GeoScience Limited
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Geothermal Energy as a provider of low carbon heat for the UK

Briefing note

GeoScience Ltd

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The UK has abundant geothermal resources that can provide low carbon heating and cooling at a wide range of scales from individual buildings to large heat networks.

Geothermal energy can play a significant role in reducing our dependency on fossil fuels, the transition to a low carbon future and help the UK meet its target of Net Zero Carbon emissions by 2050

Resources

Geothermal is heat stored in the ground. It is a clean, natural, renewable and sustainable energy source.

It is a common misconception that the UK does not have geothermal resources but, in fact, they are plentiful.

Shallow resources that can be harnessed using Ground Source Heat Pumps exist almost everywhere.

Moderate depth resources, between 500m and 2500m, can be found in many places. Rock temperatures between 30˚C and 100˚C make them suitable for direct heating applications.

Deep resources exist in some parts of the country, most notably in Cornwall and west Devon, where abnormally high geothermal gradients make it possible to generate electricity as well as supply heat.

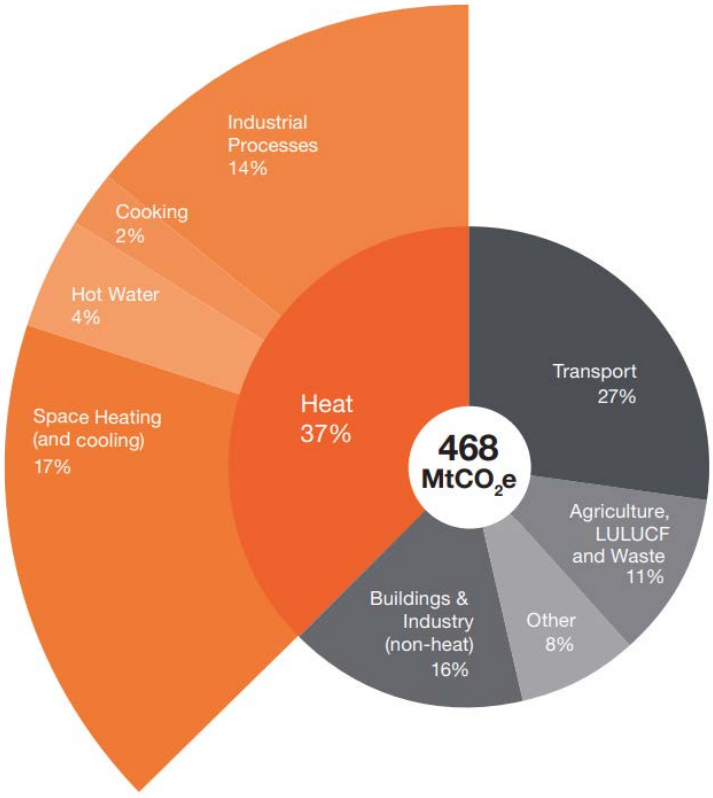
Decarbonised heating and our Net Zero target

Heat is the largest energy consuming sector in the UK, accounting for around half of our energy demand and a third of our greenhouse gas emissions. Most of this comes from space heating and industrial processes.

To meet our Climate Change Act commitments the UK will need to decarbonise nearly all buildings and industrial processes.

Geothermal energy can meet a wide variety of domestic, commercial and industrial heating needs and is already used in 90 countries for:

- Space heating and cooling
- Food and drink manufacture
- Agriculture and aquaculture
- Industrial processes
- Leisure facilities



Graphic: Figure 2.1 UK emissions in 2016 across different sectors

Sourced from, P.20: Department for Business, Energy and Industrial Strategy (2018) Clean Growth Strategy - Transforming Heating - Overview of current edivence, accessed here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766109/decarbonising-heating.pdf

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Technologies

Three types of proven geothermal technology are available to meet heating demands in the UK; Ground Source Heat Pump (GSHP) systems, Augmented GSHP systems and Open Loop systems.

The technology applied at a given location will depend on the geological conditions and specific heat requirements.

