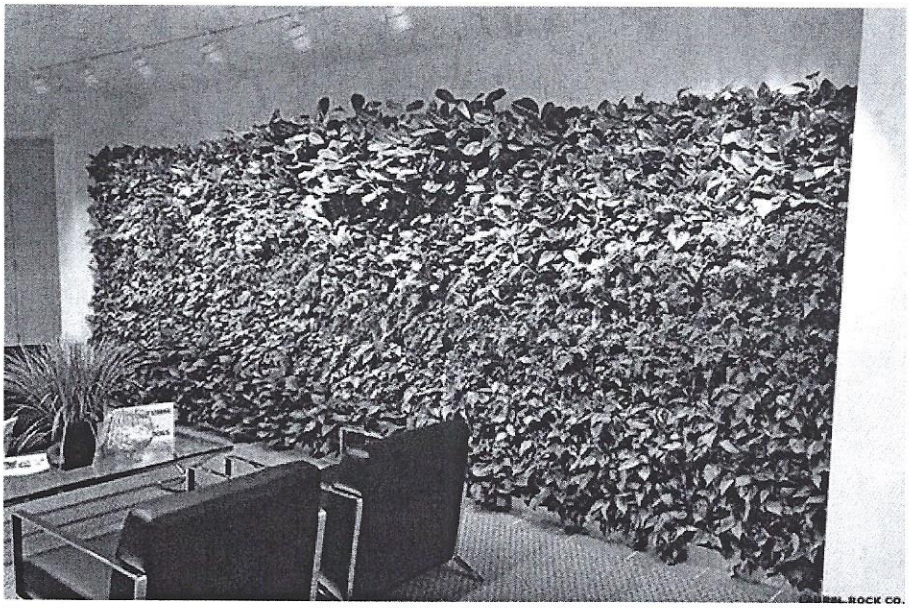
The exact amount of savings is difficult to calculate, as utility costs vary from state to state. But according to the National Research Council of Canada, a green roof can reduce air conditioning demand in the summer by as much as 75%.

An exposed roof can get as hot as 158 degrees on a sunny day, while a

green, shady roof heats to just 77 degrees, according to the council.

And green roofs do their part for the environment. By lowering air conditioning demand, green roofs decrease production of associated air pollution and greenhouse gas emissions, says the U.S. Environmental Protection Agency.

There are also numerous additional benefits, according to research from Michigan State University, including that living or green roofs improve stormwater management by reducing runoff, reduce noise pollution, increase urban biodiversity by providing habitat for wildlife, provide space for urban agriculture, provide a more aesthetically pleasing and healthy environment to work and live and improve return on investment compared with traditional roofs.



The University of Michigan, for instance, compared the expected costs of conventional roofs with the cost of a 21,000-square-foot green roof and all of its benefits, such as stormwater management and improved public health from the absorption of nitrogen oxides. The university found that the green roof would cost $464,000 to install versus $335,000 for a conventional roof in 2006 dollars. Over its lifetime, though, the green roof

would save about $200,000. Nearly two-thirds of the savings come from reduced energy needs for the building below it.

Another important financial benefit is the reduction in home maintenance costs.

"They prolong the life of the roof underneath it. They protect the roof from sun, which can wear down the roof, and from snow and rain. They have been proven to increase the length of roof life," Glazer says.

A green roof or living roof is not an option for every homeowner. For one thing, the roof must be the right pitch, Glazer says.

"The type of roof you have matters less then the slope of your roof," he says. "You don't need a flat roof, but you can't have a steep roof either. It should have no more then a 20-degree slope, if not lower. Ideally, you want it to be as flat as possible."

The roof must also be capable of bearing the weight of a garden.

There are two types of living roofs — extensive and intensive, Glazer explains. Extensive roof gardens are lighter, cheaper and shallower. Intensive gardens are heavier and more expensive. For existing homes, Glazer recommends the extensive roof garden.

Some stores sell modular trays specifically for extensive gardens. The trays are sold in a grid that can be put on a roof and grouped tightly.

The type of plants used is also key, Glazer says.

"The goal is no matter where you live, the type of plants should be native to your region," he says. "And then you don't have to irrigate at all. Find out what plants are natural to your region."

The EPA estimates that the cost of installing a green roof starts at around $10 per square foot for simpler extensive roofing, and $25 per square foot for intensive roofs. Annual maintenance costs for either type may range from 75 cents to $1.50 per square foot.

Urban areas such as New York City are among the biggest participants in the trend.

Elliott Maltby, principal at Brooklyn-based architecture, urban and landscape design firm **Thread Collective**, has not only designed green roofs for clients, but created one on her home, and can rattle off numerous buildings throughout the city that now have one.

"In New York City you have a strong history of roof terraces, so the transition from roof terraces to green roof isn't such a big leap," she says.

Among the more sizable in the city is the 2.5-acre green roof atop the U.S. Postal Service's Morgan Processing and Distribution Center on Ninth Avenue, between 29th and 30th streets. The New York City Parks Department started a living roof in 2007 on its Five Borough Administrative Building. Now covering more than 29,000 square feet, the building's roof is at the forefront of the movement.

"I think there's an increasing awareness of citywide problems, like the temperature or stormwater management," Maltby says. "People are feeling a togetherness in dealing with these issues, and green roofs have a pleasure and beauty associated with them as well."

"I think it's slowly becoming more mainstream, probably a little bit more at the higher end of construction," she adds. "People are seeing green roofs as these aesthetic places that also do all of this amazing ecological stuff."

In nearby Connecticut, Burt DeMarche's firm **The LaurelRock Co.**, an

award-winning landscape development business, has built living roofs on a handful of properties over the past five years, on pool houses and primary residences. Describing the trend as still in its early phases, he predicts it will continue to pick up momentum in the coming years.

"I would say by 2020 you will see more of them. There are more people talking about it now," he says. "I don't think there has been a lot of information or publicity about them out there yet."

Glazer, meanwhile, of Perkins+Will, says there's an additional value impossible to measure in dollars.

"There are many studies linking just being able to see nature, whether it's a park next door or a green roof, to health benefits," Glazer says. "Things such as increased productivity and reduced errors, and reduced stress levels ... There's many different ways that simply being able to see nature can quantifiably benefit your health."

— *Written by Mia Taylor for MainStreet*

Renewable energy | Luxury Goods

More from Mortgages

U.S. Economy Added 103,000 Jobs in March, Missing Projections

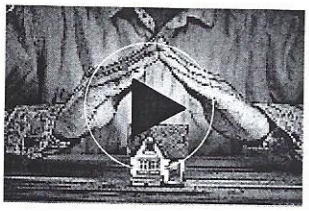
The U.S. economy added 103,000 jobs in March, below expectations, as analysts said the tighter labor market may be making skilled workers harder to come by.

