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Country Update for the United Kingdom

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ABSTRACT

The exploitation of geothermal resources in the UK continues to be minimal. There are no proven high temperature resources and limited development of low and medium enthalpy resources. Work has continued on assessment of a completed deep borehole at Eastgate. The main area of UK activity in the last five years has been in the rapid growth of ground source heat pump installations. Following worldwide resurgence of interest in Engineered Geothermal Systems, new activity in this field has been rekindled in Cornwall. Two new projects have been announced; a 10MWe scheme in west Cornwall and a 3MWe scheme to supply electricity and heat to the Eden Project in mid Cornwall. The use of flooded mine workings as a source of fluid for major projects continues to be evaluated.

1. INTRODUCTION

In a worldwide context, the exploitation of geothermal energy in the UK remains minimal. The geological and tectonic setting precludes the evolution of high enthalpy resources close to the surface and only low to moderate temperature fluids have been accessed by drilling in sedimentary basins in the south and northeast of England. are accessible. Elevated temperature gradients and high heat flows have been measured in and above some granitic intrusions, particularly in southwest England. These granites were previously the site of the UK's earlier Hot Dry Rock programme in Cornwall. Recent work at the Eastgate borehole in northeast England also suggests higher than anticipated temperature gradients and hence increased focus on the possible application of geothermal heat in that region.

Two major legislative drivers are now contributing towards increased interest in geothermal activity in the UK. The first is the European Union's 20/20/20 campaign – viz 20% Renewable Energy (electricity, heat and transport), and 20% CO_2 reductions (below 1990 levels) by 2020. The second is the 2008 UK Climate Change Bill – the first in the world, that commits current and future UK governments to publicly declared CO_2 reduction targets. These overarching drivers translate into lower level legislative drivers such as the energy/carbon components of the Building Regulations, and planning requirements for new buildings. To assist with the achievement of these targets a number of grant aided schemes are in place or are evolving. As well as ongoing support for mainstream renewable electricity generation, enabling legislation was passed in 2008 to allow for feed-in-tariffs for both small scale electricity generation and for renewable heat. The effect of this is leading to increased activity in the rapidly growing ground source heat pump industry, and to a renewed interest in the possibility of EGS systems to deliver electricity and/or heat.

The new level of interest in all things geothermal in the UK is possibly reflected in three recent symposia/meetings held on the subject:

- The Royal Academy of Engineering held a one day seminar "The heat beneath your feet: Geothermal energy in the UK" in April 2009 – see http://www.raeng.org.uk/events/pastevents.htm for details and presentations)
- The Geological Society held a packed evening meeting on Enhanced Geothermal Systems in May 2009. (see http://tinyurl.com/ludrrb)
- The Institute of Civil Engineers devoted its specialist 2009 Geotechnique Symposium in Print to the topic of "Thermal Behaviour of the Ground" which covered a number of topics of relevance to geothermalists. A one day symposium in May 2009 in London reviewed and discussed all of the papers that were accepted for publication. (see http://tinyurl.com/n9v9k5).

2. GEOTHERMAL UTILISATION

There is no electric power generation from geothermal resources in the UK (See Table 1).

The City of Southampton Energy Scheme remains the only exploitation of low enthalpy geothermal energy in the UK. The scheme was started in the early 1980s when an aquifer containing 76^{o}C fluid was identified at approximately 1800 metres in the Wessex Basin. Construction of a district-heating scheme commenced in 1987 and this has since evolved and expanded to become a combined heat and power scheme for 3,000 homes, 10 schools and numerous commercial buildings. (see: http://www.energie-cites.org/db/southampton_140_en.pdf)

The famous hot springs at Bath have long been a tourist attraction among the Roman architecture of the ancient city. Now the baths, together with four adjacent listed buildings, have undergone a major refurbishment, which began in 2000 under a Millennium Commission grant. Despite technical difficulties during the refurbishment, the baths were reopened in 2008 and are now fully operational. (see http://www.thermaebathspa.com/)

Greater use is being made of groundwater for a number of heating and cooling projects in London. Traditionally used for hospitals, swimming pools and factories, more novel applications are now being considered. The new Greater London Authority building in central London is one of the greenest buildings in the city, with both passive and active energy design elements. Among them is the use of water from the aquifer beneath London, which provides air conditioning and is then recycled for use in toilets and irrigation. Open loop geothermal systems have been used to heat and cool several other prestigious projects in the UK recently; the Queen's Gallery, Portcullis House and the

Mayor of London's offices all use this type of system. These systems in London use water from the naturally porous chalks and sandstones under the city. Several of these projects are described in a recent GRC Bulletin on geothermal energy in the UK (Hodgson 2009).

