Geothermal Energy Use, Country Update for 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. However, in the reporting period 2007-2013, there has been a significant resurgence of interest in all aspects of geothermal energy in the UK. New geothermal assessments and reports have been produced, and several deep aquifer projects, minewater projects and EGS/HDR projects are at various preliminary stages.

In terms of real activity "in the ground" a new deep hole has been drilled in the centre of Newcastle, and ground source heat pump installations have continued, albeit at a lower rate of growth than had been anticipated. "Geothermal" seminars and conferences have been held, and the UK has increasingly participated in EU and international geothermal initiatives. Compared to previous updates, there has been a significant awakening of geothermal interest in Scotland.

Over this period there has been increasing recognition both at European and at UK national levels of the importance of delivering secure low carbon sources of heating.

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. 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 Hot Dry Rock programme in Cornwall. More recent work at the Eastgate and Newcastle boreholes in northeast England also suggests higher than anticipated temperature gradients and hence increased focus on the possible application of geothermal heat in that region.

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. For a background to material provided here, readers are referred to earlier UK Country Updates provided for the GRC International Symposia on Geothermal Energy (Garnish 1985, Batchelor 1990) and the IGA World Geothermal Congresses (Batchelor 1995, Batchelor et al 2005, 2010). Extracts have also been used from an IEA Annual Report (Busby and Dunbabin 2011)

2. POLICY / INSTITUTIONAL

2011 was a significant year for the UK as it formally rejoined the IEA-GIA in September. The UK was a founder member of the IEA-GIA in 1997, but left in 2004. The contracting party is the UK Department for Energy and Climate Change (DECC). The UK is participating in three Annexes; Annex III- Enhanced Geothermal Systems, Annex VIII- Direct Use of Geothermal Energy and Annex X - Data collection and Information.

Two major legislative drivers are contributing towards increased interest in geothermal activity in the UK. The first is the European Union's RES Directive or 20/20/20 campaign – viz 20% Renewable Energy (electricity, heat and transport), and 20% CO_2 reductions (below 1990 levels) by 2020. In practice the UK has agreed a 15/20/20 commitment, which translates into 30% renewable electricity and 12% renewable heat by 2020. The second legislative driver 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 (through Renewable Obligation Certificates (ROCs)), enabling legislation was passed in 2008 to allow for feed-in-tariffs (FITs) for both small scale electricity generation and for renewable heat. The latter is the Renewable Heat Incentive (RHI) scheme which applies to biomass, solar thermal, and heat pump technologies. Whilst this was hailed as a significant, and novel development, it has in practice taken nearly three years for the complexities of a heat tariff, across several technologies, to be resolved. Whilst the RHI is now in place for non-domestic ground source heat pumps, it is now looking as though the domestic scheme will only come into play in 2014. This has had a negative impact on the growth of domestic GSHPs in the UK. There is also considerable imbalance in the RHI tariff for GSHPs vs other heat technologies which is causing market distortion, to the detriment of non-domestic GSHP installation rates. This is currently being addressed by DECC.

The resurgence of interest in geothermal in the UK is reflected in the commissioning of a report by the newly formed Deep Geothermal Group at the REA (Renewable Energy Association). Released in May 2012, it concluded optimistically that deep geothermal resources could eventually provide 9.5GWof baseload renewable electricity and 100GW of heat. This equates to 20% of the UK's annual average electricity generation capacity requirement and the equivalent of the total annual heat consumption in the UK. The report recommended that the initial support levels for geothermal energy should match those in Germany (i.e. 5 ROCs). (SKM 2012)

Legislation for deep geothermal development has been slow to catch up with the renewed level of interest in the sector. There is still no official licensing scheme for deep geothermal development in the UK. However, the Environment Agency, which regulates surface and aquifer water in the UK, has introduced (2011/12) a scheme to cover deep geothermal aquifer systems. This provides some degree of resource protection to developers but has not addressed the fundamental issue of heat ownership. At the time of writing this report, the Department of Energy and Climate Change is revisiting this topic.

