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Operational and Economic Analysis of GSHP coupled with Refrigeration Systems in UK Supermarkets

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AIM

Evaluate the operational and economic performance of Ground Source Heat Pumps (GSHP) coupled with refrigeration systems in Sainsbury's supermarket.

BACKGROUND

Food retailers in the UK account for more than 1% of the total GHG emissions, roughly constituting the 3% of the total energy consumed (S.A.Tassou et al, 2011). Ground Source Heat Pumps (GSHP) can be seen both as a low carbon technology and as a very attractive investment. Part of the interest in this technology stems from the opportunity for food retailers to couple GSHP with refrigeration units. In principle, the heat rejected by refrigerators can be harnessed to raise the efficiency of the heat pump.

SYSTEM DESCRIPTION

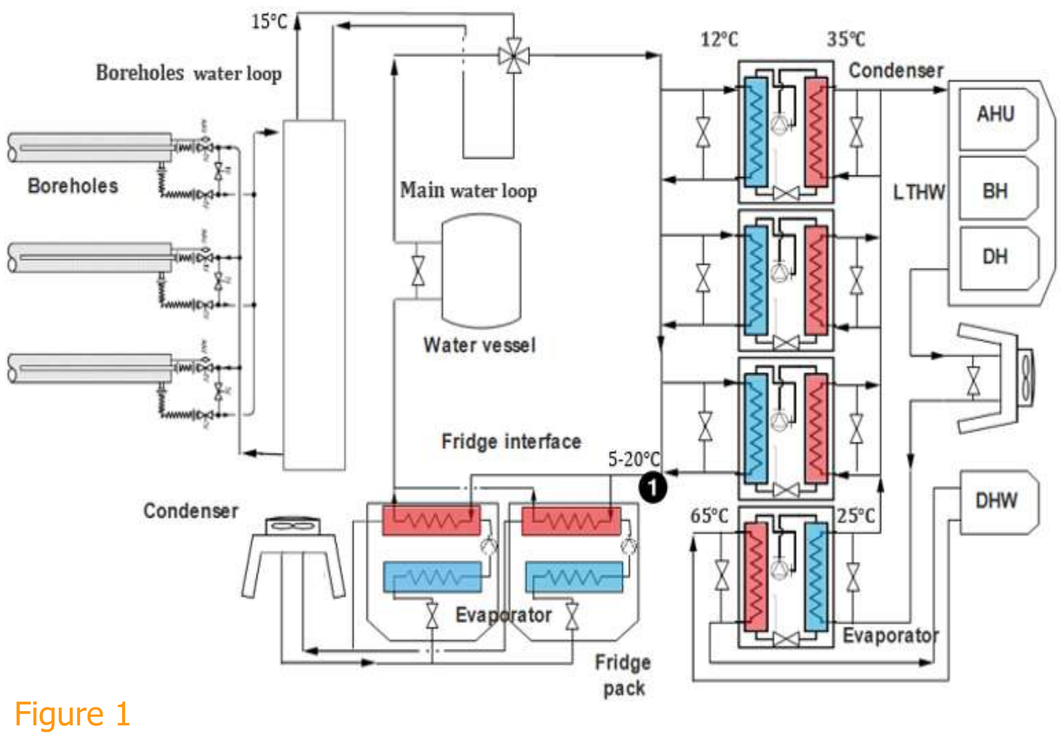

Figure 1

Three main elements:

The heat pumps: Custom-built water-to-water systems. Three Low Temperature How Water (LTHW) units and one Domestic Hot Water (DHW) unit providing a total of 1 MWh capacity.

The refrigeration units: Low Temperature (LT) and Medium Temperature (MT) fridge pack interfaced with the main water loop and air condensers on the roof.

The boreholes heat exchangers: Constituted of 15 closed loops, placed in holes extending up to 200m from the ground surface.

The system is designed to fulfil three main purposes:

I. To Improve the refrigeration COP by lowering the condensing temperature through a cold water loop interface.
II. To use that same water loop to harness the wasted heat and deliver it to the store through heat pumps, increasing their efficiency during cold months.
III. To dispense the heat to the boreholes during the summer and withdraw it during the winter increasing heat pumps efficiency.

METHOLODOGY

The operational performance of GSHP system throughout the stores and over the 30-month period ranging from the 1st of January 2013 to the 30th of June 2015 is first conducted. This consents to lay the groundwork for the economic analysis, which evaluates the investment efficiency in comparison with gas conventional systems, representing a crucial step for recommendations on cost reductions.

