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Replacement of electric resistive space heating by a geothermal heat pump in a residential application – Environmental amortisation

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ABSTRACT

This paper reports the life cycle analysis (LCA) of the replacement of a conventional boiler by a geothermal boiler in a standard, medium sized, single-family dwelling, located in a Mediterranean country such as Spain. The geothermal installation analysed is vertical, with two wells of 0.66 m diameter and 125 m depth each. This type of vertical wells has been chosen due to the smaller surface area required compared to horizontal collectors. The LCA studies the costs of the different phases, as well as the costs of the final installation. The system boundaries considered during the study cover the overall production for the creation of a functional unit in a gate-to-gate study. Findings indicate that the greatest environmental impacts are in Marine Aquatic Ecotoxicity category and the lowest corresponds to the Ozone Layer Depletion category. Regarding the phases, the drilling phase has the highest environmental impact and the second one is the boiler installation, while the lowest impact is found in the installation of probes. Finally, an amortisation analysis for environmental impact is developed, concluding that all categories are amortised in 8 years and some of them in less than 3 years.

Introduction

The rise of Renewable Energies and the search for more sustainable energy systems and less dependency on fossil fuels is a reality at present, and already noticed in recent decades, as for instance by Dovì et al. [4]. Currently, this importance can be seen in the scientific literature, such as the work of Tulus et al. [26], who consider this type of renewable energy as a replacement for conventional energy in the near future. However, it is necessary to study the current impacts and emissions generated by this type of renewable energy; for example, Miller et al. [18] perform emission estimation models for photovoltaic and wind energies, while Pehnt [20] and Varun et al. [28] report life cycle assessments of different renewable technologies.

Among the renewable energies, Geothermal energy looks attractive for the substitution of these fossil fuels in places where their installation is possible. This renewable energy uses the difference in temperature in the earth's crust to install probes that make it possible to take advantage of this energy [11]. This is a stable energy, which does not depend on external weather factors such as other types of renewable energy, as for instance solar or wind energies; so it is very attractive in terms of continuity and security of supply, and a growth in production in the near future is expected [3,25] based on reports associated to industrial [7] and commercial uses [6].

There are several types of geothermal developments, which are usually classified according to geothermal energy, depending on enthalpy and temperature:

- High enthalpy geothermal energy, with temperatures above 150 °C. This range of energy is present in areas of the planet with high activity in its crust, and that require specific characteristics of the rocks in the Earth's crust to reach this range of temperatures. They are found in areas with high geothermal gradients.
- Medium enthalpy geothermal energy, corresponding to temperatures between 70 and 150 °C. This type of geothermal energy is more

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