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Investigation of HGHE near building basement – a case study

A. M. Bulmez, V. Ciofoaia, I. Boian

1. INTRODUCTION

Ground source heat pump (GSHP) systems are becoming more and more attractive as time goes by. As of today, approximate 60% energy consumption in buildings is used for heating cooling and domestic hot water production [1]. For tapping into geothermal energy stored into the earth, GSHP systems use geothermal heat exchangers (GHE). These are split into two main groups, open loop and closed loop GHEs. The closed loop GHEs also split into two main branches of vertical and horizontal GHEs. While vertical boreholes is the most efficient solution, the drilling cost represents a barrier even today. Horizontal GHEs are cheaper, but have the disadvantage of lower efficiency due to temperature variation at the surface of the earth. In order to research possible optimizations for HGHEs, a small experiment was conducted at the Faculty of Civil Engineering at University of Transilvania from Brașov. The HGHE was positioned next to the basement wall in order to take full advantage of the heat loss from the heated basement. Few studies have been made to this point considering building foundations and basements as heat sources such as [2][3][4][5]. This study focuses on the heat loss from building basements and how HGHEs can take advantage of that.

2. MATERIALS AND METHODS

The experiment conducted is represented by a low capacity heat pump that uses as main renewable energy source the ground. For the source a horizontal GHE with the surface of 25m^2 was proposed. The HGHE is positioned next to the basement wall. The pipe used is a polyethylene Φ20mm pipe buried at the depth of 1,2m. At that depth a total of 18 temperature sensors were placed, as seen in Figure 1.

