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ScienceDirect

Energy Procedia 142 (2017) 2568–2573

Energy Procedia

www.elsevier.com/locate/procedia

9th International Conference on Applied Energy, ICAE2017, 21-24 August 2017, Cardiff, UK

An Investigation on Energy Consumption of Air Conditioning System in Beijing Subway Stations

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Abstract

This paper initially depicted on the energy consumption of air conditioning systems in Beijing subway stations. An investigation was conducted among ten underground subway stations to the examination of practical operation conditions of their cooling units. The overall field testing included information such as air conditioning system formation, equipment types, system operation parameters, energy consumption and system operation efficiency. The results showed that the COP value of refrigerators in the tested subway stations were generally high at about 4.4 in average. Nevertheless, the mean EER and SCOP values were nearly 27% and 48% lower than the average COP value due to the large amount of energy consumption in water pumps, cooling towers and fans. There was a big difference among each station in terms of the instantaneous power consumption of air conditioning systems. The most energy consuming station was nearly seven times higher than the least one. It was observed that there was a lack of maintenance and system operation strategy for these underground air condition systems. A promising potential for energy saving was found out within the air conditioning systems in Beijing subway stations.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.

Keywords: subway station ; air conditioning system ; energy consumption

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1876-6102
Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.
10.1016/j.egypro.2017.12.093

Nomenclature

COP	Coefficient of Performance of refrigerator
EER	Coefficient of Performance of cooling source
SCOP	Coefficient of Performance of air conditioning system
PSD	Platform Screen Doors system
Qc	Cooling capacity
Pc	Instantaneous power consumption of refrigerator
Pp	Instantaneous power consumption of chilled and cooling water pumps
P_T	Instantaneous power consumption of cooling towers
P_F	Instantaneous power consumption of supplying and exhausting fans

1. Introduction

In China, the public transportation system has undertaken a rapid development in this decade. Through the government propaganda of "energy saving and emission reduction", most people are encouraged to take the public transportations, especially as subway. According to the advanced report from China Association of Metros, there are 26 cities that have the urban rail transit with a total amount of 116 subway lines, almost 3600 km at the end of year 2015. The number of operating subway stations were 2236 in total. There are 13.8 almost billion passengers who chose urban rail transit as their regular traveling tool in 2015. The average daily passenger volume was almost up to 6 million in Beijing, Shanghai and Guangzhou. Moreover, in the next five years, the total distance of new construction subway lines will be beyond 3000km [1].

On the other hand, the increased subway volume requires much more energy for operation. Some research has already reported that part of air conditioning system in the South China could even consume half energy of the total "non-traction energy use" in summer [2], and the energy consumption may become higher than that due to "traction energy use" in some extreme condition [3]. Another study highlighted that the air conditioning system consumed 31% energy of the annual subway energy use in Beijing and Shanghai [4]. Obviously, reducing energy consumption of air conditioning systems is one of the most effective ways to tackle high energy demand of subway systems.

Currently, most studies only focused on the numerical simulation of air conditioning system in subway stations [6-7]. Their conclusion and recommendation were somehow very limited in terms of validation because of the insufficient field data and measurements. As a result, it is difficult to conclude a general effective energy-saving strategy from the past studies. This paper initially conducted a serious of filed measurements in the summer of 2016, with the aims to investigate the energy consumption and the operational efficiency of air conditioning systems of 10 subway stations in Beijing. The operation condition of running units and the existing technical barriers were summarized. This study may further provide useful guidance towards energy saving in Beijing subway stations.

2. Experimental Set Up and Testing Method

This investigation aims to test the real operation condition and system efficiency of air conditioning systems in Beijing subway stations. Through this investigation, the existing operational barriers and energy saving potential of air conditioning system will be identified and evaluated. The testing of 10 subway stations were selected by the Metro Operation Department, from Line 6,7,8,9,10 and 14. Most of the stations were constructed with central cooling units. The detailed information of the stations and their cooling units was shown in Table 1.

Table 1. Station and cooling units

Station	Station form	Platform	Open time	Cooling units
A	Transfer	Island	2012	Water chiller
B	Non-transfer	Island	2012	Water chiller