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Barrie House

Ground Source Heat Pump feasibility study

Marek Wojciechowski Architects

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Feasibility study of Ground Source Heat Pump

The purpose of this document is to identify whether the inclusion of a Ground Source Heat Pump (GSHP) is feasible and economically viable to be considered as a renewable technology for the Barrie House development. This comes as a successive action after the feedback that was received from the council of Camden, as per the below;

"1 - The applicant should be reminded to consider a ground source heat pump system with efficient/ultra-low NOx gas boilers backup. A detailed ground source heat pump feasibility study should be undertaken in this regard by a suitably qualified specialist, to support the scenario. The net CO_2 benefits should be applied to the Be Green stage

2 - The site is considered suitable for this technology with grounds potentially available for the less costly, trench-based type of system. The reasons given for rejection are not deemed conclusive nor convincing in isolation. A technical feasibility study should be undertaken before finalising the Be Green choice of technologies, which currently falls short on CO_2 reduction (see above)."

A feasibility study for the potential implementation of a GSHP has been carried out, based on the information found in the Energy Assessment document by Eight Associates and on the drawings developed by Marek Wojciechowski Architects, as were submitted for planning on 04/01/2018.

1.1 Camden Local Plan (2017)

Policy CC1 of Camden's Local Plan indicates that residential developments of more than 500 sqm need to achieve a 20% reduction in CO_2 emissions from on-site renewable energy generation, unless it can be demonstrated that such provision is not feasible. The 20% reduction should be calculated from the regulated CO_2 emissions of the development after all proposed energy efficiency measures and any CO_2 reduction from non-renewable decentralised energy (e.g. CHP) have been incorporated.

1.2 Ground Source Heat Pumps (GSHP)

Ground source heat pumps absorb/extract heat from the ground by circulating fluid through buried pipes either in horizontal trenches or vertical boreholes. There are two types of systems; the closed-loop and the open-loop. Closed-loop systems pump an anti-freeze solution through pipes and exchange heat with the ground in which they are laid. Open-loop systems extract heat from ground water, usually abstracted from an aquifer via a borehole, which is passed through a heat pump where heat is extracted from the water.

Information on the thermal properties of the ground is needed for determining the length of heat exchanger required to meet a given energy load. The moisture content of the soil also has a significant effect as dry, loose soil traps air and has a lower thermal conductivity than moist, packed soil. Low-conductivity soil may require as much as 50 per cent more collector loop than highly conductive soil. The design and installation of an effective ground source system depends on a thorough understanding of the movement of heat in the ground, the local geology and the heating and cooling requirements of your building. Building function is probably the single most important factor in determining whether significant energy savings can be achieved with GSHP systems. This is because GSHP systems work optimally in scenarios where heating and cooling demand is relatively balanced.

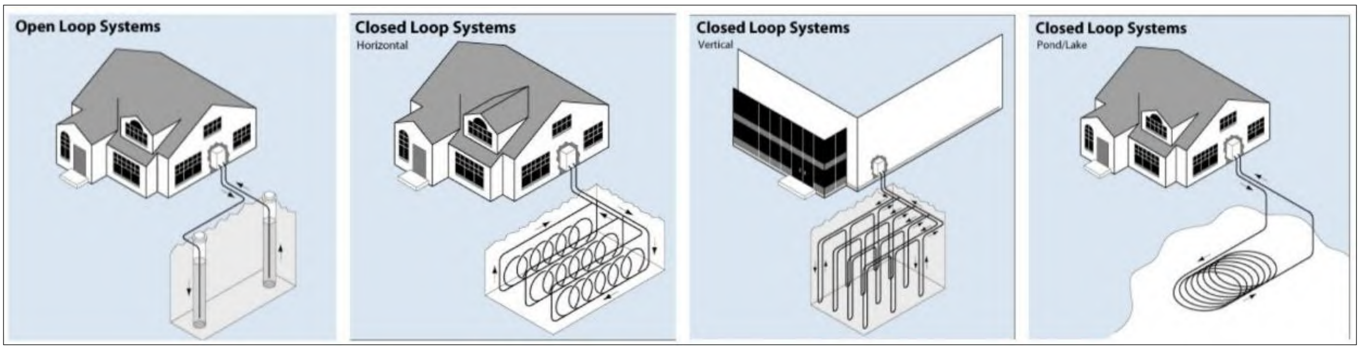

Figure 1: Types of GSHP

1.3 Feasibility study

This study has been based on the energy demand rates, as generated by the Energy Assessment that accompanied the planning application of Barrie House. The values calculated by Eight Associates have been used to develop a calculation which will determine whether the application of a GSHP would be a beneficial strategy for this development.

