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A Phase Change Materials Thermal Storage for Ground-Source Heat Pumps: Computational Fluid Dynamics Analysis of Innovative Layouts

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Abstract : The exploitation of the low-temperature geothermal resource via ground-source heat pumps is often limited by the high investment cost mainly due to borehole drilling. From the monitoring of a prototypal system currently used by a commercial building, it was found that a simple upgrade of the conventional layout, obtained including a thermal storage between the ground-source heat exchangers and the heat pump, can optimize the ground energy exploitation requiring for shorter/fewer boreholes. For typical applications, a reduction of up to 66% with respect to the conventional layout can be easily achieved. Results from the monitoring campaign of the prototype are presented in this paper, and upgrades of the thermal storage using phase change materials (PCMs) are proposed using computational fluid dynamics simulations. The PCM thermal storage guarantees an improvement of the system coefficient of performance both for summer cooling and winter heating (up to 25%). A drastic reduction of the storage volume (approx. 1/10 of the original size) is also achieved, making it possible to easily place it within the technical room, avoiding extra costs for underground displacement. A preliminary optimization of the PCM geometry is finally proposed.

Keywords : computational fluid dynamics (CFD), geothermal energy, ground-source heat pumps, phase change materials (PCM)
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