ACKNOWLEDGEMENTS

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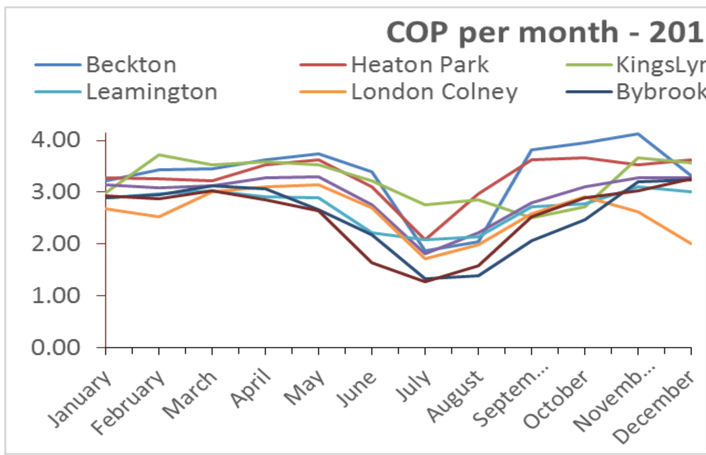
RESULTS

Operational analysis:

- Overall, the system efficiency presents a dip during the summer due to the low heat demand and the high relative electricity consumption of auxiliary components in respect of the total system consumption.
- This highlights a valuable scope for improvement for the system as a whole, achievable through an optimisation of the circulating pumps operation.

Figure 2

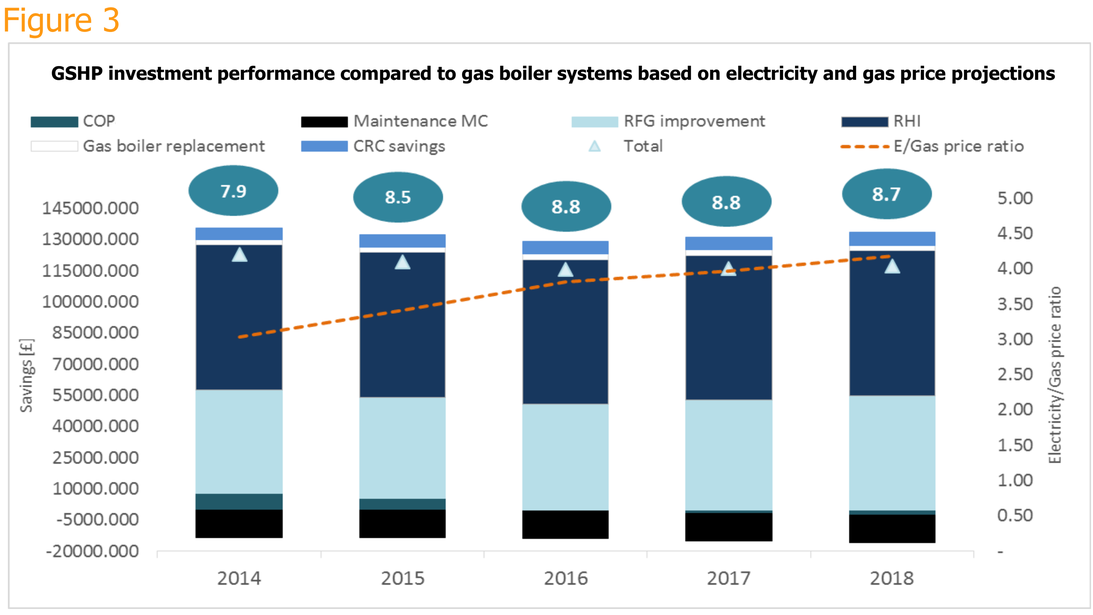


	COP min	COP max	SCOP
Beckton	1.88	4.13	3.51
Heaton Park	2.08	3.66	3.36
KingsLynn	2.50	3.71	3.30
Stirling	1.81	3.31	3.06
Leamington	2.07	3.10	2.85
Bybrook	1.33	3.25	2.75
Pepper hill	1.28	3.27	2.75
London Colney	1.71	3.14	2.61

Economic analysis:

- A considerable part of the savings stems from the improvement in the refrigeration consumption.
- The incentive accounts for roughly the 45% of the savings.
- The PBT is below than 8 years, projected to dilate up to nearly 9 due to the increasing electricity-gas price ratio

Figure 3



System enhancements

	Description	Highlights
DSM model	Heat pumps are turned off during peak hours, through two operating modes: **Buffer:** 100% or 125% of the heat delivered during the peak is generated BEFORE. **Recover:** 100% of the heat delivered during the peak is generated AFTER.	▪ Up to 5.5% cost reduction in old stores. ▪ Up to 15% (~£5,500) in new stores, by leveraging: ○ better thermal capacity ○ RHI electricity price differentials before the peak
HP-RFG system	The system is deprived of the boreholes. ▪ Direct connection between refrigeration and heat pump systems ▪ Ineligible for the Renewable Heat Incentive (RHI)	▪ CAPEX: 650 £/kW less ▪ OPEX: Lower auxiliary components electricity consumption. ▪ No reliance on the RHI ○ WACC potentially lower PBT potentially reduced by 2 years

REFERENCES

Tassou, S. a., Ge, Y., Hadawey, a. & Marriott, D. (2011) Energy consumption and conservation in food retailing. *Applied Thermal Engineering*. [Online] 31147–156. Available from: http://doi:10.1016/j.applthermaleng.2010.08.023

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