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Renewable energy and sustainable surface runoff management: combining Ground Source Heat and Porous Paving to heat buildings

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EXCELLENCE WITH IMPACT

Coventry University

Combining Ground Source Heat and Porous Paving

European Parliament: Increased % Member States use of renewables up to 27% by 2030

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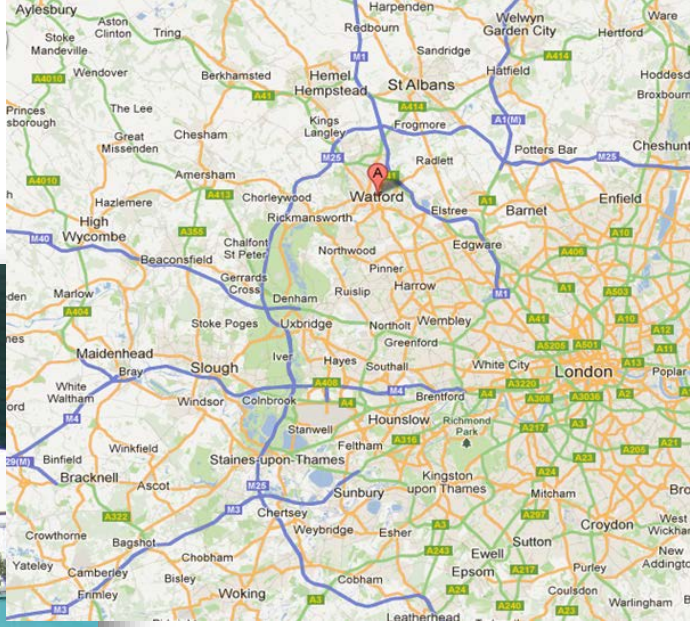
Infiltrating pavement reduces the flood peak, improves water quality and provides a hard running surface

Aims

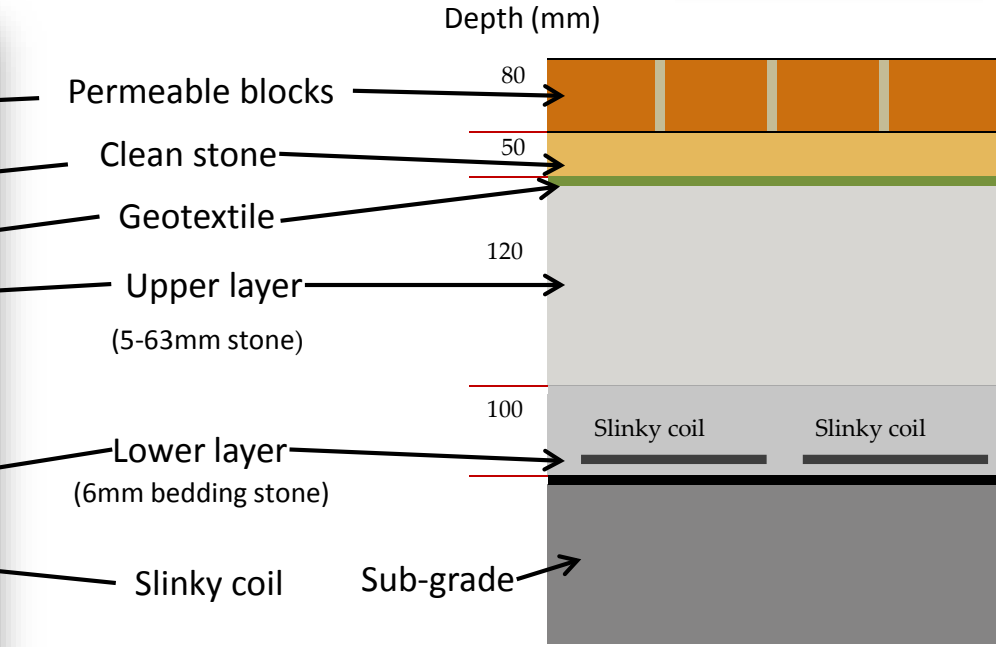
1. An assessment of the feasibility of combining a PPS and GSHP in a domestic setting for heating purposes.
2. Establishment of the performance of the combined system at the building scale.

