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Potential of air-side economizers for data center cooling: A case study for key Australian cities

Jayantha Siriwardana [a,b,*], Saliya Jayasekara [a], Saman K. Halgamuge [a]

[a] Department of Mechanical Engineering, The University of Melbourne, Parkville, Victoria, Australia
[b] Energy Research Institute, Nanyang Technological University, Singapore

HIGHLIGHTS

- Provision of low cost cooling for data centers is highly sought with the increase of cost of electricity and heat dissipation volumes.
- Many Australian cities enjoy cool and dry weather conditions during winter months.
- Data center operators can exploit these conditions by introducing outside air into their data centers and save cost of cooling.
- This paper evaluates the potential of using economizers for data centre cooling by analyzing hourly weather data of past 12 years.
- We identified that the capital cities in Southern states of Australia have sizable potential for using economizers above 60% of the time in a typical year.

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ABSTRACT

The provision of low cost cooling is challenging due to high energy costs and increasing heat dissipation volumes from data centers. In Australia, with the introduction of emissions trading scheme, the cost of energy with carbon origin is expected to increase. In order to reduce cooling costs, alternative low cost cooling methods for data centers are highly sought after. In this study, we investigated using air-side economizers to introduce outside air with desired supply air conditions, by exploiting the cool and dry Australian climate conditions. Our approach was based on analyzing the hourly temperature and humidity data gathered over past 12 years for 20 weather monitoring stations across Australia representing all geographical regions and determining the potential of using air-side economizers for those locations. As the result, we demonstrated that there is a sizable potential for using air-side economizers in some states that could lead to significant savings on cooling costs to data center operators.

1. Introduction

Data center (DC) facilities have witnessed rapidly increasing power requirement trends in recent years. The combination of increased power dissipation and increased packaging density has led to substantial increases in DC equipment heat dissipation rates. As a result, the heat load footprint per square meter of DC has been increasing. Fig. 1 published by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) [1] predicts more than 20 kW/m^2 of heat dissipation from all types of servers and communication equipment in 2012. The upward trend is expected to continue in the foreseeable future.

Due to the ballooning world resource prices, the cost of electricity has been steadily increasing during the past two decades. Accordingly, the worldwide cost of powering and cooling DCs has been increasing steadily [2]. Scaramella and Eastwood [3] predict the DC related power costs to represent an increasing percentage of purchase expenditure, also known as the cost of ownership, as illustrated in Fig. 2. As a result, DC cooling efficiency has been considered as a high priority in current operations [4–6]. With the introduction of the emissions trading scheme [7] in Australia, electricity prices are expected to rise at least in the short term. According to the Australian Bureau of Agricultural and Resource Economics and Sciences [8], in 2010, 91.8% of the total Australian electricity was produced by fossil fuels (black coal: 51.5%, brown coal: 23.2%, gas: 15.0%, other: 2.1%) and only 8.2% was produced by renewable sources (hydro: 5.2%, wind: 2.0%, solar: 0.1%, other: 0.9%). Powering DCs using renewable energy has been considered a long term strategy due to their large energy demand [9]. Although the 5 year average annual growth in solar and wind energy generation was 25.2% and 40.2% respectively, it requires at least 5–10 years for renewable sources to represent a 10% share

* Corresponding author at: Energy Research Institute, Nanyang Technological University, Singapore.
E-mail address: jay.siriwardana@gmail.com (J. Siriwardana).

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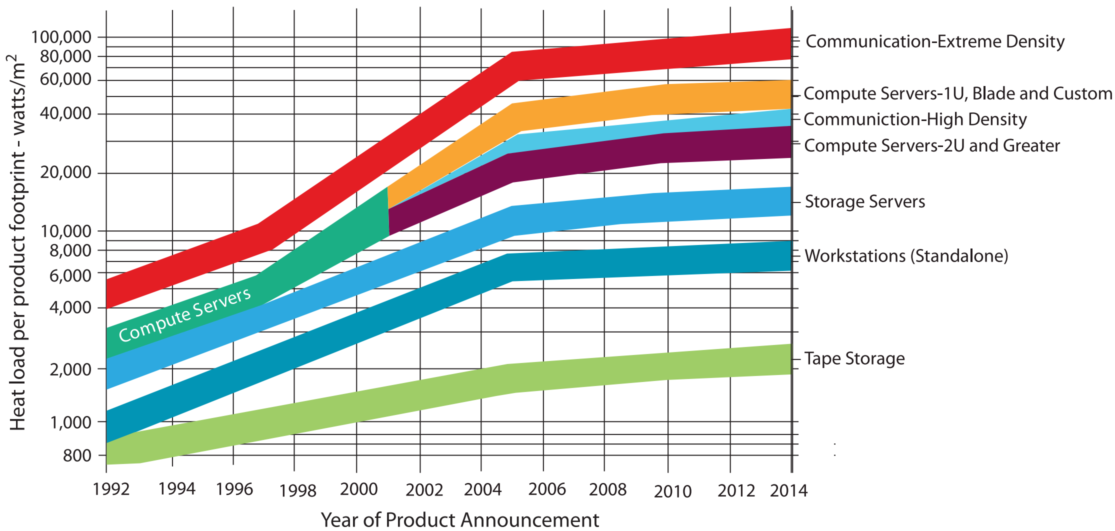

