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Feasibility of solar absorption air conditioning in Tunisia

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Abstract

Due to the high cost of fossil fuels and the environmental problems caused by the extensive use of air-conditioning systems for both residential and industrial buildings, the use of solar energy to drive cooling cycles becomes attractive since the cooling load is roughly in phase with solar energy availability particularly in Tunisia. In this paper, we present a research project aiming at assessing the feasibility of solar-powered absorption cooling technology under Tunisian conditions. Simulations using the TRNSYS and EES programs with a meteorological year data file containing the weather parameters of Tunis, the capital of Tunisia, were carried out in order to select and size the different components of the solar system to be installed. The optimized system for a typical building of 150 m^2 is composed of a water lithium bromide absorption chiller of a capacity of 11 kW, a 30 m^2 flat plate solar collector area tilted 35° from the horizontal and a 0.8 m^3 hot water storage tank.

Keywords: Air conditioning; Solar; Absorption; Lithium bromide

1. Introduction

The demand as well as the cost of energy are increasing rapidly over the world, particularly in Tunisia. In fact, more than 30% of energy consumption is used for cooling and/or heating of domestic and commercial buildings which have gained an increasing interest during latest years due to the rising demand for efficient energy use and higher comfort standards [1]. The air-conditioning systems use compression machines which are energy wasteful and have impacts on the stratospheric ozone depletion due to the chlorofluorocarbons (CFC) and the hydrofluorocarbon (HCFC) refrigerants. They contribute also to the increase of environmental pollution and global warming through releases of refrigerants and greenhouse gases resulting from the burning of fossil fuels for electricity generation.

In this respect, international research is moving in two main directions. The first focuses on the building itself, aiming to minimize heat gains through the building envelope and to simultaneously maximize the use of natural heat sinks [2]. Whereas the second is concerned by the development of technologies that can offer reductions in energy consumption, peak electrical demand and energy costs without lowering the desired level of comfort conditions.

Solar cooling is an attractive alternative since it has the advantage of removing the majority of harmful effects of traditional refrigeration machines and that the peaks of requirements in cold coincide most of the time with the availability of the solar radiation. The possible use of solar energy as the main heat input for a cooling system has led to several studies of available cooling technologies. At present, various types of solar-powered systems are available for cooling applications [3]. In Europe, in recent years, more than 50 solar-powered cooling projects in different climatic zones were surveyed and analysed to identify future needs and evaluate the overall prospects of solar cooling [4]. One wide-spread application of a solar-powered system is for absorption cooling that is largely thermally driven and requires little external work.

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Several computer models for describing the performance characteristics of absorption chillers were developed by Florides et al. [5], Atmaca and Yigit [6] and Argiriou et al. [7]. In addition, the use of solar energy in an absorption heat pump system has been investigated by Assilzadeh et al. [8] and Li and Sumathy [9]. Also, Ghaddar et al. [10] have carried out research on solar absorption system performances in Beirut. Florides et al. [11] modelled a complete system, composed of a solar collector, a storage tank, a boiler and a lithium bromide–water (LiBr–water) absorption refrigerator, which can cover a typical house load for the whole year. In order to improve the present understanding of the system dimensions and productive usage of solar energy, much more investigation still has to be done.

In this study we present a research project, in progress, whose objective is to set up a solar-powered air-conditioning system. The system comprises an absorption chillier, a solar subsystem and a building to be conditioned as shown in Fig. 5. The system is modelled using the TRNSYS and EES programs with a meteorological year data file containing the weather parameters of Tunis, the capital of Tunisia.

2. Climate and energy considerations in Tunis

In many applications, such as in solar energy technologies, an accurate climatic database is needed. In these applications, the accuracy of solar radiation and ambient air temperature are crucial. Tunisia has a Mediterranean climate characterized by a high level of the solar resource. Tunis, the capital of Tunisia, is located at 36° latitude and 10° longitude. It receives an average of 400 cal/cm^2/day with a total insolation period of 3700 h/year and 350 sunny days per year.

The climatic data from the National Institute of Meteorology based on 1 year concept for Tunis characterized by series of 8760 hourly outdoor data as dry bulb temperature, direct and diffuse horizontal solar radiation, wind velocity and direction, absolute and relative humidity have been used in this work.

The mean daily insolation duration range from 5 h in December to 12:13 h in July (Fig. 1). The mean daily solar radiation exceeds 7.4 kWh/m^2 in the summer and still more than 2 kWh/m^2 in winter (Fig. 2). The dry bulb temperature can reach as high as 46 °C in the summer with means

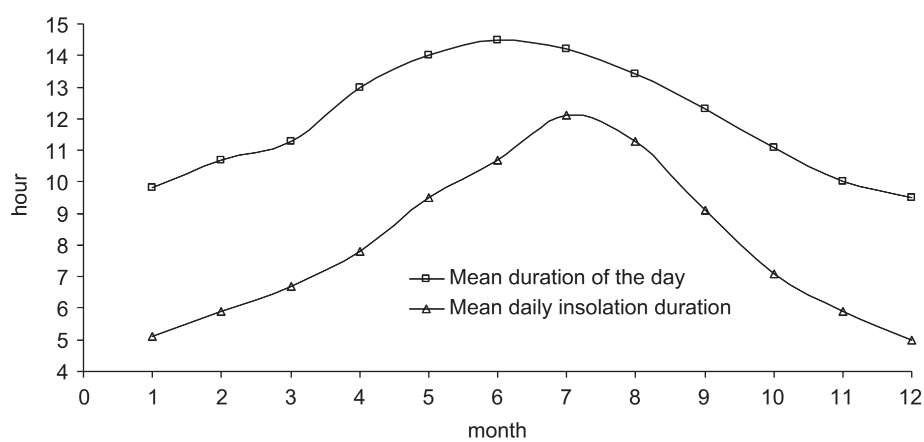

Fig. 1. Mean duration of the day and mean daily insolation duration in Tunis.

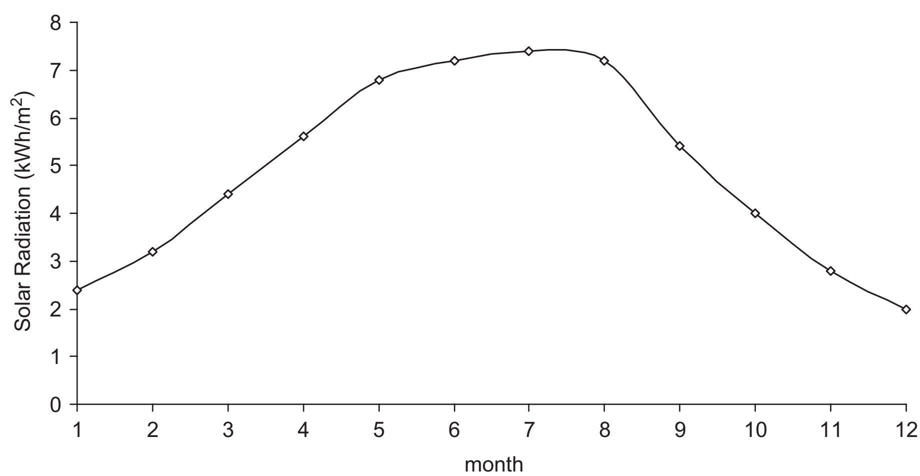

Fig. 2. Mean daily solar radiation.