Applied Energy 88 (2011) 680–689

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Determination of free cooling potential: A case study for İstanbul, Turkey

Hüsamettin Bulut [a,*], Mehmet Azmi Aktacir [a]

[a] Harran University, Engineering Faculty, Department of Mechanical Engineering, Osmanbey Campus, 63190 Şanlıurfa, Turkey

ARTICLE INFO

Article history:
Received 11 May 2010
Received in revised form 26 August 2010
Accepted 31 August 2010

Keywords:
Air conditioning
Free cooling
Economizer
Energy saving
İstanbul
Turkey

ABSTRACT

A significant portion of energy consumed in buildings is attributed to energy usage by heating, ventilating and air conditioning (HVAC) systems. Free cooling is a good opportunity for energy savings in air conditioning systems. With free cooling, commonly is known economizer cycle, the benefits of lower ambient temperatures are utilized for a significant proportion of the year in many climates. The detailed analysis of local weather data is required to assess the benefits of economizer. In this study, free cooling potential of İstanbul, Turkey was determined by using hourly dry-bulb temperatures measurements during a period of 16 years. It is found that the free cooling potential varies with supply air temperature and months. It is determined that although there are substantial energy savings during a significant portion of the year especially in transition months (April, May, September and October), the high outdoor air temperatures from June to August, made the system not beneficial for free cooling except at high supply air temperature.

1. Introduction

The higher living and working standards, the adverse outdoor conditions in urban environments and reduced prices of air-conditioning units, have caused a significant increase in demand for air conditioning in buildings. On the other hand, heating, cooling, ventilating and air conditioning (HVAC) systems are major responsible for energy consumption in buildings. As reported in the literature, air-conditioning energy consumption shows an increasing trend [1,2]. In recent years, many solutions have been suggested for reducing energy consumption in buildings. Solutions are mainly about initial stage of architectural design related to thermal performance of building and the correct selection of HVAC system. Reducing energy use for space cooling in buildings is a key measure to energy conservation and environmental protection. The yearly cooling load and the peak cooling demand of building can be reduced significantly in the thermally insulated buildings [3,4]. At the same time, there has been a rapid change in the technology of air conditioning. Energy conservative building design has triggered greater interests in developing flexible and sophisticated air conditioning systems capable of achieving enhanced energy-savings potential without sacrificing the desired thermal comfort and indoor air quality (IAQ) [5]. Various types of variable air volume (VAV) systems, air and water economizer, heat recovery, thermal storage, desiccant dehumidification, variable-speed drives, and direct digital control (DDC) devices have become more effective and more advanced for energy efficiency [6]. A considerable amount of energy can be saved if the HVAC system is properly designed, operated and controlled. In all-air HVAC systems using an economizer cycle can result in considerable energy savings [7]. Although economizer systems have existed for many years, in recent years, many packaged unit manufacturers more extensively offer air economizers to provide free cooling for energy savings as well as to improve indoor air quality.

Free cooling application, commonly is known economizer cycle, is used when outside conditions are suitable, that is, when outside air is cool enough to be used as a cooling medium [8]. Two types of economizers are in use today. Those are water-side economizer and air-side economizer. The air-side economizer takes advantage of cool outdoor air to either assist mechanical cooling or, if the outdoor air is cool enough, provide total cooling. In an all air conditioning system, outdoor air is used as supply air. The water-side economizer consists of a water coil located in the self-contained unit upstream of the direct-expansion cooling coil. ASHRAE Standard 90.1 addresses the application of water-side economizer [8].

One method of improving the indoor air quality (IAQ) is to increase the ventilation. Due to the fact that the outdoor air is used directly in free cooling applications; a high indoor air quality can be achieved. Providing high indoor air quality, compared with the mediocre air that is present in many existing office building worldwide, may increase productivity by an estimated 5–10%. An annual loss of this magnitude caused by mediocre indoor air quality will often be much higher than energy costs, capital costs, and the cost of operating the building [9].

* Corresponding author. Tel.: +90 414 3183798; fax: +90 322 3183799.
E-mail address: hbulut@harran.edu.tr (H. Bulut).

