



**PHOTOVOLTAICS & VEGETATIVE
ROOF INFORMATION**

Greater Bridgeport Transit

Bus Maintenance Facility

Photovoltaic's and Vegetative Roof

Information

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Introduction



Figure 1. Interior View of GBT Maintenance Facility.

The Greater Bridgeport Transit Authority (GBT) is planning to replace the maintenance facility roof which is over 80,000 sq. ft. (Figure 1). The roof replacement is part of a project which seeks to incorporate a photovoltaic system and a vegetative roof (Figure 2). These two environmentally-beneficial systems would contribute to a healthier environment for the Greater Bridgeport area, which currently is implementing an initiative to a greener and healthier city. The systems will demonstrate how GBT is committed to improving the environment in ways other than providing efficient, safe, and environmentally friendly public transportation.



Figure 2. Aerial photo showing the future maintenance roof design.



Photovoltaics



Figure 3. Photovoltaic Roof Panels

GBT seeks to incorporate a 200,000 watt photovoltaic (PV) system on the maintenance roof. The photovoltaic system utilizes solar energy to produce electricity through the use of silicon PV collectors (Figure 3). The system would benefit the community and GBT in many ways including cost savings; savings will be achieved because the roof life is extended since the roof membrane provided by the PV tiles allows for shading and therefore, a replacement roof can be delayed years beyond the normal life expectancy of the typical roof. The majority of the savings associated with a PV system are derived from the reduced amount of utility-provided electricity required to serve the facility. An estimate of the electric energy savings of a 200 kW crystalline PV system based on current electric rates installed on the maintenance building roof is approximately \$34,000 per year. A simple payback, including an estimated escalation in the cost of electricity at 3% annually, results in amortized electric savings of approximately \$52,000/year. The resulting simple payback is calculated:

$$\frac{\$1,200,000 \text{ equip. and install.} - \$3,000 \text{ offset roof materials}}{\$52,000/\text{year electric bill saving}} = 23 \text{ years}$$



Figure 4. One coal car carries approximately 110 tons of coal which roughly produces 2300 kwh

Reducing the consumption of utility-provided electricity, primarily generated by the combustion of fossil fuels (Figure 4⁴), offsets the amount of carbon dioxide greenhouse gas emissions into the environment. The annual amount of electricity expected to be produced by the 200 kW photovoltaic system is approximately 316,000 kWh. This amount of energy reduction from the local utility is equivalent to removing 133 metric tons of carbon dioxide emissions from the environment each year.

Unlike most electric generation systems, the annual maintenance of PV arrays is minimal. An annual cleaning of the panel faces (that involves wiping the panels with a wet sponge and drawing a squeegee over the surface similar to cleaning an automobile windshield) is all that is typically required. Maintenance of the electronics equipment is no different than the preventative maintenance required by any other electrical equipment.



Vegetative Roof

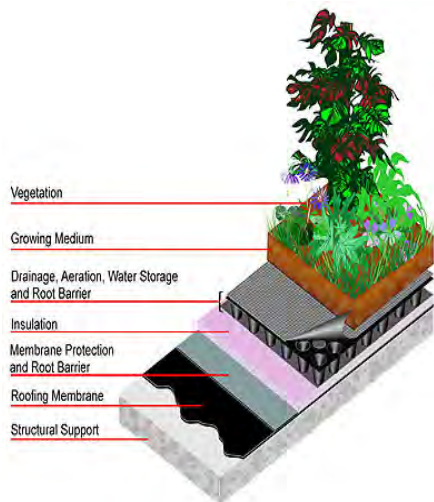


Figure 5. Typical vegetative roof assembly

In addition to PV, GBT will incorporate a vegetative roof as an integral part of the new maintenance roof (Figure 5²). The 22,000 sq. ft vegetative roof will retain roughly 70% of the rain water that falls on the vegetative roof thus preventing this water from entering the storm water utility system¹. This process reduces the utility cost to GBT and reduces the burden on the public system which decreases the need to expand or rebuild the related infrastructure. Plant substrate is eventually utilized to provide water for the plants and is returned into the atmosphere through transpiration and evaporation (Figure 6³). The roof system designed for the maintenance roof will require little or no maintenance during the year.

