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Environmental impacts from geothermal heat pump systems: A cradle-to-grave analysis

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Shallow geothermal systems such as open and closed geothermal heat pump (GHP) systems are considered to be an efficient and renewable energy technology for cooling and heating of buildings and other facilities. The numbers of installed GHP systems is continuously increasing worldwide. The objective of the current study is to fully examine environmental burdens related to applications of GHP systems from cradle to grave by employing life cycle assessment (LCA). The applied life cycle impact assessment methodology shows that climate change is one major impact category to consider, contributing more than 50% to the total environmental impacts. The life cycle impact assessment also demonstrates that the supplied electricity for the operation of the heat pump is the primary contributor to the environmental impact of GHP systems. However, impacts also stem from the heat pump refrigerant, production of the heat pump, transport, heat carrier liquid and borehole heat exchanger. Greenhouse gas emissions related to the use of such GHP systems are carefully reviewed. The magnitude of resulting savings or surplus of CO2 eq emissions for Europe depend on the primary resource of the supplied electricity for the heat pump, the climatic conditions and the inclusion of passive cooling capabilities. In fact, the difference in CO2 eq emission ranges from -31% and 88% in comparison to conventional heating systems such as oil fired boilers and gas furnaces. Factors such as degradation of coefficient of performance, as well as total leakage of the heat carrier fluid into the soil and aquifer are also carefully assessed, but show only minor environmental impacts.