3. GEOTHERMAL UTILISATION

3.1 Medium / Low Enthalpy Aquifer Projects

The City of Southampton Energy Scheme (Smith 2000) remains the only exploitation of low enthalpy geothermal energy in the UK. It is now owned and operated by Cofely District Energy. The scheme was started in the early 1980s when an aquifer in the Triassic Sandstone containing 76°C fluid was identified at approximately 1800m 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). While gas fired CHP now supplies the majority of the district energy scheme's low-carbon heat, money from DECC's Deep Geothermal Fund has been provided to allow for the replacement of the original hydraulically driven downhole pump with a modern electro-submersible pump. The new pump is intended to be operational in summer 2013 and should draw approximately 2MW of useful heat from the 1.7 km deep well.

The 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. Following significant technical difficulties and subsequent delays during the refurbishment, the baths were reopened in 2008 and are now fully operational. (see http://www.thermaebathspa.com/)

During 2011, a geothermal borehole was drilled in the centre of Newcastle-upon-Tyne on a brownfield site that is to be developed for university, commercial and residential buildings (Figure 1). The intention is that deep geothermal heat will be used to provide a renewable energy option for space heating. The project was funded by Newcastle University, DECC, Newcastle Science City, Newcastle City Council, Northumbrian Water and the British Geological Survey. The borehole, referred to as the Science Central Borehole, was drilled to a depth of 1,821 m, but the calculation of true vertical depth awaits a deviation log.

Figure 1: Drilling of the Science Central Borehole in the centre of Newcastle-upon-Tyne. (Credit: British Geological Survey)

The borehole intersected the Carboniferous Fell Sandstone Formation (the target geothermal reservoir) between 1,480-1,796m depth. It is hoped that fracture permeability, associated with the nearby Ninety Fathom Fault System, will have enhanced the natural permeability of the sandstone and may have allowed the migration of warmer water to flow from the Wearedale Granite located to the west. A temperature of 47.7 °C was logged at a depth of 968 m indicating a simple geothermal gradient of 3.9 °C /100 m. A shale bridge at 969 m depth created a temporary blockage, postponing further logging and pump tests to 2012.

The last UK country update for the WGC (Batchelor et al 2010) reported on the drilling of an exploration borehole at Eastgate in Weardale. This activity has now been taken on and expanded by Cluff Geothermal. They are focusing on projects in the notheast both at Eastgate and at Shiremoor on North Tyneside.

At Shiremoor, geological studies are close to completion and the process of securing heat customers well advanced. The 2011 borehole nearby at 'Science Central', in Newcastle's city centre, found highly encouraging downhole temperatures and offers supporting evidence for the geothermal potential across the region as a whole. Plans are also continuing for a geothermal energy plant at Eastgate where Newcastle University drilled a geothermal test borehole a few years ago. Cluff Geothermal hope to commence drilling this year.

In July 2012 the Irish company, GT Energy announced that it was working with a major utility on a proposal to develop deep geothermal heat projects in Manchester and several other UK cities. In December 2012 the Manchester project received its Ground Investigation Consent (GIC) from the Environment Agency (EA) which was followed by the granting of a 24 year water abstraction licence in January. The project is currently going through the planning process in Manchester City Council with a decision due in May 2013. To date there have been no objections and the current plans are to break ground in mid 2014 and commence operations in mid 2015. GT Energy continues to work on other projects across the UK and hope to have further announcements on these during 2013. These projects are expected to feed into urban district heating schemes. As these are relatively uncommon in the UK, it is interesting to note that DECC have recently announced funding for the development of urban district heating networks as part of their support for the update of low-carbon heat.

