Cyprus University of Technology

Faculty of Engineering and Technology

Doctoral Dissertation

Shallow Geothermal Energy Systems: Investigating possible viable solutions in the building sector

Lazaros Aresti

Limassol, December 2020

in memory of my father, Georgios Aresti

CYPRUS UNIVERSITY OF TECHNOLOGY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER ENGINEERING AND INFORMATICS

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Approval Form

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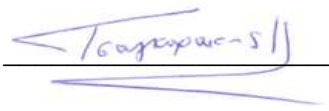
Signature 

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Abstract

Shallow Geothermal Energy (SGE), a renewable resource, finds application through the use of Ground Source Heat Pumps (GSHPs) coupled with Ground Heat Exchangers (GHEs) for space heating and cooling of buildings. GSHPs are an emerging technology and have received more attention in the recent years due to their high efficiency in comparison to the conventional Air Source Heat Pumps (ASHPs). Despite their evident advantage, the technology of GSHPs has not reached a steady and popular state, owing to high initial costs of installation and manufacturing. Depending on the building's loads, and therefore on the climate of the area, the GSHP system could be a smart investment for the building's owner. To address this, the main objective of this research is to study and suggest ways of improving GSHP systems so that a system could stand out as an attractive Renewable Energy System (RES).

Initially, an economic evaluation of two types of systems, ASHP systems and GSHP systems, was conducted for a residential building in moderate climate conditions. An example of possibly enhancing the performance of GHEs is studied for a certain characteristic of the surrounding ground, namely through the possible groundwater effect on the outlet temperature, and hence, the length of the GHEs. The length of a GHE could also depend on the configuration/geometry type of the GHE. To that extent, the implementation of the building's foundation was subsequently considered to act as GHE. The use of a residential building's foundations, namely the foundation piles or the foundation bed, were considered for investigation within the framework of the newly developed nearly Zero Energy Buildings (nZEB) concept. Such hybrid elements (energy piles and foundation bed) demonstrate promising results with low payback periods and a low environmental impact. Such systems could potentially attract more homeowners to invest in geothermal energy and to see this technology flourish in the near future.

Keywords: Ground Heat Exchanger; Energy Geo-Structures; Shallow Geothermal Energy; GSHP system cost analysis; building foundation GHE; GSHP cost analysis; GHEs LCA analysis