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Heating and cooling with aquifer thermal energy storage (ATES) in cities

Philipp Blum, Haegyeong Lee, Kathrin Menberg, and **Ruben Stemmle**
Institute of Applied Geosciences (AGW), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany (philipp.blum@kit.edu)

Aquifer thermal energy storage (ATES) is a promising technology for sustainable and climate-friendly space heating and cooling which can contribute to lower greenhouse gas (GHG) emissions. Using 3D heat transport models, this study quantifies the technical potential of shallow low-temperature ATES in the city of Freiburg, Germany. The numerical models consider various ATES configurations and different hydrogeological subsurface characteristics relevant for the study area. Based on the modeling results, spatially resolved ATES power densities for heating and cooling are determined and compared to the space heating and cooling energy demands. High ambient groundwater flow velocities of up to 13 m d^{-1} cause relatively high storage energy losses resulting in maximum ATES power densities of 3.2 W m^{-2}. Until now, these still reveal substantial heating and cooling energy supply rates achievable by ATES systems. While heating supply rates of larger than 60 % are determined for about 50 % of all residential buildings in the study area, the cooling energy demand could be supplied entirely by ATES systems for 92 % of the buildings. In addition, ATES heating alone could result in greenhouse gas emission savings of up to about 70,000 tCO_{2eq} a^{-1}. The proposed modeling approach in this study can also be applied in other urban areas with similar hydrogeological conditions to obtain estimations of local ATES supply rates and support city-scale energy planning for heating and cooling.