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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 research is to determine the economic feasibility of a solar thermal system used for Domestic Hot Water and Radiant Floor Heating. A two dwelling 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 thermal collectors and thermal storage size were determined.

Introduction.

The National energy balance indicates that the residential sector consumes about 16% of the total energy. Moreover, higher comfort levels in buildings are increasingly being demanded due to economic and technological development. Temperature is an important variable for thermal comfort inside a building and since there are a 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.

System conditions and methodology.

A solar heating system was designed to provide the required amount of energy for domestic hot water (DHW) and radiant floor heating (RFH) using solar thermal collectors, heat storage and a residential tank-less water heater as an auxiliary support. The system description has been divided into two main parts: The solar energy collection and the RFH/DHW as shown in Fig. 1.

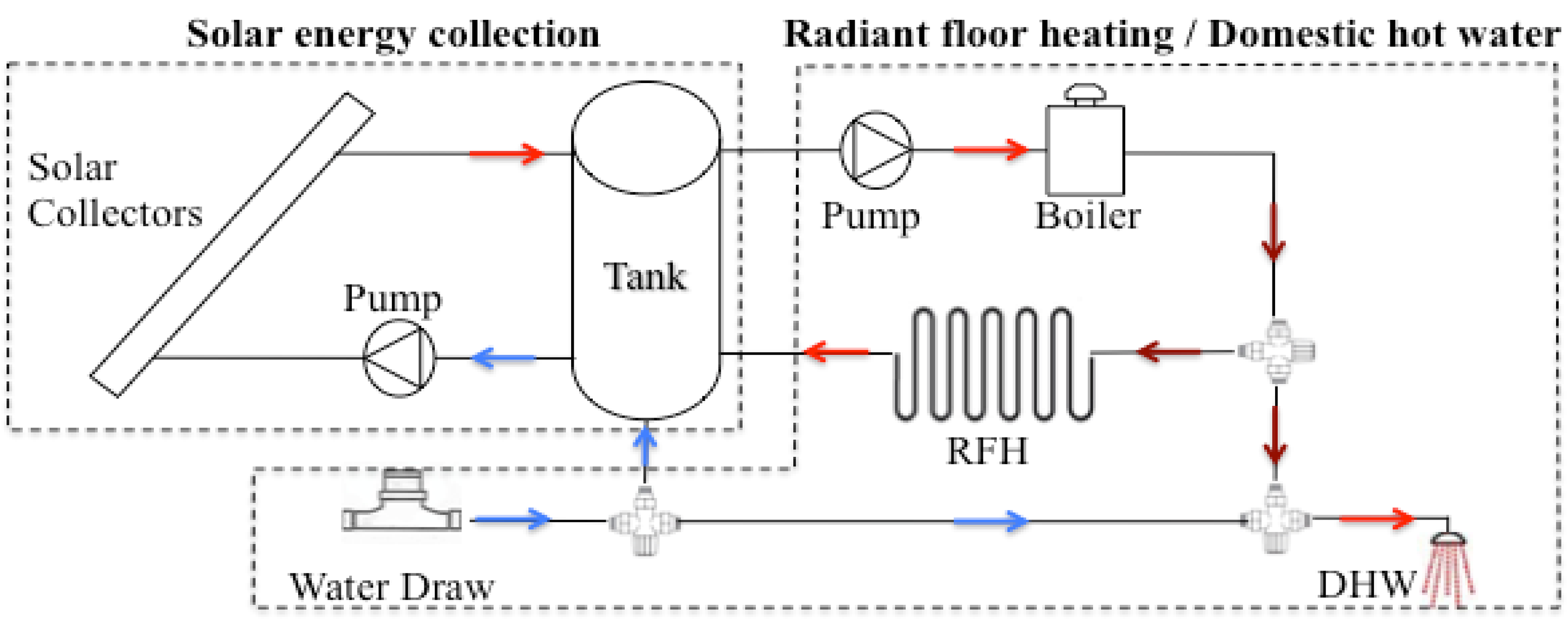

Fig. 1. Proposed system diagram.

Building.

The analyzed building is located at latitude 28.65° and longitude -106.15° in Chihuahua, Chihuahua, Mexico. The first floor was set as one thermal zone whereas the second floor was divided into two thermal zones. The building schematic and the radiant floor heating surfaces are shown in Fig. 2.

Radiant floor heating.

The RFH pump will be in operation while time is between 15:00 pm to 8:00 am and any thermal zone temperature is below 21°C. Whereas, the diverter will apply the result given by a logical function in order to control which floor need a greater hot water flow. RFH control diagram is shown in Fig. 3.

Domestic hot water.

