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Solar Energy as an Alternative to Energy Saving and Pollutant Emissions Reduction

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In the paper is analyzed thermal solar systems efficiency from the point of view of energy savings and pollutant emissions concentrations exhausted during these installations operation. For this purpose were taking into account four versions of solar panel systems combined with different types of conventional heating sources, for which were simulated the operation conditions. As a result of the simulation, there were obtained the values of energy savings and pollutant emissions during the four systems operation. By analyzing these values, the combined thermal system optimum solution was selected.

***Keywords**: solar energy, energy savings, hot water, thermal system, pollutant emissions*

1. Introduction

Considering that solar radiation is present over the entire surface of the Earth, inexhaustible and easily captured, solar energy is the source of energy used to heat buildings and water of renewable energy sources. In this respect, the most common and advantageous application is the solar energy utilization for domestic hot water (DHW) preparation, as a contribution to the required heat for heating buildings [1], [2]. Solar systems with flat plate collectors, vacuum tubes or photovoltaic are used in order to achieve this requirements.

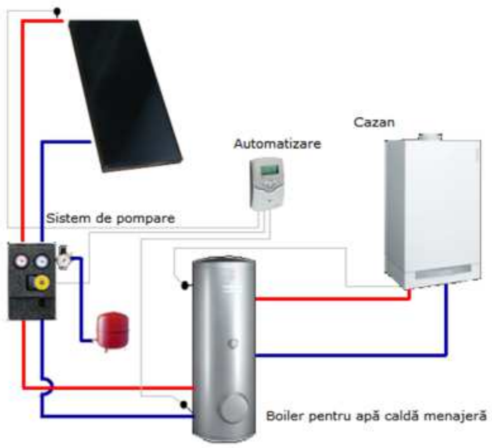
Current status regarding the efficiency of using solar panels in various constructive versions comprises a series of researches conducted by different authors, specialists in thermal field [3], [4]. Thus, were analyzed a number of parameters which significantly influence the efficiency of these systems [5], [6], [7], [8].

Flat collectors and those with vacuum tube are suitable for DHW heating and pool water heating, and also for heating support and process heat generation. The transformation of light into heat into the collector is identical in both types of collectors.

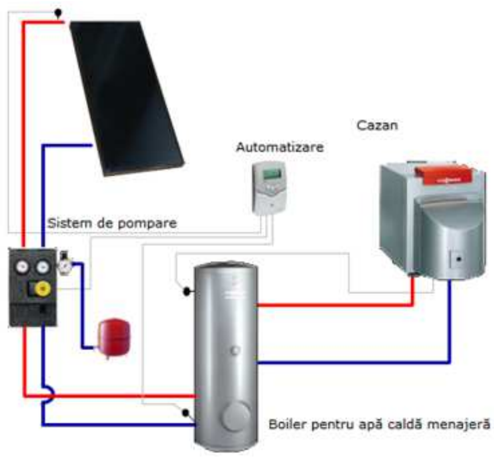
Flat solar collector systems used for DHW preparation are the most affordable in terms of efficiency / price ratio [9], [10].

2. Solar thermal systems combined with different conventional thermal systems

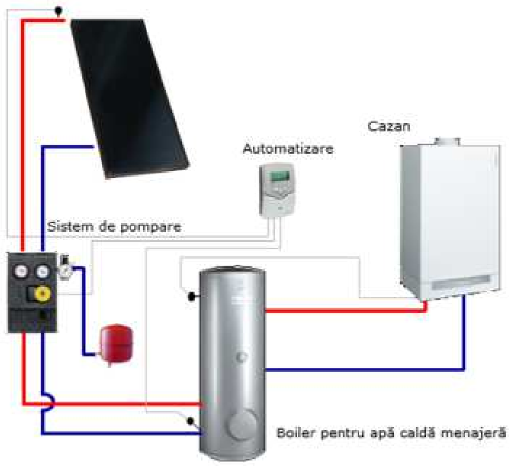
In order to analyze the solar systems efficiency in terms of energy savings and pollutant emissions, were considered four different systems of solar panels combined with different boilers types (Fig. 1), namely gaseous and liquid fuel boiler (Fig. 1a and Fig. 1b), respective condensing boiler and electrical one (Fig. 1c and Fig. 1d).



