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Estimating the CO_2 Mitigation Potential of Horizontal Ground Coupled Heat Pumps in the UK

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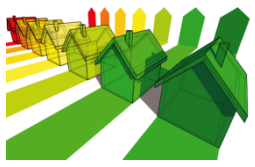

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Key messages

- By 2020, the UK will need to generate 15% of its energy from renewables to meet our contribution to the EU renewable energy target
- Heating and cooling systems of buildings account for 30%-50% of the global energy consumption
- Horizontal Ground Couple Heat Pumps (GCHPs) can contribute to reduce UK's energy bills and reduce CO_2 emissions

CO_2 Mitigation Potential

CO_2 savings by GCHPs per year is given as the difference of the Geothermal CO_2 emission and the Conventional CO_2 emission

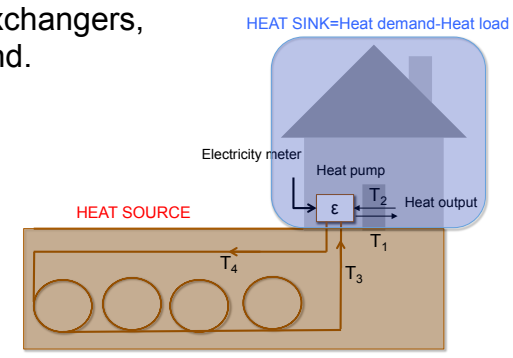
e. g. A heat pump of ~10KWh installed in the South of England is able to produce approximately 21000KWh heat annually, which means:

CO_2 savings ~ 2500 kg/year

Horizontal Ground Coupled Heat Pumps

Horizontal ground coupled heat pumps (GCHPs) use buried pipes (heat exchangers, HEs) to extract heat from the ground.

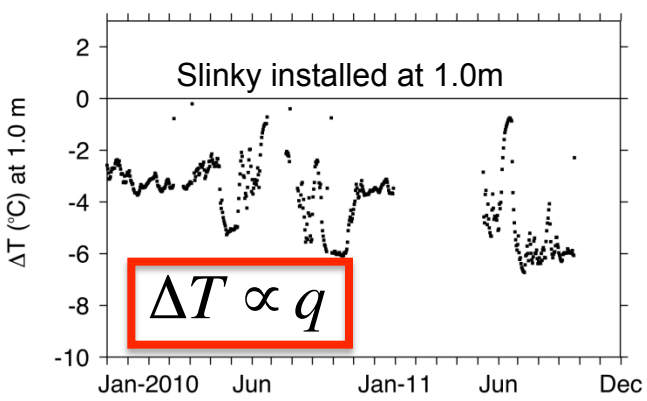
The Coefficient of Performance (CoP) is an instantaneous measure of GCHP performance, calculated as the ratio of heat output to electricity input at a particular instance.

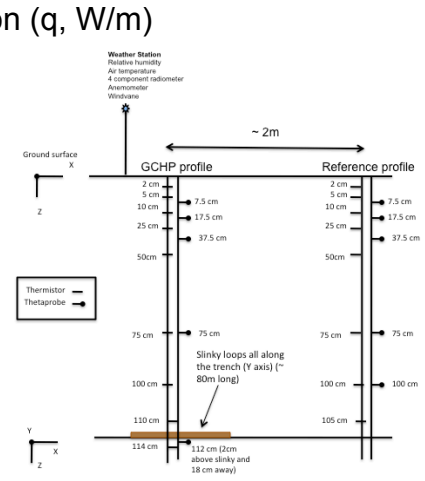


Field experiments

1

Instruments were installed in two profiles to measure soil temperatures and soil moisture contents (see schematic below). Soil temperature differences (ΔT, °C) between the slinky (GCHP) and the reference profile are proportional to the heat extraction (q, W/m)