In addition to redirecting storm water runoff, the vegetative roof provides protection from solar radiation (including solar degradation and heat build up). This is the chief element responsible for roof degradation so providing a natural shelter for the roof membrane will increase its life expectancy. The protection from the sun's rays is estimated to double the life expectancy of a roof system. The heat build up on the roof causes an effect know as and urban heat island. The urban heat island effect is the difference in temperature between a city and the surrounding countryside. The effect is caused by large expanses of hard surfaces which absorb solar radiation and re-radiate it as heat. The heat is re-radiated during the night which does not allow the surrounding area to cool¹. The vegetative roof prevents this accumulation of heat through the daily dew and evaporation cycle. A 10.76 sq ft of foliage can evaporate up to 700 liters of water annually¹. The GBT roof is anticipated to have 37,809 gallons of water evaporate annually to help reduce the heat island effect. On a typical summer day, a gravel roof surface's temperature can range from 77 to 176° F but a vegetative roof would not rise above 77° F , resulting

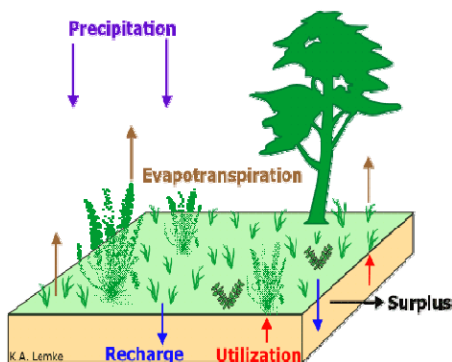


Figure 6. Evapotranspiration process

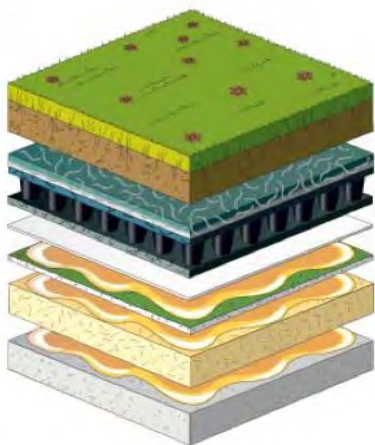


Figure 7. Typical Extensive Roof System

in energy savings for the facility¹. Studies have shown that enough green roofs in a city can reduce the average summer temperature by 1 to 2° F which would reduce energy consumption and create a more thermally-tolerable environment.¹

The vegetative roof contributes to the reduced energy cost of the facility in many ways including an increased insulation value on the roof (Figure 7⁵). The increased insulation aids in the payback of the vegetative roof which could be achieved in as little as 3 years because the summer cooling and winter heating loads can be reduced by as much as 25% ¹. The reduced heat load on the building creates less demand for the HVAC system, increasing the useful life of the system and reducing the energy demand. The vegetative roof also reduces the transmission of sound from areas such as the commuter rail (Figure 8) to the south which provides a more peaceful and productive work environment.



Figure 8. View from the maintenance roof looking at the commuter/freight/passenger rail

In addition to the thermal and cost benefits, the roof provides a healthier environment for the community at large by providing a natural air filter. Thus, a 10.76 sq ft vegetative roof will remove up to 4.4 lbs of airborne particles from the air every year ¹. The 22,000 sq. ft. vegetative roof is anticipated to remove 9,000 lbs. of airborne particles each year. The roof will also support wildlife within a city environment such as insect and nesting birds, thereby providing a safe place for habitats to establish and dynamically maintain the environment.



Conclusion



Figure 9. Vegetative Roof after 1 year of growth

The systems described in this paper discuss the benefits that PV and vegetative roofs provide, including a healthier environment (Figure 9⁶) and reduced energy costs and burden on public infrastructure for the citizens (Figure 10). The use of these elements displays environmentally conscious leadership and provides an opportunity to educate facility owners, transit providers and citizens of the benefits of photovoltaic's and vegetative roofs. This project hopes to inspire additional green designs within the City of Bridgeport and other transit facilities across the country.



Figure 10. Photovoltaic array



References

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