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Sustainable Management of Urban Heat Islands

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In recent years, geothermal energy has become increasingly popular, because it offers a number of advantages over traditional energy sources based on fossil fuels. It is a renewable energy source, it is clean and safe for the surrounding environment, and it also contributes to reduction of CO_2 emissions. Geothermal energy systems are recognized as one of the most efficient heating and cooling systems on the market. Therefore, there is great chance for future growth of geothermal energy use, particularly in densely populated urban regions. But there are also drawbacks: In many large cities, groundwater is heated up by several degrees ($\sim 5^{\circ}$C) compared to the surrounding areas. Causes might be microclimatic changes in the urban environment and the heating effect of sewage effluents. In fact, a major role plays overutilization of the ground as a cooling medium during the hot seasons for the air conditioning of large office buildings. The focus of this project is set on sustainable geothermal use in such large and densely populated areas, which are also called "urban heat islands".

Previous studies focus on spatial temperature trends in the subsurface, and only a few have been able to reveal temporal trends, for which long-term measurement records are needed. This study is dedicated to two German locations: the city of Frankfurt/Main and the city of Cologne. The purpose of the study in Frankfurt is a comprehensive field investigation of the spatial temperature variations in the underlying aquifers, while in Cologne the attention is also on the temporal trends of urban groundwater temperatures. Of particular interest is not only to develop a sustainable management concept, but also a quantitative geophysical and hydrogeological assessment. For the city of Frankfurt/Main, the Hessian Agency for the Environment and Geology (HLUG) provides access to ongoing, highly spatially resolved field measurement locations. For Cologne, about 40 years old intensive temperature records will be utilized and compared to the status-quo. Furthermore, major geothermal projects in both cities will be reported and quantitatively analyzed in order to study the urban anthropogenic impacts. For this, heat transport models will be set up for at least one city. In site-specific integrative management strategies a balance between heat extraction and injection is elaborated. Finally, the findings of these case studies will be translated into a general guidance for those other urban areas with substantial heat anomalies that exist worldwide.