CERIS Civil Engineering Research and Innovation for Sustainability

DEEPCOOL – Use of Underground Spaces for Renewable Heating & Cooling

Summary

DEEPCOOL addressed key technical and market/legislative aspects relating to the efficient and sustainable implementation of shallow geothermal energy (SGE) using energy geostructures, and their place in the Portuguese and International renewable heating and cooling market.

Promotion of SGE contributes to national strategic objectives regarding the need for new sources of renewable energy. Wider acceptance of the use of energy geostructures in SGE systems has been hindered due to a general lack of awareness regarding the technology and continuing questions regarding their long-term operation.

DEEPCOOL addressed these issues through an evaluation of National and International regulations, and market potential, with a view to promoting the commercialization of SGE systems. And addressing key technical feasibility issues pertaining to the implementation of SGE systems generally and specifically, through the quantification of the effect of thermal cycles on long-term safety & serviceability of pile foundations, the factors influencing heat exchange and quantifying heat transfer resistance across geo-interfaces.

A assessment of the technical, economic and market potential for SGE demonstrated in the broadest sense that (i) the ground thermal properties and ground temperature make it possible to utilize GSHP systems to exploit SGE given the existing climatic conditions of Portugal, with varying degrees of technical potential, (ii) the market potential for SGE is dominated by the residential sector with an estimated potential capacity of about 6 GW_{th} and value of about €16 billion, (iii) despite higher capital costs, life cycle analysis showed that SGE systems are comparable with the most commonly used space heating technologies used in Portugal (gas/electric/ firewood), compare favourably with air-source heat pump systems that dominate the market in Portugal, and represent significant savings with respect to convention HVAC, Figure 1.

The application of SGE in Portugal was explored further through the assessment of the potential for hybridizing SGE with other renewable cooling technologies such as e.g. natural ventilation and personal comfort systems, and the impact of climate change. These additional technologies were used to reduce the load on the SGE system, leading to greater efficiency, better long-term sustainability and significant reduction in operational costs. Future climate warming will inevitably lead to reduced system efficiency, but it was demonstrated that the implementation of new technologies to reduce internal heat gains could go a long way to offsetting this loss in efficiency.

The other key part of the project was to address technical issues associated with the use of geotechnical structures, namely pile foundations and embedded walls, as ground heat exchangers in SGE systems. The heat exchange potential of retaining wall panels was explored which has led to the development of simple relationships describing the influence of geometric parameters on heat exchange potential. The behaviour of pile foundations under seasonal cyclic thermal loading was also explored and led to important contributions relating the stability of the foundation which will reassure potential users of the technology and enhance the uptake of thermally-activated foundations in SGE systems.

The project concluded at the end of September 2022. One PhD and 10 Master theses were concluded within the remit of the project. The project also led to the publication of 19 articles in peer-reviewed international journals and 14 conference papers which at the end of 2023 and prompted in excess of 100 citations.

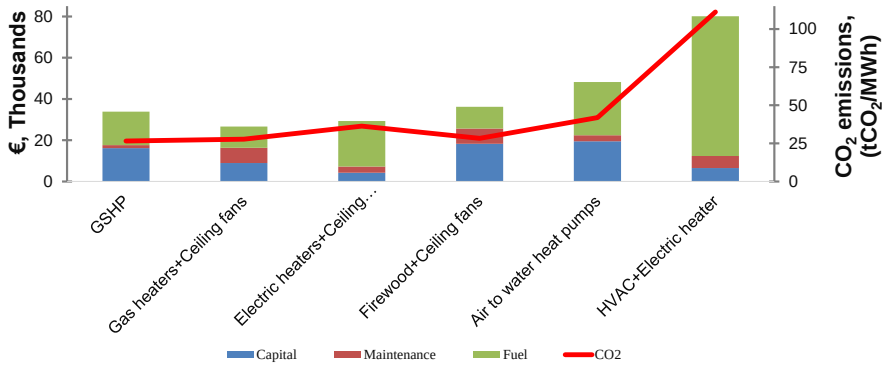

Figure 1. Comparison of NPV and CO2 emissions of GSHP systems with competing technologies over 30-years.

Project Reference

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Leading Institution

IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (Portugal)

Partners

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Project Website

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