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Preliminary studies of the water solar collector

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Abstract. Promotion of renewable energy sources and their ecological advantages in comparison to fossil fuels together with continual technological development results in the expansion of the solar collectors market even in countries where solar radiation is unfavorable for solar systems. In this paper, the analysis of the employment of plate and tube collectors in a residential buildings located in Poland was conducted. The paper shows the results of preliminary studies of a water solar collector system installed in Bialystok University of Technology, Poland. The efficiency of the system in the winter season was analyzed, based on data garthered in December 2019. Results showed that a water solar installation in the north-Europe countries, such as Poland, need additional energy supply during cold months for anti-frozen protection. The daily average of additional energy consumption can be twice higher than solar contribution for extreme conditions as studied in this paper.

Key words. Solar collectors, solar radiation, renewable energy, DHW, HVAC systems.

1. Introduction

The perspective of depletion of the basic energy sources, which are natural fuels, encourages gradual reduction of using conventional sources and replacing them with unconventional sources, especially renewable energy ones. A great need for using alternative energy sources to stop the negative changing of the environment can be noticed in actual Polish and European law regulations [1-3]. In many European countries is noted that the consciousness increases significantly in relation to the necessity of reducing the energy consumption for lighting, heating and cooling purposes in buildings [4]. It is worth underlining that the building sector consumes a substantial amount of energy and the best solution to achieve nearly zero energy building is to apply renewable energy technologies [5]. Solar energy has become the most accessible, pure and natural of available energy sources in recent years. Solar collectors are the most common technology using this type of energy.

Currently, the solar collector market is one of the fastest-growing markets for renewable energy in Europe and in the world. In the EU it is dominated by Greece, Austria, Germany, France, and Italy, whereas it is worth noting that China and the USA are leading on the world market [6,7]. It can be observed that in 2015, eleven European countries achieved the assumed goals of the percentage share of energy from renewable sources by 2020 [8].

Poland has committed to achieving a 15% target for RES energy by 2020. Over the past few years in Poland, there has been development and increased production of energy from renewable sources. The choice of solar power may be the result of municipalities and cities of EU co-financing and programs as well as many available information and solutions obtaining heat and electricity. Solar installations are very common in Poland, especially in the sector of residential buildings. Solar collectors are mostly used for preparing domestic hot water and installing them in newly built objects is a better solution. Furthermore, solar installation in Polish climate needs extra energy source in the autumn and winter period [9, 10].

Most systems use solar collectors with refrigerants like glycol technical reasons connected with low outdoor temperature during the heating season. In this paper, we present the results of a preliminary studies of the work of a water system that is more ecological. The aim of this paper is evaluation of system's work and analysis of energy gains from solar collectors versus electricity input to the water heater to avoid fluid frozen in solar collector circuits in periods with low solar radiation and outdoor temperature near zero Celsius degrees.

2. A research stand

The research stand is located in Bialystok/Poland in the building of the Bialystok University of Technology. The water collector is installed on the roof (fig.1) while all equipment, including water tank, solar station, etc. (fig.2)

is located in the basement of the building. Fluid between solar collector and the water tank is transported by Cu pipes (15×1mm) in foam EPDM (13mm).
A cold winter month was selected for this study, December 2019. It is also worthy to note that the analysed period was found untypically cloudy and the average monthly solar radiation was low (29,1 W/ m^2). The aim of the research was to check the installation performance in this extreme condition. In this month, every 5 min temperature of water just in the outflow from the solar collector water, water suppling the tank, water in the tank as well as energy consumption and electricity consumption was recorded.

Fig.1. Solar collector on the roof (source: D. Krawczyk)

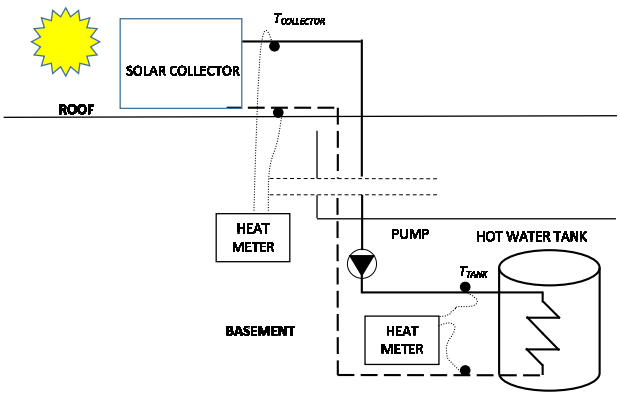

Fig.2. Schema of the system (source: D. Krawczyk)

3. Analysis of Results

Fig.3 shows daily energy gains from solar collectors and daily electrical energy consumption connected with maintaining the temperature of the fluid in a solar circuit higher than 5°C as unfrozen protection. Moreover, changes in the outdoor temperature were marked.

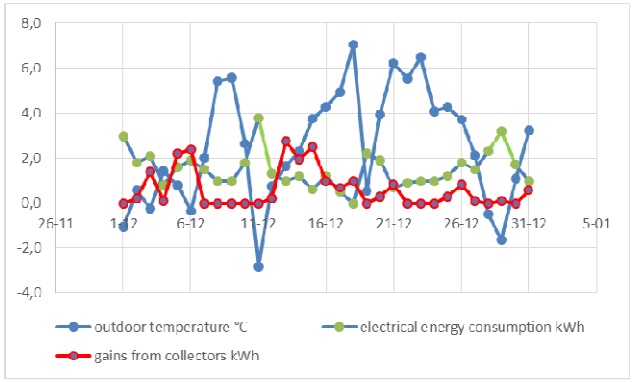

Fig.3. Daily solar energy gains and electrical energy consumption in December 2019

Changes in daily solar radiation on solar collectors measured in the stand point are presented in fig.4.

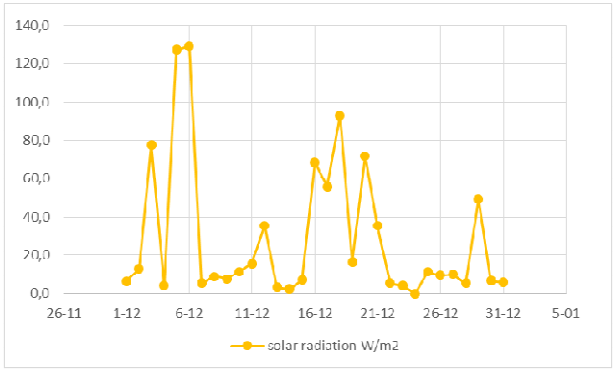

Fig.4. Daily solar radiation on solar collector surface in December 2019

During the measurement period, outdoor temperature was in a range between -2,8 and 7,2°C. Daily average solar radiation fluctuated around 0-129,3W/m2. In most days it was necessary to use electric energy for a heater work to avoid fluid freezing. The monthy electrical energy consumption recorded was 46,3 kWh while energy gains from solar collectors were estimated as 19,4 kWh.

4. Conclusion

This paper shows measurements of daily variation of energy gains, water temperatures and climatic conditions in an experimental water solar collector system installed in the Bialystok University of Technology. Results of the research showed that in a very cold month (December 2019), the water solar installation in a north-Europe country, such as Poland, needs additional energy supply for anti-frozen protection. The energy consumption for anti-frozen protection were more double higher than obtained gains from solar collector. In order to estimate the total annual efficiency of solar water systems in this location, as well as boundary conditions for the usefulness of such systems in any climatic location, further similar research in other months is necessary, thus the research will be continued the whole 2020.

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