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Energy, economic and environmental GIS–based analysis of shallow geothermal potential in urban areas—A Spanish case example

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ABSTRACT

During the last decades, both population growth and increasingly concentration in cities turn these areas into major consumers of energy, mainly due to heating and cooling energy demanded by residential and commercial sectors. In parallel, the promotion of renewables and policies aimed to decrease fossil fuel dependence and save emissions have addressed mostly solutions based on renewable energy resources. Under this scenario, this paper evaluates the feasibility of vertical Ground Source Heat Pump systems based on the spatial study of the site–-specific parameters affecting their performance at a local scale. A GIS–based energy, economic and environmental multidimensional approach is then proposed to analyze the heating and cooling energy demand by considering the urban pattern and the real space available for the installations. The paper explores and compares different Borehole Heat Exchanger Ground Source Heat Pump systems by using the G.POT method applied to residential customers. Two Spanish residential locations are included as case study. From the results, geothermal resource gives highly beneficial results also for cooling energy demand, which is not usually considered in geothermal analysis. The proposed renewable system can be also evaluated from this multidimensional perspective on both commercial and tertiary sector, as well as in other locations with a diversity of heating and cooling energy demand profiles.

1. Introduction

During the last decade, the world has significantly increased the number of the global population concentrated in high-density urban areas (Salata et al., 2017). Indeed, it can be seen for the first time that more than half of the global population is living in cities (Elci et al., 2018). A clear tendency toward the concentration of urban areas is thus turning cities into critical icons to facilitate climate action, energy transition and sustainability (Bulkeley et al., 2016). Actually, residential sector is responsible for the emission of 1931 and 454 Mt CO_2 in the world and Europe respectively (IEA, 0000), and buildings account for over 40% of total energy consumption throughout the world (Fazelpour et al., 2018). Under this scenario, Bienvenido-Huertas et al. (2020) affirm that people are required to change to a more sustainable lifestyle, reducing the current high Heating, Ventilation, and Air Conditioning (HVAC) system energy consumption and adopting new thermal behaviors. In fact, space and water heating currently account for approximately half of the global consumption, mainly dominated by fossil fuels (Sachs et al., 2019). In particular, space heating residential demand ranges from 33% to almost 50% (Yuan et al., 2020). Liu et al. (2015) also conclude that the growth of electricity demand and environmental concerns drive people to seek solutions from renewables. Moreover, cities of the modern world are increasingly developing by utilizing natural resources (Silva et al., 2018). However, renewable integration into residential loads has more complexities than industrial or commercial loads, mainly due to the stochastic patterns of such customer energy consumption (Saleh et al., 2017). In fact, a residual share 5% of Heating and Cooling (H&C) energy demand is covered by renewables —solar thermal and geothermal energy account for 1.5% (United Nations Framework Convention on Climate Change, 0000). By including all sectors, only 18% of energy for H&C is covered by renewables and

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