Renewable and Sustainable Energy Reviews 41 (2015) 68–84

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Solar water heating: From theory, application, marketing and research

Zhangyuan Wang [a,c,*], Wansheng Yang [a], Feng Qiu [a], Xiangmei Zhang [a], Xudong Zhao [b,a]

[a] School of Civil and Transportation Engineering, Guangdong University of Technology, Guangzhou, Guangdong 510006, China
[b] School of Engineering, University of Hull, Hull HU6 7RX, UK
[c] State Key Laboratory of Subtropical Building Science, South China University of Technology, Guangzhou 510640, China

A R T I C L E I N F O

Article history:
Received 7 November 2013
Received in revised form
20 July 2014
Accepted 12 August 2014

Keywords:
Solar water heating system
Global market
Mathematical analysis
Research questions
Production
Engineering application

A B S T R A C T

The aim of the paper is to provide a comprehensive critical review towards the solar water heating (SWH) technology in terms of its theory, application, market potential and research questions. The theoretical issues relating to the solar water heating technology were illustrated in terms of the working principle, classification and associated mathematical expressions. The existing SWH production and engineering application were introduced and its future market potential was also predicted. Furthermore, research questions relating to the SWH were analysed involving (1) whole structure and individual components layout, sizing and optimisation; (2) thermal performance simulation and prediction; (3) laboratory based measurement compared against the modelling prediction; (4) dynamic performance evaluation through real time and on-site measurement; (5) energy saving, economic and environmental performance assessment, and social acceptance analyses; and (6) dissemination, marketing and exploitation strategies. Finally, the opportunities for the further works on the SWH were identified. This study will help understand the current status of the economic and technical developments, identify the barriers remaining to the existing solar water heating systems, develop the potential research areas to improve the performance of the systems, establish the associated strategic plans related to the design and installation of the system and promote the solar thermal global market. The study will contribute to achieving the China and international targets for energy saving, renewable energy utilisation, as well as carbon emission reduction in building sector.

© 2014 Elsevier Ltd. All rights reserved.

Contents

* Corresponding author. Tel.: +86 20 3932 2515; fax: +86 20 3932 2511.
E-mail address: zwang@gdut.edu.cn (Z. Wang).

http://dx.doi.org/10.1016/j.rser.2014.08.026
1364-0321/© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Over the past few decades, global energy consumption has been steadily growing. In 2008, the total consumed primary energy reached a level of 11,315 million tonnes of equivalent oil (equalling to 474 EJ) [1], of which 80–90% was from the burning of fossil fuels. Despite the latest energy review [2] indicating that owing to the unexpected global financial crisis the world's primary energy consumption dropped by 1.1% in 2009, energy consumptions in some developing countries, particularly in Asia, were still rising. In addition, overexploitation of the primary energy sources has caused the depletion of fossil fuels, and there will only be 119 years of coal production, 46 years of oil production and 63 years of natural gas flow left in the ground with the current proved reserves [3]. The principle of energy supply and demand suggests that as fossil fuel supplies diminish, rising energy prices will impact on the development of the global economy.

On the other hand, the combustion of fossil fuels for energy, industrial processes and transportation has caused a significant increase in the emissions of greenhouse gases to the atmosphere. It has been agreed by most scientists that this growth is the primary cause of global warming. Over the last 30 years of the 20th century, global temperature has already risen 1.4 °C [4], and it will continue to rise over the next decades. This warming will cause significant changes in sea levels, ecosystems and weather events, which will threaten people's health and way of life, and cause irreversible losses to species of both plants and animals.

Thus, the inflation of energy prices and the impact of climate change have led to the exploration of alternative, renewable energy sources for the purposes of energy savings and environmental protection.

Solar thermal is one of the most cost-effective renewable energy technologies and has enormous market potential globally. Since the beginning of the 1990s, the world solar thermal market has been continuously developing. In Europe, the solar thermal market was tripled from 2002 to 2006 and is still booming [5]. The European Solar Thermal Industry Federation (ESTIF) has predicted that, by 2020, the European Union (EU) will reach a total operational solar thermal capacity of between 91 and 320 GW; and by 2050, the EU will eventually achieve 1200 GW of solar thermal capacity [6].

Solar water heating is one of the most popular solar thermal systems and accounts for 80% of the solar thermal market worldwide [7]. Over the past four decades, solar water heating systems have gained wide applications in the building sector globally [8]. In the meantime, the systems have been identified with a number of technical problems that have become the barriers to their promotions, e.g., low existing efficiency, high heat loss and poor solar energy harvesting capability. Some challenges also relate to their installations to the buildings and capital costs.

Most solar water heaters (SWH) for buildings are flat-plate types or conventional heat pipes array installed on roofs for layout convenience. This installation requires long runs of pipelines delivering water from the roof heaters to the outlet points and receiving water from the water mains. Thus, the cost of the system is high; most importantly, the installation detracts from the aesthetics of the building, particularly those multi-storey buildings containing a large number of end users.

In recent years, several façade-based solar heaters have been developed and used in practical projects [9–11]. These devices are simply positioned on the walls or balconies [12], which prevent the occupation of roof space and shorten the distance of piping runs, and thereby improve the building's aesthetic view. However, this layout still requires the transportation of water from the inside of the building to the outside, which may cause the hazard of pipes freezing during winter operation.

Further development has been undertaken to introduce the loop heat pipe concept into the solar collectors. Loop heat pipe [13,14] was a two-phase (liquid/vapor) heat transfer device allowing a high thermal flux to be transported over a distance of up to several tens of metres in a horizontal or vertical position owing to its capillary or gravitational structure. However, the starting-up problem of the loop heat pipe still exists influencing the operating stability of the solar collector, as well as the high initial cost of the system. Still, the loop-heat-pipe-based solar collectors are in the laboratory experimental stage that the structure of the system needs to be optimised.

Although many works have been undertaken with the solar thermal collectors, it seems to remain certain level of ambiguity

Download English Version:

https://daneshyari.com/en/article/8118310

Download Persian Version:

https://daneshyari.com/article/8118310

Daneshyari.com