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Mitigation potential of horizontal ground coupled heat pumps for current and future climatic conditions: UK environmental modelling and monitoring studies

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An increased uptake of alternative low or non-CO_2 emitting energy sources is one of the key priorities for policy makers to mitigate the effects of environmental change. Relatively little work has been undertaken on the mitigation potential of Ground Coupled Heat Pumps (GCHPs) despite the fact that a GCHP could significantly reduce CO_2 emissions from heating systems. It is predicted that under climate change the most probable scenario is for UK temperatures to increase and for winter rainfall to become more abundant; the latter is likely to cause a general rise in groundwater levels. Summer rainfall may reduce considerably, while vegetation type and density may change. Furthermore, recent studies underline the likelihood of an increase in the number of heat waves. Under such a scenario, GCHPs will increasingly be used for cooling as well as heating. These factors will affect long-term performance of horizontal GCHP systems and hence their economic viability and mitigation potential during their life span (50 years).

The seasonal temperature differences encountered in soil are harnessed by GCHPs to provide heating in the winter and cooling in the summer. The performance of a GCHP system will depend on technical factors (heat exchanger (HE) type, length, depth, and spacing of pipes), but also it will be determined to a large extent by interactions between the below-ground parts of the system and the environment (atmospheric conditions, vegetation and soil characteristics). Depending on the balance between extraction and rejection of heat from and to the ground, the soil temperature in the neighbourhood of the HE may fall or rise.

The **GROMIT** project (**GRO**und coupled heat pumps **MIT**igation potential), funded by the Natural Environment Research Council (UK), is a multi-disciplinary research project, in collaboration with EarthEnergy Ltd., which aims to quantify the CO_2 mitigation potential of horizontal GCHPs. It considers changing environmental conditions and combines model predictions of soil moisture content and soil temperature with measurements at different GCHP locations over the UK. The combined effect of environment dynamics and horizontal GCHP technical properties on long-term GCHP performance will be assessed using a detailed land surface model (JULES: Joint UK Land Environment Simulator, Meteorological Office, UK) with additional equations embedded describing the interaction between GCHP heat exchangers and the surrounding soil. However, a number of key soil physical processes are currently not incorporated in JULES, such as groundwater flow, which, especially in lowland areas, can have an important effect on the heat flow between soil and HE. Furthermore, the interaction between HE and soil may also cause soil vapour and moisture fluxes. These will affect soil thermal conductivity and hence heat flow between the HE and the surrounding soil, which will in turn influence system performance. The project will address these issues.

We propose to drive an improved version of JULES (with equations to simulate GCHP exchange embedded), with long-term gridded (1 km) atmospheric, soil and vegetation data (reflecting current and future environmental conditions) to reliably assess the mitigation potential of GCHPs over the entire domain of the UK, where uptake of GCHPs has been low traditionally. In this way we can identify areas that are most suitable for the installation of GCHPs. Only then recommendations can be made to local and regional governments, for example, on how to improve the mitigation potential in less suitable areas by adjusting GCHP configurations or design.