

## Planning Study Helps Boston Prioritize Sustainable Roof Technologies

A planning study evaluating the feasibility of retrofitting Boston's existing buildings with green roofs or alternative systems has developed construction, procurement, and maintenance standards; identified cost parameters; and performed lifecycle cost analyses on 44 facilities scheduled for reroofing under the city's ongoing capital maintenance plan. Funded by a grant from the Massachusetts Department of Environmental Protection (DEP) and commissioned by Boston's Property and Construction Management Department (PCMD) through DEP funding, the study is expected to be a model for other Massachusetts municipalities.

In 2007, as part of a long-term comprehensive approach to climate change policy, sustainable design, and green build-

ings, Boston Mayor Thomas M. Menino issued an executive order outlining broad initiatives to help reduce the city's greenhouse gas emissions. Included is a requirement that all city-owned buildings be evaluated for the feasibility of installing sustainable design features such as green roofs and power generated through solar, wind, or bio-energy. Roofs that scored high in the initial feasibility analysis are being considered for a sustainable roof in the city's capital planning process.

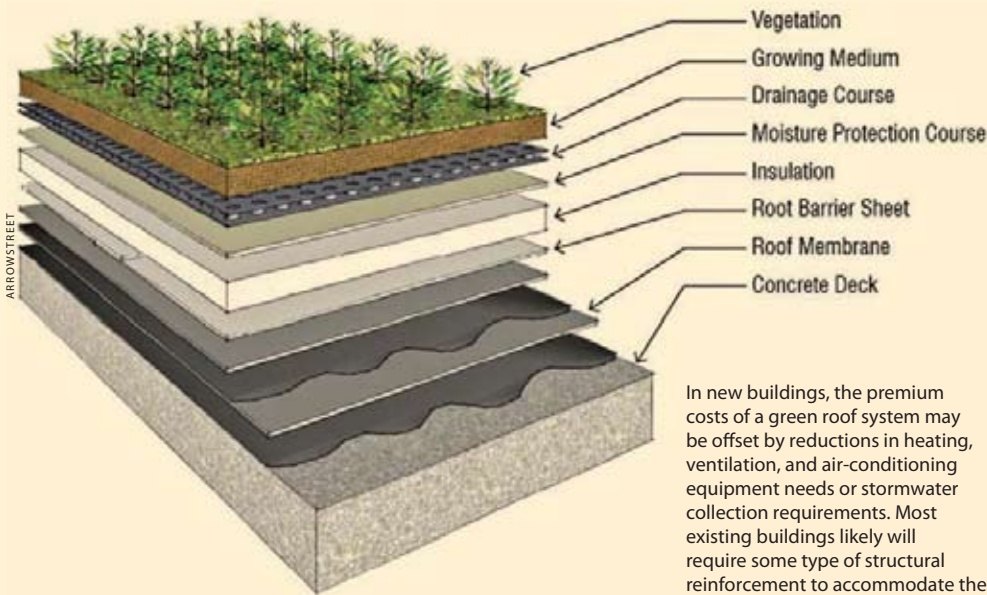
The city owns several hundred buildings, ranging in size from small brick fire stations to large downtown office buildings. Menino's executive order proved to be a challenge to the PCMD, which oversees planning, design, and construction of municipal buildings. Understanding green roof construction is one thing; figuring out how to implement it over several hundred buildings is another. The planning study, which has developed selection criteria and a database on municipal buildings, provided a shortlist of buildings that may be the best candidates for a green roof retrofit.

Although the study focused on green roofs, it quickly became apparent that other types of sustainable roofs also should be considered. These included cool (light-colored) roofing membranes for buildings unable to support the additional load of a planted roof, and integrated photovoltaic roof membranes, a recent development from Europe that is starting to be used in the United States. Some advocates expressed an interest in rooftop agriculture as a source of additional benefits from green roofs.

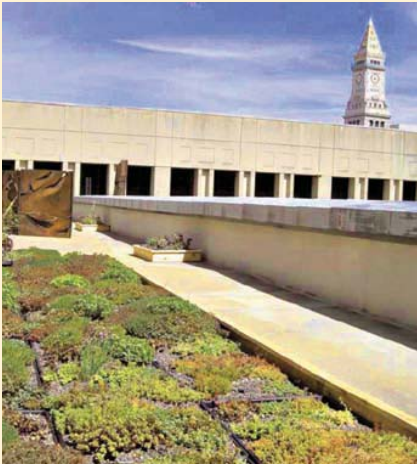
The study found that in the Boston area, a green roof system, including protection membranes, growing medium, and plants, can cost \$12 to \$15 per square foot (\$129 to \$161 per sq m), or about twice the cost of a typical roof membrane system. For new buildings, these premium costs may be offset by reductions in heating, ventilation, and air-conditioning (HVAC) equipment needs or stormwater collection requirements.