3.2 EGS / HDR Projects

EGS Energy Limited is developing a 4 MWe deep geothermal energy plant at the Eden Project, St Austell, Cornwall. This will comprise two wells drilled to a nominal depth of 4,500m in granite, to obtain a downhole temperature of at least 175°C. Primarily this plant will supply the electricity and heat demand of the facilities at Eden and have additional capacity to supply future development and local use. EGS Energy is working with its partner BESTEC GmbH, which has successfully completed two commercial deep geothermal CHP plants at Landau and Insheim in Germany and R&D work at the Soultz European Hot Dry Rock Project, with the aim of expanding this technology into the UK. A site has been agreed on land owned by the Eden Project, and planning consent was received for the development in December 2010.

In late 2009, DECC awarded £1.8 million to this project as part of the Deep Geothermal Challenge Fund. Since then design and preparation works have been carried out in readiness to start the site enabling works once funding has been secured. This work has involved undertaking a detailed resource evaluation; geological and target appraisal; reservoir scoping design; well plan and design; seismic hazard assessment and monitoring background seismicity. EGS Energy is working with its partner Balfour Beatty plc to finalise the site design works and with Moorhouse Petroleum Ltd to assist with drilling preparations, ready to take the project forward. It is currently anticipated that preparation work on-site will commence later this year and that funding will be available to enable the drilling of EP-1, the first well at the Eden Project, at the start of 2014.

Geothermal Engineering Limited (GEL) proposes to develop a deep geothermal power project at the United Downs Industrial Estate near Redruth in Cornwall, located a few kilometres from Rosemanowes Quarry, the test site for the UK’s HDR programme in the 1980s and 1990s. The proposed binary power plant will generate 10MW of electricity and up to 55MW of renewable heat for local use, utilising three wells (two production and one injection) drilled to approximately 4,500m. At this depth the temperature of the granite host rock is expected to be approaching 200^{O}C.

The reservoir will be engineered within a significant fault structure which is expected to have initial permeability significantly above the background for granite and also be amenable to permeability enhancement by shearing thanks to its favourable relationship to the in-situ stress direction. Circulation pressures are expected to be low enough to allow control of water losses and mitigate against unwanted induced seismicity.

The United Downs Project is regarded as a pilot scheme to demonstrate the concept and applicability in Cornwall as part of a wider initiative to develop up to 300MW of capacity in the region. It is also hoped to establish a Centre of Research Excellence of geothermal energy at the nearby Tremough Campus of the University of Exeter.

GEL has a drilling site and all the necessary planning and environmental permissions necessary to proceed and has the support of both central and local government, and private industry, but has not yet been able to secure enough funding for the next phase of the project; the drilling and evaluation of the first well. It is hoped that this funding will be in place during the summer of 2013, in which case drilling will commence in early 2014.

For both of the EGS projects described here there is an ongoing challenge to raise the funding for the first well of each project. In this reporting period the interest from the private sector has waxed and waned, and is currently at a low ebb. Opportunities for public sector funding have come and gone, and the hope for

5ROCs for geothermal electricity have not materialised. Cornwall Council is keen to develop and promote its renewable energy agenda. Both the Council and the Local Enterprise Partnership actively support the development of deep geothermal energy, as they recognise the potentially important contribution that this technology could make towards achieving the county's renewable energy targets and towards enhancing local employment and expertise in the renewables sector. DECC have also declared that they wish to see this type of project move forward, and it is expected that an announcement will be forthcoming later this year that should allow one or both projects to start drilling their first well.

3.3 GSHP Activity

The UK was a late arriver in the utilisation of ground source heat pumps for reasons described elsewhere (Curtis 2001). Between 1995 and 2009, the technology finally began to gain recognition, and growth of three orders of magnitude occurred, viz from 1 per annum (1995) to > 1000 per annum (2009). With recognition by the UK government of the role that GSHPs could play in the delivery of low carbon heating, they were included under the definition of "micro-generation" technology, and were supported by the Clear Skies and Low Carbon Building incentive schemes. In a period of fifteen years, installations went from the very small 3-5kW heating only systems, to multiple MW heating and cooling schemes. An unusual development was the application of this technology to new build, and retrofit, off-gas grid social housing. Examples of significant large scale installations are King's Mill Hospital in Mansfield (~5MW closed loop lake installation), One New Change, a mixed office/commercial development next to St Paul's Cathedral in London, (~2.4MW combination of thermal piles and open loop), and Churchill Hospital at Oxford, the largest closed loop borehole installation to date in the UK (~3MW).