Hanson Ecohouse, BRE, Watford, UK



Detached,
2-storey,
3-bedroomed,
fully furnished
domestic dwelling

Structure of the Combined System



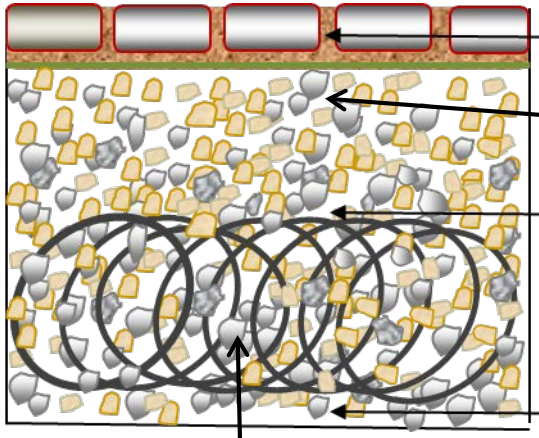
Temperature measurements associated with the PPS

Air temperature bollard installed above the GSHP tank

Sensor at 1300mm

Base of bollard

Cables from sensors 1-4



Sensor 1 at 60mm

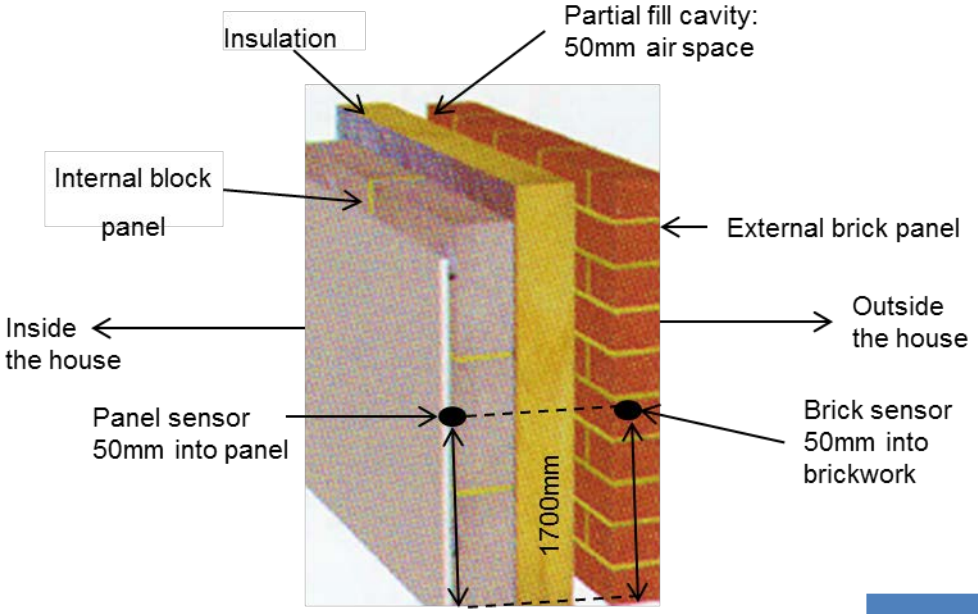
Sensor 2 at 130mm

Sensor 3 at 200 mm

Sensor 4 at 350 mm

Slinky coils laid horizontally in the base of the PPS tank

Temperature measurement inside the house



Wall and wall cavity

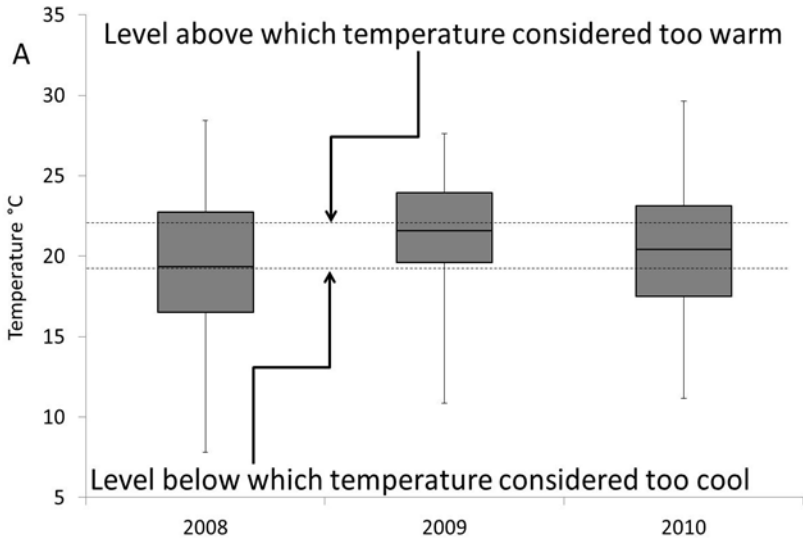
Temperature measured at:

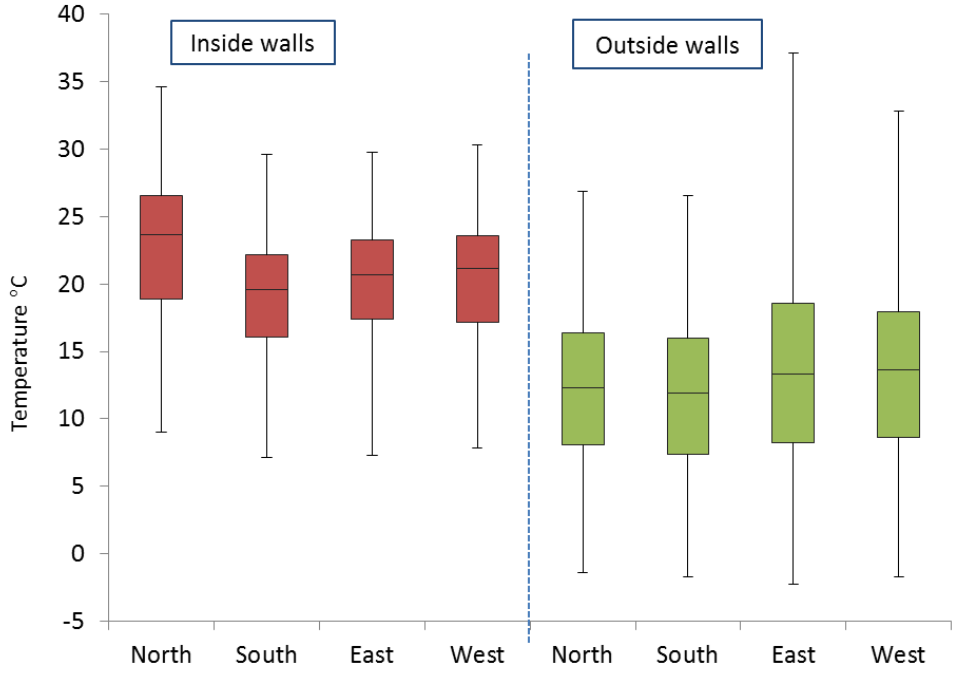
- all 4 cardinal points inside and outside walls of house
- 4 depths in PPS
- 1300mm above PPS
- 10 minute intervals
- 3 years
- >1.3 million data points

Location of data collection	N =	Number of days data collected
EcoHouse	902,151	718
PPS/GSHP reservoir	255,570	509
Bollard above the reservoir	145,658	509
Total number of observations	1,303,379	

Results of monitoring temperature inside and around the house

A. Comparison of yearly mean indoor temperatures with CIBSE's "comfort levels:
19.5±0.5°C in winter and 21±1°C in summer





n=718

Temperature (°C) of overlying air, indoors and at different depths in the PPS/GSHP during the monitoring period (n = 2,449)

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Statistical measure	Indoor	Ambient air 1300mm above the tank surface	60mm depth	130mm depth	200mm depth	350mm depth
Minimum	7.8	-3	-4.4	-3.1	-1.9	-1.1
Maximum	29.6	22.5	26.2	24.7	21.2	20.0
Average	20.2	10.0	9.7	9.5	8.8	9.6
Median	19.3	10.8	9.5	9.2	9.1	11.0
Standard Deviation	4.1	6.0	6.9	6.9	6.6	6.7
N =	5,744	509	509	509	509	413

Measuring performance

Coefficient of Performance $$CoP_{heating} = \frac{T_{supplied}}{T_{supplied} - T_{extracted}}$$

