IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

Experimental house and stratification preheating tank

IOP Conf. Series: Materials Science and Engineering **566** (2019) 012017 doi:10.1088/1757-899X/566/1/012017

Experimental house and stratification preheating tank

J Kosican[1]

[1] Technical University of Košice, Department of civil engineering, Institute of Architectural Engineering, Slovakia

Abstract. The aim of this study is to simulate two types of usage of solar panel systems and their share of heating and hot water in the experimental house. Two differently designed solar systems are tested in an experimental house with stratification and the other without stratification. Both systems provide annual demand for heat and demand for hot water. The simulation program is T * SOL 2018. By using a variant comparison program, it allows you to examine which type is better in different standards and also compare both solar panel outputs. The results can be analysed in different environments, such as different weather conditions or different heat losses of a building. The following research deals only with heating and water heating[2][2][2][2][1].

1. Introduction – Variant with stratification

The first variant has 20 solar panels Thermoslar Žiar TS 300 with a surface of 2 m^2 with 45° inclination and 40.6 m^2 of total roof area. The solar preheating tank has a capacity of 2050 litres with a heat loss of 6.36 W / K, for hot water is designed tank with capacity of 200 litres, auxiliary power is supplied by a wooden boiler with a rated output of 15 kW. The experimental house is designed in a passive standard. The object has designed a 300-liter buffer tank for floor space heating as shown in Figure 1. The location of the experimental house is at a research institution at the Technical University in Košice in a climate chamber, that can simulate various external conditions. For the following research, thermal losses are 3.1 kW and calculated climatic temperature conditions for Košice with calculated external temperature (-14 ° C).

The principle of stratification is the storage of thermal energy, which is distinguished according to the chosen physical principles. To increase the use of energy from solar collectors and other heat sources, the so-called " temperature stratification, i.e., j. storaging by layers, e.g. in the stratification storage tank. In the storage tank is gravity stratification of water according to the volume of water depending on its temperature. The circulation of water in stratification storage tanks depends on the temperature of the heating circuits from the individual heat sources.

Thus, the circulation of water depends, for example, whether it is a low-temperature system (+40 to +60 ° C), or a high-temperature system (+60 to +90 ° C). Thermal stratification is the layering of the tank volume by temperature controlled by the storage of thermal energy in layers at the same or similar temperature. The cooler and heavier the water is held in the bottom of the tank, the hotter rises up, i.e. water with a density ρ is always supplied below a layer, which has a lower density. Individual temperature layers retain different temperatures.

In most cases vertical storage tanks are used to support the natural storage of temperature layers of the tank volume due to buoyancy forces.

For the correct function of the heat energy layering, it is necessary to create not only the layering according to the temperature, but also to ensure that the layering of thermal energy in the storage tank to not degrade. The quality of the temperature stratification of the volume in the stratification preheating tank will affect the operating parameters of the whole system. The temperature layering is mainly influenced by the way in which the working substance is fed into the storage tank [2].

Table 1. Input data.

Thermal losses of the object	3,1kW
Average dayli DHW consumption	120 litres/day
Annual energy requirement for DWH	2031 kWh
Object area	53 m2
Calculated outside temperature	-14°C
Solar preheating tank	2050 litres
DWH tank	200 litres
Auxiliary heat source- wooden fire boiler	15kW
Space- heating buffer tank	300 litres