Fig. 1. Data centre equipment power trends. ©2005 ASHRAE TC 9.9 datacom equipment power trends and cooling applications.

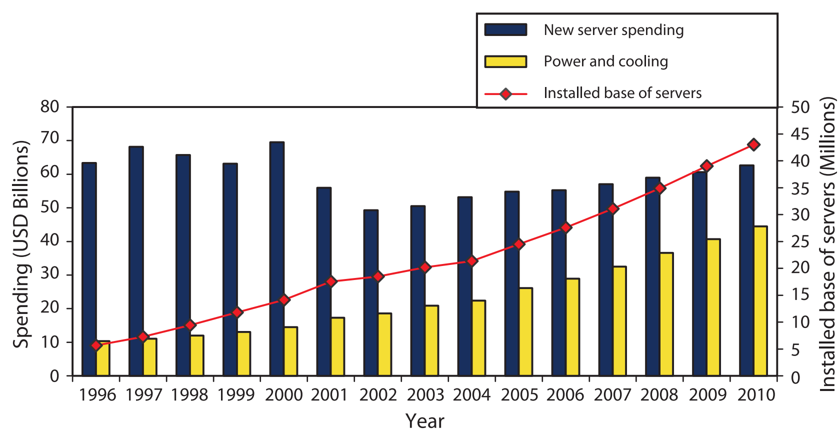

Fig. 2. Worldwide cost to power and cool data centre equipment, 1996–2010 ©IDC, 2007.

of the national electricity production at the current growth rate and at the current volume of electricity generation. Therefore, the cost of electricity can be expected to rise at an increased rate in the foreseeable future, with added costs for carbon pricing.

In contrast to other buildings, DCs have a stable cooling demand throughout the year irrespective of the weather conditions and seasonal changes in temperature. DCs generate massive amount of heat through their continuous operation that requires to be removed. In the current backdrop, using cool and dry weather conditions, when available, to cool DCs, also known as economizer cycle, would save on the cost of cooling energy. With an economizer cycle, the benefits of a low ambient temperature and low relative humidity can be utilized for a significant proportion of the year in many climates. Recent literature can be found on energy analysis of using economizer cycles for building ventilation [10], case studies of economizer cycles for building heating, ventilation, and air conditioning (HVAC) [11–13] and DC cooling [14–17]. It has also been shown that the use of economizer cycles can save on energy bills and help to maintain a low total cost of ownership [18,19].

In Australia, it can be presumed that there is a potential for economizer cycles when providing cooling to DCs, given the cool and dry conditions in winter in many major cities. However, the potential has not been studied in previous literature. In this paper, we study the potential for using economizer cycles for DC cooling using hourly weather bin data for 20 weather monitoring stations across Australia from 2000 to 2011.

2. Air-/water-side economizer cycles in HVAC systems

2.1. Air-side economizer

Economizers in HVAC systems are mechanical devices intended to reduce energy consumption by using cool and dry outside air as a means of cooling the indoor space. In simple terms, an economizer is a heat exchanger. When the outside air temperature is less than that of recirculating air from the DC, the cooling load of the chiller can be reduced with the introduction of an air-side economizer. When the outside air is both sufficiently cool and dry, depending on the climate, the amount of enthalpy in the air is acceptable and no additional conditioning of it is needed. This portion of the air-side economizer control scheme is called free cooling.

Air-side economizers [20] can reduce HVAC energy costs in cold and dry climates while also potentially improving indoor air quality, but are most often not appropriate in hot and humid climates. Fig. 3 shows a conceptual diagram of an air-side economizer in a