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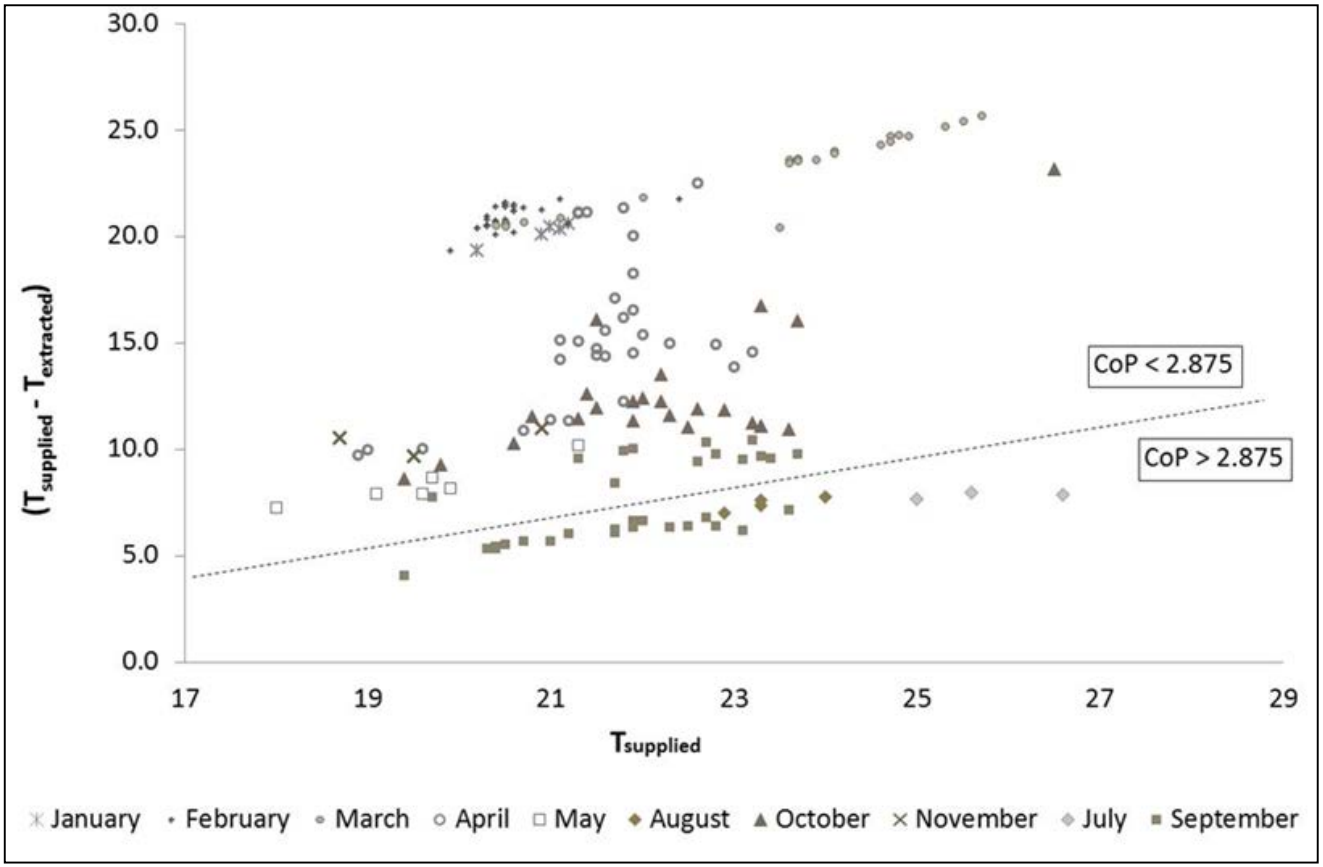
Average CoP = 1.8



Establishment of the performance of the combined system at the building scale.

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1. The PPS/GSHP had a CoP of 1.8, hence the system cannot be considered a satisfactory renewable source of energy under the 2009 EU Renewable Energy Directive which requires a CoP of 2.875.
2. It was found that when the stored rainwater temperature was below 1°C, the CoP was 1 or less; heating provided during such events was completely derived from the electricity mains.
3. The combined system was able to provide a 3-bedroom detached house with enough heat, at comfortable internal temperatures at times during the monitoring period.
4. Nonetheless, the daily temperatures inside the house showed little stability and were occasionally uncomfortably cold or warm due to a variety of plumbing, breakdown and electricity supply problems.

Lessons learnt:

- The slinky coils need to be located in a deeper structure, probably > 500mm;
- More care needs to be taken in tanking the PPS to avoid leakage;
- More research is needed in a “real-life” scenario, rather than a demonstration house;
- Research is needed to monitor water quality in such combined systems to understand better the impacts of harvesting heat in PPS.