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Effect of external air-conditioner units' heat release modes and positions on energy consumption in large public buildings

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ABSTRACT

The heat released from the air-conditioners of large public buildings, which has long-term and far-reaching influences, not only changes the thermal environment surrounding the buildings but also profoundly impacts the air-conditioner energy consumption. In this paper, a quantitative evaluation of the impact of the heat release modes and positions of air-conditioner external units on both the environment surrounding the buildings and the air-conditioner energy consumption of large public buildings is conducted using a coupled simulation of convection, radiation and conduction and air-conditioner energy cost. Principles for external unit positions are explored as well.

1. Introduction

Accompanied by the explosion of urbanization, the heat island phenomenon in cities has been seriously aggravated with worsening thermal environments [1]. (Fig. 1).

To relieve this situation, recent studies have simulated air-conditioner energy consumption to reduce this consumption and to increase air-conditioner efficiency [2–4]. Research on the effect of air-conditioner heat release on the outside thermal environment is already well known [5]. In contrast, less attention has been paid to the impact of heat release modes and external air-conditioning unit positions on air-conditioner energy consumption.

The heat release not only changes the thermal environment surrounding large public buildings but also impacts the air-conditioner energy consumption of the buildings due to the large and long-term heat release in dense cities. Some researchers have discovered that the air-conditioner cooling energy consumption increases when the outdoor temperature increases due to the air-conditioner heat release [6,7]. Moreover, other researchers have indicated that varying the positions of external air-conditioner units can affect the environment; for example, lower external units will affect the environment, especially the areas of human activities, more seriously than higher external units on the roof [8,9].

Unfortunately, external air-conditioner units are still placed merely in compliance with the visual aesthetics of buildings. Very little has been achieved in implementing systematic research of the relationship between the external units and air-conditioner energy consumption.

The impact of various heat release modes and external unit positions on the air-conditioner energy consumption is analysed in this study using a coupled simulation of convection, radiation and conduction and energy cost. A quantitative evaluation is advocated with principles for exploring the external unit positions. This is a beneficial attempt to reduce the air-conditioner energy consumption of large public buildings and to improve the thermal environment outside.

2. Research outline

2.1. Method

Due to the variation of the air temperature, humidity and velocity around buildings caused by air-conditioner heat release, three main methods of energy exchange between the inner building and outer environment have changed, altering both the sensible and latent heat energy consumption (cooling and dehumidification) of air-conditioners. These three methods are heat exchange

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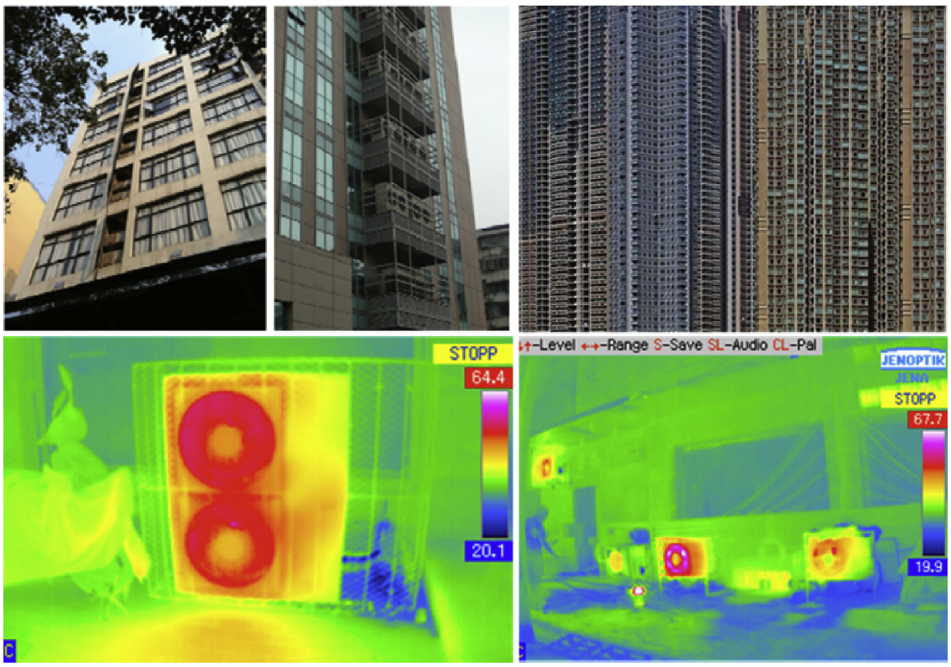

Fig. 1. Air-conditioner heat release intensifying the heat island phenomenon (Top: a picture of air-conditioner external units; bottom: the heat release shown by an infrared camera).

through the building envelope, heat exchange caused by necessary ventilation and heat exchange caused by infiltration due to poor airtightness of the envelope. Some studies indicate that the heat exchange through a building envelope has much less of an impact than the other two ways, approximately 1/400 of the other two [11]. Therefore, only heat exchanges by ventilation and infiltration are considered in this research.

Fig. 3 shows the technical route of this research: (1) the initial air-conditioner energy consumption and heat release are simulated based on the typical local weather condition; (2) the air velocity, temperature and relative humidity around the building and the average temperature and humidity of the layer adjacent to the building are simulated using a coupled simulation of convection, radiation and conduction with the heat release calculated in step 1 used as the boundary conditions; (3) the new energy consumption is calculated by simulating the air-conditioner energy consumption as affected by the heat release according to step 2.

Two kinds of computer simulation is used in this research, which are both already been validated and applied. The core simulation of this research is called a coupled simulation of convection, radiation and conduction. This method is developed by Chen and Ooka [10–12] and has been successful validated and applied in several researches [10] for over ten years. The simulation method of air-conditioner energy consumption and heat release using DeST-C is developed by Tsinghua University, which also successfully has been applied in several researches for almost

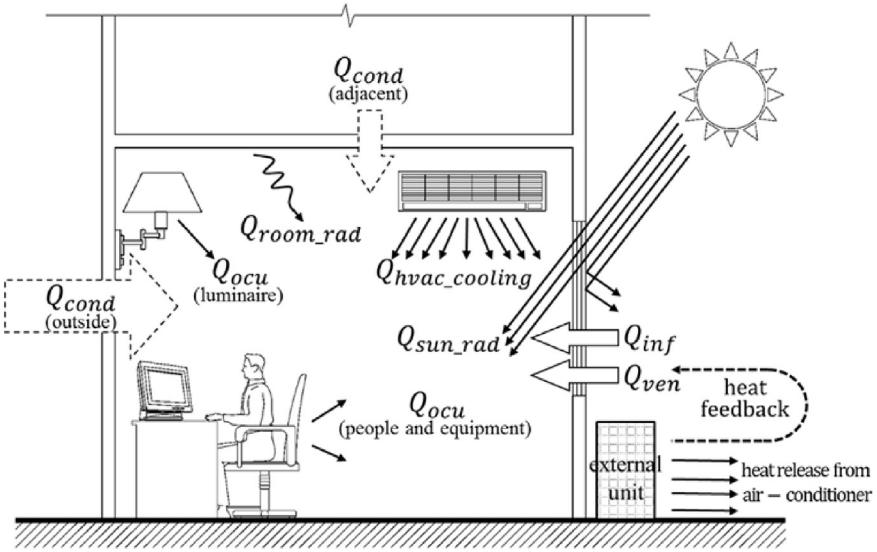

Fig. 2. Heat balance of the building.