First Cost Analysis

6.1 - Material and Labor

Built-up flat roofs are very cheap. RS Means estimates the costs of a typical built-up roof around $2 per square foot.

There have been many reports estimating the cost of green roofs throughout the US. There is a wide range, and the number is dependant on the type of project. RS Means could not be used to estimate the cost of a green roof because there is not enough data to accurately portray the market. One Google search will yield price ranges from $10-$30 dollars per square foot. For this report, it was assume that cost of the green roof was $14 per square foot. This includes all the material, labor, and instillation costs. A Green roof built in Washington DC estimated the costs of their roof to $14.43/sf. Since the project was a retrofit, I reduced the price by a small amount.

Using these numbers, the difference between a green roof and a built-up roof is an increase of $12 per square foot.

6.2 - Structural Costs

RS Means was used to estimate the material and labor costs of the four different types of columns used in the redesign. The information used is shown in Table 10. A location factor of 0.897 for Silver Spring Maryland was used. There was no time factor applied because the cost data is from 2006.

Table 10 – RS Means Data (2006)

RS Means Construction Cost Data 2006				
Type	Crew	Daily Output	Unit	Total Cost (Material + Labor Costs)
Formwork in place - 14" Diameter Round Fiber Tube	C1	145	LF	$10.43
Formwork in place - 30" Diameter Round Fiber Tube	C1	125	LF	$19.00
Formwork in place - 12" x 12" Job Built Plywood	C1	180	SFCA	$5.48
Formwork in place - 24" x 24" Job Built Plywood	C1	190	SFCA	$8.19
Reinforcement in place - #3 - #7 Column	4Rdm	2.3	ton	$1,700.00
Reinforcement in place - #8 > Column	4Rdm	1.5	ton	$1,405.00
Cast in place Concrete Mix - 3000psi	-	-	CY	$87.00
Column in place - 14" Diameter	C14A	26.23	CY	$564.75
Column in place - 30" Diameter	C14A	63.45	CY	$351.25
Column in place - 12" x 12"	C14A	11.96	CY	$960.50
Column in place - 24" x 24"	C14A	23.66	CY	$537.50

Even though the smaller columns were about half the size, the cost savings for installation and material were greater than that amount. The total cost of each column is:

Large Circular Column (30" Diameter) - $1,992
Small Circular Column (14" Diameter) - $875
Large Rectangular Column (24" x 24") - $3,203
Small Rectangular Column (12" x 12") - $1,253

By comparing these prices to Table 9, the structural savings was calculated for each off design condition. Obviously, as the green roof is decreased in size, the structural costs decrease. Even though the relation between the size of the green roof and the structural costs were not perfectly linear, the average additional structural support ended up costing about an additional $2.50 per square foot.

6.3 - Bio-Retention System Costs

Greenhorne and O'mara, the civil engineering design firm in charge of the project was able to supply an estimated cost of $30,000 per impervious acre of roof for a bio-retention. This number is their average cost of the system from all their past projects. They were also able to estimate the cost of a sand filter system to be about twice as much compared to that of a rain garden. These estimates are only useable for impervious areas of about 0.3 acres and greater. Obviously, if the impervious area was only 0.1 acres, it would cost more then $1,000 to install a bio-retention system. It was estimated that a minimum cost of a bio-retention system is around $5,000.

The location of the Central Shared Use Facility allows room for a bio-retention system. For cost analysis, it was assumed that a rain garden was already in place, and would only need to be expanded. By adding the green roof, the building owner saved about $0.69 per square foot on a bio-retention system.

6.4 - Mechanical Systems

The air handling unit costs were estimated with RS Means 2006. At the time this report was posted, a representative for York could not be reached to estimate the costs of their units. The reduced size of the air handling units saved an average of $2.25 per square foot of Green Roof.

