A critical review of heat and mass transfer in vegetative roof models used in building energy and urban enviroment simulation tools

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Abstract

Vegetated or green roofs are sustainable roofing systems that have become increasingly widespread across the world in recent decades. However, their design requires accurate numerical modeling to fully realize the benefits of this technology at the building and larger scales. For this reason, several heat and mass transfer models for vegetated roofs have been developed over the last 36 years. This paper provides a critical review of more than 23 heat transfer vegetative roof models developed between 1982 and 2018 that have been used for building energy or urban modeling purposes. Findings of the study include the following: (i) more than 55% of the vegetated roof models have been developed and validated using data from warm temperate climate zones; (ii) green roof validation efforts vary and do not follow a common verification and validation framework; (iii) four of the reviewed models have not been subjected to any simulation process; (iv) no model has been validated for semi-arid conditions or cold climates or during cold winter conditions; (v) the most common variable reported for validation (in more than half of the models) is substrate surface temperature; however, surface temperature does not fully test the accuracy of a model to represent all heat and mass transfer phenomena; (vi) practitioners access to these models is limited since only five of the 23 models have been implemented in whole-building energy models, such as EnergyPlus, TRNSYS, ESP-r, and WUFI; finally, (vii) despite the extensive studies on the impacts of vegetative roofs on building energy performance and urban temperature reduction, no studies have validated the model using whole-building energy data or at larger scales.

Keywords

Green roof, Heat transfer, Building energy simulation, Evapotranspiration, Vegetated roof