Deep geothermal

Snapshot: Recent geothermal energy activity in the UK has been at modest depths of less than 2km, including several schemes using mine waters (two in Scotland - at Shettleston (Glasgow) and Lumphinnans (Fife)) and a hot sedimentary aquifer (HSA) plant in Southampton. In August, 2010, planning permission was granted by Cornwall County Council for the UK's first commercial geothermal power plant using hot dry rocks (HDR)) at depths of approx 5km, with the company benefiting from Department of Energy & Climate Change's (DECC) Deep Geothermal Challenge Fund. The proposal could produce up to 10MW of baseload electricity for the National Grid and 55 Megawatts (MW) of renewable heat for local use. Various geothermal technologies are also actively being developed in the USA, France and Australia, and Germany has an estimated 150 geothermal power plants in the pipeline.

DECC estimate deep geothermal could provide between 1 and 5 Gigawatts (GW) of renewable electricity by 2030. Research to date indicates significant potential in Scotland at all depths and the Scottish National Minewater Potential Study (PB Power) 2004 indicated that minewaters alone could potentially contribute up to 27% of the Scottish Government's 11% renewable heat target.

The Scottish Government is currently commissioning a study to examine the potential of deep geothermal energy in Scotland and Scottish Enterprise are concurrently commissioning research. Planning authorities might expect significant developer interest if the Cornwall project proves to be successful and if opportunities appear realisable from research and borehole studies.

Suggested areas of focus for planning authorities:

- Collate information on redundant mines and existing geological data, draw on available geological expertise, and work with academic institutes to help predict scope for deep geothermal within area
- Use heat maps to identify main opportunities for developing heat networks/providing off-gas-grid heat/combating fuel poverty
- Consider land use opportunities, including regeneration of brownfield sites, and constraints to help indicate where deep geothermal might be located;
- Detail criteria to be applied in assessing deep geothermal applications;
- Establish protocol and key consultees for involvement in spatial planning, policy making, pre-application work and applications for deep geothermal operations;
- Identify proportionate levels of information to service pre-application discussions and to assess applications on deep geothermal;
- Ensure planning conditions and agreements for deep geothermal operations are reasonable and proportionate.

Opportunities within Planning Processes for Planning Authorities:

Stage in Planning Process	**Actions for Deep Geothermal**
Monitoring and Evidence Base and Main Issues Report (MIR)	• Gather existing information on redundant mines • Draw on available geological expertise, including academic institutes • Build a database to provide a starting point for assessing potential for the various types of deep geothermal operations • Consider potential economic and environmental opportunities, alongside potential impacts and constraints

	• Involve key consultees for deep geothermal such as the British Geological Survey, Scottish Environment Protection Agency (SEPA) and Scottish Natural Heritage (SNH). • If further data becomes available, through developer assessment, determine if deep geothermal possibilities merit consideration as a main issue in the MIR
Spatial Planning (Recognise that securing sufficient data to predict the potential for hot dry rock geothermal operations is likely to be outwith the scope of planning authorities, but this may come forward via other sources)	• Incorporate deep geothermal information in spatial planning exercises where possible to maximise opportunities for renewable heat • Assess scope for using existing brownfield or industrial sites or former collieries • Determine whether operations can be located near to facilities or areas of high heat demand or if there is a need for or scope for heat mains • Secure input from key consultees on opportunities and possible impacts

Drafting Development Plan Policy	• Ensure that policies for deep geothermal cover:
	  o the potential different scales and types of deep geothermal operations;
	  o design of plant and supporting infrastructure, drilling, reservoir stimulation, pollution control, amenity issues, decommissioning.
	• Engage key consultees at an early stage on the drafting of deep geothermal policies

Securing Sufficient Information to Determine Planning Applications	• Develop supporting guidance notes to detail typical information needs for pre-application discussion and planning applications for deep geothermal proposals • Ensure that information needs are proportionate • Ensure that design statements are submitted for major deep geothermal applications generating over 20MW of electricity
Pre-Application Stage	• Ensure that key consultees are given the opportunity to be involved in pre-application meetings / site visits • Ensure that early advice is given on potential pre-application consultation procedures for major applications and Environmental Impact Assessment (EIA) requirements
Determining Planning Applications	• For major applications, ensure developers maximise opportunities to involve communities in formal pre-application consultation procedures, where appropriate to overcome concerns regarding noise from drilling, seismic activity and subsidence • Ensure key consultees are involved in meetings and site visits to help overcome constraints • Technical information and typical planning considerations for deep geothermal are provided below which planning authorities should draw upon in determining applications.

