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WHO OWNS (GEOTHERMAL) HEAT?

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Deep geothermal


Shallow geothermal

Heat from the earth, or geothermal heat, arises from the heat dissipated from the centre of the earth and, at shallow depth, from heating by the sun. High-enthalpy (deep) geothermal heat is found within some granitic rocks due to slightly raised levels of the radiogenic isotopes of potassium, uranium and thorium. This resource in the UK is estimated to be able to provide the equivalent of around 2280 MWe of electrical power from a depth of around 4.5 km (Busby and Terrington 2017), sufficient to cover 85% of Scotland's or 9% of England's current (2016, BEIS 2018) electricity consumption. Another geothermal heat resource is low-enthalpy (shallow) geothermal heat, which is found in sedimentary basins and more widely available throughout the UK as 'ground heat' where heat from sunlight and from building foundations, tunnels and sewers is stored in the shallow subsurface. This heat resource is typically distributed by natural groundwater systems and through man-made structures such as the abandoned coal-mines that underlie many of the UK's cities and towns and can be exploited through Ground Source Heat Pump (GSHP) systems that could provide sufficient heat for around 650 000 homes nationally (Adams and Gluyas 2017).

Geothermal heat has the potential to make a significant contribution to meeting the UK's legally binding emissions targets set out in the UK Climate Change Act. Taking shallow and deep geothermal resources together, the contained accessible heat in the UK is estimated to be around 200 EJ. This is sufficient to deliver about 100 years of heat supply for the UK at present consumption rates (Gluyas et al. 2018). Geothermal heat, undoubtedly, is a natural resource that can benefit the nation at both, national and local level. Therefore, it needs to be managed and regulated in a similar way to other natural resources such as oil, gas, coal and water. This requires a

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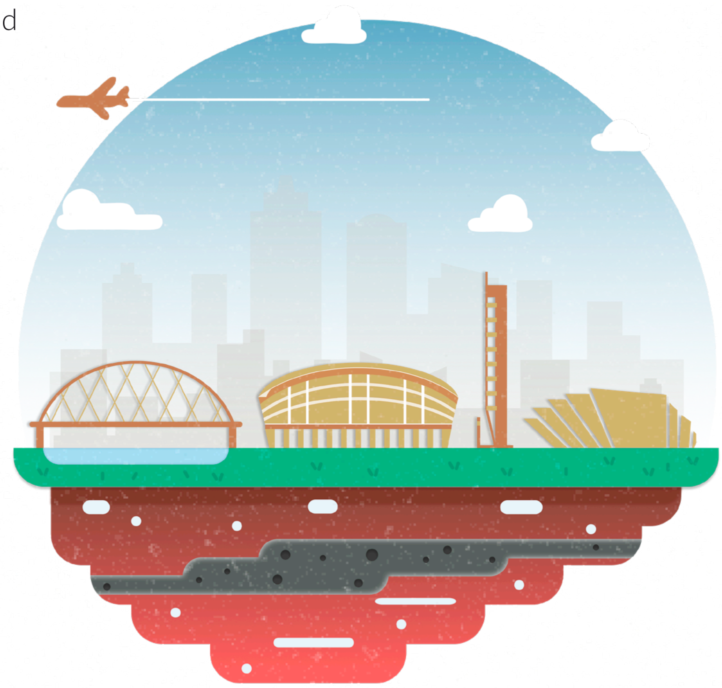
clear definition of the term 'geothermal energy' as well as a clear understanding of 'Who Owns Heat' in the ground.

One of the key challenges with ownership and regulation of geothermal heat is that it is regarded as a physical property, not a recoverable (raw) material such as ore or gravel. As such, 'heat' is not a legally-defined entity and this causes some difficulties when it comes to assigning legal ownership and regulating it. In some countries, like Germany, geothermal heat is defined as a natural resource with clear rules of ownership and regulations similar to those for metals and fossil fuels.

Geothermal heat 'First come, first serve?' – What do we need from regulations?



The recent rise in exploration for shallow and deep geothermal resources internationally has seen many countries expand national legislation with the aim to protect against environmental damage. As a result, a diverse set of regulations define rules around the development and exploration process rather than managing the resource, i.e. heat/energy, itself. A practice of 'first come, first serve' will never be the optimum method to manage a valuable resource nor ensure its long-term sustainability. This can only be achieved by a revision of the regulations.

