

4.1. Heating/air-conditioning system of the Auditorium

BHEs fields typically work by heat injection into the surrounding rock mass. Hotels, office buildings, commercial facilities, university buildings, and private residences can use BHEs for heating and air-conditioning. The simple payback time for investment costs of such installations can be lower than 10 years. Using heat pumps can avoid the need for separate heating and cooling equipment. Also operational costs of heating and cooling are often lower than traditional methods. In countries with temperate climates, the amount of energy from air-conditioning injected into rock mass in summer is usually lower than the heat extracted from ground in winter time.

4.2. Solar collectors

Five solar collectors have been investigated in terms of heat recovery performance. The best results regarding efficiency is achieved for a collector “heat pipe”, while the lowest efficiency is observed for a stationary flat-plate collector. Much better efficiency is observed when the temperature of working fluid of the heat pipe, glycol, is low. In typical heating systems, for domestic hot water heating for example, the efficiency of solar collectors is about 60-70%. In case of circulating the heat carrier from BHEs, at low temperatures, the efficiency can be higher than 80% (Sliwa 2012). In the Laboratory of Geoenergetics, the heating stream was also observed in the night. That occurred in summer, when the ambient air temperature was high. About 0.5 kW heating power can be attained with five solar collectors, using low-temperature glycol to transfer heat into rock mass (Sliwa 2012).

4.3. Snow melting installation

In laboratory testing facility, a heating rate of over 33 kW was possible. Over a minimum duration of 32 minutes, it was possible to attain 58.5 MJ of heat transfer from the parking area, which was 1880 m² (Śliwa and Poniedziałek 2014). The system working fluid is a glycol solution. The time to raise the temperature of 1.50 m³ glycol from 0 to 10 °C was observed.

The snow melting installation works like a solar collector in summer. It receives heat from solar radiation and warm air on the surface. The unit heating rate observed is 17.5 W/m² when the maximum solar energy (900-1000 W/m²) is received from collectors. The unit heat extracted from the parking area is 31.1 kJ/m² over a period of 32 min.

Research was also undertaken by partially shading the parking area. It is necessary to prepare long term observations (at least one year) to determine seasonal effects and outputs.

The installation for snow melting can be used in summer not only for heat extraction, but also for cooling the surface of road, to protect against ruts (Heliasz and Ostaficzuk 2002).

4.4. Fan (heater/cooler)

In the Geoenergetics Laboratory, research was undertaken on heating 1.0 m³ of glycol solution. For the snow melting installation, the initial temperature of the heat carrier was 0 °C, and the final temperature was 10 °C. Poniedziałek and Sliwa (2013) demonstrate that it is possible to obtain examples of research. Various air temperatures with time of heating have been measured. For the average air temperature (18.1 °C), the average heating time was 233 min, leading to an average heating power of 4.18 kW.

Using the fan is probably the most inexpensive way for heating, considering investments and operational costs. The fan can heat the working medium when the air temperature is higher than the temperature of the glycol solution, also in warmer winter days.

5. Conclusions

1. Natural ways of heat regeneration can permit full or partial temperature restoration. For supplemented heat resources, when natural full renewability is not possible but necessary (or advantageous), artificial sources of heat can be used.
2. In real projects, it is necessary to take into consideration all possible options for obtaining heat. Sometimes it is possible to obtain a low-temperature heat flux from other sources, such as waste heat.
3. Nowadays designers should analyze all energetic aspects of buildings and other structures as well as the neighborhood of designed projects.
4. BHE fields can be effectively used for energy storage. This is particularly important for renewable energy sources, which are often characterized by intermittency (like wind energy for example). Energy storage also enables greater use of distributed energy sources.
5. Natural heat regeneration options for BHEs storages are sun, wind, surrounding rocks and underground water. Artificial options that can be used include solar heat using, for example, air-conditioning installations, solar collectors, fans and snow melting installations working in reverse mode. It is also possible to use waste heat from industry.

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Conflict of Interest

The authors declare no conflict of interest.

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