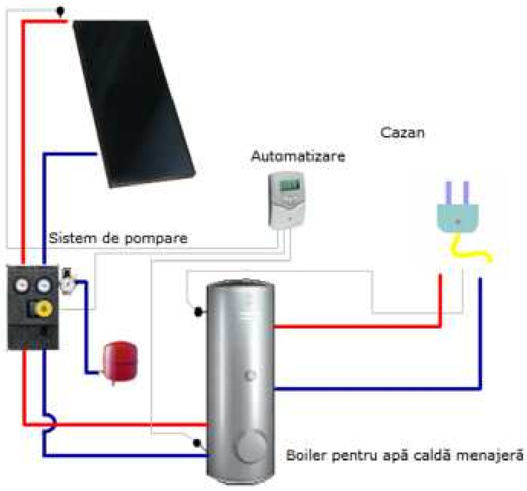
a) flat solar panel-gaseous fuel boiler



b) flat solar panel-liquid fuel boiler



c) flat solar panel-condensing boiler



d) flat solar panel-electric boiler

Figure 2. Thermal systems operational schemes

For each version the energy saving and emission concentrations exhausted during thermal solar systems operation were simulated.

The four considered versions were simulated using SELTECO Software, in order to estimate which is the optimum solution of thermal system with flat panel for DHW preparation [11].

3. Comparative assessment of energy savings and exhaust emissions when using thermal systems with flat solar panels

For the comparative study of thermal systems with flat solar panels used to prepare DHW for a residential building with a height of P+1 in Timișoara, located in the climatic zone II [12], were considered four constructive versions of thermal installation fueled by different energy sources.

The estimation was carried out considering a number of four consumers at an average consumption of 50 l / person / day, and an operating temperature of 45°C. For all considered versions were chosen 200F Vitosol flat solar collectors mounted on a roof with inclination of 30° oriented in a southerly direction.

The boiler volume resulted of 200l, regardless of system type and power source, because it is influenced by the consumer number and type, and the water temperature difference between input and output, respectively operating time.

To provide the heat required, the software set up a required solar collector area of 3,2m^2. From the technical characteristics of the type of Vitosol 200F flat solar panel, The absorbent collector surface is equal to 2.3 m^2, resulting in the need for mounting two collectors of total area of 4,6m^2.

3.1. Comparative assessment of energy savings: conventional thermal system versus flat solar collectors

In order to obtain the optimum solution of the thermal system from economy savings point of view, was simulated the operation with and without recirculation of the four combined thermal systems, namely flat solar panel - boiler with gaseous fuel, flat solar panel - boiler with liquid fuel, flat solar panel –condensing boiler and flat solar panel –electric boiler.

Following the simulation, there were resulted the average annual and during summer values of energy savings, which are presented in Table 1.

Table 1. Average annual and during summer energy savings estimation [%]

TYPE	Boiler with gaseous fuel	Boiler with liquid fuel	Condensing boiler	Electric boiler
No recirculation	59.30	6.,04	60.04	59.75
	93.49	93.61	93.61	93.56
With recirculation	60.44	59.75	60.44	60.44
	93.67	93.56	93.67	93.67

By analyzing comparatively the characteristic values from Table 1, it is noticed that the highest savings are recorded during summer.

From a comparative analysis between thermal systems types with ad without recirculation is carried out, there can be observed differences only in the second case, the most advantageous systems being those with condensing boiler and liquid fuel.

3.2. Comparative analysis of pollutant emissions: conventional thermal system versus flat solar collectors

For the four term systems there was carried out also a comparative analysis regarding the emissions resulted from conventional thermal systems operation and their reduction by combining these systems with flat solar panels. The values of CO_2, CO, NO_x and SO_2 emissions resulted from the simulation are presented in Table 2.