1.3.1 Site layout

The proposed development is an extension to an existing building, with existing buildings and trees surrounding the proposed development site. There is relatively small available land for the groundwork that is required for installing the GSHP's pipe network and the necessary machinery that is required for such a process.

Two potential areas are identified for the installation of a potential ground source heat pump, to the east and to the west of the existing building. However, the area on the east side of isn't considered appropriate as there is no provision of a new layout and any remodelling would involve cutting down the existing trees to accommodate the machinery required. As such, any potential GSHP system would need to be positioned on the west side of the site, underneath the parking area which will be redeveloped to accommodate the new layout that is proposed.

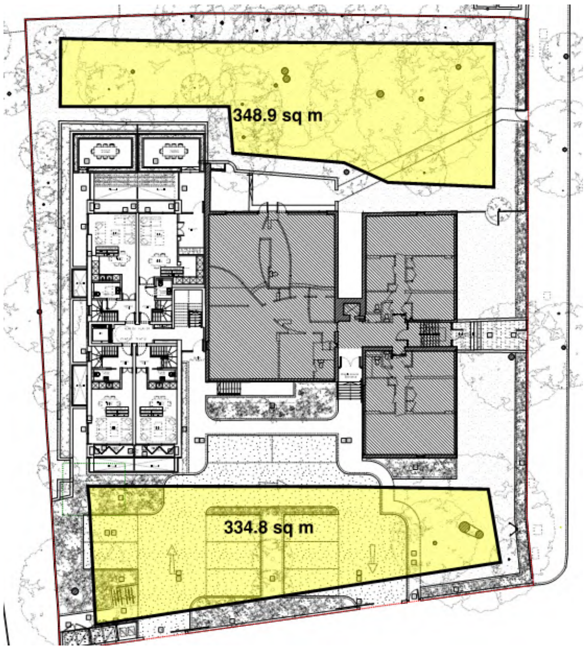

Figure 2: Available space for excavation

Beyond accessibility considerations, development of a GSHP system within an established neighbourhood with an existing building on site adds another layer of complexity. There would be the need for a detailed assessment to be carried out by a structural engineering team, which would indicate any potential threats to the foundations of the existing building and also the correct way to carry out such a process. A full utilities survey would also need to be undertaken to confirm no existing utilities would be disrupted.

Assuming no existing utilities run through the area to the west of the site, it is anticipated that the area to the west of the site may be able to accommodate a 6kW GSHP system once enough spacing is allowed to ensure optimum heat exchange with the ground, as indicated in the diagram below:

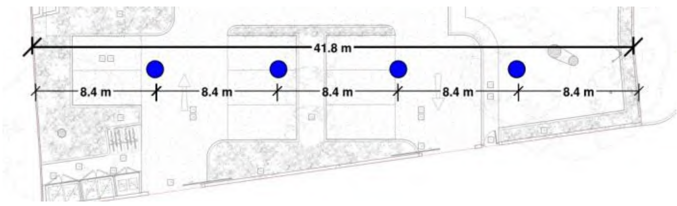

Figure 3: GSHP feasibility: maximised capacity pipe layout (blue circles)

1.3.2 Building's energy profile

Based on the heating and cooling demand calculated by Eight Associates and application of a typical residential hourly conditioning demand curve we anticipate an approximate peak heating demand of 12.5kW, and peak cooling demand of 1.5kW. The peak heating demand of 12.5kW is double our estimated GSHP system capacity, and the peak cooling demand is roughly 25% of the potential maximum GSHP system capacity.

GSHPs work best when there is a relatively balanced heating and cooling load. The proposed development has a far larger heating (30.4 kWh/m²) than cooling demand (0.6 kWh/m²). Over time, this would result in the abstraction of heat permanently from the ground, reducing the ground temperature to a point whereby the seasonal efficiency of the heat pumps drops off to a point where they are no more efficient than direct electric heating.

