Energy piles and other thermal foundations for GSHP

– Developments in UK practice and research

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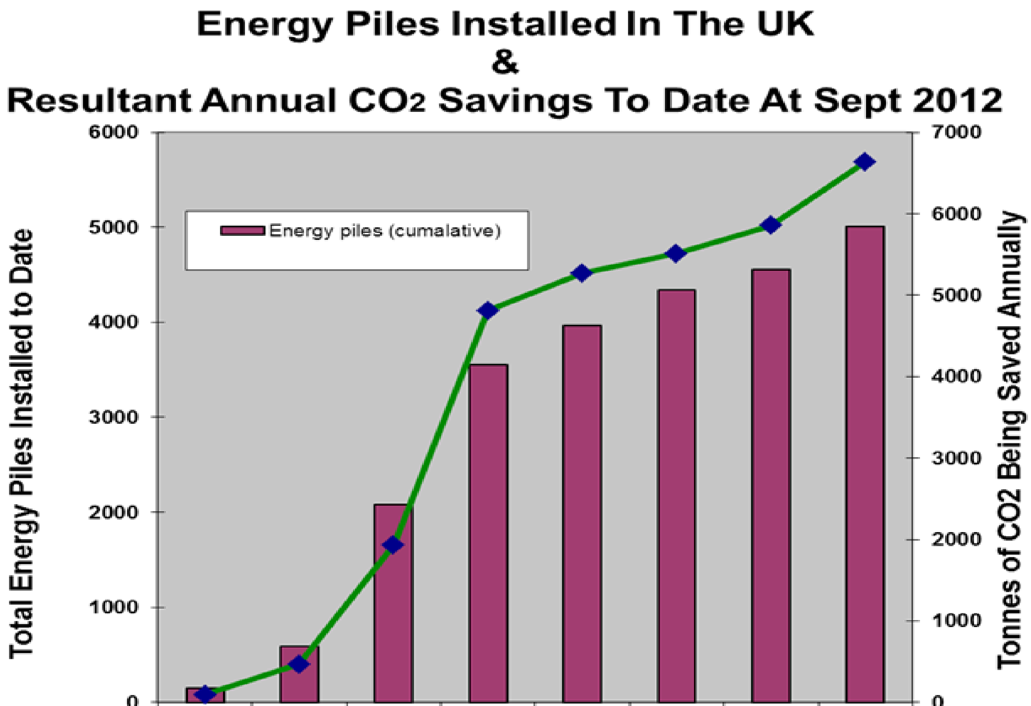
Introduction

In a typical scheme all or part of the building foundation is equipped with geothermal loops connected to a ground source heat pump, leading to delivery of, on average, 15% to 25% of the building heating and cooling requirements The concept of energy piles is not new. The approach was pioneered in Austria in the 1980s (Brandl, 2006) and taken up in a number of other northern European Countries (e.g. Koene et al, 2000, Pahud & Hubbuch, 2007, Desmedt & Hoes, 2007). A single energy pile may delivery between 25 to 50 W/m depending on its size, construction details, the surrounding soil types and how the system is operated (Bourne-Webb, 2013). These figures are not dissimilar to borehole heat exchangers, but if anything, the larger diameter of many energy piles offers the opportunities for greater heat transfer rates.

Even without considering heat transfer rates, placing geothermal loops into the buildings foundation, thereby creating energy piles or other thermal foundations is simply a "*no brainer*", *t*hey provide a very simple, low cost and time saving solution compared to other ground loop options. Firstly, the intention is never to increase the size of foundations, rather use the structurally designed requirements and calculate the amount of heating and cooling that can be provided from the foundations; only very few projects have been designed around the geothermal requirements. Secondly, geothermal loops can be attached to structural reinforcement cages being installed within the foundation, thus adding little additional cost to a project compared to other geothermal solutions. Additional minimal steelwork is only required where cages do not extend the full depth of the pile and also for continuous flight auger type piles. Thirdly significant advantages can also be applied on the construction programme; with good early coordination the installation of geothermal loops using the buildings foundation will require little to no additional time being added.

