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Moving from Air Source Heat Pumps to Ground Source Heat pumps: an environmental investigation of different types Ground Heat Exchangers

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Abstract

Shallow Geothermal Energy (SGE) systems falls well within the new European strategies for further adoption of Renewable Energy Systems (RES) and reduction of fossil fuels. A major application of SGE systems is space heating and cooling through the use of Ground Source Heat Pumps (GSHPs). GSHPs are coupled with Ground Heat Exchangers (GHEs) in order to absorb/reject heat from/to the ground. GHEs come in different forms and types, and orientation. The conventional systems for an urban environment use vertical GHEs, with either single U-tube, double U-tube, or coaxial configurations. In comparison to the Air Source Heat Pump (ASHP) systems, the GSHPs offer a superior performance, but have failed to prevail due to their longer payback periods and higher initial investment. However, new decision criteria within an overall multi point criteria framework, seen to be favored in the EU, with the environmental impact of a process/ product playing an important role. The aim of this study is therefore to investigate environmentally whether the switch from ASHPs to GSHPs, in terms of GHE types, provides an environmental advantage.

To this end, the widely adopted Life Cycle Analysis (LCA) methodology is used. A case study is considered as a baseline from which the Functional Unit (FU) is set. The system boundaries are based per FU and the processes and Life Cycle Inventory (LCI) involved include the production of raw material, the installation, and the operation of the systems. The Life Cycle Impact Assessment (LCIA) is investigated in terms of a mid-point and an end-point perspective using two methods of the openLCA software, namely the CML2001 and Eco-Indicator99. The results indicate that the ASHP systems exhibit the highest impact in comparison to the GSHP systems, while the coaxial GHE configuration, although requiring the smallest GHE depth, has the highest impact among the GHE types. Finally, one should note that the GSHP systems are case sensitive and the heating and cooling loads of the investigated case plays an important role on these results.