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Design of a Rooftop Photovoltaic Array for the George C. Gordon Library at Worcester Polytechnic Institute: Structural, Thermal, and Performance Analysis

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EXECUTIVE SUMMARY

A rooftop photovoltaic array has been designed for the George C. Gordon library at WPI. The photovoltaic array is made up of 96 Evergreen Solar photovoltaic modules tilted at 27 degrees and oriented along the southern face of the library rooftop. This configuration is expected to produce over 27,000 kWh annually and offset over 56,000 lbs carbon dioxide emissions that would have otherwise been generated from conventional power generation. This solar array designed to meet the electrical needs of the library. It is also designed to be connected to the electrical grid so that extra power produced is fed into the grid. A performance analysis of this photovoltaic system design is presented. The performance analysis assumes that WPI is awarded the following federal and state incentives which were available in 2009:

- 30% grant from the U.S. Department of Treasury
- 25% grant from the U.S. Department of Agriculture
- 30% federal tax credit
- $162,500 grant from the Massachusetts Solar Stimulus

Based on the above incentives and assuming WPI pays for the remainder of the photovoltaic system upfront, the calculated payback period is 1.5 years. The system is expected to last 25-30 years, which makes this system a very valuable investment.
An important part of the design of the photovoltaic system is to ensure that the photovoltaic modules and mounting system will withstand environmental loads common to Worcester, MA such as wind, snow, ice, and hail. Structural analysis using ANSYS™ simulation software is presented in this thesis for a variety of commercial photovoltaic modules and two different mounting systems: attached and ballasted. Attached mounting systems are drilled into the roofing material whereas ballasted mounting systems are placed on the

roof and weighed down with concrete blocks. The structural analysis proves that the Evergreen Solar photovoltaic modules will withstand these structural loads and reveals that an attached mounting system has higher performance than a ballasted mounting system under the same loading conditions. Another important aspect of photovoltaic system design is the effect of photovoltaic module operating temperature on the performance of the system. It is well known that the performance of the system will decrease as the operating temperature increases. In this thesis, a thermal analysis of three different photovoltaic modules was completed and the temperature map generated from the ANSYS™ simulation software was used to observe the structural effects of temperature changes and to develop a correlation of the operating temperature to system performance. The most important result of this analysis shows that the Evergreen Solar photovoltaic module will have higher performance in the Worcester climate than other photovoltaic materials such as cadmium telluride.

WPI has recognized the need for improving campus environmental performance and has formed a Presidential Task Force to engage the WPI community in sustainability. One of the main objectives is to increase energy conservation on campus. Implementing a photovoltaic system on the library rooftop will not only increase clean energy and decrease carbon emissions on campus. it would also bring general awareness to the state, city, and college community of the advantages of the use of photovoltaic energy in New England. This array will also provide the opportunity for future student project work on the performance and maintenance of the system.