Ground Source Heat Pump systems

Ground Source Heat Pump (GSHP) systems utilise low to moderate temperatures in the ground near the surface. Plastic pipe loops are installed in trenches or shallow boreholes, and water is circulated to bring low grade heat to the surface, where a heat pump boosts the temperature to, typically, 55-60°C.

Well-designed systems operate with a Coefficient of Performance (COP) of between 3 and 3.5 which means that they provide 3 times as much heat energy as they consume in electrical energy.

There are many factors that dictate the performance and cost of such systems, some of which concern the design of the end use buildings, but for an installation of 50kW, CO^2 savings of 250 tonnes could easily be achieved over a 20 year life, at a cost of less than £400 per tonne.

These systems can be installed anywhere provided there is space for the necessary trenches or boreholes, and they can supply heat loads from a few kilowatts to several megawatts. They can also be operated to provide cooling by removing heat from buildings and discharging it to the ground.

Closed loop Water Source Heat Pump (WSHP) systems can also be deployed in rivers, lakes or the sea, eliminating the need to drill boreholes or dig trenches.

Augmented GSHP systems

Augmented GSHP (AGSHP) systems take advantage of favourable geological conditions, or the availability of warm water resources from, say, flooded mines, to supply water to the heat pumps at a higher temperature; typically up to about 25°C.

This improves the thermal efficiency and increases the COP to above 5, resulting in both greater carbon savings and reduced running costs.

For the 50kW system above, the carbon savings would increase by 35% and the cost per tonne of carbon saved would reduce to below £200. It may also make it possible to boost the delivery temperature to above 60°C, which is desirable for some applications.

Water at this temperature could be produced from boreholes 500m to 600m deep, either new-drilled or repurposed, or from flooded mines.

Open loop systems

Open loop systems can be used where there is sufficient permeability in the rocks at depth to provide hot water directly for the end use, without the need for heat pumps. Typically, two boreholes (or wells) are required; a production well and an injection well.

To reach directly usable temperatures (say, 40°C) would require drilling to depths of approximately 1,000m in Cornwall. This type of system is in common use in Europe. In some applications, shallower, warm water aquifers are accessed in this way, but heat pumps are also used to boost the temperature.

Deep and novel systems

In some locations with high geothermal gradients and suitable geology, drilling to depths between 2500m and 6000m allows access to resources hot enough to generate electricity. Two pilot projects of this type are underway in Cornwall. In addition to producing power, these systems can make a significant amount of heat available for nearby use.

Finally, single borehole heat exchange systems are a more novel concept that has yet to be applied commercially in the county. A single borehole is drilled and a coaxial heat exchanger is installed within it to extract the energy. Open ended tubing is installed in the well and water is pumped down the annulus to raise its temperature and then produced as hot water from the tubing at surface.