Table 11 – Additional First Costs

Green Roof (%)	Material/Labor ($)	Structural ($)	Bio-Retention ($)	Mech. Eq. ($)	Total ($)
66	209,880	43,725	-12,068	-39,353	202,184
60	190,800	39,750	-10,971	-35,775	183,804
55	174,900	36,438	-10,057	-32,794	168,487
50	159,000	33,125	-9,143	-29,813	153,170
45	143,100	29,813	-8,228	-26,831	137,853
40	127,200	26,500	-7,314	-23,850	122,536
35	111,300	23,188	-6,400	-20,869	107,219
30	95,400	19,875	-5,486	-17,888	91,902

Lifetime Cost Analysis

7.1 - Annual Operating Costs

The energy savings produced by a green roof provide some relief for the heightened cost. The central utility plant supplying the CSUF reported that they are currently paying $0.10/kWh. The initial cost of their electrical generation was only about $0.05/kWh, but the cost of gas has increased significantly over the last couple years.

Table 12 sums up the estimated and simulated energy savings. As noted in section 4.1, the estimated energy savings are the savings predicted by studies done on existing buildings which found a reduced energy cost of about 50% with a fully designed green roof. The simulated energy savings use the results calculated by TRACE700.

Table 12 – Annual Energy Cost Savings

Green Roof (%)	Simulated On-Peak Electrical Consumption Decrease (kWh)	Simulated Savings ($)	Estimated On-Peak Electrical Consumption Decrease (kWh)	Estimated Savings ($)
66	32,475	3,248	258,250	25,825
60	29,035	2,904	234,773	23,477
55	26,178	2,618	215,208	21,521
50	23,095	2,310	195,644	19,564
45	20,200	2,020	176,080	17,608
40	17,609	1,761	156,515	15,652
35	15,189	1,519	136,951	13,695
30	12,055	1,206	117,386	11,739

Table 12 shows that the energy savings calculated by TRACE are much lower than that seen in existing buildings. If the TRACE results are used, the estimated payback period is around 60+ years for the designed (66%) green roof. This is clearly not acceptable. When looking at the results from existing buildings, the estimated energy savings will yield a payback period of only 7-10 years for the designed green roof.

7.2 – Maintenance Costs

The maintenance cost of a green roof is a topic of controversy. There is no collected data on these costs, and some people claim that a green roof requires zero maintenance. To estimate the costs of maintaining a green roof, I compared the green roof to a garden. Since the growing material is not sod, but instead small plants, no mowing is required. However, there may be small weeding, and watering necessary. It was assumed that one person would spend about 5 hours a week maintaining a green roof. This covered watering, weeding, and the time spent walking around the roof to check on it. This would only be done about 5 months out of the year. This is because during the winter months and periods of no growth, there would be no need for watering or weeding. The location of the CSUF is in Silver Spring Maryland, right outside of DC, so the estimated cost of the worker was $15 per hour. These assumptions calculated an annual maintenance cost of $1500.

To estimate the maintenance of a built-up roof, the same process was used. It was estimated that the same man would be hired to check the roof, but would need to do so 10 months over the course of a year. January and February were not counted because most likely snow will be covering the roof in those months and it would be impossible to check the roof. It was also assumed that the roof would only need to be repaired or worked on once a month instead of once a week. However, additional materials would be required to repair a crack in the roof, so this material cost was estimated at $10. The cost of the salary of the worker was assumed to be the same. With these assumptions, the annual maintenance cost was also equal to $1500.

Even though the annual maintenance costs of a green roof and built-up roof are probably the same, one benefit of a green roof is that the roof membrane is protected. This increases the lifespan of the roof itself. The lifespan of a built-up roof is about 15 years. The lifespan of a green roof is about the lifetime of the building itself. This means that every 12 years, an existing built-up roof will need to be completely replaced.

By combining the estimated energy savings and the lifetime savings of a green roof compared to a built-up roof, it can be estimated that the buyback period for a green roof is probably less than 10 years. Therefore, green roofs are very reasonable investments.