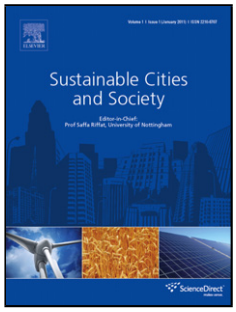

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PII: S2210-6707(17)31750-X
DOI: https://doi.org/10.1016/j.scs.2017.12.036
Reference: SCS 908

To appear in:

Received date: 6-6-2017
Revised date: 21-12-2017
Accepted date: 27-12-2017

Please cite this article as: Choi, Wonjun., Ooka, Ryozo., & Nam, Yujin., Impact of long-term operation of ground-source heat pump on subsurface thermal state in urban areas.*Sustainable Cities and Society* https://doi.org/10.1016/j.scs.2017.12.036

Impact of long-term operation of ground-source heat pump on subsurface thermal state in urban areas

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Highlights

- Long-term GSHP operation under cooling load dominated conditions was examined
- Dynamic building simulation was coupled with a 3D numerical BHE model
- A ground surface heat balance model was integrated into the numerical model
- Possible scenario arising from implementing GSHP in an urban area was discussed
- Realistic boundary condition gives new insights into subsurface thermal behavior

Keywords: Ground-source heat pump; Long-term GSHP operation; Unbalanced heat load; Axial heat transfer; Ground surface heat balance; Ground surface boundary condition; Coupled numerical simulation

Abstract

Long-term operation of a ground-source heat pump (GSHP) under a load imbalance condition can lead to thermal build-up or depletion; consequently, this results in performance degradation. In addition, in urban areas where building densities are considerably high with building sites in close proximity to each other, thermal intrusion problems can occur. Under the assumption that GSHPs are used in all the buildings in a city with the same cooling dominant load condition, we assessed the effect of the long-term operation of a GSHP on the subsurface thermal state. Using a coupled simulation scheme that combined a building simulation and numerical borehole heat exchanger (BHE) model, ten years of GSHP operation was simulated under the condition that the cooling load assigned to a BHE is twice the heating load. In the numerical model, the top and bottom axial heat transfer was explicitly considered; a ground heat balance model was integrated into the numerical model as a ground surface boundary condition to examine subsurface thermal behavior realistically. Results showed that detailed consideration of the surface boundary condition plays an important role in a long-term simulation. Moreover, based on the results, possible future problems that may occur in an urban area were discussed.