Bradley Keoun | Apr 6, 2018 8:49 AM EDT

U.S. Economy Seen Adding Jobs at 'Goldilocks' Pace For Stock Investors

The U.S. economy probably added 185,000 jobs in March while wage gains accelerated, a survey of economists showed, reinforcing the Federal Reserve's case for continuing to increase interest rates gradually to keep inflation from overheating while keeping unemployment low.

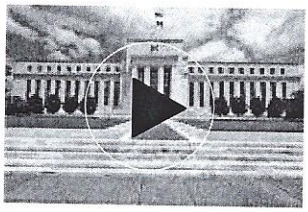
Bradley Keoun | Apr 5, 2018 4:09 PM EDT



Can You Skip a Car or Mortgage Payment?

Negotiating with the lender at the first sign of trouble could help consumers receive a reprieve.

Ellen Chang | Mar 27, 2018 3:34 PM EDT



AAP Exclusive: Rate Hikes and Inflation (Or Lack Thereof)

In March's Action Alerts PLUS members' call, Cramer discusses which companies will be affected by the interest rate hikes and how the lack of inflation affects the economy overall.

Tracy Byrnes | Mar 27, 2018 3:03 PM EDT

Pay Banker Bonuses in Bonds to Reduce Risk, N.Y. Fed Chief Says

Bill Dudley, who as president of the Federal Reserve Bank of New York oversees big banks like JPMorgan and Citigroup, says bankers

might police risk-taking by employees more aggressively if their compensation came in the form of bonds instead of stock. That way, they'd care more if their company could pay back its debts.

Bradley Keoun | Mar 26, 2018 3:11 PM EDT

About the new Website design

Please view the **Site Map** if you need assistance locating a particular page on the LID Urban Design Tools Website.

This update is merely a design change. No content has been changed or updated.

Trouble with Website?

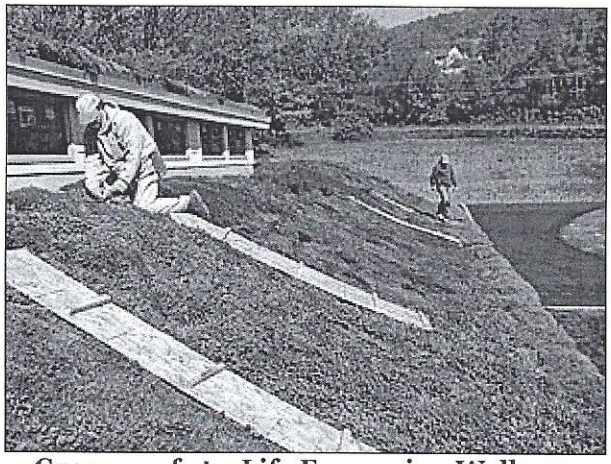
If you have any trouble accessing pages on this website, please **contact** us by email and we will get back to you as soon as possible.

Please include the URL (i.e. web page link) that you are referring to so that we may better assist you. Thanks.

Green Roofs

Costs

Costs for green roofs in the United States are estimated to average between $15 to $20 per square foot for all use types, i.e., high density residential, commercial, industrial etc.[1] These costs include all aspects of green roof development, from the waterproofing membrane to soil substrate creation to planting. By far the highest costs associated with green roof creation are the soil substrate/growth medium and the plant components associated with it. Green roof retrofit projects may have increased cost associated with traffic and resource scheduling concerns as well as the on-site availability of equipment and materials. The cost of planting can also increase if plants are placed individually rather than pre-grown on vegetation mats.



Green roof at a Life Expression Wellness Center in Pennsylvania
(Source: Roofscapes, Inc.)

The often customized installation methods in the U.S. stand in sharp contrast to the green roof creation practices of other countries such as Germany, where an entire service industry has evolved in response to green rooftop development and costs run between $8 and $15 per square foot. Because this is relatively new technology in the United States, much information is still lacking

about the full range of 'traditional' and 'public' costs as well as the long-term benefits of green roofs. A potential client may still lack a thorough understanding of the direct, tangible and long-term economic benefits of building a green roofing system.

Different types of installation costs include initial capital costs, ongoing maintenance costs, and lifecycle costs (i.e., green roof replacement might cost more than conventional roof replacement). Green roof technology often requires that maintenance costs be built into the original budget, especially with more elaborate, extensive green roof covers. Long-term ancillary costs related to the increased costs of insurance, and liability issues in regards to weight, drainage, interior damages from roots, damage to walls and liability to personal injury are potential concerns.[2]

Offsetting the initial capital and ongoing maintenance costs, green roofs provide a number of long-term cost savings. Rooftop vegetation moderates the temperature extremes of a roof surface and prevents it from being exposed to ultraviolet (UV) radiation and cold winds that could accelerate its break down. The result is an extended life span for the roof. A vegetated roof, on average, can be expected to prolong the service of the life of a conventional roof by at least 20 years (ZVG, 1996). When the savings associated with deferred maintenance and reduced energy consumption are taken into account, vegetated rooftops are comparable in cost to conventional roofs.[3]

Other long-term economic advantages to consider in the construction of green roofs, which can further offset their initial construction costs, include:

1. Direct and indirect cost savings opportunities for the building owner, such as:
    - Increased insulation value, resulting in savings on energy heating and cooling costs.
    - Potential for greenhouse gas emissions trading credits.
    - Provision of amenity space and aesthetic appeal, increasing the value of the property and the marketability of the city as a

whole.

- The possible easing of impervious coverage restrictions for developers who incorporate green roofs into their site plans.
- Visual and environmental benefits that increase property value.

2. Cost savings in terms of environmental benefits to the community include:
   - Cost savings from increased stormwater retention, attenuation of peak flows and urban flooding, through the reestablishment of predevelopment hydrology.
   - Decreased need to expand or rebuild separate storm sewer system infrastructure due to a decrease in total hydraulic loads.
   - The reduction of pollutant loads to receiving waters by nonpoint source pollutant treatment through nutrient cycling of the plants and the soil chemistry of the rooftop matrix.
   - Decreased cost of meeting greenhouse gas reductions and the ability to "bank" heat gains from the "Urban Heat Island Effect." [4]
   - Possible acoustic insulation benefits of green roofs in areas of high noise such as near airports or in the heart of major urban areas.
   - Quality of life benefits through the additional ecosystem and environmental amenities achieved through habitat and biodiversity preservation.