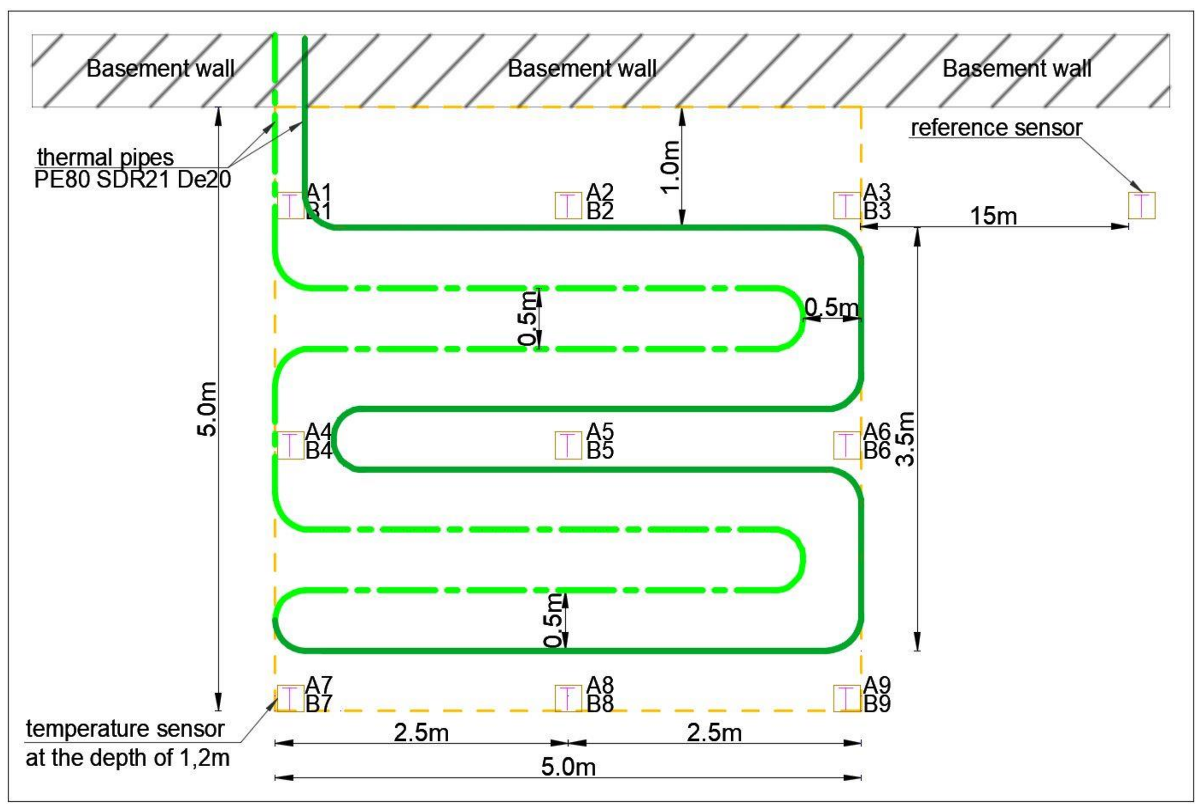

Figure 1 – HGHE experiment schematic

The reason for positioning the HGHE next to the heated basement wall is to use as much energy as possible which is lost from the basement to the ground. Also, the experimental system was assisted with solar panels that supplied heat into the HGHE based on temperature differences. The experiment was conducted for the heating season of 2019-2020.

Although solar auxiliary source was also embedded into the experiment, this study focuses on how much energy the basement is losing during the heating season. Similarly, the interest focused on how the heated basement affects the temperature inside the HGHE.

3. HEAT LOSS FROM THE BASEMENT

The heated basement can be considered a heat source for HGHEs. The basement room next to the HGHE is the room of the thermal power plant, which operates intermittently during the heating season. To calculate the energy from the heated basement, the standard SR EN ISO 13370/2017 "Thermal performance of buildings. Thermal transfer through the ground. Calculation methods " was used. After that, multiple wall and floor thermal resistances were used, as well as different interior temperatures to obtain the results. The calculation was made for three interior temperatures during the heating season: 10°C, 20°C and 35°C as was the case of the experiment.

