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Coupled Water and Energy Balance Models for Green Roof Systems

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To reduce energy demand and storm water pollution are crucial issues for Taiwan. Because of the over development in Taiwan, not only the energy supply may gradually become insufficient but also the environment pollution is getting worse. It is more and more difficult to develop centralized systems to solve these problems. Thus, distributed adaptive system is required, which each building should share responsibilities to reduce storm water and energy demand. Air temperature is easily higher than 35oC in summer and autumn seasons, while rainfall intensity of 181mm/hour has been observed currently in Taiwan. Climate change may cause higher temperature and more intensive rainfall. The traditional black and impervious rooftops cannot block solar energy and thus may have higher indoor temperature that will require more energy for air conditioner. Besides, those rainfalls on rooftop may very quickly discharge to ground and thus result in high storm water, which may cause more serious flood and pollution. Today, building green roofs has become one of the most efficiency solutions for solving these problems. Green roofs have been in use in Europe for centuries and are more recent applications in the U.S. But, there are limited research and information on quantifying the function of green roofs for Taiwan. Thus, the purpose of this study is to develop models to simulate both water and energy balance for a building. The components of hydrological process of green roof include infiltration, percolation, evapotranspiration, and discharge from rooftop. A rainfall harvesting system is also designed, which can reduce storm water and save water for later uses. On the other hand, an energy balance model is developed, which includes components of solar radiation, long wave radiation, sensible heat, latent heat, conduction, convection, etc.. The linkage between water balance and energy balance is considered through evapotranspiration and its associated latent heat. After developing models to couple water and energy balance for a green roof, some further applications are done, including effects on storm water reduction, rainfall harvesting systems and water demand, building in door temperature and energy saving. Furthermore, this study focuses on a single building. How to advance the coupled water and energy models to a community is also discussed in this study.

Keywords: Green Roof, Energy Balance, Water Balance, Rainwater Harvesting, Storm Water.