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Analysis on limitation of using solar fraction ratio as solar hot water system design and evaluation index

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Abstract

Solar fraction ratio is a key index and reference of solar hot water system design, and is also a key factor to evaluate solar hot water system according to *Evaluation Standard for Application of Renewable Energy in Buildings in China*. By analyzing relevant inspection data of actual projects, it was found that using solar fraction ratio to evaluate the actual running systems has certain limitation, which cannot reasonably reflect the actual supplementation of conventional energy, especially with the residential buildings applying central solar hot water system. Based on the total energy consumption control concept raised by government during the Twelfth Five-Year Plan period, the actual supplementation level of conventional energy should be used as a factor to evaluate solar hot water system. This study will analyze the limitation of solar fraction ratio in design and evaluation, and propose corresponding ideas of solution as references for relevant design and evaluation professionals.

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Keywords: Solar hot water system; Evaluation; Index; Solar fraction ratio

1. Introduction

In recent years, the application technologies of renewable energy have developed rapidly around the world. China has very rich solar energy resources, it is estimated that solar radiation on China land surface is about 147×10^8GWh each year, and annual national total solar radiation has reached 335~837kJ/cm^3[1]. Solar hot water system

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is the most basic application of solar energy, and currently has rather obvious economic benefits.

Long-term Plan of Renewable Energy released in 2007 clearly stated the goal to gradually increase the ratio of renewable energy consumption up to 15% of whole energy consumption by 2020 [2]. And in 2011 more details of this goal were further clarified in Notice *on Further Promoting the Renewable Energy Application in Buildings* (Cai Jian [2011] No. 61) jointly issued by Ministry of Housing and Urban-Rural Development (MOHURD) and Ministry of Finance[3]. Beginning in 2006, MOHURD and Ministry of Finance have launched nationwide demonstration projects of building applying renewable energy including solar thermal, which has effectively driven the solar thermal application market and fostered the rapid development of solar thermal industry. By the end of 2009, MOHURD and Ministry of Finance have implemented four turns of renewable energy building demonstration, counted more than 300 projects. 130 solar thermal demonstration projects were established in total, and solar thermal demonstration projects area is of 4.93 million square meters. From 2009 on, MOHURD and Ministry of Finance began to organize the implementation of demonstration cities/demonstration counties. By 2012, solar thermal application area is of 2.46 billion square meters in China cities [4-6].

On the other hand, since 2007, more than 40 provinces and cities in China have formulated and promulgated solar obligations. Most policies require mandatory installation of solar water heating system in civil buildings less than 12 floors [7]. With large-scale applications of solar hot water system and huge number of constructions completed, to evaluate the actual effects is the key step to achieve energy-saving and emission reduction, and to foster the industry development.

Nomenclature

A_C	direct system collector area, m^2
Q_w	daily water consumption, L
C_w	water specific heat capacity at constant pressure, $kJ/(kg \cdot ℃)$
t_{end}	design water temperature in water tank, ℃
t_i	original water temperature, ℃
J_T	local annual average solar radiation on collector lightening surface, kJ/m^2
f	solar fraction ratio, %; which should be 30% ~ 80% according to solar radiation, system economic benefits and user needs, etc. during system functioning period
η_{cd}	annual average heat efficiency of collector, falls in between 0.25 ~ 0.50 according to the experience, specific value should be decided according to collector's actual test result
η_L	heat loss in water tank and pipes, falls in between 0.20 ~ 0.30 according to the experience

2. The rapid development of solar thermal application in building design and evaluation standards

In 2005, MHOURD promulgated *Technical Standard of Solar Hot Water System in Civil Buildings (GB50364-2005)*, which laid the technical foundation for solar hot water system application in civil buildings. Following by the publication of national building design standard and atlas: *Solar Collector System Design and Installation (06SS128）* and *Central Solar Hot Water System Selection and Installation（06SS128）*, which set up basis for architectural design engineers. In order to ensure the application effect, test and evaluation according to *Evaluation Standard for Renewable* Energy *Application Projects in Buildings (GB / T 50801-2013)* is required when project construction finished.

2.1. Design methods and standards for solar hot water system

Existing solar hot water system design is mainly based on *Technical Standard of Solar Hot Water System in Civil Buildings* GB50364-*2005）* and *Design Standard of Water Supply and Drainage in Buildings（GB 50015)*. The design process can be briefly summarized into six steps, as shown in Figure 1. The design key work in several sectors is to determine the collector area of the system. The collector area should be calculated according to average daily water consumption, local annual average daily solar radiation, solar collector heat efficiency and solar fraction ratio, etc.