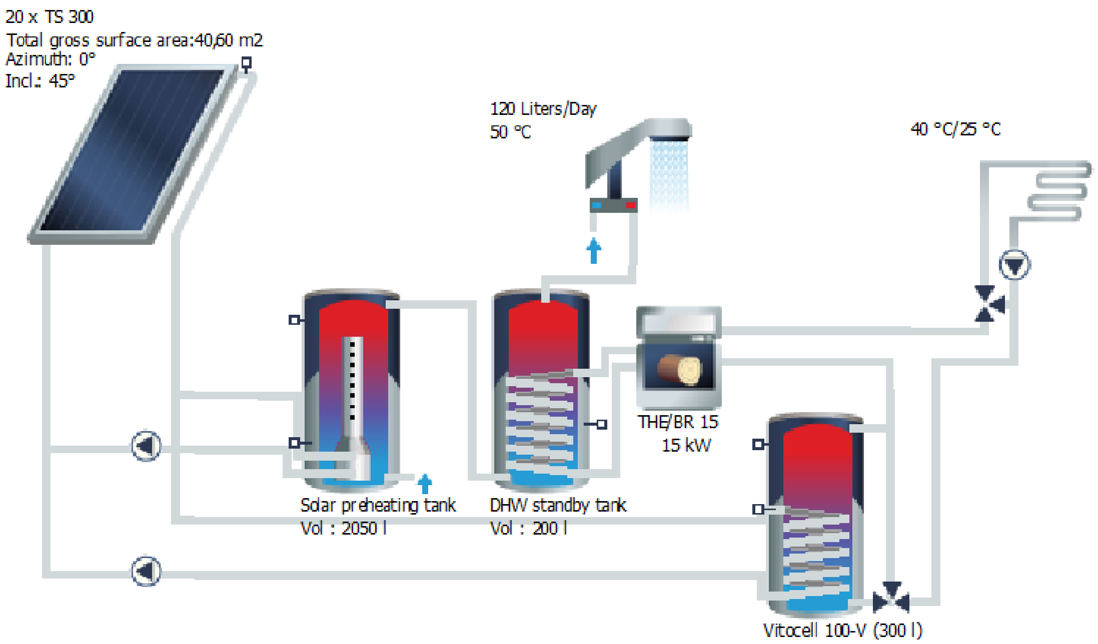

Figure 1. DWH system with stratification.

The results of the yearly simulation for the experimental house are shown in Figures 2 and 3. The simulation time was from the beginning of January to the end of December. The simulation for heating was throughout the year, but without a period from May to August, because at that time is no heating season. Figure 2 shows that the share of the solar panel for DHW is 94% - the red column, the share of the solar panel for heating - 20% - the blue column and the total solar energy is 37% - the green column.

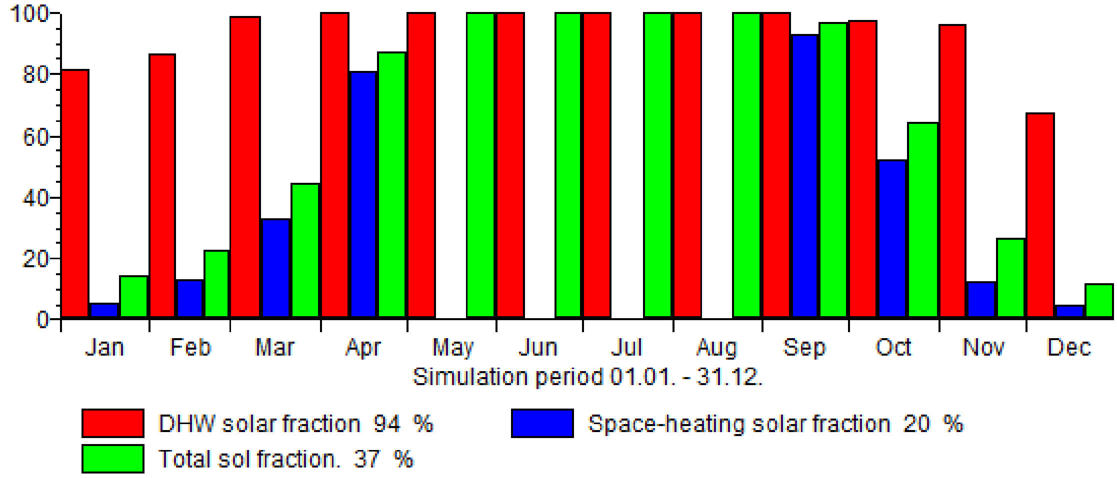

Figure 2. Share of solar energy for heating and DHW- variant 1.

Installed collector power:		28,42 kW
Installed solar surface area (gross):		40,6 m²
Irradiation on collector surface (active):	45 184,34 kWh	1 269,22 kWh/m²
Energy delivered by collectors:	9 219,53 kWh	258,98 kWh/m²
Energy delivered by collector loop:	7 480,93 kWh	210,14 kWh/m²
DHW heating energy supply:		2 040,65 kWh
Space-heating energy supply:		9 040,29 kWh
Solar energy contribution to DHW:		2 602,52 kWh
Solar contribution to heating:		1 801,61 kWh
Energy from auxiliary heating:		7 417,4 kWh
Wood chips - dry savings:		**1 343,2 kg**
DHW solar fraction:		**93,6 %**
Heating solar fraction:		**19,9 %**
Total solar fraction:		**37,3 %**
Relative savings of supplementary energy (DIN EN 12977):		**35,4 %**

Figure 3. Efficiency of solar energy per year – variant 1.

