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# SPRAWNOŚĆ EKSPLOATACYJNA UKŁADÓW SOLARNYCH MAŁEJ MOCY

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## Summary

Although there are many low-power solar systems utilising liquid-based flat plate collectors for the purpose of domestic hot water preparation in single-family buildings, there is no exhaustive information on their work and the effects achieved in real operational conditions as compared with what was planned at the stage of design.

Low-power solar systems for domestic hot water preparation are usually made of 2-6 solar panels and a tank, and use the energy generated by solar collectors to heat up domestic water. Domestic hot water tanks, which have the capacity of 300 to 500 $dm^3$, are bivalent, i.e. they can also be connected to the conventional heating source for domestic hot water.

The aim of this dissertation was to diagnose the effects of work of small solar systems utilised in domestic hot water preparation systems in real operational conditions.

As part of the dissertation, a group of small solar systems was monitored. The systems were selected for monitoring from over 3000 solar systems in operation. The observations involved operational parameters of 40 low-power solar systems utilised in various domestic hot water preparation systems in single-family buildings in real conditions of use.

The following parameters were observed: mass and temperature flows within the solar system, the conventional heating system and the system of hot domestic water storage and its transmission to the user. Moreover, the following temperature values were recorded: the temperature at the outlet of the solar collectors, the temperature in the characteristic points within the hot water tank and the temperature within the room where the hot water tank was located. Heat meters measuring the energy generated by the solar system, the conventional source of heat for domestic hot water preparation and the energy delivered to the user of the system together with domestic hot water were installed within each low-power solar system.

The observations were carried out within one calendar year. The data measured by the system were collected by a telemetric set and delivered using a GPRS network to the main server, where they were stored and processed. The system of data collection, transmission and storage was equipped with a diagnostic system providing information about any problems with data transmission. Thus developed system continues to be in operation and collect information on the parameters of the solar systems in order to determine their sustainability and the investment effects.

The measurements of operational parameters aimed to define the actual energy efficiency of low-power solar systems utilised in domestic hot water preparation systems.

The solar systems were also observed in order to determine the difference in efficiency depending on the local weather conditions registered by the weather stations which were part of the monitoring system and measured, among others, the total solar radiation stream, ambient temperature and wind velocity.

The dissertation presents the following issues on the basis of the systematisation and preparation of the measurement results:

- general conclusions based on the observation of real weather conditions and the operational parameters of low-power solar systems which have an impact on their energy efficiency, and the comparison of results with the data obtained from the GetSolar Professional 11.3.0 simulation programme,
- annual values of average monthly total radiation streams falling on the inclined surface were determined within three weather stations, including minimum and

maximum values of average hourly total radiation streams falling on the inclined surface within a year,

- average monthly values of the temperature of glycol flowing from solar collectors to the exchanger and average monthly values of the temperature of the working agent at the outlet of the exchanger were determined,
- the highest average monthly values of the temperature of the working agent and their correlation to the system size were defined,
- average monthly temperatures of the working agent at the inlet and outlet of the exchanger were determined on the basis of the observation of the operational parameters of the conventional source – average monthly values of the temperature in the rooms were domestic hot water tanks were located were determined,
- the highest and the lowest average monthly values of the temperature of water delivered to the domestic hot water preparation system were defined,
- the highest average monthly values of the temperature of water flowing from the tank were determined and correlated with the size of solar systems,
- the average annual temperature in the top and bottom part of the bivalent tank depending on the size of the solar system was defined,
- the lowest and the highest average monthly temperature values in the top and bottom part of the tank and the lowest and the highest temperature differences between the top and the bottom part of the tank were determined,
- the temperatures of the working agent in the solar system and the temperatures of the heating agent in the conventional system for domestic hot water preparation were determined and correlated with the periods of temperature rise in individual parts of the tank as well as the average monthly values of total radiation streams falling on the inclined surface,
- the regular operation time for the solar systems in different times of the year and the duration of work at night was defined.

The characteristics listed above are the elements of the description of real operational conditions for the solar system, the conventional system providing heat for domestic hot water preparation and the domestic hot water preparation system.

The final stage of the measurement result preparation involved the determination of the energy effectiveness of the domestic hot water preparation system utilising a solar system and a conventional heat supply system.

Moreover, this dissertation includes an attempt to compare the average annual amount of energy captured by the solar system and delivered to the doemstic hot water preparation system as indicated by the heat meters and the value obtained in the computer simulation. This comparison also included the amount of energy yielded by the solar system as calculated in the simulation and the amount of energy measured by the meter of the solar controller.

On the basis of the analysis of the operation of the solar systems utilised in domestic hot water preparation systems, the deficiencies of the simulation programme caused by the failure to include the real conditions of work for low-power solar systems could be captured.

The analysis included in the dissertation encompassed the degree to which the demand for domestic hot water was satisfied by the solar system in different times of the year and the periods when maximum values in the top and bottom part of the tank were determined.

The real average monthly value of the heat transmitted from the source to the domestic hot water preparation system connected with the solar system was compared with the amount of energy delivered to the user with domestic hot water.

The results of the average monthly calculations of the solar collector efficiency generated by the GetSolar Professional 11.3.0 programme were compared to the efficiency values obtained on the basis of the monitoring system developed.