Renewable and Sustainable Energy Reviews 54 (2016) 99–109

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Potential application of solar water heaters for hot water production in Turkey

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ARTICLE INFO

Article history:
Received 24 February 2015
Received in revised form
1 June 2015
Accepted 17 September 2015
Available online 11 November 2015

Keywords:
Solar water heater
Renewable energy
Turkey
Potential
Solar Energy

ABSTRACT

Turkey has become one of the fastest growing energy markets in the world in parallel to its economic growth registered in the last 10 years and is rapidly gaining a competitive structure. Turkey is increasingly turning to renewable energy sources as a means to improve its energy security and curb dependence on imported gas from Russia and Iran. Turkey is a country which has the highest hydropower, wind and solar energy potential among European countries. Current energy policy of Turkey primarily aims to maximize solar, geothermal, wind and hydropower potential of the country until 2023. In this study, solar energy potentials of country and solar water heaters were investigated using meteorological and geographical data from six cities in Turkey. Two different collector types were compared in terms of absorber material (galvanized sheet and vacuum tube). The energy requirements for water heating, collector performances, and economic indicators were calculated using climate data. Results showed that galvanized sheet absorbers were the most appropriate in terms of coverage rate of the energy requirements for water-heating across Turkey. The prices of a galvanized absorber type and a vacuum tube heating systems in Turkey are 950 and 1250 USD on average (including installation), respectively. Copper and selective absorber type collectors did not appear to be appropriate based on economic conditions. Six provinces in Turkey were chosen, which were ideally located to take advantage of solar thermal energy and technologies. The data also show that most of the solar water heaters are mainly used by the domestic sector for hot water production (about 96%). The regional popularization analysis indicates that the limited installation of solar water heaters in the Eastern and the Northern district. In these districts, the problem of climatic conditions and lack of purchasing power are addressed.

Contents

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http://dx.doi.org/10.1016/j.rser.2015.09.061
1364-0321/

1. Introduction

Today, there are only a handful of countries that produce their energy to be consumed. This fact forces countries to develop workable strategies on energy trade and security concerns. It is important to control and manage energy resources. Moreover, efficient use of these resources enables sustainable development and economic growth. Due to finite reserves of fossil fuels and adverse environmental effects, such as air pollution, depletion of the ozone layer and global warming, it is important to promote renewable energy. Despite the intermittent nature of renewable energy resources, they are a sustainable and clean energy asset derived from nature.

Turkey is increasingly reliant on imported sources of oil and natural gas. However, in order to supply the demand, almost all renewable energy forms are found in the country to comply with the need for sustainable energy. The Turkish government encourages investors to implement energy projects in Turkey with new incentives on renewable energy. This ensures that the government's feed-in tariff will accelerate investment projects in the coming years. In terms of geographical position and solar energy potential, Turkey provides better conditions than many other countries and offers very low installation costs, and similar effects increase the benefit from these energy sources. The easiest and most direct application of solar energy is the conversion of sunlight into low-temperature heat. Solar energy can be used for low grade heating by two types of technologies: passive and active solar energy conversion. Solar collectors are commonly used for active conversion of solar energy to heat.

There are many studies in the existing literature dealing with the performance of solar water heating systems Mills [1] and Nahar [2], simulation of thermosyphon systems Michaelides et al. [3], Bojie [4], configuration of solar water heating systems Hasan [5] and modeling of such systems using artificial neural networks Kaligirou [6] some studies deal with the estimation of solar radiation in an area Sen and Sahin [7], Sozen et al. [8] suggested a formula for solar potential estimation based on artificial neural networks. Chang et al. [9] presented a study, on the capacity of solar water heaters in Taiwan. Budihardjo and Morrison [10] compared and tested a glass evacuated tube solar water heater and a flat plate solar water heater in Sydney and reported that the performance of the glass evacuated tube solar water heater was higher. Chang et al. [11] showed the local market action of solar water heaters in Taiwan. There are only a few studies on the potential estimation of solar water heating systems and consumer adoption of solar water heating systems (SWHS). Kaya [12] and Balat [13] investigated the renewable the energy policies and political organizations that shaped these policies in Turkey. Erdem [14] has reported a detailed literature review about the renewable energy studies in Turkey, and she discussed the policy and legal aspects of renewable energy in Turkey. Barış and Kucukali [15] presented the availability and potential of renewable energy sources in Turkey and government policies, financial and environmental aspects of renewable energy projects.

SWHS have been proven to be reliable and economical in cases of hot water production, and are also the most successful study for the development of renewable energy in Turkey. The accumulated area of solar collectors installed at the end of 2012 reached 15,497,913 m^2, and total capacity reached 108,455 [MWth] (Table 1) [16]. The Turkish industry has a lot of experience in the SWHS market and production. On the other hand, solar collector production has been the largest growing market over the last few years. Thus, the aim of the present study is to compare two different solar water heaters having high and low prices and performances. Six provinces in Turkey were chosen, which were ideally located to take advantage of solar thermal energy and technologies. The distribution of global solar insolation in Turkey is shown in Fig. 1. The analyses were carried out for six provinces in Turkey (Fig. 1), ranging from three to 1500 m in altitude and from 36° to 41° in latitude. It is believed that this analysis will assist in the assessment of the SWHS market in Turkey, and these locations reflect all different types of climates occurring in Turkey.

2. Geographic profile of Turkey

Turkey is situated at the meeting point of three continents (Asia, Europe and Africa) and stands as a bridge between Asia and Europe. The country is located in southeastern Europe and southwestern Asia. Its size is 779,452 km^2. Turkey's population was about 77 million in 2014 [17]. Because of the social and economic development of the country, the demand for energy is increasing rapidly. Turkey is the most active energy transfer point due to its unique geographical position. Turkey stands out with the

Table 1
Total Collector Areas and total capacity (2014). Source: Ref. [16]

Country	m^2
China	257,700,000
USA	23,324,841
Germany	16,870,320
Turkey	15,497,913
Brasilia	8,262,056
Australia	7,613,200
Japan	4,964,509
Israel	4,177,367