The average daily hot water consumption for personal sanitation in Chihuahua is 96.1 L per person. Four persons are being considered in this analysis, which means a daily consumption of 384.4 L in a draw period between 6:00 and 8:00 am every day. DHW outlet is set to 45°C by combining hot water from the tank and cold water from the draw (Fig. 4). Cold water reposition from the draw to the storage tank was also considered.

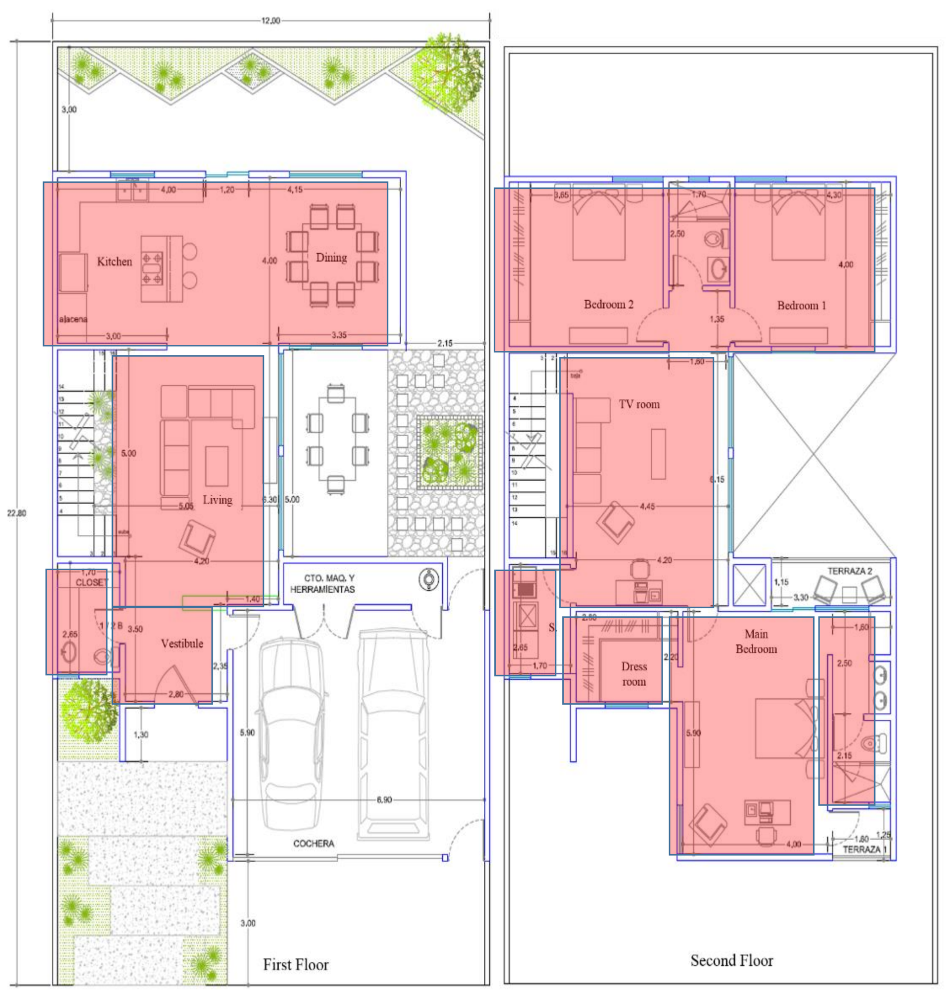

Fig. 2. Radiant floor heating surfaces

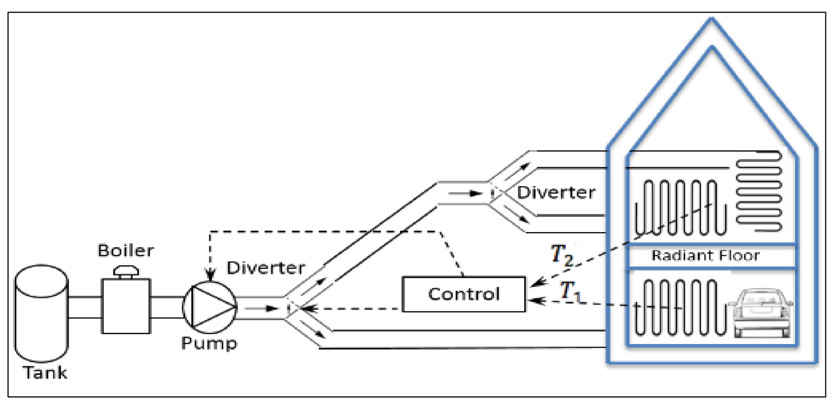

Fig. 3. RFH Control diagram

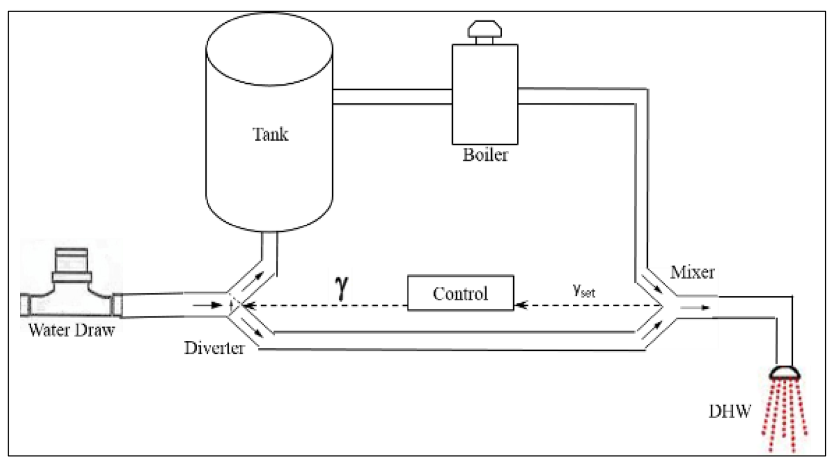

Fig. 4. DHW Control diagram

Economic Analysis

The feasibility of these systems is analyzed considering the equipment cost, operation cost and life span of the solar equipment.

Equipment Cost. The cost considered for the solar thermal collectors includes two types: Flat plate solar collectors or evacuated tube solar collectors.

The tank cost is calculated based on a polynomial regression developed using Swimquip costs information.

Operation Cost. Operation cost is calculated based on the auxiliary amount of energy which is parametrically obtained by the simulations when variating collectors and storage capacity.

The present worth value is influenced by the LPG interest (9%), inflation (4%) and the solar equipment life span (25 Years).

Results.

Fig. 5 and Fig. 6 show the results of the parametric analysis for evacuated tube and flat plate solar collectors, respectively. It can be observed that the lower cost corresponds to the optimum system configuration, which for the case of evacuated tube analysis results in 8 collectors at a storage relation of 40 L/m^2 ,whereas the flat plate analysis results in 12 collectors at a storage relation of 50 L/m^2.

