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Free Cooling Investigation of RCMS Data Center

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Abstract

Cooling equipment consume most of the electric power inside data centers, which serve as a back bone of modern-day information technology infrastructure. Most data centers use traditional vapor compression systems, which not only consume a lot of energy, but also have to be continually operated round the year to ensure optimum operation of all the equipment and servers within. A lot of attention is therefore focused on energy saving methods and free cooling is one of these technologies. In this study, the free cooling potential of Islamabad has been determined. Outside dry-bulb temperature and relative humidity are used as control parameters, and have been estimated using meteorology data of past sixteen years. This data is then used to optimize energy efficiency of the Research Center for Modeling and Simulation (RCMS) data center at National University of Sciences and Technology (NUST). Using the load data obtained from detailed analysis of RCMS data center, it is determined that significant savings in energy through free cooling can be achieved during the months of December, January, and February.

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Keywords: Data center, HVAC system, meteorology data, free cooling, energy efficiency

1. Introduction

Information Technology has revolutionized the way humans live. Its sustainability however, depends upon the proper maintenance of data centers, which can be defined as huge buildings or rooms containing data servers, telecommunication, power and cooling equipment [1]. These data centers are the nerve center of managing loads of data, but also present a major drawback when it comes to power consumption. According to recent estimate, an average data server consumes about 30 kW of power, a number which is projected to increase up to 70 kW in the years to come [2]. This power consumption depends on the number of racks in a building, which in turn depend on the nature of operational use.

Data centers are much more energy intensive as compared to normal residential and commercial buildings, nearly 40 percent more so, according to a recent report [3] published in 2007. In United States alone, the total energy consumption by data centers increased by 36 percent between the period spanning from 2005 to 2010 [4]. This increase makes up nearly 02 percent of the total energy consumption in the country. Computer room air conditioning units (CRACs) consume a major chunk of this energy [5],

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nearly 40 percent according to one estimate [6]. This high rate of electricity consumption has been a sore point for researchers for many years, and as such many theories have been presented. Free cooling technology is one of the most pragmatic and effective in this regard, both in terms of cost effectiveness and implementation. This concept uses ambient environment conditions to provide cooling. The cooling potential is dependent on control parameters such as dry-bulb temperature and relative humidity etc. The major high point of this technique is that no mechanized cooling equipment is required.

A lot of work can be cited in literature regarding free cooling. A pioneer work in this regard was carried out by Bulut et al. [7, 8]. He extracted the cooling potential for different cities of Turkey using the bin weather data, and then used this model for free cooling in domestic buildings. This concept was further extended by Papakostas et al. [9], who developed the bin data for 38 Greek cities. Ghiaus et al. [10] also concentrated on the domestic use of free cooling and used a method which was focused on the temperature differential between the inside and outside environment. Dovrtel et al. [11] studied the free-cooling method with variable flow rate control, which incorporated weather forecasts into a control system while Budaiwi et al. [12] studied the energy performance of an economizer cycle under three different climatic conditions to explore the energy saving potential. However, no such approach has ever been implemented in Pakistan and this was something which served as a motivation for this study.

The objective of this study is to present a methodology through which energy consumption can be optimized in the RCMS data center, removing its complete dependence from mechanical cooling equipment. Bin data concept for free cooling has been used in this work. This data was collected from the Meteorology Department of Pakistan for a period of 16 years. Free cooling potential has been explored by using dry bulb temperature and humidity as control parameters with detailed analysis performed with the help of ASHRAE psychrometric charts and software, such as ELITE, CHVAC, and AUTOCAD. An inside temperature range of 18 to 27℃ is defined and with the help of ASHRAE recommended envelopes, it has been shown that this range can be applied safely till an outside temperature of as much as 27℃. It is pertinent to mention that this study does not incorporate the usage of air side economizers and the sole focus is on achieving free cooling with the help of outside ambient temperature. For this very reason, the study has been limited to three months only.

2. RCMS data center cooling infrastructure

There are a total of 3 server racks inside the RCMS data center. One rack has a capacity of 34.66 kW while the other two have a combined capacity of 7 kW. There is no communication rack and only one CRAC unit installed, with a capacity of 11.4 TR. This unit has a single compressor, having a capacity of 11.4 TR. The detailed infrastructure of the data center has been shown in Fig. 1. Raised flooring has been used in this data center so that the supply air can be fed through the floor via perforated tiles and return air is sucked by the CRAC units freely. Currently, there is no provision of hot and cold isling.

3. Methodology and discussion

The total cooling load of this facility is 12.56 TR (150,702.78 Btu/hr). The focus of this study is on the ambient air temperature for free cooling, a suitably low value of which could only be achieved in winter months (December-February), according the weather patterns in Islamabad. For these months, we can subtract the space load from the total load, which then reduces to 11.85 TR (142,149.78 Btu/hr). Thus we have to design a free cooling system which can remove 142,149.78 Btu/hr from the RCMS data center.

The amount of supply air which can remove that much Btu/hr can be calculated using Eqn. (1).

$$Q = [Hs / 1.08 \times (T_R - T_S)] \quad (1)$$