Along with installation activity, a number of parallel supporting activities have been taking place. The UK Ground Source Heat Pump Association (www.gshpa.org.uk) has held technical seminars and has developed two new technical standards (GSHPA 2011, 2012). The Environment Agency has shown a positive engagement with the technology, and issued a good practice guide (EA 2011). The British Drilling Association coordinated the development of a new accreditation scheme for drillers who wish to engage in GSHP installation activities (UKAS 2012) and the Chartered Institute of Building Services has issued a new Technical Note on GSHP specification and design (CIBSE 2012). Following a monitoring study carried out by the Energy Savings Trust on 82 domestic ground and air source heat pumps it was decided to revise the design and installation standards for installers registered under the Microgeneration Certification Scheme (Curtis et al 2013). Reading Borough Council was a participant in the EU wide GeoPower programme. As well as holding awareness sessions in the UK, their final deliverable was a booklet on GSHPs for social housing providers. (Ovuorie and Carr 2012). The British Geological Survey has also been actively engaged in developing supporting data services for the industry. To this end they have been evolving their GeoReport services for GSHPs, they have been the UK participant in the EU ThermoMap project, and have recently released a screening tool for initial assessment of the potential for open loop systems.

Whilst all of these activities have been positive developments for the technology in the UK, a combination of factors have recently led to a collapse in the rate of growth and a significant downturn in the scale and activity of the UK GSHP industry. A combination of the recession, the downturn in the UK construction industry, the overnight cessation of the Low Carbon Building Programme, and the "Building Schools for the Future" programme all contributed significantly. An additional factor has been the failure of the Renewable Heat Incentive scheme to materialise. At the time that the UK announced a Feed in Tariff for renewable electricity, it also put in place enabling legislation for a Renewable Heat Incentive (RHI). Whilst the FIT scheme has now been operational for several years, the RHI has proved to be far more difficult to establish. Unfortunately a heat tariff is far more complex to design and implement than an electricity tariff. The RHI for non-domestic systems has now been in operation since 2012, but the tariffs for GSHPs appear to have been miscalculated vs other heat technologies - leading to a significant economic bias against the adoption of GSHP systems. This has been recognised by DECC, and a reevaluation of the tariff is currently underway. The domestic RHI is proving even more difficult to resolve, and has now been delayed until later in 2014.

This is all despite the requirement of the declared UK strategy for carbon reduction which calls for a significant deployment of heat pumps. The 'Medium Abatement' scenario of the 4th carbon budget projects the deployment of 0.6m domestic heat pumps by 2020, rising to 2.6m by 2025 and 6.8m by 2030. (Ecuity 2012) These are essential and attainable deployment targets - however, the GSHP industry is currently treading water, losing ground and capability to other technologies. As has been remarked on before by other European countries, extreme care needs to be taken in the deployment of incentivisation schemes. At the moment the presence of an incentive scheme that is promised, but not in place - is paralysing both customers and installers.

4. MINEWATER.

A number of mine workings have been abandoned in recent decades 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 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. The major minewater projects described in the 2005 Country Update report (Batchelor, et al 2005) at Midlothian in Scotland and at Camborne in Cornwall have not come to anything - despite several UK participants at the Minewater 08 Conference at Heerlen in the Netherlands. in 2008.

More recently, the British Geological Survey has been carrying out increasingly detailed studies into the resource in the minewater underneath Glasgow. There have been reports that up to 40% of the city's heating requirements could be realised from these resources. With the increased interest shown in renewable and low carbon energy by the Scottish government, there is some optimism that this project may move ahead.