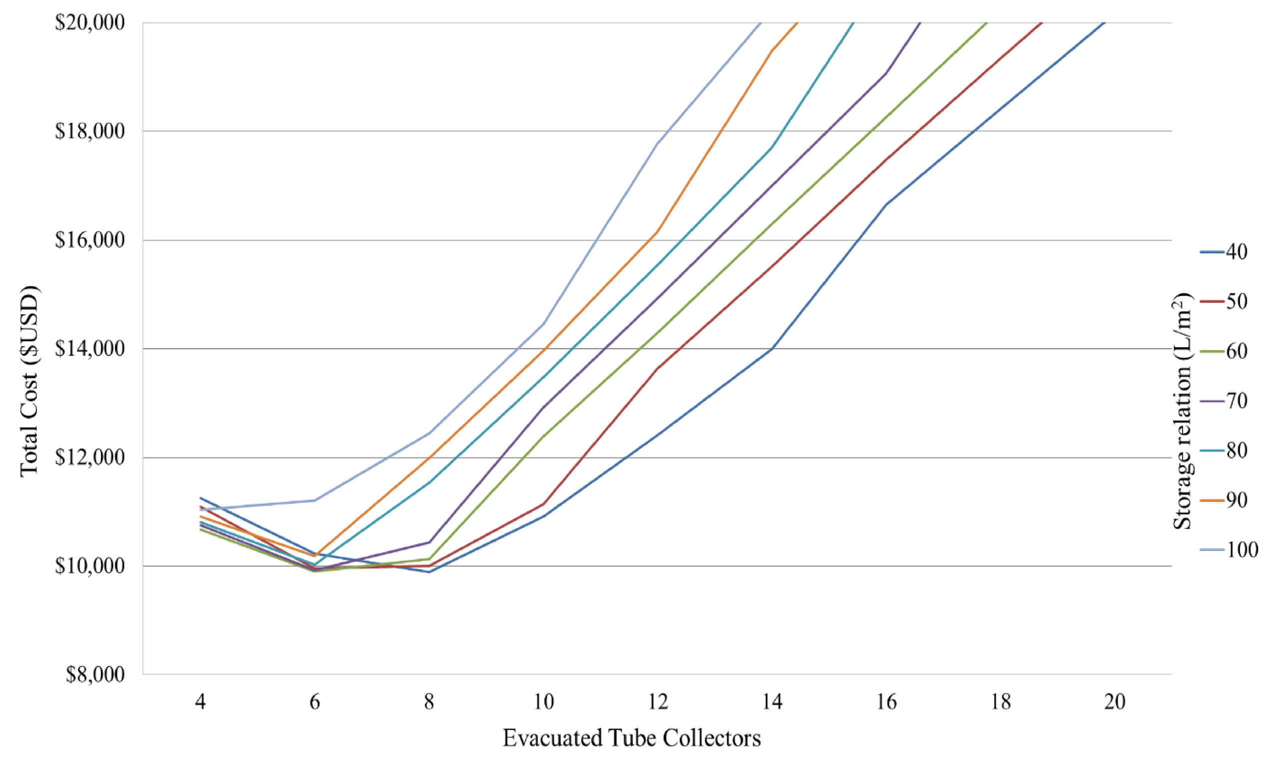

Fig 5. Results for evacuated tube collectors.

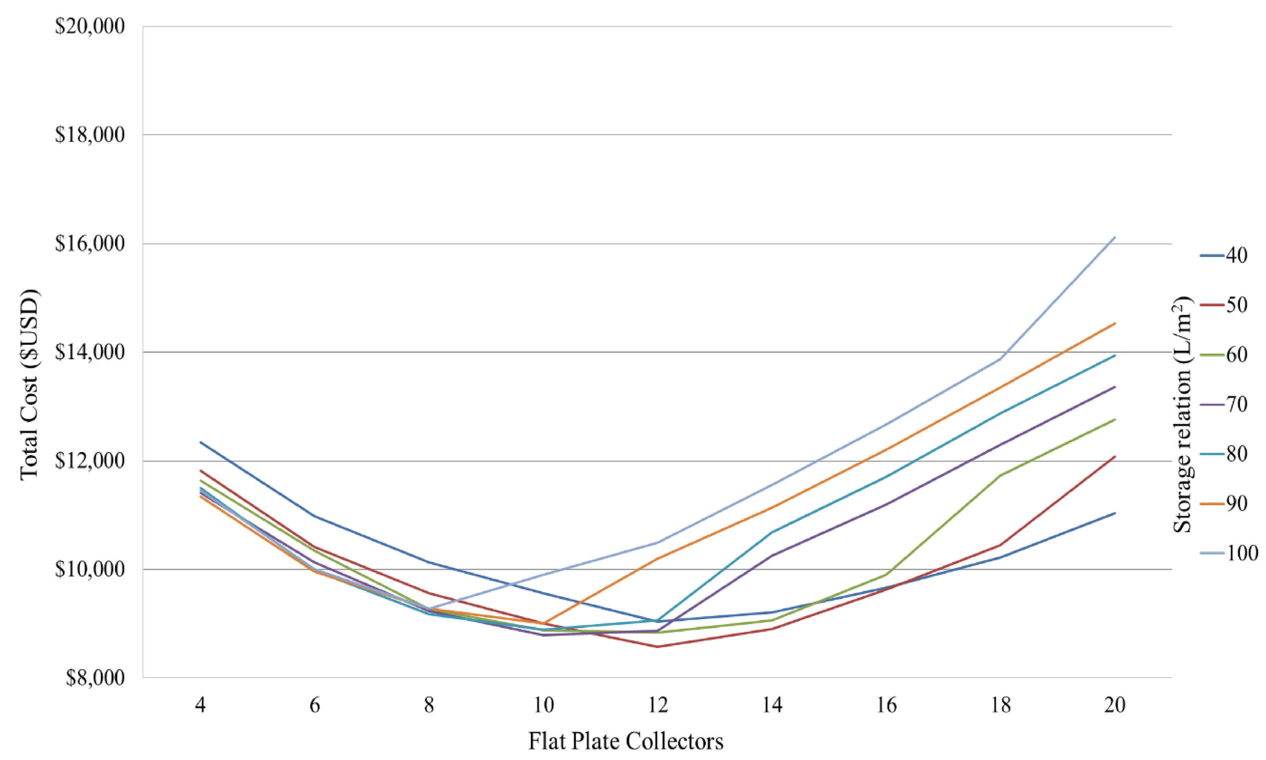

Fig 6. Results for flat plate collectors.

Conclusions.

The developed simulation can be further used for dimensioning and optimization of a solar combisystem for a different house in a different location.

Considering the total cost (Equipment plus operation) of a non-solar collector system, the return on investment (ROI) is calculated for both evacuated tube and flat plate systems. Whereas the ROI for the flat plate system is calculated at 9 years, the evacuated tube system results in approximately 11 years. Even tough the total cost is lower and the ROI is shorter for the flat plate system, it would be convenient to consider installation and maintenance costs in further analysis.

Acknowledgements.

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