Return to top

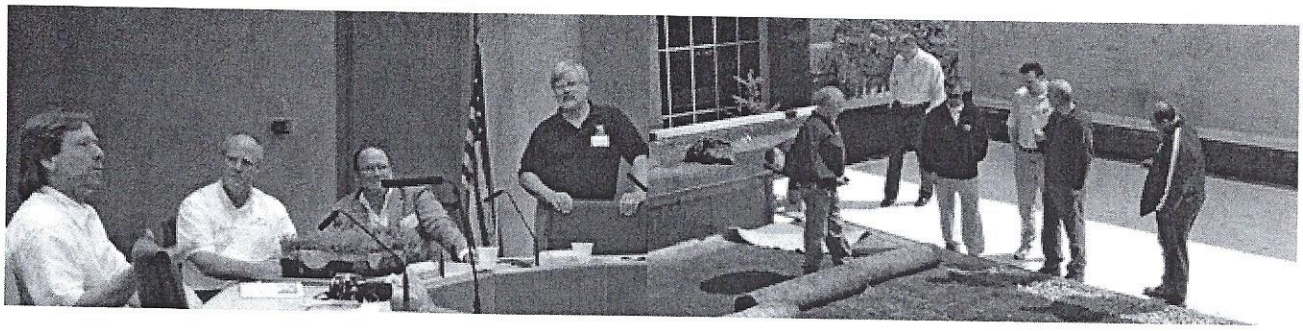
References

[1] Scholz-Barth, K., 2001: Green Roofs, Stormwater Management From the Top Down. Environmental Design and Construction. Accessible at http://www.edcmag.com/.

[2] Peck, S.W. and C. Callaghan, 1999: Greenbacks

Search
Search the Site
Search the site Search the Site Search
MENU +

FAQ



Below are some of the more commonly asked questions. If you have a questions that you don't see below please feel free to contact us at info@greenrooftechnology.com and we may even add it to the list!

- **How much does a green roof cost?**
- **Can you put a green roof on an existing building?**
- **What is the difference between a modular system and a traditional built up system?**
- **Can I have a green roof on my sloped roof?**
- **Are there incentive programs or grants that can help with the cost?**
- **Can I grow food on my roof?**
- **Can I use potting soil or any soil from the ground on a green roof?**
- **What is the maintenance involved in a green roof?**
- **Do I need to water my green roof?**
- **How long will my roof last with a green roof?**
- **How do I check for a leak if I already have a green roof?**
- **What are the first steps in planning a green roof?**

How much does a green roof cost?

Counting all the material above the waterproofing, the cost of a green roof on a flat roof typically starts around $15 a square foot. This covers a basic 4" system with sedums and hearty herbs. Growing media depth, desired water storage, and plant material, and slope determine the increase in cost from there. Green roofs generally become up to 50% cheaper by the square foot as the square footage exceeds 10,000 feet.

Can you put a green roof on an existing building?

Yes. Many of our green roof projects involve existing buildings. The building must first be check by a structural engineer to determine the weight bearing capacity. Waterproofing must be in excellent condition, typically no older than 5 years, though having a green roof installed when you need to redo your roof is the best option. Having the waterproofing replaced right before the green roof is installed ensures maximum protection for the waterproofing and a more compatible system. This is also the best time to set up a leak detection system.

What is the difference between a modular system and a traditional built up system?

Most modular systems basically function as planters. They are laid directly on the waterproofing membrane and can cause leaks if placed on debris or moved. Waterproofing damage from UV rays and roots can also be a problem. There are some with open sides to let the roots spread out. These are better than the above

mentioned modular planters however drainage is not as good as a traditional system and they are still typically more expensive. The advantage is that you can have instant green on your roof. However, this can also be achieved on a traditional green roof through the use of vegetated mats similar to sod mats.

A traditional built up system has many names such as loose-laid, wall to wall, and continuous system. Whatever the name, it is a layered system that covers a defined area and is assembled on the roof. This system offers superior UV, debris, elements, and root protection. Drainage, water retention, and plant health are typically superior as well.

Can I have a green roof on my sloped roof?

Yes. There are many different ways to set up growing media and drainage supports to keep the green roof from moving. In terms of cost however the price will increase with the steepness of the slope.

Are there incentive programs or grants that can help with the cost?

Yes. We have worked with many groups that have found funding for their green roof through city incentive programs, government grants, and organization grants. Check your local environmental groups, municipalities, and federal grant websites for more info.

Can I grow food on my roof?

Yes. You can grow hearty drought tolerant herbs like rosemary, thyme, and chives on a green roof very successfully.

Traditional crops such as tomatoes and peppers require a deeper growing media depth with lots of irrigation and maintenance. Some of the more tender crops may find the location too harsh and the growing media unsuitable. If you are in an urban area be sure to check to see if the plants and parts you want to eat are air pollution sinks. Plants and or sections of the plant absorb and store pollutants differently and at different levels.

Your best bet would be to have a raised planter system for traditional crops. This requires less irrigation, maintenance, and the rich organic soils that the crops love is kept separate from the green roof and or roof drains. Rich organic soil is horrible for green roofs mainly because of the multitude of drainage problems they cause with a green roof system.

Can I use potting soil or any soil from the ground on a green roof?

NO! This is recipe for disaster. Growing media is used not because it sounds cool or is an accessory designed by manufacturers. Growing media is specially mixed and selected light weight materials composed mainly of mineral components with very little organic matter that has been sterilized. This allows for proper water retention and drainage which is key for a green roof's success. Low organic matter is good because the plants that grow normally in a green roof environment don't need lots of nutrients. In some cases too much nutrients can actually damage the green roof plants. More importantly, the fine particles created from organic material breaking down can clog the drainage systems of the green roof causing it to fail.

What is the maintenance involved in a green roof?

That depends on the green roof. A typical extensive green roof composed of a 4 inch system with mixed sedums needs water sparingly for the first year and weeding every few months. The following year it shouldn't need any water and will only need to be weeded 3 to 4 times a year. After the second year it should only need to be weeded twice a year. Fertilize only once a year.

More garden like green roofs need more maintenance and will need to be maintained similar to their ground level counterparts. In general, avoid using mulch and similar materials that can break down.

Do I need to water my green roof?

During the first year, regardless of plants or system used, it is recommended that you water to aid establishment. In general, for a green roof to be "green" in terms of being ecologically friendly it shouldn't need to be watered after the first year. Irrigation wastes water and energy, both are what the green roof should be conserving.

How long will my roof last with a green roof?

