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TRNSYS Modeling of flat plate and vacuum tube solar collector systems for residential use under equatorial middle altitude climate condition

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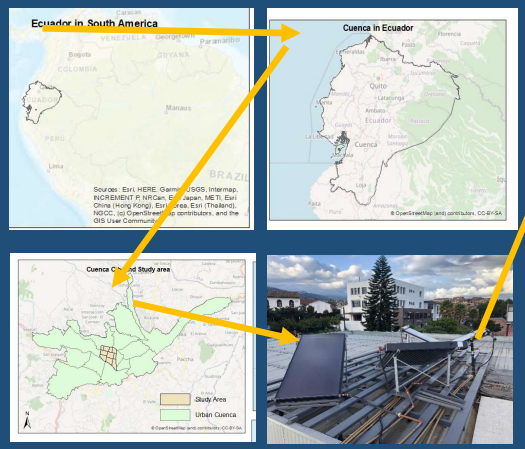
ABSTRACT

Residential solar systems were simulated to predict feeding domestic hot water, using TRNSYS (TraNsient SYstem Simulation), under the operating conditions in Cuenca, Ecuador. The research process is quantitative and with a correlational approach. Using data from an experimental test, a technical sheet was prepared that sought to identify the main variables to be applied in the model. The diffuse and direct radiation data were obtained by applying the isotropic diffuse model. When simulating in the software, the results show that the system presents an efficiency of 56.54% when heating water in a range of 30° to 45° C. For the validation of the model, the chi-squared statistical test was applied, with which it was determined that the simulated data follow the same distribution as the real data.

INTRODUCTION

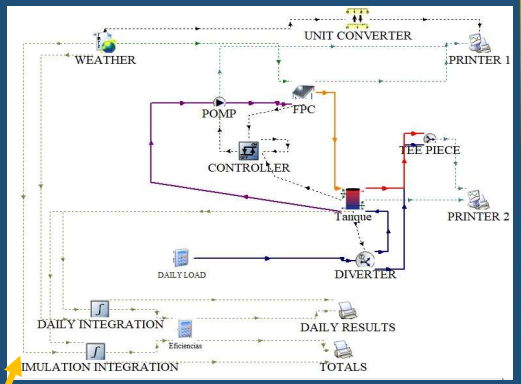
This work characterizes the performance of solar collectors to obtain DHW in the city of Cuenca, using the TRNSYS software. The results obtained will be contrasted with the real measurements obtained in four systems installed at the University of Cuenca. These systems are made up of two types of collectors and operate in a way that simulates the demand conditions of a home. With this, the representative performance of a residential scenario is determined, as well as the performance under different orientations and inclinations. To calculate the incident radiation on an inclined surface in the study area, the Isotropic Diffuse Model is applied.



Two flat plate solar collectors
Two evacuated tube solar collectors

METHODOLOGY

For the validation of the virtual model, the real outlet temperatures of each collector are compared with the temperatures in the simulated model. With the outlet temperatures, an error is calculated for each hour.



Using the TRNSYS interface, the thermal network and the connections for each thermal solar system were made.

Using TRNSYS, virtual connections were made between the different elements that make up each solar thermal system. The technical specifications of each element were entered and for the demand a consumption was established for a family of four inhabitants.

RESULTS

The validation of the simulation allows comparing the results of the developed models and the real temperature data (°C).

The efficiencies of the collectors according to their orientation and inclination. It is observed that at a lower angle of inclination there is better performance as a consequence of the more direct solar incidence at the equatorial latitude.

In total, 16 simulations were carried out, since four collectors (two FPC and two ETC) were installed, each one operating independently and at different inclinations and orientations. In each case, the real results were compared with the simulated results.

N° SIM.	COLLECTOR	ERROR	AVERAGE ERROR	SD	AVERAGE SD
1	FPC01	5.71%	5.79%	6.69	5,12
2		5.77%		4.48	
3		5.43%		4.05	
4		6.26%		5.27	
5	FPC02	6.15%	6.20%	4.55	4,85
6		6.42%		5.10	
7		5.54%		4.31	
8		6.67%		5.43	
9	ETC01	4.60%	5.60%	3.27	4,43
10		6.18%		5.59	
11		5.74%		4.23	
12		5.87%		4.62	
13	ETC02	4.68%	5.57%	3.84	4,51
14		5.44%		4.62	
15		5.84%		4.42	
16		6.33%		5.16	

N° SIM.	COLLECTOR	INCLINATION	ORIENTATION	AZ (°)	EFFICIENCY (%)
1	FPC01	14°	East	90	52.73
2		45°	North	0	53.28
3		26°	North	0	53.79
4		18°	North	0	56.54
5	FPC02	14°	North	0	54.00
6		45°	East	90	50.04
7		26°	East	90	52.83
8		18°	East	90	54.89
9	ETC01	14°	South	180	61.26
10		45°	South	180	66.12
11		26°	South	180	69.16
12		18°	South	180	69.76
13	ETC02	14°	West	270	57.95
14		45°	West	270	63.87
15		26°	West	270	69.05
16		18°	West	270	68.55

CONCLUSIONS

Simulation and validation of solar thermal systems allows uncertainty to be reduced by using simulation tools. Four solar collector systems of two different technologies were characterized in different orientations and inclinations of the collectors. The validation between the data obtained and the results of the simulation will allow different scenarios to be analyzed, without the need to install thermal systems that, apart from being expensive, would not allow different working conditions to be proposed.

The TRNSYS model allowed to analyze the efficiencies of the systems at more than water outlet temperatures. It was established that a system made up of a 2 m2 FPC and a 200 L storage tank can satisfy approximately 50% of the water demand of a 4-person house with a consumption of 200 L per day. While a system composed of a 3 m2 evacuated tube collector and a 300 L storage tank can satisfy around 60% of this demand. This indicates that it is necessary to complement the production of thermal energy with auxiliary systems to maintain comfort conditions