INVESTIGATION OF SUSTAINABLE COOLING STRATEGY FOR DATA CENTER

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Summary

It is noticed that energy consumption in data centers has increased dramatically in recent years due to the increased demands for data center computing. One of the most efficient ways to improve a data center's sustainability is by reducing power and cooling usage. The paper aims to investigate the possibilities of improvement of more sustainable energy saving strategies for data centers. We particularly evaluate air management and energy performance of cooling system and explore the potential of energy saving and reuse through a case study of a data center in Finland. We provide assessment of performance metrics for the cooling system and power consumption of the data center. Based on the analysis results, a simulated heat recovery system is presented demonstrating that the data center could potentially provide yearly space and hot water heating for 30,916 m^2 non-domestic building.

Keywords: sustainable, data center, energy performance, heat recovery

1 Introduction

It is noticed that energy consumption in data centers has increased dramatically in recent years due to the increased demands for data center computing. Survey has shown that data centers can be over 40 times as energy intensive as conventional office buildings and power consumption will be doubled in five years [1]. In typical data centers, cooling accounts for 25 % or more of the total power which is a large portion of those energy costs. Therefore, one of the most efficient ways to improve a data center's sustainability is by reducing power and cooling usage.

In general, cooling systems can be classified into two categories: air-forced cooling and liquid cooling. Air cooling is still predominant. Currently, the evaluation of the air cooling performance in data centers often focuses on two aspects: energy performance and air management. Some energy performance metrics, such as the Power Use Effectiveness (PUE) [2], the Supply Heat Index (SHI) [3], and the Return Temperature Index (RTI) [4] have been used. The aim of this paper is to firstly conduct these energy performance metrics for the cooling system and power consumption using real filed data based on a case study of data center in Finland. Apart from analyses, we explore the opportunities for improving energy efficiency in cooling and waste heat reuses for a more sustainable data center.

2 The Methodology

The following metrics are used for **energy** efficiency **evaluation of the date center**.

The Supply Heat Index, SHI, is a performance metric for the cooling system which is used to measure the local magnitude of hot and cold air mixing [3]. SHI is defined as

$$SHI = \frac{T_i - T_v}{T_o - T_v} \tag{1}$$

A typical SHI-value is less than 0.4. The smaller the SHI-value, the less air mixing occurs. A large SHI-value often suggests mainly recirculation air, but also implies that the rack experiences oversupplied air.

Another energy performance metric for the cooling system is the Return Temperature Index, RTI, which is used to measure the actual utilization of the available airflow. The index is defined as follows [4]:

$$RTI = \frac{T_{\mathrm{return}} - T_{\mathrm{supply}}}{\Delta T_{\mathrm{Equip}}} \tag{2}$$

Where T_{Return} is the return air temperature (weighted average)
T_{Supply} supply air temperature (weighted average)
$\Delta T_{\mathrm{Equip}}$ temperature rises across the electronic equipments (weighted average)

The interpretation of the index is given at [4].

Power Usage Effectiveness, PUE, is the recommended metric for characterising overall data center infrastructure efficiency. PUE is defined as the ratio of IT load power to data center input power (facility power). The ideal PUE value is 1.0. A PUE of 2.0, for example, indicates that for every watt of IT power, an additional watt is consumed to cool the IT equipment. The reciprocal of PUE expressed as a percentage is known as the data center's infrastructure efficiency.

3 The data center

The data center is located in the southern city, Espoo, in Finland. Its design IT power is near 1 MW, but currently the data center is operating under the half the designed power (i.e. about 500 kW). Total floor area is about 420 m^2 with the room height = 2.9 m from the raised floor to the ceiling, giving about 1218 m^3 volume. The plan view of the data center is presented in Figure 1. In this figure, the computer room air-conditioning units (CRAC) are displayed. CRAC cools the exhaust heat (i.e. hot air) from racks and pushes the chilled-air supply (i.e. cold air) into the floor plenum. Cold air enters the Cold Aisle through perforated floor tiles (i.e. ventilation tiles) to cool IT equipment in the racks. Exhaust air from the racks enters the Hot Aisle and finally migrates back to CRACs.