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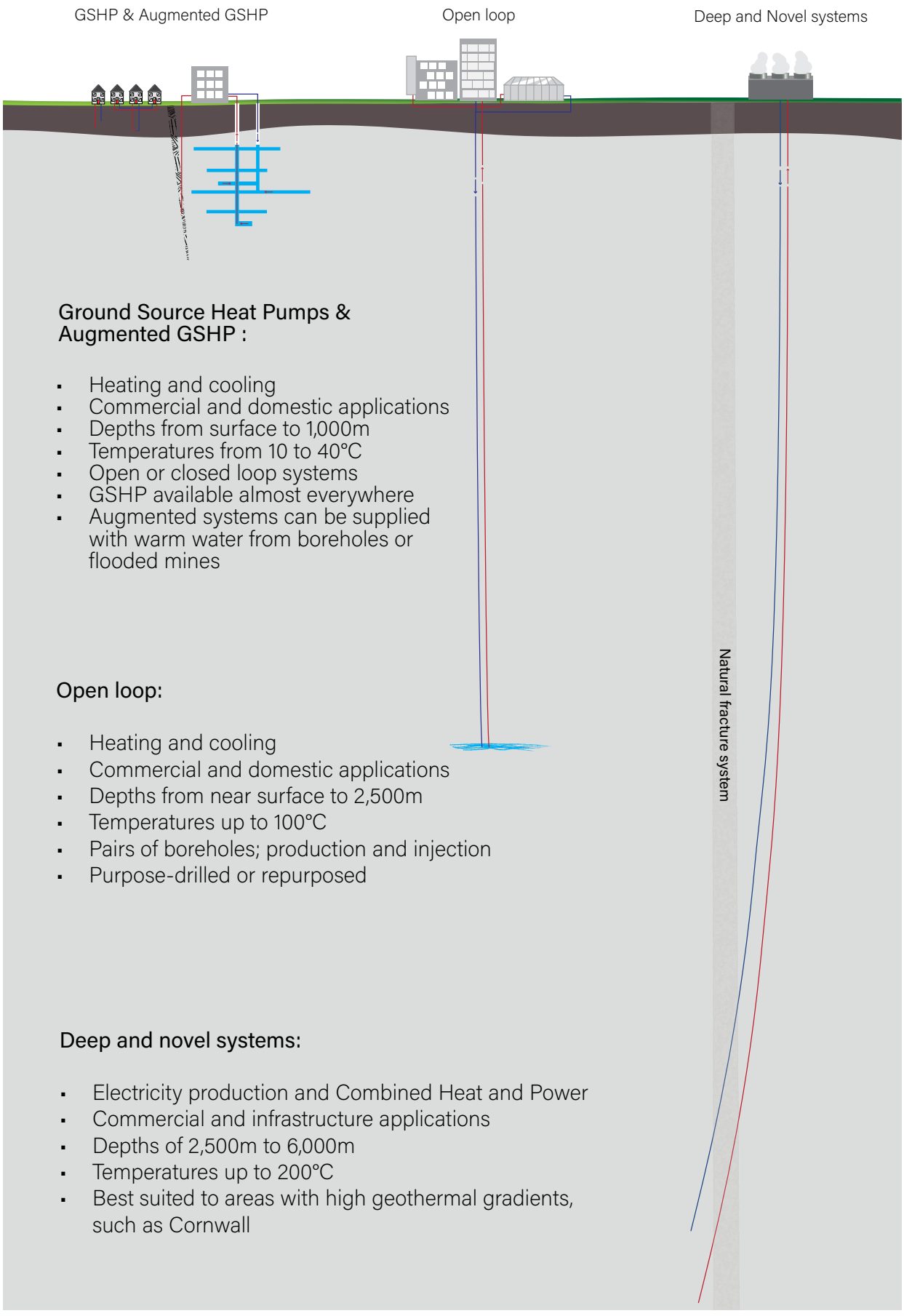
Schematic showing the different types of geothermal technologies available in the UK



Ground Source Heat Pumps & Augmented GSHP :

- Heating and cooling
- Commercial and domestic applications
- Depths from surface to 1,000m
- Temperatures from 10 to 40°C
- Open or closed loop systems
- GSHP available almost everywhere
- Augmented systems can be supplied with warm water from boreholes or flooded mines

Open loop:

- Heating and cooling
- Commercial and domestic applications
- Depths from near surface to 2,500m
- Temperatures up to 100°C
- Pairs of boreholes; production and injection
- Purpose-drilled or repurposed

Deep and novel systems:

- Electricity production and Combined Heat and Power
- Commercial and infrastructure applications
- Depths of 2,500m to 6,000m
- Temperatures up to 200°C
- Best suited to areas with high geothermal gradients, such as Cornwall

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Benefits of geothermal

Low carbon, sustainable, renewable energy source
Variety of temperatures and end users
Available 24/7
Potential for intergration into heat networks
Offers significant carbon savings
Small footprint on the surface
Applicable at small scales
Low visial impact
Low to zero carbon emissions when in operation
Regional development opportunities
Aids the energy transition to Net Zero

What about the geological risks?

Closed loop GSHP systems do not require specific geological conditions and therefore carry little or no geological risk. They are an established low risk technology and are applicable anywhere.