3. EXPLOITATION OF FLOODED MINES

A number of mine workings have been abandoned in recent years in the UK and most of them have now flooded, or are flooding. In many areas these represent a renewable energy resource that can be exploited now with current technology. Any project with a heating, hot water or cooling load in the vicinity of mine workings is a potential candidate to use the resource.

The mines reached depths in excess of 1000m with rock temperatures of over 50°C. It is estimated that more than 25% of the mined volume still forms permeable and open pathways in the rock despite the collapse of the old workings. This mine water energy resource is one form of an open loop, low temperature geothermal resource that is in common use throughout the world. However, the underground voids created by mining allow the ground water to accumulate in otherwise low permeability formations where it can be pumped out for use.

Several projects using mine water as the energy source are already in operation; two are in Glasgow, heating blocks of apartments. Major minewater projects described in the 2005 Country Update report (Batchelor, Curtis, Ledingham 2005) at Midlothian in Scotland and at Camborne in Cornwall have been in discussion in the last five years – but it currently seems unlikely that either will proceed in the near future.

There are no technical barriers to putting the old mine workings back to work in sustainable developments to provide heating, hot water and cooling. However, the issues of surface and subsurface ownership, licences for abstraction and discharge, the control of pollution and the potential claims of mineral owners are issues that need resolution for any particular project. In addition, the UK still has difficulty in establishing planning and financing schemes to develop and control district heating schemes. These legal and commercial issues present major barriers to the development of these minewater based systems – despite the urgency for developing low carbon alternatives to traditional methods of heating and cooling.

4. GSHPS

As with the last update report, the major area of UK geothermal activity in this period has been the upsurge in interest in ground source heat pumps (GSHPs). Starting from a very low base, the level of activity is probably in the region of about 3000 – 5000 installations per year. Whilst a handful of these are larger scale open loop systems (~500kW – 2MW), the majority are closed loop systems. These range in size from 3.5kW heating only systems in social housing, through to multi MW installations delivering heating and cooling. The main driver for this activity has been the realization that GSHPs connected to the UK grid can offer significant reductions in overall carbon emissions compared to traditional methods of heat delivery. With projected improvements in the carbon intensity of the UK electricity generation grid, GSHPs will be able to deliver even larger carbon reductions with time.

The main funding schemes have been the government's Low Carbon Building Programme and the new Carbon Emission Reduction Target (CERT) scheme - both of which are focused on carbon reductions in the building sector. The latter has been particularly effective in allowing the delivery of over 1000 GSHP installations in the social housing sector where it is particularly challenging to deliver affordable, whole house, low carbon heating – often as retrofits to existing housing stock.

The industry is still embryonic in the UK compared to other northern European and North American countries, but a wide range of projects are now being tackled. New build and retrofit social housing schemes through to large commercial and institutional projects and a wide range of domestic installations are now operating at locations throughout the UK. The government grant programmes have led to the development of the Microgeneration Certification Standards for GSHPs. The recently developed EU HP-Cert training course has been trialed at two locations in the UK, and the first of the GSHP designer and driller courses developed under the EU GeoTrainet project has been attended (http://www.geotrainet.eu/moodle/) to see how it will fit with UK practice. The UK Ground Source Heat Pump Association (http://www.gshp.org.uk) evolved from a club to a formalized trade association in 2006 and has held annual conferences since then. A domestic Heat Pump Association has also been formed by BEMA (British Electrical Manufacturers Association) for heat pump manufacturers to actively promote heat pump activity, including GSHPs, in the UK. All of the major domestic heating manufacturers now offer GSHPs in their portfolios of heating (and cooling) equipment. The two yearly GeoDrilling exhibition and symposium was re-launched in 2005 with a focus on GSHP activity which has continued to be reflected in the subsequent bi-annual shows in 2007 and 2009. Some of the growing interest in this activity is reflected in two recent publications – an English translation of a popular German language GSHP installation manual (Ochsner 2008), and a completely new book on "Thermogeology" (Banks 2008).