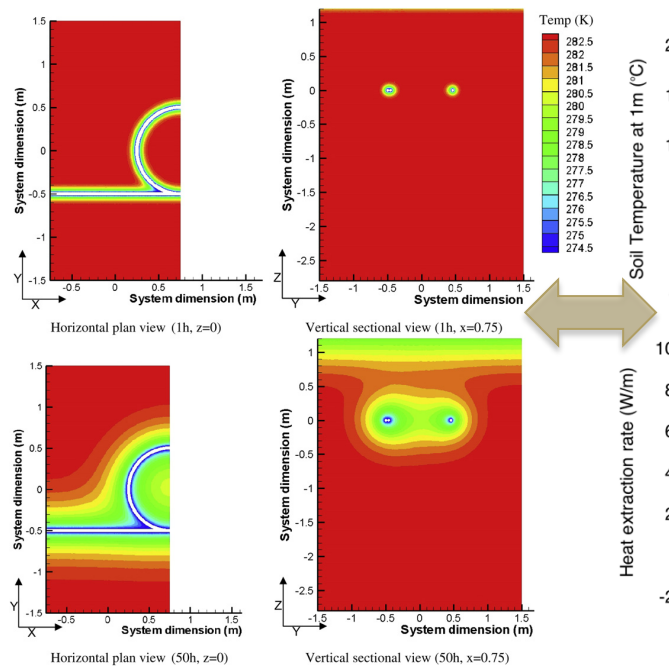


Modelling studies

2

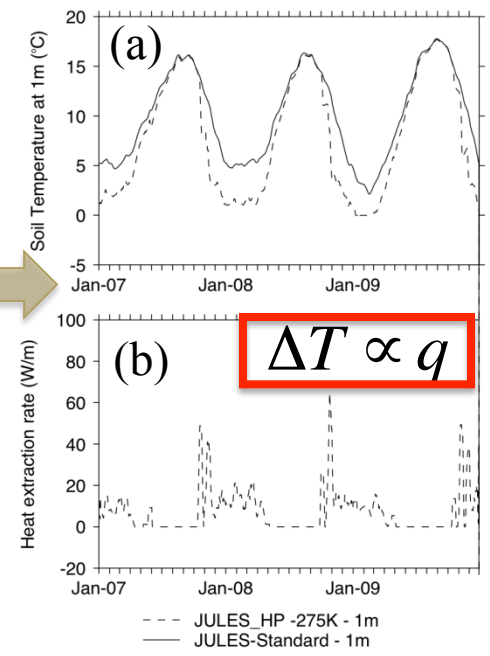
A land surface model (JULES) that calculates coupled soil heat and water fluxes was combined with a heat extraction model (HE) to study the dynamic interaction between the environment and horizontal GCHPs.

Heat extraction model (HE)



Plan view (horizontal and vertical) of isotherms generated from prediction for a slinky heat exchanger, at 1 and 50 hours. Note heat extraction near the GCHP (Wu et al., 2010). The HE-influenced the soil temperatures to within a distance of around 0.8 m for a slinky system.

JULES-HE model

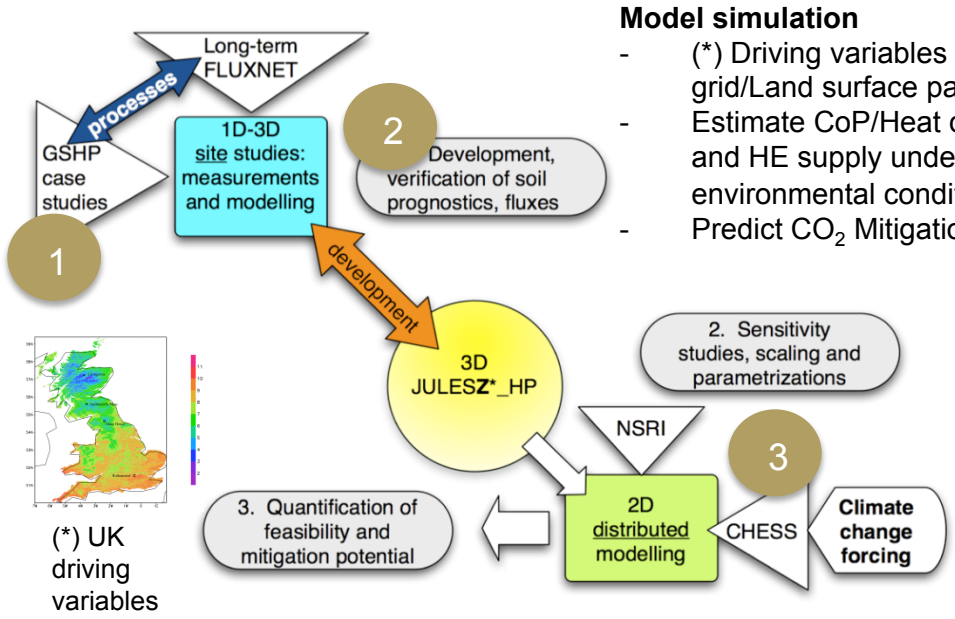


Modeled (standard and JULES-HE) (a) temperature (°C) at 1.0m for a site in South England, from 2007 to 2009; (b) heat extraction rate for the JULES-HE runs (installation depth at 1.0m and a fluid temperature of 275K).

Climate Change impact studies

3

Long-term simulations, using high resolution (1km) meteorological (historical and projected data), soil physical and land cover data over the entire UK-domain, will allow us to consider the effect that global warming will have on the environment as well as on the energy demand of buildings, and hence the changes in GCHP mitigation potential.



Model simulation

- (*) Driving variables (UK 1km grid/Land surface parameters)
- Estimate CoP/Heat demand and HE supply under future environmental conditions
- Predict CO_2 Mitigation Potential

Conclusions

The outcomes of this study will allow us to give recommendations to relevant government bodies, as well as to installers and users, concerning the optimal configuration of future installations of horizontal GCHPs at UK domestic, institutional, commercial and agricultural developments.

Find out more…

- Garcia et al., Renewable Energy (2012), 141-153.
- Wu et al., International Journal of Low Carbon Technologies (2011), 6(4), 261-269.
- Wu et al., Applied Thermal Engineering (2010), 30(16), 2574-2583.

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