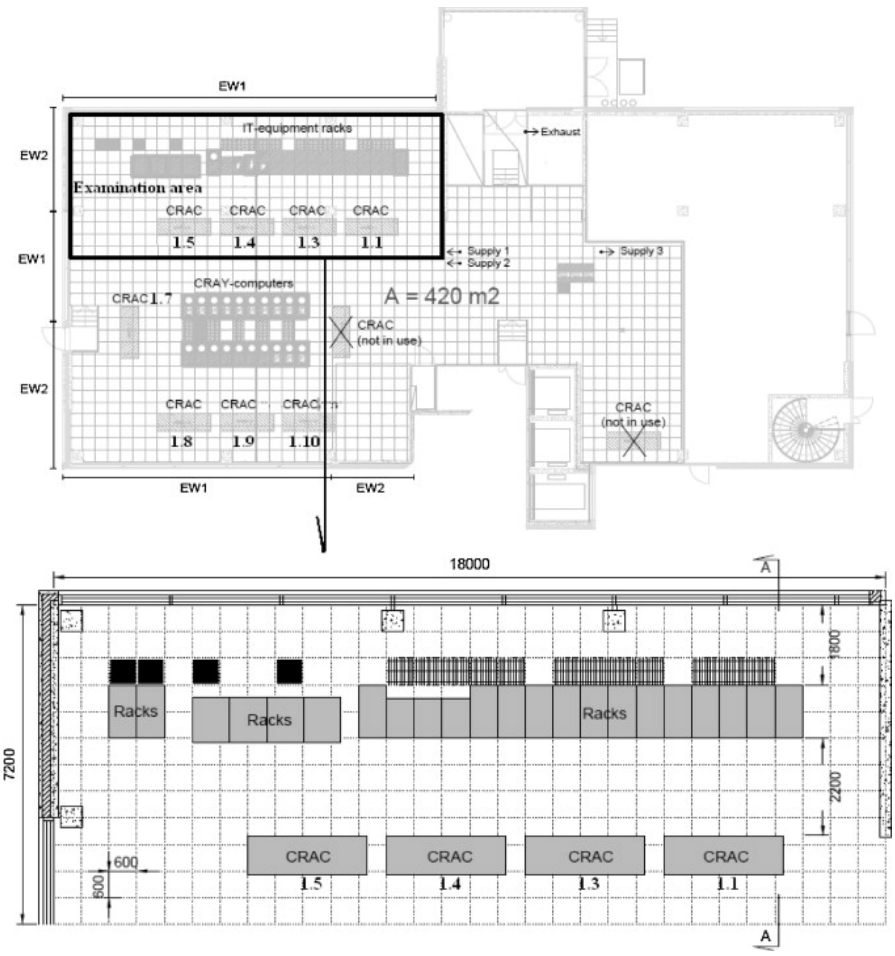

Fig. 1 Plan view of the case study data center

4 Analyses Results

Performance metrics SHI and RTI were calculated. All the SHI-values were near zero because the measured inlet air temperatures of racks were either lower than or near the measured air temperatures from the adjacent plenum vents. This indicates that the recirculation of hot air was negligible and that the hot and cold air streams were perfectly separated. Overall, calculated performance metrics suggest that enough cooling was provided but cold air was oversupplied. Therefore, CRAC fan speed can be reduced in order to mitigate oversupplied cold air and save energy.

For cooling power, it was estimated about 575 kW. The heat released from IT equipment and CRAC fans was: 544 kW. Given the fact that besides IT equipment and CRAC fans there were other sources also dissipating heat, estimated the total cooling power had satisfactory energy balance with the total heat load from the center (544 kW+).

For overall energy, the PUE value was slightly above 1.2 in winter time and about 1.5 in summer. Further power breakdown was: 494 kW for IT power, 149 kW for chiller, 53 kW for CRAC fans,17.4 kW for pumps and dry coolers and 28kW for the rest of others.

5 Proposed Heat Reuse Strategy

The data center has no heat recovery system. The huge amount of rejected heat from the data center could be reused. In typical buildings, the recovered heat is in the form of hot water at 40–43 °C. Such temperatures are high enough for most applications. However, if free cooling is in operation, the generated hot water from rejected heat may be much lower than 40 °C (e.g. 15–17 °C in our case). Such temperature of water can be possibly used for preheating cold outdoor air before entering the ventilation duct or water for domestic uses. We estimate about 5627 MWh per year can be reused for the data center [5]. In Finland, the average yearly energy demand for space heating and water heating is about 182 kWh/m^2 for non-domestic buildings. The reuse heat, therefore, can support 30,916 m^2 non-domestic building for yearly heating.

6 Conclusions

Case study data center in Finland was examined. A series of field measurements were conducted to evaluate air management and cooling performance. Results show that inlet conditions (temperature and humidity) for racks in the data center were all within the ASHRAE recommended or allowable ranges. PUE values were in the range of 1.2–1.5 depending on free-cooling mode. Analyses results show the possibilities of energy conservation and system improvement. Further simulation demonstrates that potentially the data center can provide yearly space heating and hot water heating for 30,916 m^2 non-domestic building.

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