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Developing a modified typical meteorological year weather file for Hong Kong taking into account the urban heat island effect

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ABSTRACT

Building energy computer simulation software is a useful tool for achieving sophisticated design and evaluation of the thermal performance of buildings. For successful thermal and energy simulation of buildings, it requires hourly weather data such as dry bulb air temperature, relative humidity, solar radiation, wind speed, etc. Nowadays, an urban city faces a problem of an urban heat island which causes the urban area to have a higher air temperature than the rural region. Since the currently available weather dataset used in building simulation software mainly comes from weather stations located in remote and rural areas, the impact of the urban heat island on thermal and energy performance of buildings may not be effectively reflected. This paper reports an approach to construct a modified typical meteorological weather file, taking into account the urban heat island effect in the summer season. Field measurements have been carried out in the summer months and the corresponding urban heat island intensities were then determined. With a morphing algorithm, an existing typical meteorological year weather file was modified. An office building and a typical residential flat were modeled with a renowned building energy simulation program EnergyPlus. Computer simulations were conducted using the existing and modified typical meteorological year weather files. It was found that there was around a 10% increase in air-conditioning demand caused by the urban heat island effect in both cases. The implications of this and further work will also be discussed in this paper.

1. Introduction

With its rapid economic development, Hong Kong has become one of the well-developed cities of the world. In this high-density city, a number of modern buildings have been designed and constructed in the past few decades. In order to achieve sophisticated building design and performance evaluation, computer simulation using thermal simulation software is a commonly adopted and effective approach. Computer simulation software requires hourly weather data such as dry bulb temperature, dew point temperature, solar radiation, wind speed and direction, etc. For successful building thermal and energy simulation, a set of representative weather data is one of the key factors. Since weather conditions can vary significantly from year to year, there is a need to derive a set of typical weather year data to represent the long-term typical weather conditions over a year. It is internationally recognized that a typical meteorological year (TMY) weather dataset can represent the long-term typical weather conditions and is more reliable in replicating average historical conditions. Therefore, TMY weather data files are commonly used by researchers around the world for studying building thermal and energy performance. In the past, there has been no local TMY weather dataset available in Hong Kong. Since 2006, a Hong Kong TMY weather data file has been developed by the author based on a 25-year hourly measured data record (1979–2003) [1].

In recent years, Hong Kong has encountered the problem of the urban heat island (UHI). The UHI effect means that an urban area is significantly warmer than its rural surroundings. The major causes of this effect include over-crowding of high-rise buildings with bulky thermal mass properties, tall buildings blocking the sea breeze and releasing thermal radiation, and lack of vegetation in urban areas. Since the meteorological data used for developing the TMY weather file come from data measured by the Hong Kong Observatory (HKO) stations which are mainly located in rural or sub-urban areas, the impact of the UHI effect cannot be reflected by these meteorological data and the subsequent TMY file developed. As a result, using the existing TMY weather file for evaluating the thermal and energy performance of buildings located in city centers with a UHI effect may not be accurate, or the average energy consumption of these buildings may be underestimated.

Therefore there is a potential need to derive a modified TMY weather dataset for Hong Kong and evaluate the difference of

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