Technical information for Deep Geothermal

Definition: For the purposes of this renewables advice, deep geothermal includes any geothermal energy source below 100m in depth. This will include minewaters, aquifer sources (HSA) and HDR enhanced (or engineered) geothermal systems (EGS). This is distinct from ground source heat which provides low temperature heat found at relatively shallow depths within the earth's crust, derived from solar warming.

Basic Process: Deep geothermal operations involve tapping into a heat source stored naturally below the earth's surface. There are various types of geothermal resource. Works can involve recovering hot waters from mines (circa 50-1000m depth, <40 degrees C), or from water enclosed within permeable rocks known as hot sedimentary aquifers (HSAs). In the case of EGS, water is injected to depths of around 4-5km where it can be heated by suitable hot rocks to temperatures >150 degrees C. Water or steam is then recaptured through another borehole and returned to the surface to produce renewable heat or drive steam turbines to produce renewable electricity. This technique is being developed in several countries and on a large scale in the Cooper Basin (Innamincka) HDR project, South Australia.

Suitable Locations: Former mining areas may have suitable thermal minewater resources. Elsewhere, determining suitable locations will usually involve geological, geochemical and geophysical surveys, and borehole testing as the distribution of heat sources will vary geographically. For EGS this will be governed by the availability of suitable hot rocks at accessible depth, which will invariably involve tapping into large bodies of granite 'plutons' where radiothermal processes generate useful heat. Scotland has abundant granite resources especially in the Highlands, although further scientific testing is required to assess actual potential for EGS. There is also scope for directional (diagonal) drilling which means ground level plant may be located at a significant distance away from the underground geothermal resource.

Physical Works: The testing phase for the geothermal plant is likely to comprise water and diesel storage tanks, drilling rig and mast (50m in the recent Cornwall case). Globally there are several types of geothermal power plants in use and these vary in terms of physical ground works depending on the depth, temperature and pressure of the geothermal energy source. The facilities would be expected to have connection to the grid. The greatest efficiencies are normally achieved if operations are sited close to facilities or areas of heat demand, but heat mains can transport heat over some distance.

Attributes: The waters recovered from geothermal aquifers at depths of 2-3 km, where temperatures are close to 100 degrees, are particularly suitable for district and industrial heating applications. Geothermal energy generally is well suited to producing renewable heat and has the potential advantage over other renewable energy technologies of supporting baseload power generation without being reliant on weather conditions. Geothermal power plants can also be used for cooling.

Typical Planning Considerations in Determining Planning Applications for Deep Geothermal

Exploratory Works: It is possible that several planning applications may be required to finalise the nature of deep geothermal operations. Initial boreholes are unlikely to determine the full potential of the geothermal resource and later testing phases are normally required to clarify the full extent of the resource. This could unavoidably affect the design of the plant and supporting infrastructure. Planning authorities are therefore encouraged to work with applicants to ensure that where possible flexible arrangements are built into initial project designs.

Noise: Highly specialised drill rigs have been developed for drilling geothermal wells in urban areas close to dwellings and techniques on dampening drilling noise are continually developing. In some cases, drilling operations may determine that works are not appropriate in close proximity to sensitive receptors, although in other cases, the long term energy benefits of drilling may outweigh short term disturbance. A detailed noise impact assessment would be required from the applicant to inform the planning assessment.

Subsidence: Within some volcanic regions, if extraction of geothermal fluid is too rapid, surface rocks may subside into the underlying reservoir. However, this is not likely with deep reservoirs in Scotland.

Waterway Pollution: Geothermal fluid has the potential to pollute and may be toxic to aquatic life. Waste water requires to be treated before discharge into water courses. This requirement is removed if a closed loop system using heat exchangers is adopted allowing fluid to be returned in a continuous system to the reservoir.

Seismic Activity: EGS involves a technique known as reservoir stimulation; a process of fracturing rocks by injecting fluids under exceptionally high pressures. In some countries this has been known to lead to earthquakes large enough to be felt by residents. However, this is less likely in Scotland as it is situated well away from the edge of any tectonic plate and is seismically relatively inactive. Additionally reservoir stimulation techniques are improving.

Other Planning Considerations – Depending on site location, the scale and nature of the proposal, planning authorities would be expected to consider landscape and visual impact of the temporary testing works and power plant, together with other matters relating to transport, hydrology, ecology and decommissioning.

Useful References:

'Scotland's Potential for 'Hot Rock' enhanced Geothermal Systems 20/7/2010, Potential Aquifer Sources of Geothermal Energy in Fife 14/7/2010 (W.E. Stephens, C.R. Bates, R.A.J Robinson, A.Prave, University of St Andrews). (Not available as a web resource)

Alternatively use the following links:

For minewaters

For aquifers

For hot rocks

Geothermal Energy in Scotland: Exploring the Territory and Identifying Opportunities March 2010 (University of St Andrews).