A properly installed and maintained green roof should extend the life of the roof 2-3 times its normal life. 30 to 50 years is not an unusual lifespan for green roofs in Europe.

How do I check for a leak if I already have a green roof?

To avoid a needle in a haystack search the best thing that you can do for yourself and your green roof is to

have your waterproofing checked for leaks prior to installation and to have a leak detection system installed.

Electro Field Vector Mapping (EFVM) is very accurate and able to find leaks that traditional flood testing wouldn't. EFVM testing can also be done anytime after the green roof is installed and is often cheaper than the cost of a waterproofing manufacturer's warranty. Roughly 80% of the green roofs we have specified contain this system.

Latest Blog Posts

1. Fluent Transition from Green Roof to Green Wall Green Team at Green Roof Technology, 06-Apr-2018
2. Rooftop Vineyard Green Team at Green Roof Technology, 03-Apr-2018

Testimonials

"Jorg was instrumental in the successful implementation of both these national award winning projects."

Bruce D.
Conservation Design Forum
Chicago City Hall Green Roof and Peggy Notebaert Museum

Sign Up For Our Newsletter!

Full Name

Email Address Subscribe

3.0 COST BENEFIT ANALYSIS

Key findings:

- Compared to a black roof, a 3-inch to 6-inch green roof covering 10,000 feet has a Net Present Value of $2.70 per square foot per year, Payback of 6.2 years and an Internal Rate of Return of 5.2% nationally.
- The longevity of green roofs has the greatest effect on savings, whereas installation and maintenance have the greatest effect on cost (maintenance costs are even greater than the installation premium).
- Over a 50-year period, stormwater, energy, equivalent carbon dioxide (CO_2e, which measures the potential global warming effect of a greenhouse gas) and community earnings of green roofs more than made up for the increased premium of installing, maintaining and replacing them. Results can vary depending on one's relationship to the subject real estate.
- The fewer floors a building has, the greater the energy savings are for a green roof compared to a black roof.
- The greater the surface area, the greater the stormwater management savings are for a green roof compared to a black roof.
- Cost savings will increase as stormwater regulations become more stringent and green roofs become more acceptable as mitigation measures.

A major goal of this report is to compare the costs of green roofs with the benefits they provide. This requires an understanding of the costs of green roofs, a quantification of the benefits, savings and value produced by green roofs, a comparison of these costs and benefits, and an analysis of the results. This section includes each of these required steps.

3.1 PURPOSE

This report has thus far described many of the costs and benefits of installing a green roof instead of a conventional black roof. However, to put the cost and benefit of each type of roof in context, an analysis was conducted in which the expected cash flows of both green and conventional roofs were modeled over time. For instance, the additional cost of installing a green roof was accounted for in year one but was followed by years of energy savings as a result of this installation. This analysis thus gives a financial overview of a green roof as an investment, and allows this investment to be compared to similar, building-level investments. Building owners, as do most investors, typically choose to make investments with the greatest expected return, though they often weigh competing, non-financial influences such as building image, as well.

3.2 METHODOLOGY

The cost-benefit analysis presented in this section is based on a direct comparison between installing either a black roof or a state-of-the-art extensive green roof as a replacement for an existing conventional roof. The costs and benefits of the extensive green roof are averaged between a 3-inch multi-course extensive profile and a 6-inch semi-intensive profile. Because the size of green roofs on commercial and institutional projects can vary greatly, this study included three roof sizes: 5,000, 10,000, and 50,000 square feet.

The relative costs, cost-saving benefits and added value of a green roof versus a black roof over a 50-year timeframe was then accounted for and discounted back to present value. Six separate cash flows were created to allow data segregation and identification of the relative benefits:

- Installation, replacement and maintenance
- Stormwater
- Energy
- Carbon
- Community benefits
- Real estate effects

The cash flows from the following benefits were not included in the analysis:

- Urban agriculture
- Acoustics
- Job generation
- Productivity

The costs and benefits are experienced by the following:

- Directly by the developer through installation, rent or operations,
- By the municipality through reduced infrastructure maintenance or replacement costs,
- By the community through improved aesthetics, biodiversity or job generation, or
- To building occupants through productivity gains or improved health (productivity and improved health was not integrated into this analysis due to the difficulty in assigning a particular performance attributable to either roofing type).

For transparency purposes, rather than aggregating all of the data and stating an overall **net present value (NPV) or internal rate of return (IRR)**, this analysis openly shares its data and keeps the results separated to demonstrate the relative costs and benefits of green roofs versus their conventional counterparts.

3.3 ASSUMPTIONS

Users should be aware that the intent of this analysis is to present "average" costs and benefits on a very broad, national level and on a more specific, metropolitan level, for Washington DC. Results may differ for specific states or municipalities.

3.3.1 COST

The decision of whether to install a green roof should be considered on a case-by-case basis. Variability in structure, municipality, ownership, tenant, investment, technology, climate and other aspects requires specific attention to ensure accuracy. This analysis aims to limit some of these variables by focusing only on roof replacements and on the financial performance "premium" between state-of-the-art extensive green roofs and state-of-the-art black roofing. The cost-benefit model includes inflation, growth rates for labor and materials, energy, stormwater, community benefits, diminishing returns (based on expected increase in supply), a discount rate evaluation, a 50-year timeline and community (public) benefits of green roofs. A detailed description of the assumptions is in Appendix B.

For the purposes of this study, we conducted a cost-benefit analysis comparing the two simplest, beneficial and least expensive examples of the extensive and intensive varieties of green roof with a conventional, black roof. These were a 3-inch multi-course extensive roof with a geosynthetic drain layer, and a 6-inch semi-intensive roof.

The 3-inch profile is the minimum recommended for maintenance requirements and stable plant coverage without permanent irrigation, and is used in places where stormwater management is the main reason to install a green roof. The 6-inch profile includes four inches of growth medium over two inches of drainage medium, and includes permanent base-level capillary irrigation to sustain plants. These roofs are typically used where garden aesthetics and biodiversity are priorities, in addition to stormwater management. Performance characteristics, layers, recommended plant lists and wet weight loads (see *Section* 4.1.1 for structural issues) of both roofs examined are detailed in Appendix A.

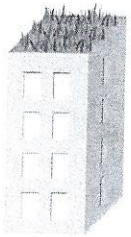
Key findings:

- Green roof installation costs per square foot decrease as size increases.
- The installed cost premium for multi-course extensive green roofs ranges from $10.30 to $12.50 per square foot more compared to a conventional, black roof.
- The installed cost premium for semi-intensive green roofs ranges from $16.20 to $19.70 per square foot more compared to a conventional, black roof.
- Annual maintenance for a green roof is typically higher than for a black roof, by $0.21 to $0.31 per square foot.