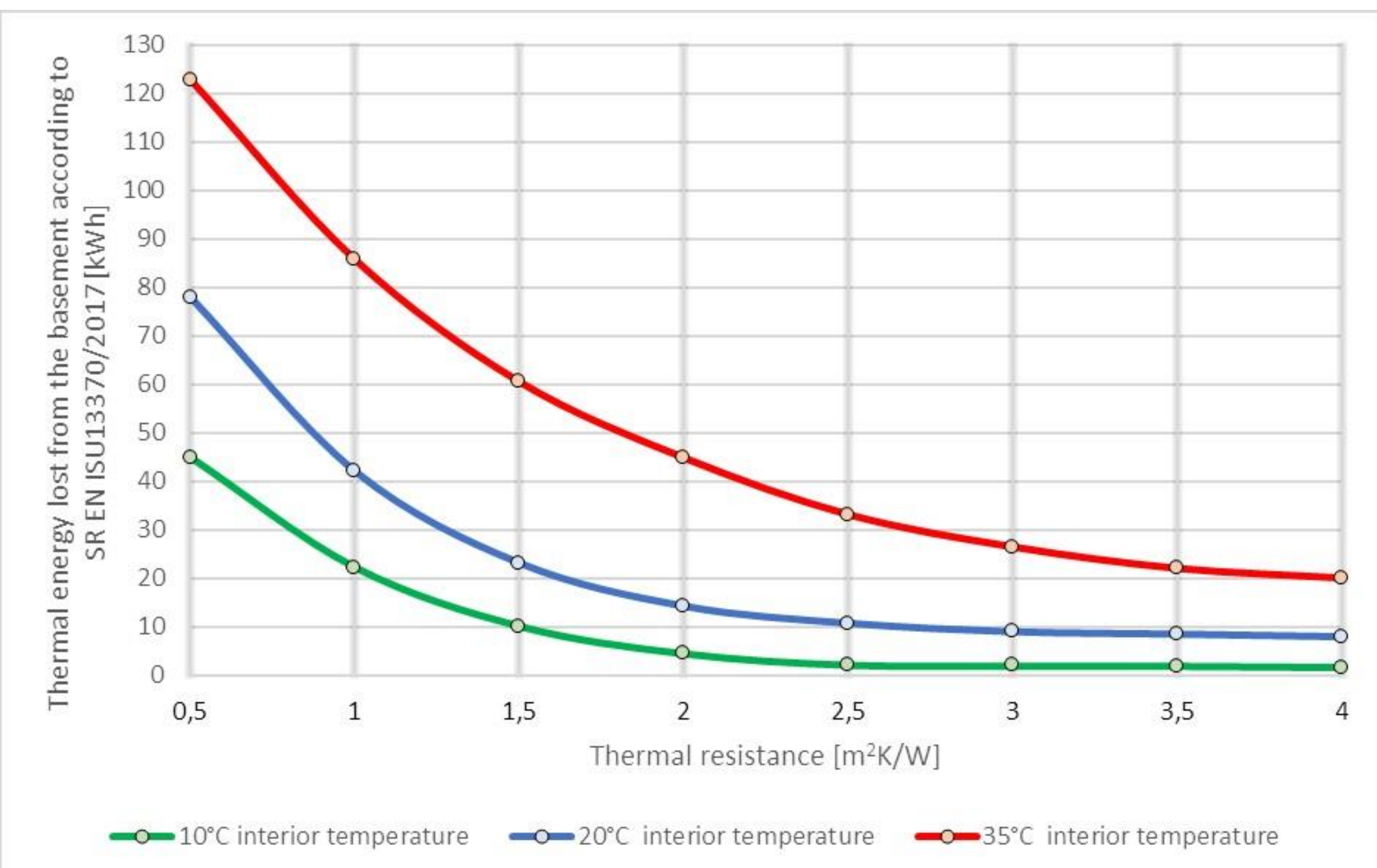

Figure 2 – Thermal energy lost from the basement to the surroundings

Firstly, as seen in Figure 2, the insulation degree of the basement walls and floor represents the most important parameter when considering heat loss. Secondly, the interior temperature also has an important role, as a heated basement has more thermal energy than an unheated one. In the case of the experiment, the average temperature inside the room next to the HGHE is 30-35°C. The calculation results show that 122,75 kWh/heating season are transferred into the ground near that room. The basement wall and floor are not thermal insulated, this being the main reason when the HGHE position was chosen.

4. NUMERICAL SIMULATION RESULTS

In the experiment the temperature inside the ground where the HGHE is placed was registered. All the measurements made from all 18 sensors were averaged. To verify the measurements, a virtual model was created in COMSOL Multiphysics in which HGHE temperature was simulated based on the same working conditions the experiment had. The conditions used were the same as in the experiment, respectively same outside air temperature, basement room temperature, inlet and outlet temperature as well as pipe geometry and depth. In Figure 3, the results from the simulation confirm the experimental measurements. Also, the case with the same basement but unheated was simulated, showing the ground cooling more during the peak of the heating season.