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. There is some indication that the UK is beginning to understand this issue, with funding recently becoming available for the development of urban district heating networks.

5. MEETINGS AND PUBLICATIONS.

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

i) The Royal Academy of Engineering one day seminar “The heat beneath your feet: Geothermal energy in the UK”, April 2009

ii) The Geological Society held a meeting on Enhanced Geothermal Systems in May 2009.

iii) 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.

iv) In September 2011, EGS Energy organised the first UK Geothermal Symposium to review where engineered (or unconventional) geothermal system development had reached worldwide and to consider its deployment in the UK. This event was run in tandem with the International Energy Agency – Geothermal Implementing Agreement (“IEA-GIA”) Executive Committee meeting. The second UK Geothermal Symposium was run in October 2012, at which a minister from the Department of Energy Climate Change announced that consideration would be given to providing a multi-million pound capital grant to help build the UK's first deep geothermal electricity plant in a move that could potentially stimulate further private investment in this sector.

6. CONCLUSIONS

With the increasing pressure to develop secure, low carbon, sustainable energy sources for the delivery of both electricity and heating, there has been a revival of interest in geothermal energy in the UK. This ranges from the prospect of seeing activity in Enhanced Geothermal Systems returning to Cornwall, through to growing numbers of GSHP installations throughout the UK. In addition, the geothermal resource surveys and review work carried out in the 1980's is now being turned into low and medium enthalpy heating projects particularly in the northeast of the UK.

The next five years will prove to be critical for geothermal developments in the UK. Hopefully the recent decline in the growth rate of GSHP installations will be reversed through the timely introduction of a well managed Renewable Heat Incentive scheme, one or both of the proposed EGS systems will have completed the drilling of their first boreholes, and one or more of the proposed deep heat schemes in the North East will have come to fruition.

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Tables A-G

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2012	0	0	80,000	360,000	0	0
Under construction end of 2012	0	0	2,000		0	0
Total projected by 2015	14	~90 (estimate)	70,000	~370,000 (estimate)	0.02	0.024

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants do not yet exist in the country.

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

	Geothermal DH Plants		Geothermal heat in agriculture and industry		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2012	2	14.0	0	0	0.55	~3.0
Under construction end of 2012	0	0	0	0	0	0
Total projected by 2015	12	~80 (estimated)	0	0	0.55	~3.0

Table D: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Southampton		1987	YES	NO	~2.0	9.7	0.0 *	0.0 *
total					**~2.0**	**9.7**	**0.0***	**0.0***

* downhole pump failure - currently being replaced.

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012	~16000	~280	~500	~2500	~25	<1
Projected by 2015	~22000	~380	~650			

Table F: Investment and Employment in geothermal energy

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power	£0.1M	4	~£18M	20
Geothermal direct uses	~£1M	8	~£9M	10
Shallow geothermal	~£2M	~125	~£5M	~200
total	**~£3.1**	**~137**	**~£32M**	**~230**

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	N/A	N/A	N/A
Financial Incentives – Investment	N/A	N/A	N/A
Financial Incentives – Operation/Production	ROCs*	RHI**	RHI**
Information activities – promotion for the public	Private company promotion	Private company promotion	Government agencies, Carbon Trust, EST
Information activities – geological information	N/A	British Geological Survey	British Geological Survey
Education/Training – Academic	as part of Renewable Energy MSc and BSc	as part of Renewable Energy BSc and MSc	as part of Renewable Energy BSc and MSc
Education/Training – Vocational	N/A	N/A	GSHP training, EU-HPCert, GEOTRAINET, MCS Installer training

Key for financial incentives:					
DIS	Direct investment support	RC	Risc coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota

* Renewable Obligation Certificates (Electricity) ** Renewable Heat Incentive (Heat)