Such revision of geothermal regulations is one of various measures needed in the UK to encourage exploitation of this resource as an alternative to currently used, carbon-intensive energy sources like coal and gas. This requires that technology users, companies and financiers have some safeguards for their financial commitment and that an authority is available that can issue exploration and development licenses for geothermal heat that will, in law, guarantee and protect the licensee's exclusive right to develop, exploit and profit from a geothermal resource, for a specified period, i.e.

1. Protection and management of the geothermal resource and its long-term sustainability
2. Protection of the geothermal user/licensee from other external parties depleting or damaging the geothermal resource available within their property/licence area.

Regulations enact the law. A change to UK law is needed so that it better defines heat, and thereby allows implementation of such regulations. Currently, heat is not dealt with in UK law, except as a pollutant, i.e. where it has a detrimental impact on the environment. Such cases are covered by the EU Water Framework Directive and UK groundwater regulations. Detrimental impact of geothermal schemes on other users (e.g. neighbouring schemes) are covered by 'private nuisance', i.e. they are a civil issue, which cannot be regulated as described here.

Early development risks are one of the main reasons why so few geothermal energy projects have been implemented in the UK to date. According to Bader and Bauer (2017), the renaissance of geothermal in Germany is not only due to a stable regulatory framework, but also due to the increasing ability to insure the associated economic risks. In Germany, insurance is offered by private insurers, but in the Netherlands and France it is funded by the state. Private insurers will only be attracted if the legal issues are resolved, and regulations and codes of practice are in place (as in Germany).

Securing long-term contracts for the supply of heat to consumers is the most important factor for a project to be economically viable. Where the prospect of a reliable, long-term customer base are damaged, or where energy prices are undercut by government subsidy, the projects quickly become economically unviable, causing investors to pull out, even at an advanced stage of project development.

Current regulatory approaches

Geothermal applications can be classified and regulated based on the depths of the sources (e.g. shallow or deep) and the technology used for extracting heat from the ground.

Shallow-geothermal open-loop ground source heat pump (GSHP) systems pump (abstract) groundwater and return (discharge) the water back to the ground after it has been used for heating or cooling. They fall under environmental permitting and groundwater regulations, as defined by the Water Framework Directive, in EU countries, and equivalent protection rules elsewhere. While these regulations usually include limits on the permitted return water temperatures (e.g. in the UK it is [Tinlet –Toutlet] < ±8°C , Toutlet = 25°C), only a few countries require an assessment of the overall thermal impact of heat extraction on groundwater

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temperatures. Here, numerical modelling is required to predict changes in groundwater temperatures.

In the UK, the regulatory control of abstraction and discharges, required for open-loop GSHP systems, is solely aimed at protecting groundwater, not regulating heat (due to the legal issues mentioned earlier) or guaranteeing that the abstracted water is suitable for its intended use. The success of the design and operation of the ground-source heat pump system, and its impacts on the efficiency of other systems, is therefore the applicant's responsibility. Shallow geothermal closed-loop GSHP systems extract heat from the ground by circulating a heat exchanger fluid through buried pipes installed in trenches or boreholes. Regulations around these systems are very varied between different countries including (1) no regulations (systems do not require any permits or registration, (2) notification schemes (no permits but need to be registered/reported to authorities) and (3) permitting schemes (systems require relevant permits). In the UK, installation and operation of these systems does not require any environmental permits, consents or licenses, or registration of the system, even though these systems can have considerable impact on heat availability and temperature distributions within the subsurface, specifically where groundwater flow is present (Abesser and Busby 2017) and the possibility exists that they may interfere with each other.

System interference is also a concern for open-loop systems, especially in city environments. For example, studies of four GSHPs in a fractured carbonate aquifer in Winnipeg, Canada, located within 1.5 km of one another, have demonstrated thermal interference between the systems (Ferguson and Woodbury 2006). Many sites within central London are within 250–500 m of each other, and the proximity and density of these systems is likely to make interference effects unavoidable (Fry 2009).

