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Economic feasibility of flat plate vs evacuated tube solar collectors in a combisystem

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Abstract

The aim of this research is to determine the economic feasibility of a solar thermal system used for Domestic Hot Water and Radiant Floor Heating. A two floor house is modeled to create a thermal load. The system design and thermal analysis is studied using TRNSYS. The technical-economic analysis is performed using Microsoft Excel. The optimal type/number of solar thermal collectors and thermal storage size were determined based on the economic figures. The optimum system configuration for the case of evacuated tube system resulted in 8 collectors using a storage relation of 40 L/m^2 whereas flat plate system resulted in 12 collectors using a storage relation of 50 L/m^2. The return on investment for the flat plate system was calculated in 9 years and the evacuated tube system resulted in approximately 11 years.

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Keywords: Solar Energy; TRNSYS; Combisystem; Radiant Floor; Hot Water; Economic feasibility.

1. Introduction

The National energy balance indicates that the residential sector consumes about 16% of the total energy [1]. However, around half of that energy it is consumed in terms of space and water heating.

Due to economic and technological development higher comfort levels in buildings are constantly being demanded. Although human comfort involves many inputs influenced by physical, physiological, psychological, and other processes, thermal comfort in buildings is a primary objective. As a consequence temperature is an important

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variable for thermal comfort inside a building. Since there are wide temperature variations in weather conditions in the northwest region in Mexico, designing a well-insulated building with an adequate HVAC system represents a challenging work [2].

Radiant floor heating is not a new concept; moreover, it has been used since the very first moments of human reason, when heated rocks were buried below the ground in order to create a comfort condition. Although it is a well-known concept, it is still being studied and discussed all around the world getting more and more popularity for its great number of advantages over the most commonly used heating systems.

The Water council assures that 96.1L of hot water are consumed daily by person. This consume represent the 47% of the total energy used by an entire building [3]. Since water and space heating represents a significant part of house daily energy consumption and moreover the solar radiation over the analyzed region is among the best of the world, an economic analysis is needed to determine the optimum combisystem configuration for this specific application.

Solar thermal behavior of several systems under different thermal loads for heating and domestic hot water has been studied. Leckner and Zmeureanu, presented the performance of a base case solar combisystem, focuses on the search for the optimal configurations of a residential solar combisystem for minimum life cycle cost, life cycle energy use, and life cycle exergy destroyed in Montreal [4].

In 2012 an analysis was performed using 4 different types of construction in two different locations. TRNSYS was used in order to model and simulate the buildings with different thermal loads. The results show that these systems are more cost effective when there is a greater solar availability and are applied in buildings with higher energy demands [5].

Ampatzi and Knight analyzed the importance and consequent complexity of gaining a reliable estimate of the temporal energy demands made of active domestic solar systems. TRNSYS was used to study the influence of weather data, thermal comfort operating schedule, lighting and plug loads, on the predicted thermal energy demands that are to be met by solar thermal combisystems with heat storage. The study demonstrates also that dynamic system simulation tools like TRNSYS can handle the complexity of elaborate building modelling descriptions but highlights the need for more suitable modelling methods which incorporate comprehensive, building-focused interfaces [6].

Nomenclature

DHW	Domestic Hot Water
RFH	Radiant Floor Heating
PEX	Crosslinked Polyethylene
PW	Present Worth
SPWF	Series Present Worth Factor
GPWF	Gradient Present Worth Factor
i	Inflation
G	Gradient
R	Uniform Amount
Aux	Auxiliary amount of energy
Eff	Tank-less heater efficiency
EC	Energy Cost
ΔEC	LPG Annual Cost Interest
PW	Present Worth
ROI	Return on Investment