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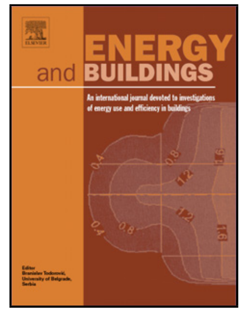

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A methodology to calculate long-term shallow geothermal energy potential for an urban neighbourhood

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Abstract

Ground source heat pumps typically use Borehole Heat Exchangers (BHEs), which are drilled vertically into the ground to extract heat. Space limitations in urban areas can limit the total length of BHEs. Continuous heat extraction over long periods from BHEs especially those with restricted lengths, will result in cooling of the ground. Furthermore, the presence of neighbouring BHEs adds to the cooling effect, thereby reducing the overall geothermal energy potential. Due to these restrictions, it is important to consider spatial constraints and the thermal interference from neighbouring BHEs when evaluating the geothermal energy potential of urban areas. In this paper, a methodology to calculate the long-term geothermal energy potential for an urban neighbourhood is developed. A GIS based workflow is used to design the BHEs for multiple buildings, in order to satisfy their total heating/cooling demands with consideration of spatial constraints. A model that accounts for thermal interference between neighbouring BHEs is developed in order to simulate their operation and calculate their long-term geothermal energy potential. The method is applied to an urban neighbourhood in Zurich, Switzerland with 170 buildings. Results show that the geothermal energy potential is overestimated if thermal interference between BHEs are not accounted for. A long-term declining trend is observed in the geothermal energy potential due to ground cooling.

Keywords: Building energy demand, Borehole heat exchanger, Shallow geothermal energy, GIS, Renewable energy

1. Introduction

1.1 Background

Human induced climate change is pushing the energy sector towards a transition to cleaner technologies with lower CO_2 emissions. The seeds of this transition have been sowed through the development of energy strategies by the world's major economies. For instance, the European Union (EU) is committed to reducing its collective greenhouse gas emissions by 20% from the 1990 levels by 2020 [1] and 80-95% by 2050 [2]. These targets are ambitious and necessitate an energy system with an exceptionally high share of renewable energy. Furthermore, contributions are needed from various energy consuming sectors such as buildings, transport, industry, agriculture. The building sector in the EU represents 40% of the total final energy use [3] and contributes 36% of the total CO_2 emissions [4] thus providing an opportunity to reduce a substantial amount of emissions. The Energy Performance of Buildings Directive, which is the main legislation in the EU for energy efficient buildings, also advocates