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Combined Geothermal Potential of Subsurface Urban Heat Islands

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The subsurface urban heat island (SUHI) can be seen as a geothermal potential in form of elevated groundwater temperatures caused by anthropogenic heat fluxes into the subsurface. In this study, these fluxes are quantified for an annual timeframe in two German cities, Karlsruhe and Cologne. Our two-dimensional (2D) statistical analytical model determines the renewable and sustainable geothermal potential caused by six vertical anthropogenic heat fluxes into the subsurface: from (1) elevated ground surface temperatures, (2) basements, (3) sewage systems, (4) sewage leakage, (5) subway tunnels, and (6) district heating networks. The results show that at present 2.15 ± 1.42 PJ and 0.99 ± 0.32 PJ of heat are annually transported into the shallow groundwater of Karlsruhe and Cologne, respectively, due to anthropogenic heat fluxes into the subsurface. This is sufficient to sustainably cover 32% and 9% of the annual residential space heating demand of Karlsruhe and Cologne, respectively.

However, most of the discussed anthropogenic fluxes into the subsurface are conductive heat fluxes and therefore dependent on the groundwater temperature itself. Accordingly, a decrease in groundwater temperature back to its natural (rural) state, achieved through the use of geothermal heat pumps, will increase these fluxes and with them the sustainable potential. Hence, we propose the introduction of a combined geothermal potential that maximizes the sustainability of urban shallow geothermal energy use and the efficiency of shallow geothermal systems by balancing groundwater temperature with anthropogenic heat fluxes into the subsurface. This will be a key element in the development of a demand-oriented, cost-efficient geothermal management tool with an additional focus on the sustainability of the urban heat sources.