Energy Piles in the UK

In the UK heat pump systems more generally were slow to take off, principally due to the availability of relatively inexpensive gas. However, as all energy prices are rising and the difference between electricity and gas costs is reducing, the UK heat pump industry is consequently expanding (Research and Markets, 2012. As part of this expansion, installing geothermal loops into building foundations is becoming increasingly popular in the UK (**Figure 1**) and with recent changes in planning policy is likely to become increasingly so. In Central London there are very costly penalties for buildings that do not achieve the 40% energy savings above Building Regulations Part L. In addition the UK Renewable Heat Incentive is making all types of renewable heat and especially GSHP schemes more attractive. Significant growth is expected in 2014 as the final parts of the incentive scheme come into place and consequently the costs of energy piles and other ground loops schemes will decrease further.



	2005	2006	2007	2008	2009	2010	2011	2012
Energy piles (cumalative)	150	590	2085	3552	3967	4339	4554	5012
Tonnes of CO2 Savings Annually	92.8	467.2	1930.24	4809.0	5267.8	5513.3	5857.92	6640.64

Year

Figure 1. Energy Piles Installed in the UK and Resultant Annual CO_2 Savings (to date at September 2012).

There have recently been a number of landmark energy pile schemes constructed in the UK as well as numerous smaller projects. GI Energy has recorded over 50 projects across the UK with installed and functioning systems. Most of these 50 projects GI Energy have completed, with the most notable being the 2 MW heating and cooling solution at One New Change (**Figure 2**) which is currently delivering annual energy savings of £65K and saving almost 300 Tonnes of CO_2 every year. GI Energy have also recently commenced work on two similar sized energy pile projects during 2013 for Network Rail (the UK rail asset owner) at London Bridge Station and also at a New London Embassy Building.

Figure 2. The One New Change Development, near St. Paul's Catherdral, has a Gross Floor Area of 52 000 m² made up of 31 000 m² of office space and 21 000 m² retail space.

Geothermal Loops have been successfully installed into all foundation types and in both large scale commercial and residential developments. There are a multitude of options for installing geothermal loops. For a project to be successful it is recommended that a GSHP specialist should be appointed early in the development of a project to assist in providing various options with a view to identifying the best value solution, which may even be a combination of ground loop techniques. To this end it is important to set clear guidance on roles and responsibilities and ensure coordination is central to all parties. The UK Ground Source Heat Pump Association Thermal Pile Standard sets our clear guidance on roles and responsibilities in this respect (see book reviews).

It is not just foundation piles that are suitable for installation of ground loops. Gl Energy, the UK's leading GSHP specialist, also completed geothermal loop installation into the first diaphragm retaining wall at the Bulgari hotel in Knightsbridge in 2010 after much early coordination with the project management team. The project also included energy piles and is now delivering over 200 kW of heating and cooling. GI Energy with WSP, the consultant, won the Concrete Societies Sustainability award for this project and most recently the project won the prestigious Architecture of the Year Award in the New Build Hotel category at the European Hotel Design Awards. The UK's largest Civil Engineering project, Crossrail has also offered the opportunity to equip piled foundations and retaining walls with geothermal loops, refer to **Figure 3**.

Research for a Sustainable Future

The last decade has seen an increase in research into energy pile applications at UK Universities. Roger Bullivant, a piling contractor with a strong business in the domestic housing sector, was keen to develop energy pile solutions and worked with Nottingham University to develop a test bed site (Wood et al, 2010a). The first year of operation showed the viability of short energy piles for the domestic market. However, it also illustrated some limitations of existing design methods such as Earth Energy Designer when applied to such short heat exchangers for which it was not designed (Wood et al, 2010b). The research also suggests that for heating dominated domestic properties it will be important to ensure appropriate solar recharge in the summer months to provide for the long term sustainability of schemes.

Research into the thermal performance of energy piles is also going on at the University of Southampton. A key result from the work is the importance of the contribution from the concrete within the pile to the short term thermal storage within the heat exchanger (Loveridge