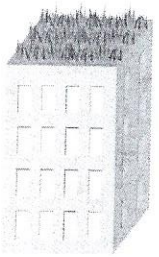
Green roof installation costs

This analysis developed a standardized cost for both intensive and extensive roofs using the federal prevailing wage rates for Washington DC, and current material costs.* As demonstrated in Figure 21, extensive green roofs are approximately $6 to $8 per square foot cheaper to install than semi-intensive green roofs, and in both cases larger green roofs cost less per square foot to install than smaller green roofs.

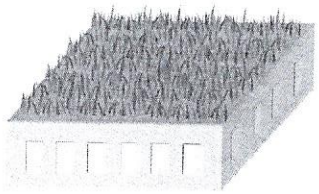
This analysis found that the typical installation cost for a green roof depends on its size, with the price per square foot decreasing as the size increases. The cost premium of installing an extensive green roof ranges from $10.30 to $12.50 per square foot more compared



5,000 sqft



10,000 sqft



50,000 sqft

*Roofmeadow verified these costs by comparison with projects that it has completed in each green roof profile/size configuration. The specific projects are not discussed for reasons of client confidentiality.

to a black roof, while installing a semi-intensive green roof costs from $16.20 to $19.70 per square foot more compared to a black roof (see *Section* 4.2 for installation issues).

Green roof maintenance

The first years of a green roof's existence are considered an **establishment period**, in which maintenance is critical to the roof's long-term success and maintenance requirements are greatest. Maintenance of a green roof includes weeding, harvesting cuttings and distributing them in bare spots to improve coverage, checking for loss of growth medium, and inspecting for other potential problems. Maintenance costs will be higher any time a green roof includes a landscaped design, as workers will also need to spend time maintaining the design aesthetic. A typical maintenance crew includes two workers, though more may be needed for a larger roof. For this study, labor hours were rounded up to the next half-day for cost estimating purposes.

A minimum of three maintenance visits per year is recommended for an extensive green roof during the establishment period. The typical labor requirement is 4 person-hours per 1,000 square feet per year, or 1.33 person-hours per 1,000 square feet per visit. Maintenance requirements will decrease after the establishment period; this analysis assumes a reduction to two visits a year for this type of green roof.

For an intensive green roof established with plants listed in Appendix A, a minimum of four maintenance visits per year is recommended during the establishment period. The spring and fall visits will be more labor intensive, requiring cutting and removal of dead grasses, removal of organic litter, and other tasks. The typical labor requirement is six person-hours per 1,000 square feet per year, or 1.5 person hours per square feet per visit. After the establishment period, maintenance demands will decrease but the number of visits will hold steady at four per year (see *Section* 4.3 for maintenance issues).

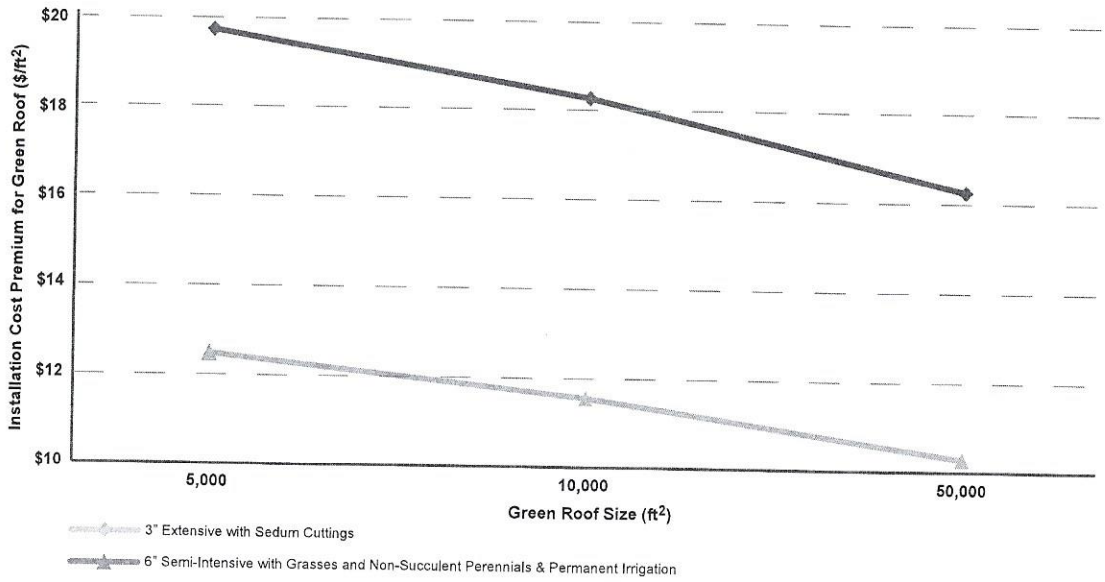


Figure 21: Green roof installation premiums

In general, maintenance costs for both types of green roofs are greatest during the establishment period, or the two years after installation. Intensive roofs require more frequent and longer maintenance visits than extensive roofs, both during the establishment period and afterward.

Annual maintenance of green roofs costs from 21 cents to 31 cents more per square foot per year than maintenance of a black roof. White roofs typically need more maintenance than black roofs, as they must be kept free from debris to continue to reflect solar radiation as expected.

3.3.2 BENEFITS

The benefits of an extensive green roof versus a conventional black roof are described at the end of each subsection in the Benefits Section. The benefits specifically accounted for in this analysis fall in two groups:

- Those that **directly affect owners/occupants/ investors**, including installation, replacement and repair, stormwater and energy
- **Other financial impacts**, including greenhouse gas savings, market-based savings, and community benefits.

Additional details can be found in Appendix B of this report.

3.4 RESULTS

The results presented below are itemized to show the relative differences in costs and benefits, in an effort to help the reader to understand the relative impacts on the costs and benefits of installing a green roof.