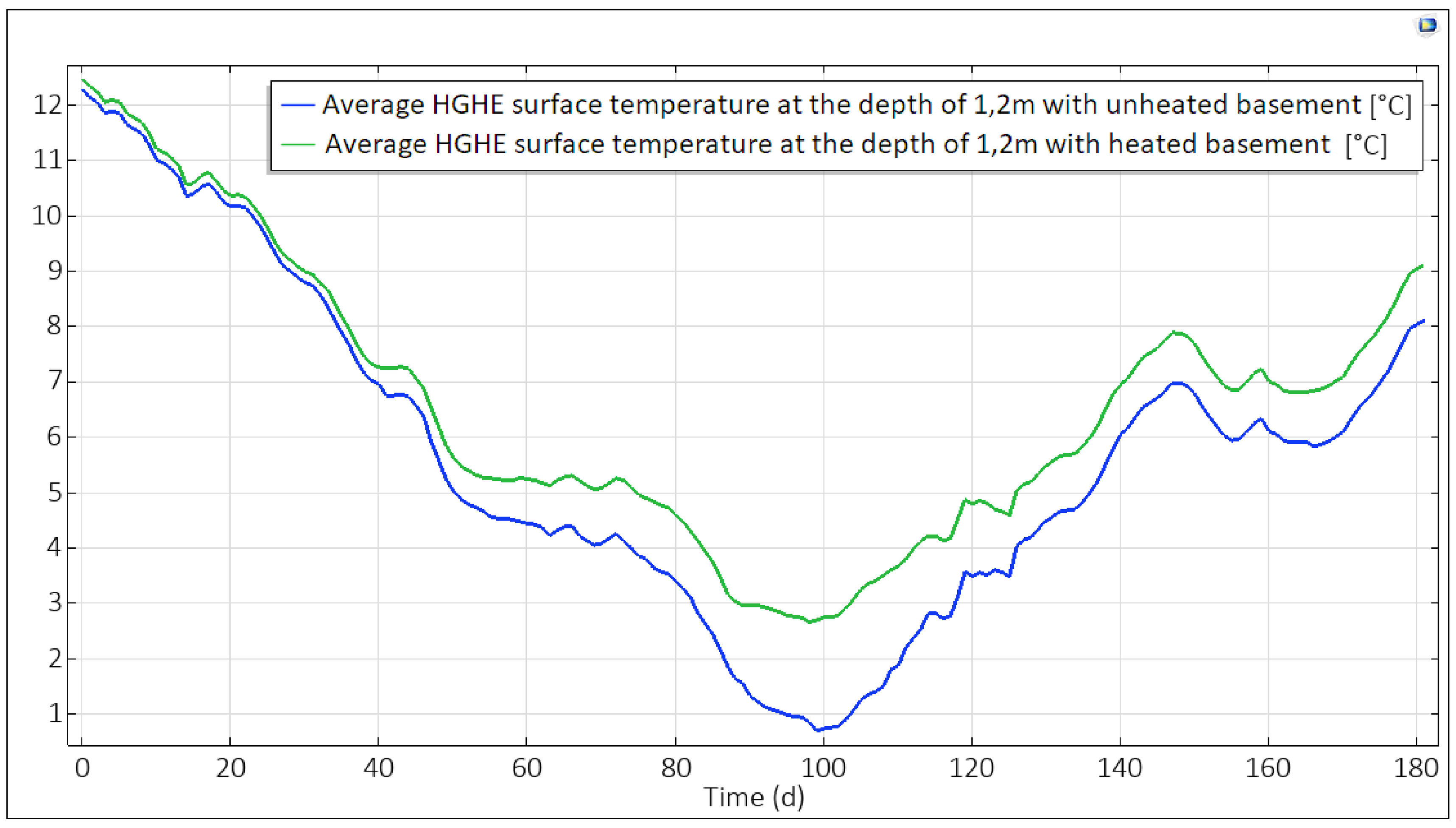

Figure 3 – Average HGHE temperature for the experimental case and unheated basement

5. DISCUSSION

Based on the results that validated the experimental measurements, two more cases were simulated. The first case simulated treated the basement as unheated with an average temperature of 10°C inside. The second case simulated, eliminated the thermal energy supplied to HGHE from the solar source, showing further decrease in temperature in the season peak. Third case eliminated all heat sources (solar and heated basement). From analyzing the results, it can be seen that the heated basement contributed during the season peak with approximate 2°C, maintaining a higher temperature inside HGHE. Similarly, the solar energy supplied and the heat from the basement maintained the HGHE temperature with approximate 5°C during heating season peak, as seen in Figure 4.