5. THE EASTGATE BOREHOLE

The Eastgate Geothermal Exploration Project commenced in 2003 to investigate the potential exploitation of the Weardale Granite in Northeast England. Local minewater chemistry indicated the presence of shallow mineralized fluids that had been in contact with rocks at much higher temperatures and pressures. This water was feeding into the shallow mine workings from a steeply dipping fracture structure known as the Slitt Vein, which became the target for deep exploration drilling.

A 995m deep vertical borehole was completed in 2004, penetrating more than 700m into the buried granite. Logging, testing and sampling programmes followed and interpretation of the results continues to the present. The maximum bottom hole temperature measured was 46°C. A highly productive zone at 411m produced significant yields during testing at temperatures of 27 to 30°C

The data collected has led to a re-evaluation of the local geological structure and the in-situ geochemical signatures, and to a revival in interest in applying geothermal potential to urban areas in the northeast of England. (Manning et al 2007)

The comprehensive work by the British Geological Survey, (reported by Downing and Gray, 1986) is still the definitive reference to the geothermal prospects of the UK.

6. EGS / HDR

In the 1980s and 1990s Cornwall, in the southwest of England was the focus of the UK's research into Hot Dry Rock geothermal energy.

During 2005 Tester at MIT and a panel of international experts carried out a review of the potential for EGS systems. Three UK players (Batchelor, Baria, Garnish) participated in this consultation which resulted in a significant publication covering the technology and its potential for energy generation (Tester et al 2008). The high profile release of this document in the USA, together with the current EGS activity in Australia has caused a worldwide revival of interest in EGS technology.

This is also the case in the UK, where reviews of the original work at Rosemanowes in the 1970s-80s in the light of more recent experience, are leading to potential projects.

Most of Cornwall is underlain by high heat production granites with measured heat flows well in excess of 100mW/m^2 and temperature gradients in the range 30 to 40^{o}C/km. The granites outcrop at several locations but are elsewhere buried beneath Devonian marine sediments up to several km thick.

The deepest temperature measurements made are at the HDR research site, where 100^{o}C was recorded at a vertical depth of 2.7km. Higher temperature gradients are predicted in other locations, based on near surface heat flow work, and it is expected that temperatures in the range 160 to 180^{o}C may be encountered at depths of 4 to 4.5km.

At the time of writing, two proposed power generation schemes are being considered; a 10MWe project in west Cornwall and a 3.5MWe project to supply power and heat to the Eden Project in mid Cornwall. Both projects plan to be drilling deep wells in 2010 or 2011.

7. CONCLUSION

In conclusion, ground source heat pump systems offer the most immediate opportunity for geothermal utilization in the United Kingdom. The minewater and deep aquifer sources offer a strategic resource with local applications and benefits when appropriate heat loads are located nearby. Deep and hot formations with temperatures in the 175 – 200^{o}C range at approximately 5000m depth appear to be limited to south west England and will require considerable developments in technology to be exploited effectively.

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity)

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (Specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. Gwh/yr	Capacity MWe	Gross Prod. GWh/yr
In Operation in May 2009			60,796	291,757	4,256	5,962	12,098	88,686	1,394	6,708	78,544	393,113
Under Construction in May 2009												
Funds committed, but not yet under construction in May 2009												
Total project use by 2010												

TABLE 2. UTILISATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF MAY 2009 (other than heat pumps)

Locality	Type	Maximum Utilisation					Capacity (MWt)	Annual Utilisation			
		Flow Rate (kg/s)	Temperature C		Enthalpy kJ/kg						
			Inlet	Outlet	Inlet	Outlet		Ave Flow (kg/s)	Energy (Tj/yr)	Capacity Factor	
Southampton (Western Esplanade)	D	15	72	28			2.761	12.5	72.545	0.83	
Penryn (Gabbons Nursery)	G	5	22	10			0.251	5	7.914	1.0	
Bath Spa (Avon)	B	13	46.5								

TABLE 3. GEOTHERMAL (GROUND SOURCE) HEAT PUMPS AS OF MAY 2009

Locality	Ground or Water Temp C	Typical Heat Pump rating (kW)	Number of Units	Type	COP	Heating equivalent Full Load Hr/Year	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
~4500 domestic sites throughout UK	9 -13	Avg 7 (3.5 to 16 kW)	~ 4500	V And H	3 to 4	1800	204	
~ 500 commercial & institutional sites throughout UK	9 – 13	Avg 200 (30 – 2500 kW)	~ 750	Mainly V	3 to 5	1500	405	250
Total							609	250