3.4.1 NET PRESENT VALUE PER SQUARE FOOT OF ROOF

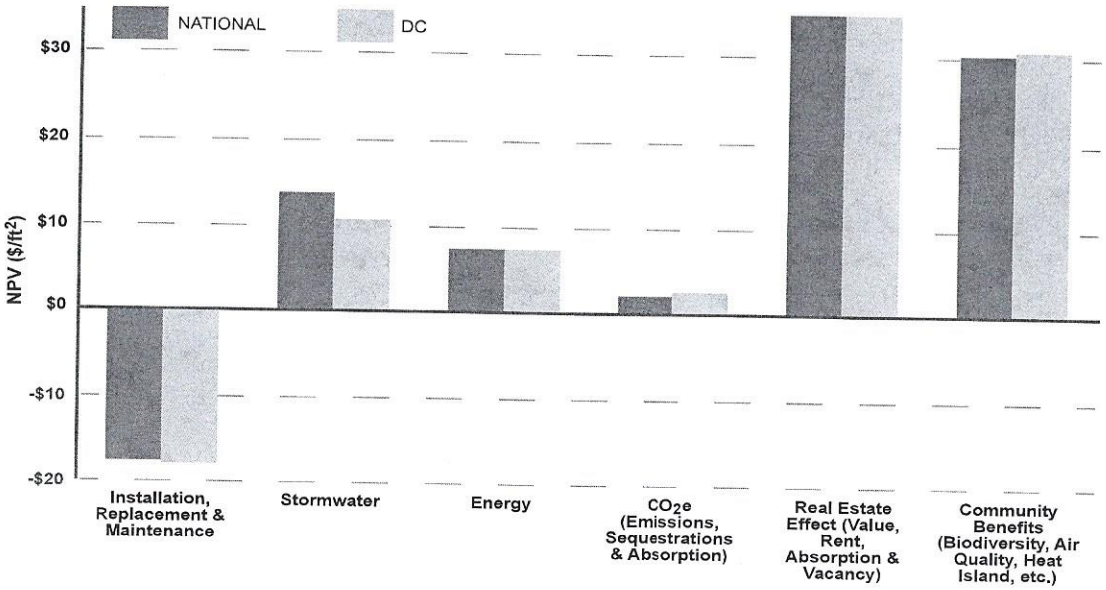


Figure 22: NPV cost-benefit analysis results of green roof versus black roofs

Key terms:

- **Net Present Value (NPV)** is a measure of the potential profitability of an investment. It takes the expected value of the future costs and benefits associated with this investment, and accounts for the effect of inflation. A positive net present value means an investment will produce greater returns over the time frame being considered than an alternate investment.
- **Internal Rate of Return (IRR)** is a measure of the expected annual financial benefit yielded by an investment over a given time frame (e.g., an IRR of 6% suggests a stream of cash growing, on average, at 6% per year). This benefit can be compared with the expected yields of other investments over the same period.
- **Payback** is the number of years it takes to recoup an initial investment through the income from that investment.
- **Return on Investment (ROI)** is percent of money gained or lost on an investment, relative to the initial cost.

Over a 50-year period:

- The installation, replacement and maintenance of a green roof has the greatest negative impact on net present value at a cost of approximately $18 per square foot of roof.
- Stormwater and energy savings make up for this cost by providing a benefit of approximately $19 per square foot of roof.
- Benefits to the community have the greatest positive impact on net present value at a savings of almost $38 per square foot of roof.

Table 8: Cost-benefit analysis results of green roof vs black roofs

NATIONAL LEVEL RESULTS	ROOF SIZE (ft^2) 5,000	10,000	50,000
Impact on Owners/Occupants/Investors			
Initial Premium, $/ft² of roof (extra cost of installing a green roof instead of a black roof)	-$12.6	-$11.4	-$9.7
NPV of Installation, Replacement, & Maintenance, $/ft² of roof	-$18.2	-$17.7	-$17.0
NPV of Stormwater, $/ft² of roof (savings from reduced infrastructure improvements and/or stormwater fees)	$14.1	$13.6	$13.2
NPV of Energy, $/ft² of roof (energy savings from cooling and heating)	$6.6	$6.8	$8.2
Net Present Value (installation, replacement & maintenance + stormwater + energy NPV)	$2.5	$2.7	$4.5
Internal Rate of Return (IRR)	*5.0%*	*5.2%*	*5.9%*
***Payback**, years*	*6.4*	*6.2*	*5.6*
Return on Investment (ROI)	*220%*	*224%*	*247%*
Other Financial Impacts (less realizable)			
NPV of CO_2e, $/ft² of roof (emissions, sequestration & absorption)	$2.1	$2.1	$2.1
NPV of Real Estate Effect, $/ft² of roof (value, rent, absorption & vacancy)	$120.1	$111.3	$99.1
NPV of Community Benefits, $/ft² of roof (biodiversity, air quality, heat island, etc.)	$30.4	$30.4	$30.4

WASHINGTON DC RESULTS	ROOF SIZE (ft^2) 5,000	10,000	50,000
Impact on Owners/Occupants/Investors			
Initial Premium, $/ft² of roof (extra cost of installing a green roof instead of a black roof)	-$10.7	-$9.5	-$8.0
NPV of Installation, Replacement, & Maintenance, $/ft² of roof	-$18.1	-$17.9	-$17.7
NPV of Stormwater, $/ft² of roof (savings from reduced infrastructure improvements and/or stormwater fees)	$11.0	$10.5	$10.2
NPV of Energy, $/ft² of roof (energy savings from cooling and heating)	$6.8	$6.8	$8.3
Net Present Value (installation, replacement & maintenance + stormwater + energy NPV)	-$0.2	-$0.6	$0.7
Internal Rate of Return (IRR)	*4.3%*	*4.2%*	*4.7%*
***Payback**, years*	*6.6*	*6.5*	*6.0*
Return on Investment (ROI)	*198%*	*194%*	*209%*
Other Financial Impacts (less realizable)			
NPV of CO_2e, $/ft² of roof (emissions, sequestration & absorption)	$2.6	$2.6	$2.6
NPV of Real Estate Effect, $/ft² of roof (value, rent, absorption & vacancy)	$98.4	$88.2	$74.1
NPV of Community Benefits, $/ft² of roof (biodiversity, air quality, heat island, etc.)	$30.9	$30.9	$30.9

In regards to the ROI, on a national level, a dollar invested in a green roof today suggests a return of $1.29 in today's dollars after 50 years. For Washington DC, the same dollar invested would yield one dollar in return (in today's dollars); in other words, the green roof investment is the same as an average, alternative investment of 4.4%. If CO_2e and community benefits were added in, that same dollar invested would result in $3.19 and $3.57, respectively.

