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Potential map of Borehole Heat Exchanger system for the central part of Kanto Plain and the Obama Plain

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A Borehole heat exchanger (BHE) is an economically and environmentally friendly technology that is widely used in Europe and North America, but rarely used in Japan. One of the reasons for this is the relatively complex topography and geological structure in Japan compared with those in Europe and North America.

Complex structures produce regional differences in subsurface thermal properties and temperature structures, leading to regional variation in the efficiency of BHEs. Thus, it is important to evaluate the available subsurface heat energy through thermal response tests and/or numerical simulations and to design appropriate systems (depth and number of boreholes for heat exchange). Geological structures, groundwater properties, and subsurface temperatures are essential input data for numerical simulations.

We performed BHE numerical simulations using measured data and present a new method for constructing a BHE potential map from regional geological structure models for typical Japanese plains. Our target areas are the central part of the Kanto Plain and the Obama Plain. The Kanto Plain contains the capital city of Japan and has a population of more than 40 million. On the other hand, the Obama Plain is located in the central part of Japan and faces the Sea of Japan. And population density of the Obama Plain than that of the Kanto Plain. It is important to evaluate the energy potential of BHE in a part of this area for socio-economic studies. We have performed measurements of subsurface temperatures at 23 stations in the central part of the Kanto Plain (Saitama region). Subsurface temperatures and thermal conductivities at four stations at Obama Plain. In our presentation, we discuss that the difference of subsurface thermal environment and efficiency of BHEs.

Results of the numerical simulations show that the BHE efficiency increases by 20% when the subsurface temperature increases by 5 degC and the efficiency also increases by 30% when the groundwater flow varies from 0 m/year to 15 m/year.

In addition, the results of the subsurface temperature profiles show long-term subsurface warming in the Kanto plain during the last century. The influence of subsurface warming effects on the BHE efficiency through numerical simulations is discussed. We show that subsurface warming effects cause the BHE efficiency of heating to increase.

Keywords: Borehole Heat Exchanger system, groundwater, Kanto Plain, Obama Plain