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The BSI indicator: preventing thermal interferences between groundwater heat pump systems

Alejandro García-Gil[1], Miguel Ángel Marazuela[2], Miguel Mejías Moreno[1], Enric Vázquez-Suñè[2], Eduardo Garrido Schneider[1], and José Ángel Sánchez-Navarro[3]

[1]Geological Survey of Spain (IGME), Madrid, Spain (a.garcia@igme.es)
[2]GHS, Institute of Environmental Assessment & Water Research (IDAEA), CSIC, Barcelona, Spain
[3]Department of Earth Sciences, University of Zaragoza, Zaragoza, Spain

Shallow geothermal systems are the most efficient and clean technology for the air-conditioning of buildings and constitutes an emergent renewable energy resource in the worldwide market. Undisturbed systems are capable of efficiently exchanging heat with the subsurface and transferring it to human infrastructures, providing the basis for the successful decarbonisation of heating and cooling demands of cities. Unmanaged intensive use of groundwater for thermal purposes as a shallow geothermal energy (SGE) resource in urban environments threatens the resources´ renewability and the systems´ performance, due to the thermal interferences created by a biased energy demand throughout the year. To ensure sustainability, scientifically-based criteria are required to prevent potential thermal interferences between geothermal systems. In this work, a management indicator (balanced sustainability index, BSI) applicable to groundwater heat pump systems is defined to assign a quantitative value of sustainability to each system, based on their intrinsic potential to produce thermal interference. The BSI indicator relies on the net heat balance transferred to the terrain throughout the year and the maximum seasonal thermal load associated. To define this indicator, 75 heating-cooling scenarios based in 23 real systems were established to cover all possible different operational conditions. The scenarios were simulated in a standard numerical model, adopted as a reference framework, and thermal impacts were evaluated. Two polynomial regression models were used for the interpolation of thermal impacts, thus allowing the direct calculation of the sustainability indicator developed as a function of heating-cooling ratios and maximum seasonal thermal loads. The BSI indicator could provide authorities and technicians with scientifically-based criteria to establish geothermal monitoring programs, which are critical to maintain the implementation rates and renewability of these systems in the cities.

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