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Future trends of building heating and cooling loads and energy consumption in different climates

Kevin K.W. Wan [a], Danny H.W. Li [a], Dalong Liu [b], Joseph C. Lam [a,*]

[a] Building Energy Research Group, Department of Building and Construction, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong SAR, China
[b] School of Architecture, Xi'an University of Architecture and Technology, Shaanxi 710055, China

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Principal component analysis of dry-bulb temperature, wet-bulb temperature and global solar radiation was considered, and a new climatic index (principal component *Z*) determined for two emissions scenarios – low and medium forcing. Multi-year building energy simulations were conducted for generic air-conditioned office buildings in Harbin, Beijing, Shanghai, Kunming and Hong Kong, representing the five major architectural climates in China. Regression models were developed to correlate the simulated monthly heating and cooling loads and building energy use with the corresponding *Z*. The coefficient of determination (R^2) was largely within 0.78–0.99, indicating strong correlation. A decreasing trend of heating load and an increasing trend of cooling load due to climate change in future years were observed. For low forcing, the overall impact on the total building energy use would vary from 4.2% reduction in severe cold Harbin (heating-dominated) in the north to 4.3% increase in subtropical Hong Kong (cooling-dominated) in the south. In Beijing and Shanghai where heating and cooling are both important, the average annual building energy use in 2001–2100 would only be about 0.8% and 0.7% higher than that in 1971–2000, respectively.

1. Introduction

There is a growing concern about energy use and its implications for the environment. Recent reports by the Inter-governmental Panel on Climate Change (IPCC) have raised public awareness of energy use and the environmental implications, and generated a lot of interest in having a better understanding of the energy use characteristics in buildings, especially their correlations with the prevailing weather conditions [1,2]. It was estimated that in 2002 buildings worldwide accounted for about 33% of the global greenhouse gas emissions [3]. In their work on climate change and comfort standards, Kwok and Rajkovich [4] reported that the building sector accounted for 38.9% of the total primary energy requirements (PER) in the United States, of which 34.8% was used for heating, ventilation and air-conditioning (HVAC). In China, building stocks accounted for about 24.1% in 1996 of total national energy use, rising to 27.5% in 2001, and were projected to increase to about 35% in 2020 [5,6]. Although carbon emissions per capita in China are low, its total emissions are only second to the US. When the life cycle energy use and emissions footprint are considered, buildings account for a significant proportion of the energy-related emissions [7,8].

A significant proportion of this consumption was due to the ever growing demand for better thermal comfort in terms of space heating in winter and space cooling during the hot/humid summer months [9,10]. Buildings typically have a long life span, lasting for 50 years or more. It is, therefore, important to be able to analyse how buildings will response to climate change in the future, and assess the likely changes in energy use. Earlier work had revealed an increasing temperature trend over the past decades, resulting in less discomfort in winter and more discomfort during summer [11–13]. The extent to which overall energy use for space conditioning would be affected would depend very much on the prevailing local climates and the actual climate change in future years. Reductions in the space heating could well outweigh the anticipated increase in energy use for space cooling and vice versa. Office building development is one of the fastest growing areas in the building sector, especially in major cities such as Beijing and Shanghai. On a per unit floor area basis, energy use in large commercial development with full air-conditioning can be 10–20 times higher than that in residential buildings and is an important element in building energy conservation programmes [14,15]. The

* Corresponding author. Tel.: +852 2788 7606; fax: +852 2788 7612.
E-mail address: bcexem@cityu.edu.hk (J.C. Lam).

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