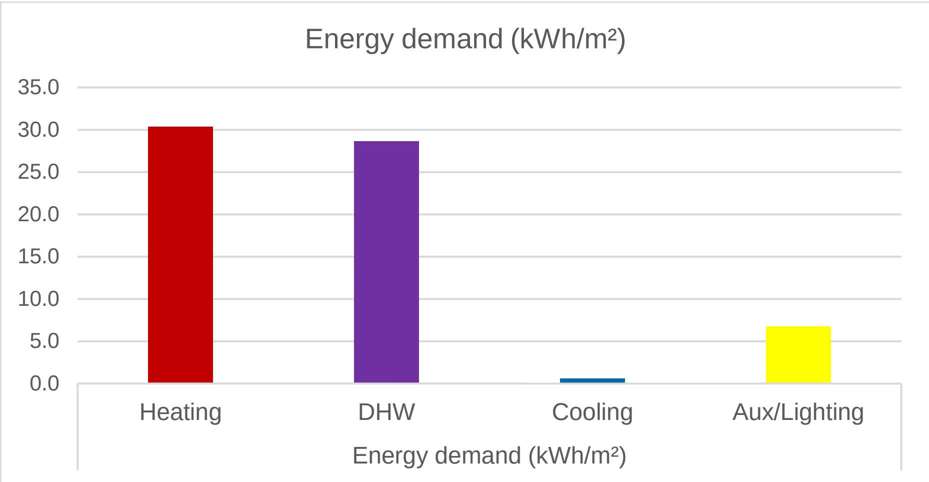

Figure 4: Building's energy demand profile

One approach to managing load imbalance is to oversize the GSHP system, however the site constraints prevent this approach from being applied in this instance. An alternative approach is to size the system to serve the cooling load such that the annual energy balance is zero: i.e. that as much heat is extracted as is replaced over the year. However, application of this approach substantially reduces the benefits of the system as shown in the following theoretical performance assessment.

1.3.3 GSHP performance assessment

	Heating	DHW	Cooling	Electricity
Total kWh	22878	21578.3	452.5	5088.2
Total tCO_2	4941.7	4660.9	234.8	2640.8

Table 1: Energy demand and carbon emissions

Based on the modelling of a 1.5kW GSHP system, operating in heating mode in January and December only (in order to prevent thermal load imbalance) the building's cooling load can be covered by GSHP, with the system consequently able to serve only 9% of the building's annual heating load. As seen in the tables below, this can potentially lead to a 2.4% reduction of CO_2 emissions. The savings are achieved from the reduction in heating emissions: in cooling mode, additional pumping energy required in comparison to a traditional air source heat pump results in additional carbon emissions.

Heating		Cooling	
Peak GSHP Heat Capacity	2.0 kW	**Peak GSHP Coolth Capacity**	1.2 kW
Heat to Building	2976 kWh	**Coolth to Building**	1499 kWh
Heat from Ground	2232 kWh	**Heat Rejection to Ground**	1874 kWh

Heating		Cooling	
Electrical Consumption of GSHP	744 kWh	**Electrical Consumption of GSHP**	375 kWh
Percentage of Heat Load Generated	9 %	**Percentage of Cool Load Generated**	96 %

Table 2: GSHP performance

Potential Carbon emission savings		
Heating CO_2 Saving	293	$kgCO_2/yr$
Cooling CO_2 Saving	-5	$kgCO_2/yr$
Net Potential Annual CO_2 Saving	287	$kgCO_2/yr$
Potential Emissions Reduction	**2.4**	**%**

Table 3: Potential carbon savings

1.4 Conclusion

The proposed site is extremely constrained in available space for a GSHP system. Installation of a GSHP to the east of the site is undesirable due to impacts on established landscaping and trees. Space to the west of the site is identified as a potential option, with an approximate capacity of 6kW (or half of the peak heating load) however this assessment has not considered existing utility services that may run through this area, nor the existing geotechnical ground conditions, nor possible structural impacts on surrounding properties.

Given the limitations presented above, incorporating a GSHP as a renewable energy technology is not deemed appropriate for this development. In addition to spatial constraints, the key technical constraint is the fact that there is not a balanced heating and cooling demand to the building, which would eventually degrade the efficiency of the system throughout the years and minimise the actual carbon savings generated by the GSHP. Implementing a GSHP system such that cooling and heating demand is balanced over the year would achieve only a 2.4% carbon emissions saving.

Cundall Johnston & Partners LLP
One Carter Lane London EC4V 5ER
United Kingdom Tel:+44 (0)20 7438 1600
Asia Australia Europe MENA UK and Ireland
www.cundall.com

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