Table 2. Emission concentrations exhausted during the four system operation

SYSTEM TYPE		POLLUTANT EMISSIONS			
		CO_2 [kg/year]	CO [g/year]	NO_x [g/year]	SO_x [g/year]
Boiler with gaseous fuel	No recirculation	793	40	198	-
	With recirculation	900	45	225	-
Flat solar panels - boiler with gaseous fuel	No recirculation	317	16	79	-
	With recirculation	360	18	90	-
Boiler with liquid fuel	No recirculation	1031	79	198	793
	With recirculation	1170	90	225	900
Flat solar panels - boiler with liquid fuel	No recirculation	412	32	79	317
	With recirculation	468	36	90	360
Condensing boiler	No recirculation	700	35	175	-
	With recirculation	794	40	198	-
Flat solar panels - condensing boiler	No recirculation	280	14	70	-
	With recirculation	318	16	79	-
Electric boiler	No recirculation	2661	34436	12522	31305
	With recirculation	3019	39067	14206	35516
Flat solar panels - electric boiler	No recirculation	1064	13774	5009	12522
	With recirculation	1208	15627	5682	14206

It is obvious that by using combined systems, pollutant emissions are much lower compared to those exhausted by conventional thermal systems. This fact can also be observed by analyzing the values from Table 2.

By performing an analysis of emissions resulted from the thermal system operation, with recirculation versus no recirculation, it can be observed that emissions of CO_2, CO, NO_x and SO_2 are higher. Therefore, the opportunity of using the other systems was analyzed. Thus, in terms of CO_2, the values are significantly higher than for systems with solar panel and condensing boiler or boiler with gaseous liquid. The CO_2 values for the last two systems are similar.

When analyzing CO emission, the conclusion is the same. The difference is that CO emissions for the boiler powered by liquid fuel are twice higher compared to those exhausted during the operation of the other two boilers types of which emissions values are equal.

NOx values are slightly lower in case of the combined system with condensing boiler compared to the other two combined systems with boiler powered by gaseous fuel and liquid fuel of which values are equal.

Due to the fact that in gaseous fuel composition there are no sulphur compounds, the combined thermal systems with condensing boiler and powered by gaseous fuel are more attractive from this point of view. On the other hand, using boiler powered by liquid fuel within the combined thermal system is quite pollutant in terms of SO_2.

4. Conclusions

The result of the performed study is the efficiency assessment of using Vitosol 200F flat solar panels for DHW preparation during an annual operating period.

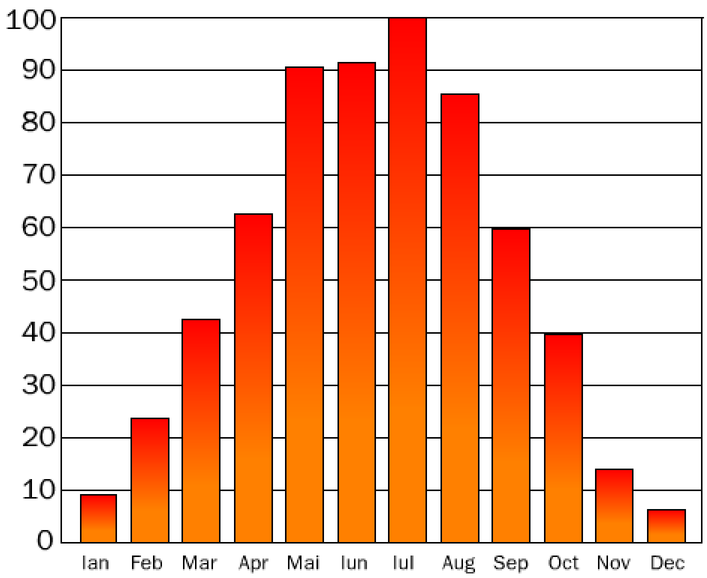


Figure 2. Efficiency of Vitosol 200F flat solar collectors

From Figure 2 it can be observed that on July the system efficiency is of 100% which means that an additional source of energy is not required in order to prepare DHW or for heating. In this case, the economy in energy cost resulted from the thermal solar system installation is of 100%.

The time required to install an additional heat sources for heat production is represented primarily by January-March and November-December, when the economy in energy cost is much reduced.

In this respect, both in terms of pollutants released into the atmosphere and energy saving, the most efficient thermal systems in terms of its operation during a year is the one with solar panel and condensing boiler.

In conclusion, although the investment cost for solar panel - condensing boiler system is higher than the other three systems, this one represents a viable solution because of the advantages mentioned above.

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