3.4.2 SENSITIVITY ANALYSIS

A sensitivity analysis was also conducted to identify the more important variables based on their ability to impact the total NPV. The factors that most influence the value/costs of a green roof are:

HARD COST VARIABLES	CHANGE IN TOTAL NPV PER 1% CHANGE IN VARIABLE
Roof Longevity (1-year change)	13.24%
Installation Costs	11.32%
Discount Rate	4.89%
Maintenance Costs	3.38%
Energy Savings	2.51%
Stormwater Equipment Cost	1.44%
Stormwater Surcharge	1.35%
Green Roof Risk Contingency	1.21%

3.4.3 NPV BY REAL ESTATE RELATIONSHIP

The NPV analysis in *Section* 3.4 provides seven different areas of either costs or benefits, however, these costs and savings vary because of significant differences in ownership. Additional analysis appropriately separates costs and benefits according to the relationship of each to the subject real estate:

- Owner
- Owner/occupant (i.e., an owner who occupies its building)
- Tenant
- Community

The results in Table 9 and Figure 23 indicate NPV per square foot of roof based on ones relationship to real estate. The assumptions of the analysis are in Appendix B.

Table 9: NPV of a green roof based on ones relationship to its real estate

	OWNER	OWNER/ OCCUPANT	TENANT	COMMUNITY	MARKET EXPECTATION (YEAR 1)
NATIONAL	$0.06	$6.0	$5.4	$29.8	$12.9
WASHINGTON DC	-$1.0	$3.1	$4.1	$30.3	$10.0
TOP 2 DRIVERS	Maintenance Costs & Avoided Stormwater Infrastructure	Maintenance Costs & Avoided Stormwater Infrastructure	Maintenance Costs & Energy Savings	Biodiversity & Urban Heat Island	Longer leases & Rent

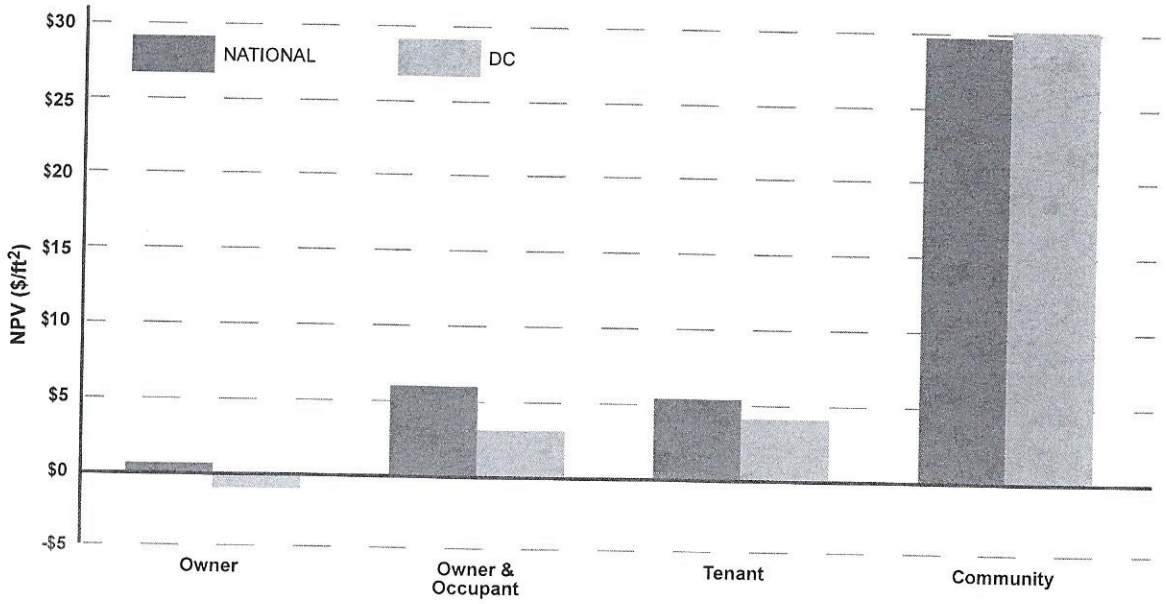


Figure 23: NPV of a green roof based on ones relationship to its real estate

3.5 DISCUSSION

The added cost of installing a green roof is mostly made up for by its increased longevity; however, the added maintenance costs are significant. Over a 50-year period, the stormwater, energy, carbon dioxide equivalent (CO_2e, which measures the potential global warming effect of a greenhouse gas) and community earnings of green roofs more than made up for the increased premium of installing and maintaining them. A detailed look at the net present value per square foot of roof on a cash flow basis shows an installation and replacement cost of -$1.10, as compared with a maintenance burden of -$16.89, for Washington DC.

Although building and site characteristics, stormwater regulations and energy costs vary greatly, long-term savings of green roofs help make up for their maintenance costs. The fewer floors a building has, the greater the energy savings will be. The greater the surface area of a green roof as a proportion of the overall site surface area, the greater the stormwater management savings will be. These savings are expected to increase as stormwater regulations become more stringent and green roofs are increasingly viewed as an acceptable stormwater mitigation measure.

As energy prices increase, the energy-related savings also will increase. The additional analysis suggests that the costs and benefits vary significantly depending on perspective. An owner/operator such as the GSA might yield strong financial benefits from replacing non-green roofs of their assets with green roofs. In the National Capital Region, if green roofs were to replace conventional roofs on all 54 million square feet of real estate (an estimated 5.9 million square feet of roof area*), this cost-benefit analysis projects a 50-year NPV of $22.7 million,† or $0.42 per square foot of building area. The community benefits in the National Capital Region could total almost $180 million, or $3.30 per square foot of building area.

