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Using Ground Source Heat Pumps for Micro-scale 5G DHC in Eastern Mediterranean conditions

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Abstract

Ground Source Heat Pumps (GSHPs) are one of the most well-known types of geothermal energy systems. GSHP systems are used for heating and cooling extract/reject heat from/to the ground through the coupling of a HP with Ground Heat Exchangers (GHEs). GHEs essentially consist of a network of underground tubes with a circulating refrigerant fluid. GSHPs can achieve a higher performance than the conventional Air Source Heat Pumps (ASHPs), thus seeing an increased interest, following the European Union (EU) "Fit for 55" target and the "nearly Zero Energy Buildings (nZEB)" derivative. However, the high initial cost and the consequent long payback period has been a preventive factor for GSHP systems use in the residential sector.

An alternative application of Geothermal energy that has seen increased interest is the District Heating (DH). This could actually make GSHP systems more viable, contributing to lower cost, lower maintenance and lower carbon emissions. Although such systems for DH exist in central and northern Europe, where heating demand is higher compared to southern Europe, the infrastructure required for a central unit and distribution however, makes the application not readily available. An alternative to the above could be the use of GSHP systems at a micro scale level.

To this end, the current paper investigates the potential of using GSHP systems for 5th Generation (5G) DH, but also DHC (district heating and cooling), in a micro-scale urban environment. In particular, some theoretical case studies are developed for "islands" (i.e., residential blocks) at a neighbourhood level in the Mediterranean island of Cyprus. Typical multiple multi-story residential buildings or multiple detached residential buildings within a residential block, of nZEB characteristics, are included in the study. The investigation is performed computationally. Once the heating and cooling demands, along with the corresponding peak loads have been estimated per case, the Ground Loop Design (GLD) software is used to size the appropriate vertical GHEs for various configurations. Then the COMSOL Multiphysics software is employed for examining the effect of the unbalanced ground temperature and the temperature gain/loss from the heat distribution. Based on a parametric analysis, the obtained results seem to favor the possible use of GSHP systems for DHC at a residential micro-scale level in relation to cost reduction, environmental friendliness and renewable energy use.

Keywords: Geothermal energy, District Heating and Cooling, Ground Source Heat Pump