0306-2619/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apenergy.2010.08.030

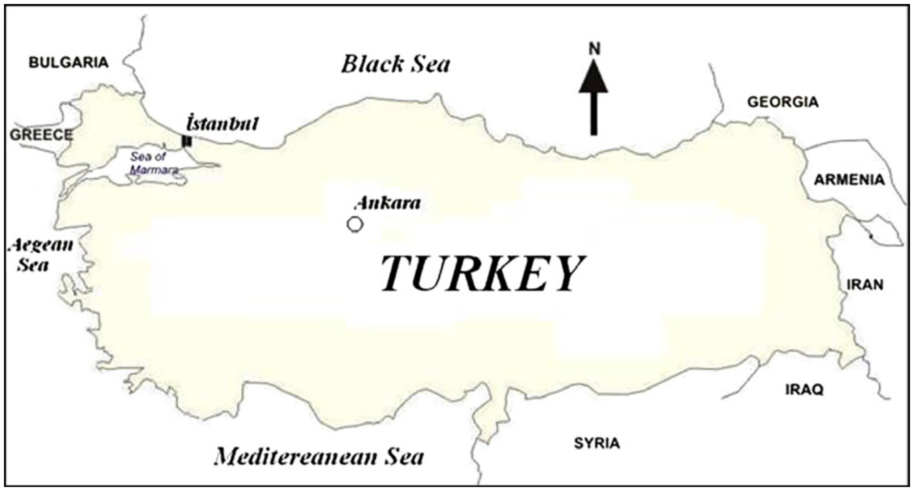

Fig. 1. The location of İstanbul on the map of Turkey.

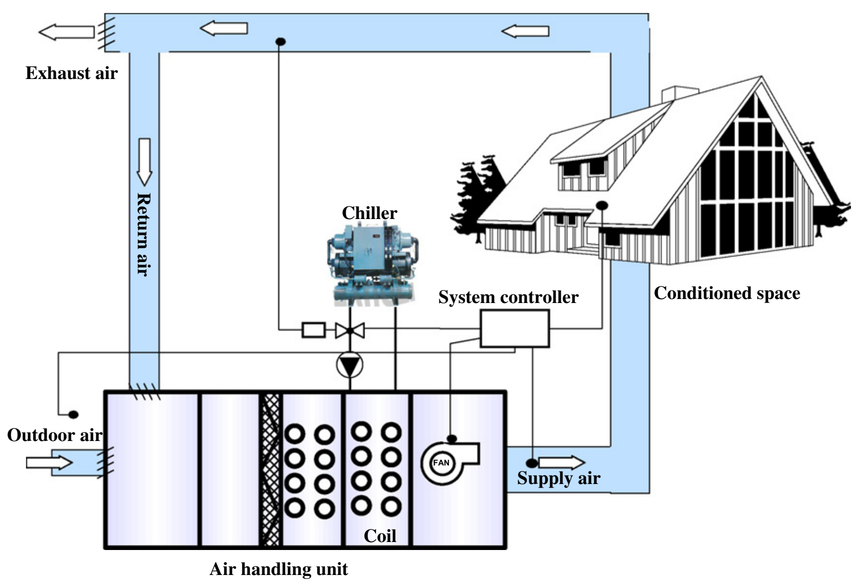

Fig. 2. Schematic of a typical all air conditioning system.

The potential of free cooling represents a measure of the capability of ventilation to ensure indoor comfort without using mechanical cooling systems [10]. Free cooling is not alternative of mechanical cooling, it must be thought as complementary and supportive application for air conditioning system. Available studies revealed that considerable energy savings could be achieved using the free cooling under different climatic conditions. Olsen et al. [11] showed that low-energy cooling systems that maximize free cooling from outside air have the best energy performance under mild UK climate conditions. Budaiwi [7] investigated energy performance of the economizer cycle under three climatic conditions in Saudi Arabia and presented significant results for HVAC designers and operators seeking energy efficiency in buildings through the economizer cycle. Wacker [12] investigated the energy-savings potential and indoor comfort implications of economizer controls for packaged rooftop HVAC equipment under weather conditions in Asheville, North Carolina, USA. Karunakaran et al. [5] proposed a combined variable refrigerant volume (VRV) and variable air volume (VAV) air conditioning system that was controlled by the intelli-

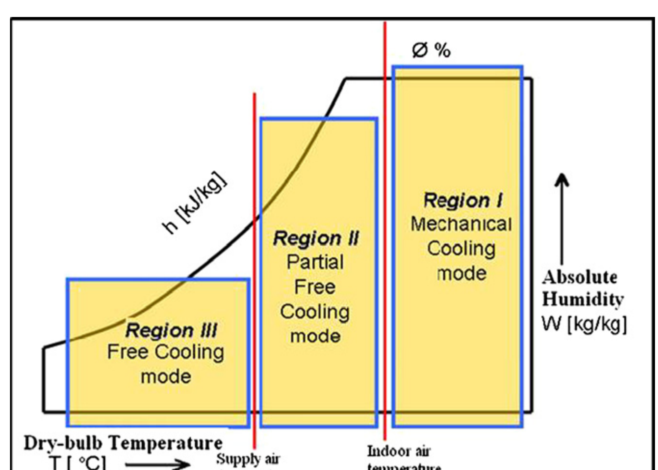

Fig. 3. The control regions of a fixed dry-bulb temperature economizer on psychrometric chart.