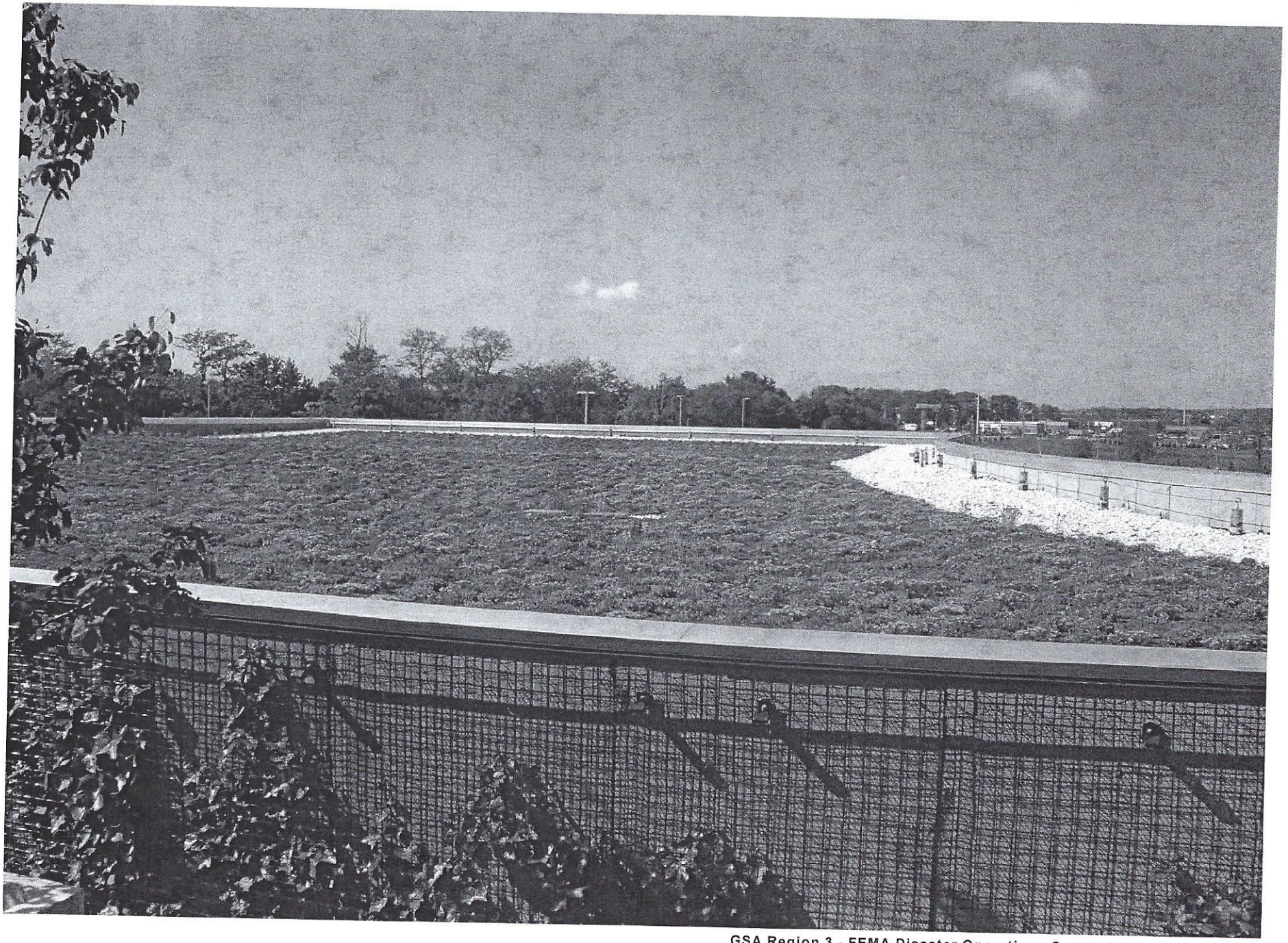
Significant consideration should be given to competing and symbiotic initiatives. This cost-benefit analysis does not consider the question of whether an existing building even needs a new roof. The decision of whether to install a green roof should consider the impact of this work on building tenants.

This analysis supports the general cost-benefit analysis finding that green roofs offer great potential savings and benefits. The specific real estate effect of green roofs, or their impact on real estate economics from a market and financial perspective, yields varying benefits that can affect a building's net operating income and market valuation. A onetime valuation of this real estate effect is similar to the NPV of the actual benefits, whereas the NPV of these ongoing savings and a greater building value are hard to realize.

The various aspects considered in the community portion of the cost-benefit analysis are only part of the actual impact of a green roof. If real estate value and the productivity of neighboring properties were included, the benefits would potentially far outweigh the costs. Similarly, the value and productivity of the building itself could add to the already positive NPV. Market acceptance of green roofs and the value of the work occurring in the space are two areas that need to be better understood before they can be accounted for.

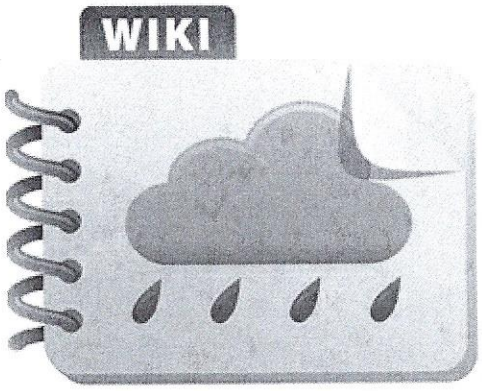
*This assumes a 9-story average for all GSA buildings in the National Capital Region

†This assumes a 24% owner/occupancy and 76% tenancy for GSA in the National Capital Region



GSA Region 3 - FEMA Disaster Operations Center, Winchester, Virginia
A 50,000 square foot extensive green roof planted on the new LEED Certified building (2008).

GSA



Cost-benefit considerations for green roofs

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.

Contents

Green roof capital costs

Green roof capital costs vary widely. Examples of important factors that influence green roof capital costs include:

- roof size: all other factors being equal (location, ease of access, etc), per square foot cost would typically decrease by a factor of at least 3 as size increases from a 1,000 square foot roof to a 20,000 square foot 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; and
- type of warranty.

Based on local projects, extensive green roofs in Minnesota typically range from $10 to $30 per square foot for the components above the waterproofing assembly and a simple irrigation system. These costs are consistent with costs noted in the literature (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.

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 (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 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 return on investment (ROI) of green roofs in 5 municipal regulatory environments and concluded "Local policy initiatives, however, can create direct incentives that result in positive 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.

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 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 should 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.

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, permeable 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 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.

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.

References

- 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.
- Green Roofs for Healthy Cities (GRHC). 2005. Green Roof Design 101 Introductory Course Participant Manual. Green Roofs for Healthy Cities and the Cardinal Group Inc.
- Miller, C., K. Weeks, B. Bass, R. Berghage, and S. Berg. 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.
- Peck, S.W. and M.E. Kuhn, 2002. Design Guidelines for Green Roofs. Report prepared for the Ontario Association of Architects and the Canada Mortgage and Housing Corporation, Toronto, Ontario.
- 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.
- Saiz, S., et al. 2006. *Comparative Life Cycle Assessment of Standard and Green Roofs*. Environmental Science and Technology 40: 4312-4316.
- 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.

Related pages

- Green roofs
- Overview for green roofs
- Types of green roofs
- Design criteria for green roofs
- Construction specifications for green roofs
- Assessing the performance of green roofs
- Operation and maintenance of green roofs
- **Cost-benefit considerations for green roofs**
- Plant lists for green roofs
- Case studies for green roofs
- Links for green roofs
- References for green roofs
- Supporting material for green roofs
- Green roofs terminology and glossary
- Green roof fact sheet
- Requirements, recommendations and information for using green roofs as a BMP in the MIDS calculator