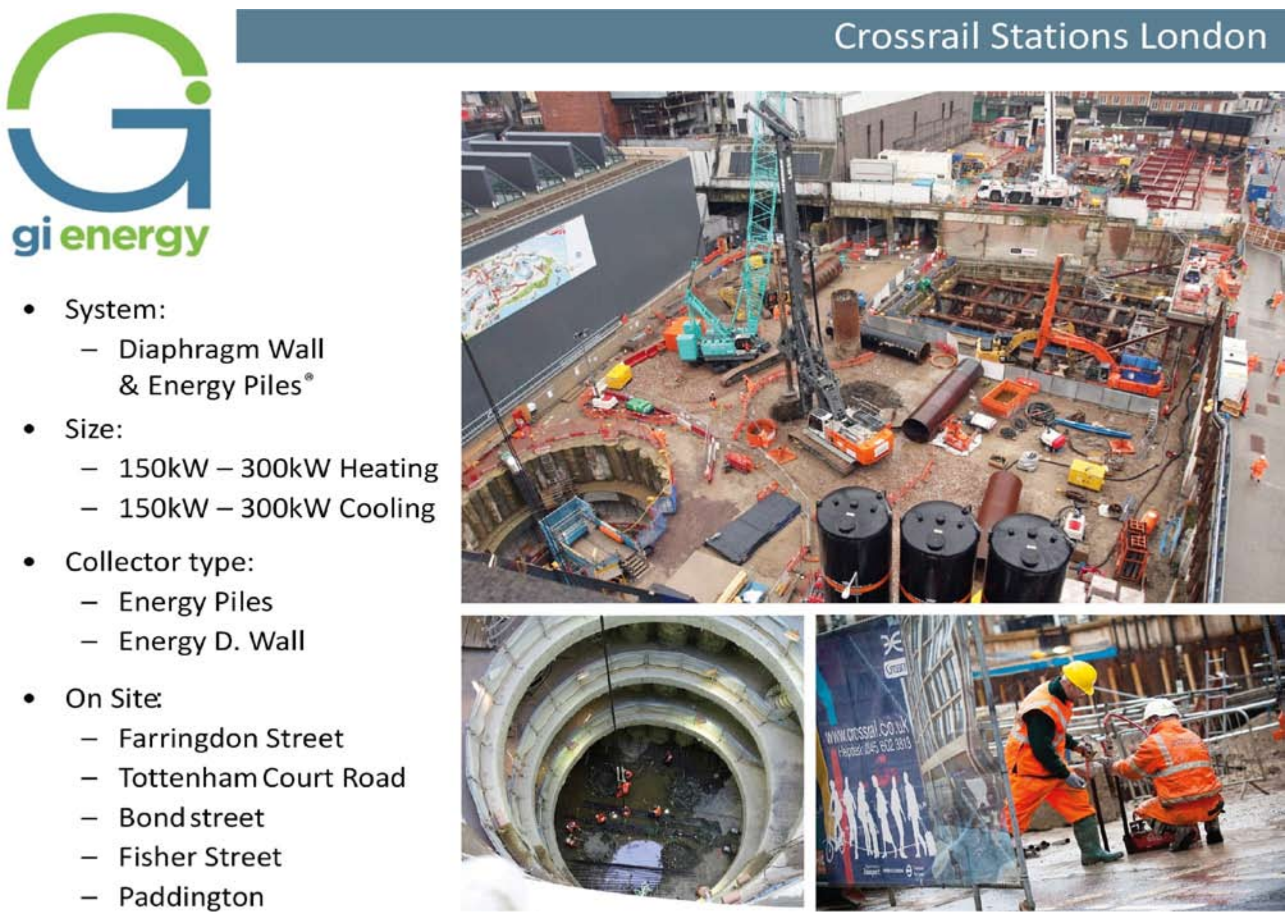


Figure 3. Energy Foundations Installed for the Crossrail Project in London.

& Powrie, 2013a). The heat capacity of the ground heat exchanger is not normally taken into account in traditional ground loop design methods, but research suggests that this approach could lead to underestimation of the energy capability of energy piles (Loveridge & Powrie, 2013b). This means that the true potential for energy piles is yet to be fully realised.

Some resistance to the adoption of energy piles arises from concerns that the temperature changes that will occur within the piles may impact the structural and geotechnical performance of the pile. Despite the successful operation of energy piles schemes in Austria for many decades some Clients require more robust assurance. Cambridge University and collaborators have been working to set out the mechanisms of thermo-mechanical response of energy piles (Bourne-Webb et al, 2013) and to develop new design approaches which will allow any such concerns to be allayed. Other work has also shown that previous approaches may have overestimated the temperature changes that would be occurring in the soil surrounding the piles (Loveridge et al, 2012) and this is also helping to show that properly designed and operated energy piles will pose no risk to the structural operation of the foundations.

Conclusions

Energy piles and other thermal foundations are a technology with a growing take up in the UK. Implementation of energy piles has been supported by an active group of researchers who are working with industry to show the benefits of making dual use of building foundations. A number of successful projects have recently been implemented and these include the developments at One New Change and the Bulgari Hotel in London. With the recent UK Government incentives for renewable heat, the potential for further adoption of energy pile solutions is growing fast. ■

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