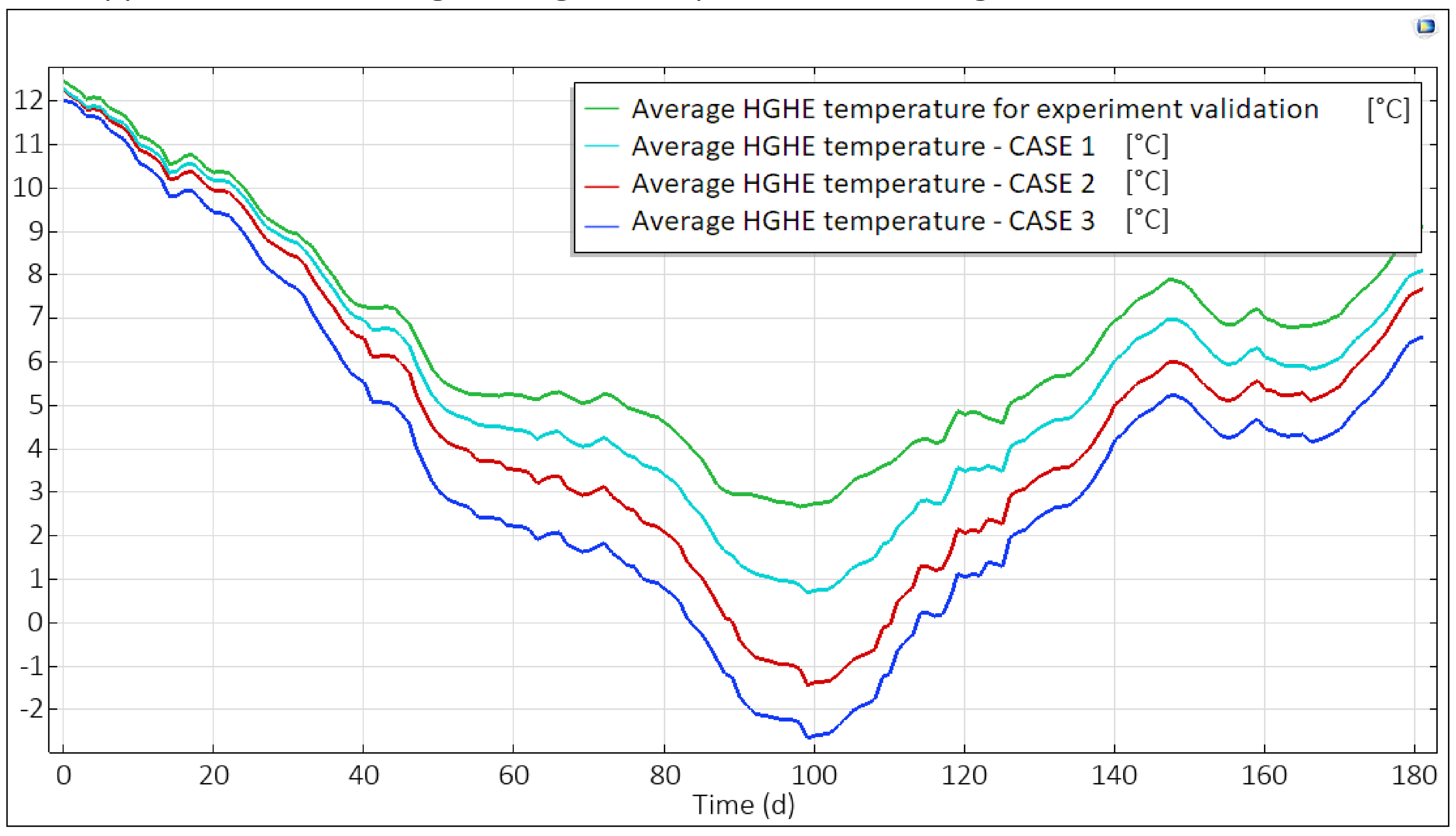

Figure 4 – Average HGHE temperature for experimental case and three simulated cases

6. CONCLUSIONS

The optimization of HGHEs is necessary for the spread of GSHP systems. After analyzing the results, it has been concluded that overall, heated basements can be a reliable heat source for the HGHEs. The most important parameters for this to happened is a high temperature and a low thermal resistance. The experimental measurements show that the heated basement rivals the solar panels as auxiliary heat source for the HGHE and the GSHP system overall. Where the solar panels contributed with an approximate 3°C average temperature during season peak, the heated basement accounted for approximate 2°C. This implies that for existing buildings where space is an issue and the existing basements are not thermal insulated, positioning HGHEs next to them need to be considered. Therefore, as temperature variation is a well known issue when designing HGHEs, basements provide a reliable heat source towards increased efficiency and thermal equilibrium.

References:

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