Figure 3 shows that the installed power of the collectors is 28.42 kW, the amount of energy delivered for DHW is 2040.65 kWh, the amount of energy for floor heating is 9040.29 kWh, the amount of solar energy input for DHW is 2602.52 kWh, the amount of solar energy for heating 1801.61 kWh and the amount of energy from an additional source - wooden boiler- 7417.4 kWh. The relative saving for additional energy is 35.4%.

2. Variant without stratification

The second variant for the experimental house is designed with the same number and area of solar panels with the same additional heat source, i.e., wood boiler with a rated output of 15 kW with a different 200 litres pre-heated solar tank and a heat loss of 2.14 W / K. External conditions were designed for the climatic region of Kosice with a calculated outside temperature of -14 ° C.

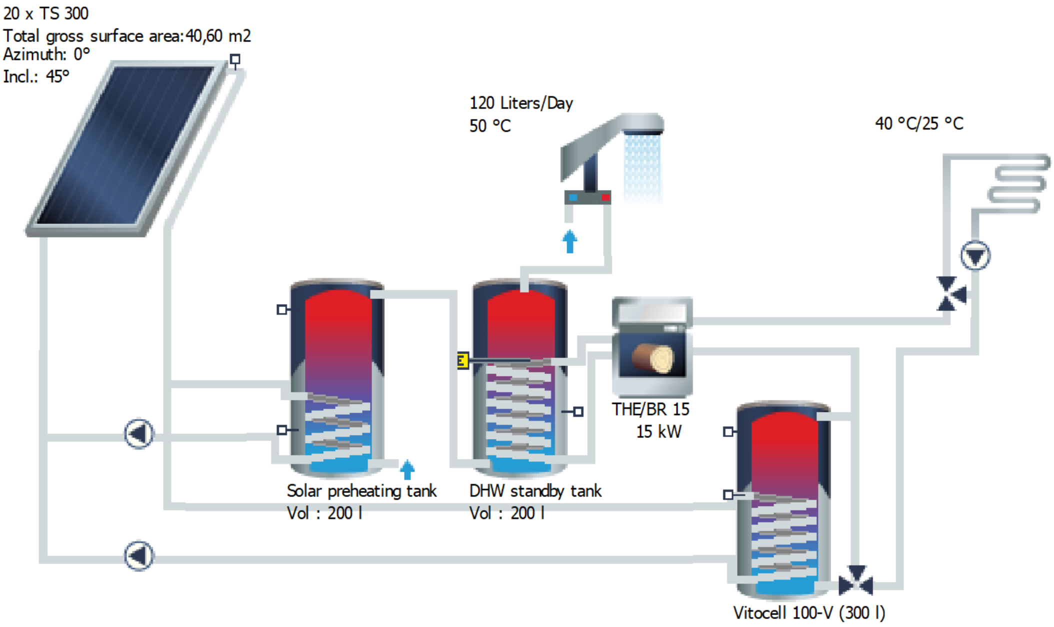

Figure 4. DWH system with heating buffer tank – variant 2.

