The Cost of Green Roofs vs. Conventional Tar Roofs

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GPS: Power the World

Abstract

The goal of this project is to determine where it is economically feasible to have a green roof and where it will become cost effective. We will compare the energy savings in four cities of varying climates to discover where a green roof will become economically feasible and how long it will take to pay for itself compared to a conventional roof. The four cities that we have chosen are Los Angeles, Houston, Miami, and New York City. Los Angeles was chosen for its dry hot climate, Miami for its hot humid climate, Houston is a slight combination of Los Angeles and Miami, and New York for a northern temperate climate. We have also chosen a standard building size of 55'x55' to be hypothetically placed in each city. After researching the climates in each city, the cost of heating the buildings and the cost of a green roof, we took those numbers and calculated how long the payback period was for each city. We found that the payback period for the cities ranged from 300-400 years and that in southern warmer climates is best for a green roof.

Goal

The goal of this project is to determine whether the energy savings of green roofs versus conventional outweigh the costs in a reasonable amount of time in Houston, Miami, New York, and Los Angeles.

Background

There are many advantages to installing green roofs, which range from environmental benefits to economic savings. Some benefits have saving amounts on them while others may not be as easy to determine. The main benefit that has a dollar amount is the savings from heating and cooling costs, which is why many businesses are looking into installing green roofs. The layer of vegetation acts as an insulator which absorbs the heat from the sun to keep the building cooler in the summer and warmer in the winter. Another benefit that will save money is the roofing repairs. An ordinary tar roof requires roofing replacement after a certain amount of years, while green roof do not require roofing replacement because the vegetation protects the roof from the environmental elements.

The environmental benefits of green roofs do not have an exact dollar amount, due to the fact that its impact is on a much larger scale. Such benefits include reducing the amount if polluting storm water runoff. This does not have an exact dollar amount because it is hard to calculate all the factors that go into maintaining storm water runoff and being able to pin point the building's storm water runoff's role in it. Another environmental benefit is creating more green space in an urban environment to reduce carbon emissions. It is almost impossible to place a dollar amount on this benefit because there is no telling how much carbon dioxide is reduced and how to convert that to dollar amounts.

Methodology

In order to calculate the energy savings for having a green roof we used the site http://roofcalc.cadmusdev.com/RoofCalcBuildingInput.aspx. The site asks when the building was constructed, building type, days of operation, type of heating system, gas furnace efficiency, A/C seasonal efficiency ratio (SEER), roof insulation R-Value, existing dark roof solar reflectance, roof products solar reflectance, roof area, cost of electricity, cost of natural gas, and zip code.

For when the building was constructed we chose after 1980. Our building type is an office measured 55 by 55 ft and it operates 5 days a week. The type of heating system we chose was a gas furnace with moderate efficiency. The A/C SEER

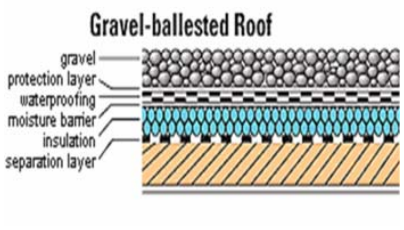
also had moderate efficiency. To calculate the value of R we used the thermal conductivity of soil with a moisture content of .75 W/m^2K. (http://soil.scijournals.org/cgi/content/full/64/4/1285/FIG6) Divide 1 by the thermal conductivity to get R. Doing this yields 1.33 m^2K/W. We then multiply the R value by 5.67 to convert to English units of ft^2Fhr/Btu resulting in 7.56ft^2Fhr/Btu. Because we have an intensive roof we will have two feet of soil so we multiply the r value of moist soil by two resulting in 15.12 ft^2Fhr/Btu. For a four inch fiberglass insulation layer the r value is 15 ft^2Fhr/Btu. The r value for gravel is 3.14 in^2Fhr/Btu. We need to convert this to feet yielding 37.68 ft^2Fhr/Btu. Because we have a five inch layer of gravel we have a r value of 15.7. The other materials included in the green roof are so thin they have negligible r values. Adding the r values of moist soil, fiberglass insulation and gravel we get 45.82 ft^2Fhr/Btu. Because the calculator we used compares green roofs to traditional roofs, the calculator has the r value of traditional roofs built in.

We chose a value of .05 for existing dark roof solar reflectance because a typical roof is covered in black tar which has a solar reflectance value less than .1. For solar reflectance the green roof has a value of .25 which is the solar reflectance of grass. Our roof has an area of approximately 16,000 square feet. The average cost of electricity in New York is 15.51, for California its 14.33, for Texas its 9.85, and for Florida its 9.91 cents/kwh. (http://www.eia.doe.gov/cneaf/electricity/esr/table4.xls) The average cost of natural gas is 121.8 cents/therm. (http://www.npga.org/i4a/pages/index.cfm?pageid=914)

Green Roof

Vs.

Asphalt Roof



Results

	Roof Costs				
	Material Cost per Sq. Ft	Construction + Material Costs per Sq. Ft	Total Construction + Material Costs	Yearly Matienance Cost	Total Cost per year
Green Roof	156	224	677600	84.5	11378
Conventional Asaphalt		6	18150		908

Energy Savings			
Cities	Electricity Savings (per year)	Natural Gas Savings (per year)	Total Energy savings (per year)
New York City	31.17	-4.47	26.70
Los Angeles	30.83	0.81	31.64
Miami	33.45	0.28	33.73
Houston	28.45	0.97	29.42

Total Cost Difference and Payback Time		
Cities	Total Cost Difference	Payback T ime (years)
New York City	10443.63	391
Los Angeles	10438.69	330
Miami	10436.60	309
Houston	10440.91	355

Conclusion

Through our project we discovered that it takes about 300-400 years to payback the initial costs of a green roof. We decided that Miami would payback in the least amount of time or in 309 years. We found that the payback period is shorter in warmer climates. This is mainly because in the winter the insulation for a green roof has a greater R-value but because the solar reflectance is greater then an asphalt roof the rooms below are not warmed by the sun, thus requiring more energy spent for heat. This is the reason why New York City has the longest payback period.

It is possible that the calculator we used to find the savings was not accurate. So using a more detailed calculator or writing out the calculations would give an accurate measure of the energy savings of a green roof with a smaller error percentage. Alternatively we could use a different sized roof and/or use an extensive green roof instead, in order to decrease the payback period.

In a further investigation of roof design we might want to compare different types of high reflectance roofs, with green roofs and conventional roofs. "Surface heat budget on green roof and high reflection roof for mitigation of urban heat island," is a journal article by Hideki Takebayashi and Masakazu Moriyamahigh, which gives a detailed comparison between those types of roofs. By starting of with that article we could expand on it and find the energy savings of each in multiple cities in the United States.

Contact information

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