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TRNSYS simulation of a solar cooling system for the hot climate of Pakistan

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Abstract

Cooling is a basic need for buildings in hot and sunny climates. In most countries the major source of cooling is electrical power based. During summer in hot climates there is an increase in electricity consumption due to cooling load. Pakistan is facing an electricity shortage crisis, which becomes worse in summer due to the high demand for cooling. The annual average insolation for Pakistan is 5-6 kWh/m^2/day, reaching 6-8 kWh/m^2/day in summer with sunshine of 10-13 hours a day, which gives suitable conditions for solar powered cooling system operation. TRNSYS software provides the possibility to simulate a complete solar air conditioning system integrated with a building. In this study, TRNSYS is used to model an absorption chiller operated by hot water from an evacuated tube collector. It is found that, with a hot water storage tank, a collector area of 12 m^2 is sufficient to maintain the temperature in a room in a typical house at or below 26°C during the cooling season.

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Keywords: Solar Cooling Pakistan; TRNSYS Simulation; Solar Thermal Cooling

1. Introduction

Pakistan has a generally hot and sunny climate, and many buildings use electrically powered air conditioning for much of the year. Most of the electricity system is dependent on fossil fuels (Fig.1(a)), which are expensive and damage the environment by their emissions (including greenhouse gases) [1]. Pakistan is an energy deficient country, where the majority of the population has inadequate provision of basic energy facilities like electricity and

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gas [2]. The current electricity shortage crisis started in 2007 and has affected the operation of cooling systems, causing discomfort in buildings, particularly in summer [3].

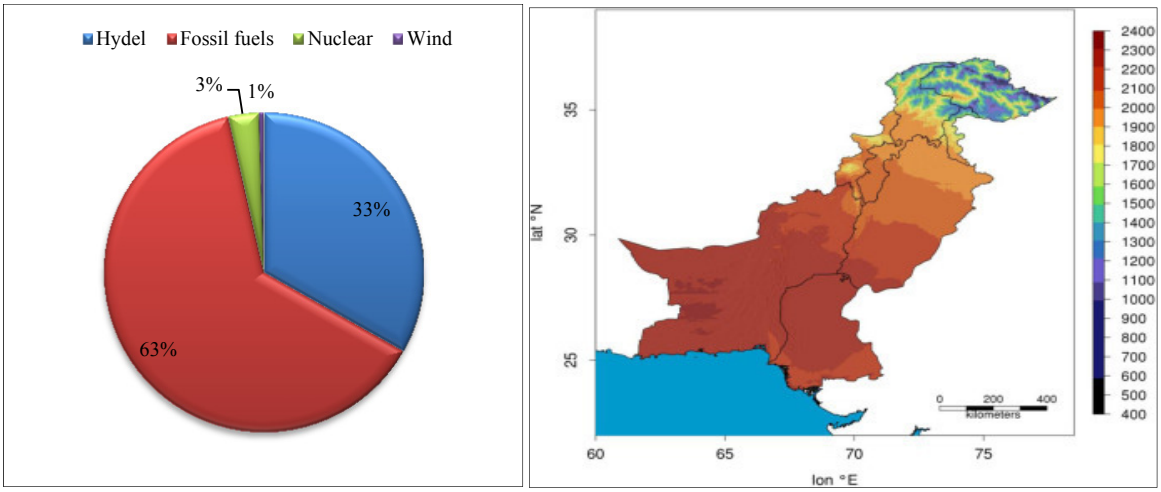

Fig. 1: Pakistan's (a) electricity generation by fuel type; (b) solar energy potential

The annual mean global insolation in Pakistan is 5-6 kWh/m^2/day, with 10 - 13 sunshine hours per day, which gives suitable conditions for solar powered cooling system operation[4]. The multi-year (2000-2012) mean of annual global horizontal irradiance for Pakistan is shown in Fig.1 (b)[5]. A clean and sustainable cooling system, such as solar energy cooling, can provide an alternative green source for comfort in buildings.

TRNSYS is a widely used, thermal process simulation program. It was originally developed by the members of the solar energy laboratory at the University of Wisconsin for solar energy applications, and can now be used for a wider variety of thermal processes. The first version was released in 1977 [6]. TRNSYS has the capability of interconnecting system components in any desired manner, solving the system differential equations, and producing information output. Component models may be selected from the libraries, or written by the user and linked to the main TRNSYS model [7].

The aim of this research is to use a TRNSYS simulation to determine whether it is feasible to use a system comprising an evacuated tube solar collector driving an absorption chiller, to maintain a comfortable temperature in a typical single family house in Pakistan during the cooling season.

Nomenclature

COP	Co-efficient of Performance
kW	Kilo Watt
kWh	Kilo Watt hour
TRNSYS	TRaNsient SYstem Simulation
TESS	Thermal Energy System Specialists
TR	Ton of Refrigeration

2. System description and modelling

The building comprises one room of a typical single-storey house in Pakistan, with one single-glazed window and one timber door. The room is of brick and concrete construction, uninsulated. The cooling system comprises an