Deep geothermal

In most countries, legal procedures governing the subsurface exist and enable the development of deep geothermal resources, although they are not always tailored to geothermal energy. It usually involves a two-stage permitting process consisting of an exploration permit to find geothermal resources followed by a development license or concession to exploit the geothermal resource. As the extraction of heat from the deep geothermal sources, in most cases, also involves the use of water, either groundwater available within the deep rocks (hydrothermal systems) or water injected from the surface (petrothermal systems or Enhanced Geothermal Systems-EGS). Hence, in the UK, the same requirements for environmental permissions and licences from the Environment Agency apply as for the open-loop, shallow-geothermal systems. However, as for shallower open-loop systems, 'an abstraction licence protects the water quantity, not heat (and) the Environment Agency is not liable for any loss of heat if a new scheme takes heat away from an existing scheme.'

(https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/692989/Envirnment-Agency-approach-to-groundwater-protection.pdf).

How to regulate geothermal heat in the UK?

Heat, although not a 'substance' in the physical sense, behaves in many ways analogous to water. Given these similarities, heat should be regulated in a similar fashion, i.e. where licensing decisions consider the available resource, its existing exploitation, as well as the hydrogeological and geological conditions at the exploitations site to determine how fast the resources can be replenished and where interferences/adverse impacts on the environment may occur. However, this requires a legal definition of heat, not only in the UK but EU-wide, to provide a basis for regulations. Therefore, including a definition of heat in UK law but also in the 2019 revision of the Water Framework Directive is a prerequisite for enabling effective regulation of heat in the UK and EU-wide.

Regulating heat in a similar way to water will require detailed resources assessments as well as the development of predictive resource management tools for geothermal heat, e.g. such as planned in France (Pasquali 2013). This would require heat being legally defined as a natural resource. Doing so would enable more integrated management of heat in the wider context, e.g. in the subsurface of cities where management of different heat sources may become necessary in order to avoid inefficiencies or conflict.

For **shallow geothermal regulation** in the UK it is recommended that these are based on a regulation model for closed-loop systems similar to that of the city of Zürich, which operates a permitting system. It considers the planned heat extraction and size of the proposed scheme as well as the underlying geology in its permitting procedure, and imposes restrictions in areas where a high risk of interference or overexploitation has been identified. The procedure, at present, does not require consideration of or consent from existing installations, although there are discussions to introduce this as an additional condition, e.g. as part of the planning or other consultation processes. To maintain sustainability, regulators are also considering imposing a requirement for schemes to actively contribute to the regeneration of the thermal heat stores (e.g. by recharging heat from solar collectors or from summer cooling). Depletion of geothermal heat is currently not a problem in the UK. The opposite effect has been observed where heat rejection from cooling schemes and infrastructure has built up the heat reservoirs beneath UK cities (e.g. Banks et al., 2009, Farr et al., 2017).

Planning and regulation (if made possible) in cities must also consider other subsurface structures and infrastructure that is sensitive to and/or generates heat, such as train tunnels, sewers, cable tunnels. More research is needed to understand how these systems interact, but it is perceivable that interferences between these different heat sources or sinks can negatively impact on these schemes, resulting, for example, in undersized tunnel ventilation or reduced efficiencies of nearby GSHP cooling schemes. Integrated subsurface planning and management are essential to balance the heating and cooling resources beneath the city and use it for reducing its carbon footprint. Such strategic planning is also a critical first step in any regulation process as it will enable identification of constraints and issues that need to be addressed when considering a permit application.

For **deep geothermal regulation** it is recommended to adopt a model similar to that used in the Netherlands, where exploration and development of deep geothermal resources (>500 m depth) are subject to licensing under the same rules that apply in relation to oil and gas activities. The applicant will be required to take into consideration other existing natural resource licences (e.g. related to mining, hydrocarbons, carbon capture and storage, quarrying, groundwater protection) in their risk assessment as part of the application for geothermal exploration and development licences, to prevent adverse impacts.

Goodman (2010) suggest that the costs for geothermal exploration licences should be set lower than the petroleum and mineral exploration licensing costs to reflect the comparatively lower economic return potential and to promote geothermal energy development as part of the national renewable energy action plans. In addition to costs, it is important to keep licensing/permitting procedures as simple as possible and to provide licence decisions within a timeframe that is relative to the overall timeframe required for developing the resource. As part of this, it should be ensured that licence requirements for different aspects of the environmental system are integrated in the overall licencing procedure.

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