Measurement on Heat Balance of Solar Panels and Simulation for Influence of Large-scale Introduction of Solar Panels in Tokyo

Qinyu Yang GPSS, ID 47-176848
Advisor: Associate Professor Tomohiko Ihara
Co-advisor: Professor Yoshikuni Yoshida

ABSTRACT

The development of photovoltaic panels (PV in short) has gone through a rapid period in the last few years all over the world with efforts from researchers and huge subsidy from governments. Apart from the traditional silicon-based materials, the heated PV materials, e.g., amorphous silicon (a-si), CIGS thin film and some advanced PV systems are showing their potential no matter talking from carbon dioxide reduction effect or market share. The great environmental performance of these PV systems to control greenhouse gas emission has already been widely researched while other sides of environmental impact such as air temperature change are paid less attention to.

On the other hand, the introduction of PV systems is imperative in Japan under the condition of the historically low primary energy self-sufficiency, increasing concern on the energy safety in the emergency after the Tohoku earthquake, along with "The New Basic Energy Plan" by Ministry of Economy, Trade and Industry (METI). The study area is the Tokyo metropolitan, the largest metropolitan area in the world, with approximately 30 percent of the Japanese population living here.

This study turns the eyes to the balance of heat and energy of three PV materials and their application in the urban areas. The general objective is to study the energy change and air

temperature brought by large-scale application of solar panels in Tokyo metropolitan. To realize the goal, two specific objectives were investigated:

1) to measure the heat budget of three different PV materials to identify the thermodynamic parameters which work as the input data in the following simulation part. This measurement was done in National Institute of Advanced Industrial Science and Technology, focusing on the reflectivity of short wavelength radiation (albedo) and longwave length radiation (emissivity). The results show that the actual proportion of solar irradiation to be electricity is much less than the part to exchange heat.

2) to identify the air temperature change and energy consumption change by the deployment of solar panels on the rooftop in each grid in the Tokyo metropolitan. This simulation is accomplished by canopy modeling and building energy modeling (CM-BEM). The results show that the cooling loads in August 2006 will be lower in almost all grids although the air temperature will be slightly higher than the baseline in some grids. The correlation analysis is also conducted for each grid to find out the most important factor to decide these changes. The building coverage was considered to be the most important factor.

The study garnered satisfying results for each objective, but there are still some limitations. For instance, the simulation period of CMBEM is set as August 2006 only, thus the situation in the winter could not be answered yet. Currently, what we can learn from this research is that the introduction of each PV panels (a-si, multi-si, CIGS) in Tokyo metropolitan will slightly enhance the air temperature but significantly reduce cooling loads based on the meteorological data in August 2006.

Key words: Heat balance; Solar panels; Heat island effect