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ScienceDirect

Procedia Engineering 205 (2017) 2839–2846

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Symposium on Heating, Ventilation and Air Conditioning, ISHVAC2017, 19-22 October 2017, Jinan, China

Assessing the Impact of Urban Heat Island Effect on Building Cooling Load based on the Local Climate Zone Scheme

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Abstract

The impact of urban heat island on building cooling load is assessed based upon the Local Climate Zone (LCZ) scheme. The field observed data from the nine LCZ sites in Nanjing, China, for the period from 21 July to 30 September 2016 were used to generate new EnergyPlus Weather (EPW) files. Then the cooling loads of a typical office building and apartment building were simulated with EnergyPlus. The heat island features of the LCZs and their impacts on building cooling load were analyzed. For the whole studied period, the cooling load increases for the office building and the apartment building range between 4.0%–7.1% and 11.2%–25.2%, respectively. For the night time (19:00–06:00) of the 22 identified days with the weather condition of light winds and clear skies, the cooling load increases of the apartment building range from 12.8% to 52.5%.

*Keywords:*Heat island magnitude; local climate zone; field observation; EnergyPlus

1. Introduction

One of the best-known effects of urbanization is urban heat island (UHI). The UHI results in an increased cooling energy demand in summer. There has been much work on this area. For Athens, Greece, measured air temperature data from the network of urban climate stations have been used as inputs to a building energy software to assess the

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1877-7058 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.
10.1016/j.proeng.2017.09.904

cooling load of a typical office building [1]. It was found that, compared with the rural area, the urban cooling load may be doubled and the peak electricity load forcooling may be tripled. However, investigators rarely provide detailed descriptions about the local characteristics of urban climate stations in the literatures. The observed temperature from a site is significantly affected by its local surrounding (surface structure, land cover, anthropogenic heat flux, etc.). Therefore, it is necessary to explore the connection among local surrounding, local thermal climate, and building energy demand on-site.

The Local Climate Zone (LCZ) scheme, developed by Stewart and Oke [2], aims to provide an objective and standardized classification protocol for urban temperature studies in any city. A Local Climate Zone is defined as an area with a minimum radius of 200–500 m which has uniform features in terms of surface cover, structure, material, and human activity. Each LCZ has a characteristic screen-height temperature regime that is most evident on calm, clear nights. The evaluations of the LCZ scheme and its application in analyzing heat island have been increasingly reported from various cities around the world [3-6]. So far, there is a lack of studies using the LCZ scheme to evaluate building energy demands.

This work attempts to assess the impact of heat islandon building cooling load with the observed data from the nine LCZ sites in Nanjing, China, for the period from 21 July to 30 September 2016. The heat island features of the LCZs and their impact onthe cooling loads of a typical office building and apartment building were analyzed.

2. Methods

2.1. Temperature observation based on the LCZ scheme

Nanjing, which covers an area of 860 km^2 with a population of more than 8 million, is located in the Yangtze River Delta (32°49′ N, 118°48′ E). Nanjing endures a hot summer and cold winter climate, with a daily average temperature between 28.6 ℃ (Jul.) and 2.2 ℃ (Jan.). According to the indicators and illustrationsofthe LCZ scheme[2], 12 LCZ sites were selected by viewing satellite images, field visit, and urban indicators calculations. Since there is no building in three of the sites (LCZ A: *dense trees*, LCZ D: *low plans*, and LCZ G: *water*), the nine LCZ sites were investigated for assessing the impact of heat island on building cooling load. The locations of these LCZ sites vary from the downtown district to the periphery of Nanjing. The classifications, photos, and indicators values for the selected nine LCZ sites are provided in Table 1.The values of the morphological and surface indicators of three LCZ sites do not exactly match with the values of any single standard LCZ type. According to the LCZ scheme, new subclasses were applied to the three sites, namely LCZ 2_E, LCZ 3_2, LCZ 6_5 (where the subscript is the lower parent LCZ class).

Temperature data were collected from the three fixed observation points located within the core area of each site (within a radius of 100 m). Each observation point housed a HOBO Temp/RH data logger (type U23-001, precision ±0.2 K/±2.5%) in a matching louvred radiation shield. All data loggers were mounted on lamp posts at 2.3–2.7 m height above ground for the sake of safety. Data were recorded in the internal memory at 1-hour intervals and were downloaded in situ every couple of months. The averaged temperature of the three points of each LCZ site was used to obtain a better spatial representativeness of the local thermal climate. The field observation was scheduled to last for at least one year starting from 20 July 2016. The first batch of data from 21 July to 30 September 2016 was analyzed.