For existing buildings, installation of a green roof typically can be more difficult than for a new building unless it is part of a broader renovation project. In addition, most buildings likely will require some type of structural reinforcing to accommodate the additional weight of a green roof. Concrete-framed buildings are more likely to be able to support a green roof; wood-framed buildings less likely. Additional secondary modifications may also be required for installation of the structural reinforcement, such as removal and replacement of interior finishes or relocation of existing mechanical, electrical, plumbing, or fire-prevention systems.

The study's lifecycle cost analyses compared the city's standard modified bitumen roof with a light-colored roof and a green roof to determine the cost benefits. The analysis included direct benefits such as potential energy savings, but did not include indirect benefits such as reduction of the heat-island effect or increased biodiversity. The analyses suggest that the payback



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In Boston, all city-owned buildings, including City Hall, must be evaluated for the feasibility of installing sustainable design features such as green roofs.

for the additional capital costs of a green roof varies between 40 to 60 years, depending on the cost of the installation, retrofit work required for the existing building, and the potential for energy savings. In terms of payback, a heavily insulated white roof is probably more cost-effective in Boston than a green roof because of the cold climate and relatively short cooling season.

The study's selection protocol establishes a point rating system for different building parameters, including location, construction system, existing roof condition, maintenance access, potential user benefits, and other considerations. By processing building information such as size, structural framing system, and other parameters in the green roof database, PCMD is now able to establish a shortlist of potential candidates for further study. The database has the added benefit of allowing the city to collect, store, and process other information about its building inventory.

The shortlist includes a variety of different building types, such as police and fire stations, libraries, and several community centers. They are flat-roofed struc-

Green Roof Loading Requirements			
	Concrete Deck	Metal Deck	Wood Deck
<b>Dead Load</b>	50 - 60 psf	20 - 30 psf	20 - 30 psf
<b>Snow Load</b>	32 psf	32 psf	32 psf
<b>Total Load</b>	<b>82 - 92 psf</b>	<b>52 - 62 psf</b>	<b>52 - 62 psf</b>
<b>Extensive Green Roof Weight</b> (saturated, soil ht. 1 - 4.75")	± 12 - 38 psf	± 12 - 38 psf	± 12 - 38 psf
<b>Total Load w/ Green Roof</b>	<b>94 - 130 psf</b>	<b>64 - 100 psf</b>	<b>64 - 100 psf</b>
<b>Increased Load %</b>	<b>15 - 41%</b>	<b>23 - 61%</b>	<b>23 - 61%</b>
<b>Live Load Considerations</b>			
<b>Live Load</b> (occupied use)	100 psf		

Source: Massachusetts State Building Code/DM Berg Structural Engineers.

tures with concrete or metal deck framing and have enough area available for a green roof—more than 2,000 square feet (185 sq m) of clear roof area, not including HVAC equipment, roof edges, parapets, and the like. The next phase of the study will include preliminary roof design, structural analysis, energy modeling, and cost estimates to understand in more detail whether a green roof is practicable.

Boston is also considering a pilot program to evaluate and construct prototypical green roofs on a few buildings as a test for a broader retrofit program. "This study is a great benefit to help us prioritize our capital investments in green and sustainable technologies," notes Joe Mulligan, the city's deputy director for capital construction.

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The table above illustrates the loading requirements for green roofs, indicating that the additional load created by a green roof will vary greatly depending on the thickness of the growing medium, types of plants, and waterproofing system. For an extensive green roof 4 to 6 inches (10-15 cm) thick, the additional load can range from 15 to 35 pounds per square foot (psf). The table lists typical loading requirements for different structural systems—concrete, metal deck, and wood—and includes both the dead load (the weight of the structure itself) and the code-required live load for snow loading, not including snowdrift factors. The additional load from a green roof can result in an increase of 15 to 40 percent for concrete structures and 25 to 60 percent for metal-deck and wood-framed structures. In addition, if a green roof is occupied, a code-required 100 psf live load factor needs to be included.