Augmented GSHP systems require proximity to a source of warmer water, extracted from the ground at depths of up to about 600m. Drilling for this resource carries some geological risk because sufficient rock permeability, or an aquifer, needs to be found at the right depth. However, the geological risk is removed if the water can be extracted from a flooded mine. The mine excavations provide infinite permeability and a practically inexhaustible supply of water.

Open loop systems require deeper drilling and carry some geological risk for the same reasons as above. Since geological uncertainty often increases with depth, this risk is arguably higher than for shallower drilling but the reward is significantly higher thermal power.

Single borehole heat exchange systems eliminate the geological risk because they do not rely on the natural permeability of the rocks. The heat is extracted purely by conduction. However, the drilling depth is greater than for the other systems, which carries its own risk and is more expensive. This type of system may be suitable for a new build development where grant funding is available for low-carbon heating.

What are other European counties doing?...

Other European countries have made good progress developing geothermal resources similar to those that we have in the UK.

Encouraged by initial government policy interventions and regulatory support, private investors and developers have been encouraged into the sector.

France, Germany and the Netherlands have well established industries and ambitious plans for increasing both power and heat installed capacity significantly in the next decades to meet carbon targets.

As well as the environmental benefits, these developments will result in thousands of direct and indirect jobs and a multi-billion Euro stimulus to those countries' economies.

Image behind shows a greenhouse heated by low temperature geothermal energy in the Netherlands, courtesy of Greenbrothers/ ThinkGeoEnergy

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GeoScience Ltd was established by staff from the UK's Hot Dry Rock geothermal research programme.

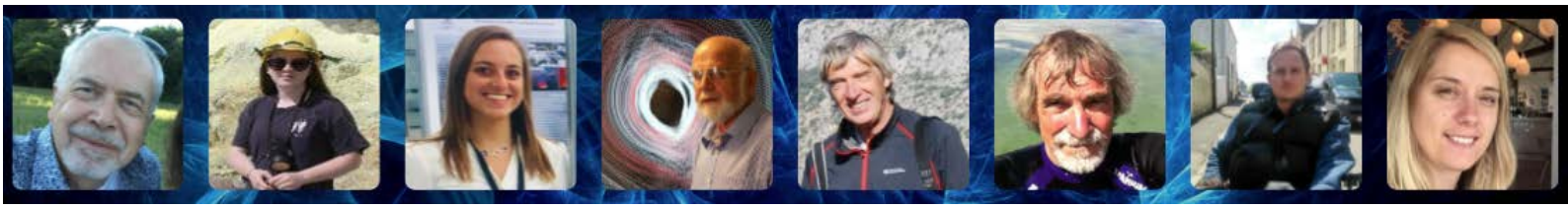
We have provided geothermal consultancy to heat and power projects all over the world.

We pioneered the utilisation of shallow Ground Source Heat Pump systems in the UK.

We were a delivery partner on the United Downs Deep Geothermal Power programme in Cornwall.

Founding members of the Southwest Geothermal Alliance: www.southwestgeothermalalliance.co.uk.

We are currently providing wellsite geology services to Eden Geothermal.



Why GeoScience?

GeoScience staff have been in the geothermal business for 40 years.

Our mission is to promote geothermal energy as a viable and attractive option for meeting low-carbon heat and power demand in the UK and other immature markets.

Our team have the skills and experience to support projects at every stage, from pre-feasibility to commissioning.

Services we provide

Geothermal geology

- Regional and site geology assessments
- Wellsite geology services
- Borehole logging
- Data analysis and interpretation
- Geological modelling

Project planning & implementation

- Feasibility studies
- Due diligence
- Funding advice
- Planning permission and permitting
- Project delivery

Communications

- Community outreach
- Educational resource and programme design
- Public relations advice
- Presentation material
- Project visualisations

Geothermal engineering

- Resource assessment
- Concept development
- Well design
- Geomechanics
- Well testing

Ground Source Heat Pumps

- Feasibility studies
- Preparing specifications and designs
- Undertaking and analysing Thermal Response Tests
- Overseeing procurement
- Supervising installations
- Troubleshooting existing systems.

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