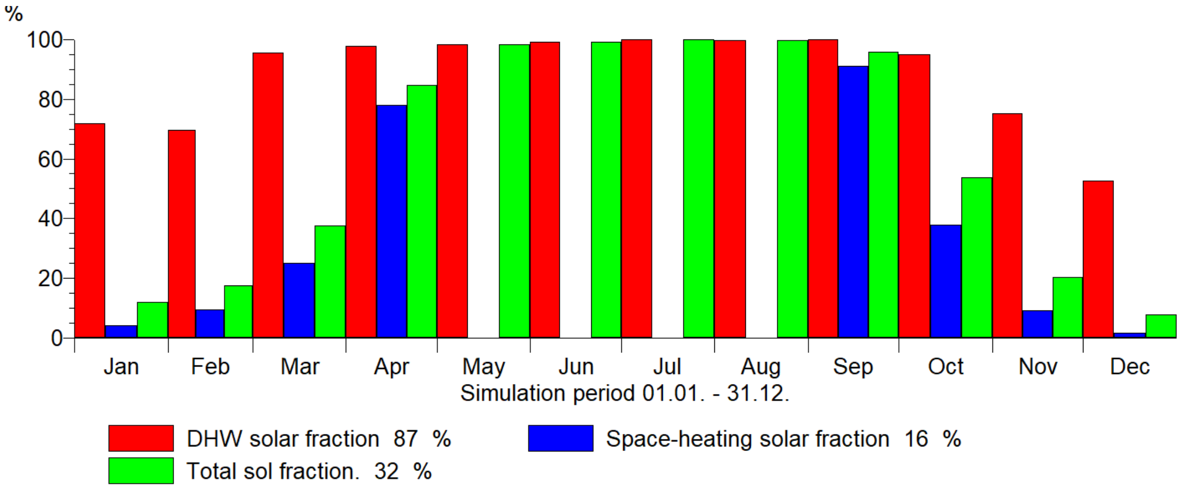

Figure 5. Share of solar energy for heating and DHW- variant 2.

Figure 5 shows that the share of the solar panel for DHW is 87% - the red column, the share of the solar panel for heating - 16% - the blue column and the total solar energy is 32% - the green column. The simulation for heating was year-round except for the months from May to August.

Figure 6 shows that the installed capacity of the collectors is the same as the first case of 28.42 kW, the amount of energy supplied for DHW is the same as the first variant - 2040.65 kWh, the amount of energy for floor heating has been reduced to 9039.78 kWh, the amount of solar energy for DHW has also been reduced to 2402.47 kWh, solar energy for heating also decreased to 1430.27 kWh, and the amount of energy from an additional source - the wood boiler has increased to - 7966.9 kWh. The relative saving for additional energy is 30.6%

Results of annual simulation

Installed collector power:		28,42 kW
Installed solar surface area (gross):		40,6 m²
Irradiation on collector surface (active):	45 184,34 kWh	1 269,22 kWh/m²
Energy delivered by collectors:	6 991,86 kWh	196,40 kWh/m²
Energy delivered by collector loop:	5 112,60 kWh	143,61 kWh/m²
DHW heating energy supply:		2 040,65 kWh
Space-heating energy supply:		9 039,78 kWh
Solar energy contribution to DHW:		2 402,47 kWh
Solar contribution to heating:		1 430,27 kWh
Energy from auxiliary heating:		7 966,9 kWh
Wood chips - dry savings:		**1 171,4 kg**
DHW solar fraction:		**87,0 %**
Heating solar fraction:		**15,8 %**
Total solar fraction:		**32,5 %**
Relative savings of supplementary energy (DIN EN 12977):		**30,6 %**

Figure 6. Efficiency of solar energy per year – variant 2.

3. Conclusion

The main difference between the classical accumulation preheating tank and stratification preheating tank is: The hot water in the classic tank is greatly mixed and the outlet water temperature does not reach the required collection point parameters, whereas the stratification tank has an internally directed thermal stratification of hot water by stratification elements (automatic check valves, plastic cone or plate control elements), which allows to extract hot water from a different temperature tank as required [2]. The comparison of the two variants suggests, that the stratification tank in combination with the solar panel is more efficient in terms of the amount of heating energy, the amount of solar energy for DHW and the reduced amount of energy from additional sources[2].

4. References

[1] Dr. Valentin Gerhard ,T*SOL basic version 5.0 Design and Simulation of thermal solar systems User Manual (2012)

[2] https://www.asb.sk/stavebnictvo/technicke-zariadenia-budov/vykurovanie/akumulacne-zasobniky-teplej-vody-na-principe-stratifikacie

Acknowledgements

This study was financially supported by the project VEGA No. 1/0307/16. Výskum kvality vnútorného prostredia budov pre školstvo a vzdelávanie zameraný na ochranu zdravia detí a mládeže and project ITMS Centrum výskumu účinnosti integrácie kombinovaných systémov obnoviteľných zdrojov energií - VUKONZE