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Country Update for the United Kingdom

Tony Batchelor[1], Robin Curtis[1], Peter Ledingham[1], Ryan Law[2]

[1]GeoScience Limited, Falmouth Business Park, Bickland Water Road, Falmouth, Cornwall, TR11 4SZ, UK

[2]Geothermal Engineering Limited, 82 Lupus St, London, SW1V 3EL, UK

contactgeo@geoscience.co.uk

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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 2010-2015, 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. Two EGS/HDR projects in Cornwall have sites and planning approval. 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. A direct use, deep coaxial heat exchanger project is underway. "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. To address this, the UK has introduced a novel Renewable Heat Incentive scheme for both domestic and non-domestic applications. This is expected to stimulate activity both with deep geothermal heat projects and in the GSHP sector.

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 to 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. New European Union Targets for 2030 are currently under discussion but are still expected to focus on carbon reduction, energy efficiency and energy security issues.

These overarching drivers translate into lower level legislative drivers such as the energy/carbon components of the UK 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 took nearly four years for the complexities of a heat tariff, across several technologies, to be resolved. The RHI initially came into play for non-domestic ground source heat pumps in 2012, and for domestic installations in the spring of 2014. In May 2014 the tariffs for non-domestic GSHPs were revised upwards to counter the dominant uptake of RHI funding by biomass schemes. This delay in the implementation of the RHI scheme has had a negative impact on the growth of GSHPs in the UK.

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 9.5 GWe of baseload renewable electricity and 100 GWt 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, the Department of Energy and Climate Change is revisiting this topic. Also, at the time of writing (May 2014), the government has just launched a consultation into simplifying the granting of sub-surface access rights for deviated shale gas/oil wells and deep geothermal wells.

3. GEOTHERMAL UTILISATION

3.1 High Enthalpy Projects

There is no electric power production from geothermal resources in the UK. (See Tables 1, 2)

3.2 Medium / Low Enthalpy Aquifer Projects

The City of Southampton Energy Scheme (Smith 2000) remains the only significant 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 1,800 m 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 currently being specified and procured and should be operational in the near future, drawing approximately 2MWt 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. As reported in the 2010 Country Update, the baths, together with four adjacent listed buildings, underwent major refurbishment and were re-opened in 2008 (see http://www.thermaebathspa.com/). There are currently plans to use the heat from the Bath hot springs to supply a new underfloor heating system for Bath Abbey.

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 metres, but the calculation of true vertical depth awaits a deviation log.

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. At the time of writing a new temperature survey and permeability test have recently been undertaken and the results are expected to be announced shortly.

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

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 northeast 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.

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 which was followed by the granting of a 24 year water abstraction licence in January. The project has obtained planning permission for the geothermal element of the project, which involves the drilling of two 3,200 metre deep boreholes in the Ardwick area of Manchester. The objective is to deliver heat to around 6,000 homes and businesses in the locality. The current plans are to break ground in mid-2014 and commence operations in mid-2015. GT Energy (now a UK company) continues to work on other urban geothermal based district heating scheme projects across the UK. 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. At the time of writing there has been an announcement that the City of Stoke is to receive a £20 million grant for the development of a geothermal based district heating scheme. This is projected to deliver 45 GWh of heat per annum and is being developed in conjunction with Cluff Geothermal. In addition, Cheshire East Council announced an open day for June 2014 to solicit interest in the Crewe Deep Geothermal Energy Project. This is believed to have arisen out of a resource identified by the SKM work (SKM 2012).

3.3 Low enthalpy - Deep Coaxial Project

As part of DECC's interest in the delivery of low carbon heat, funding has been awarded to Geothermal Engineering Limited (GEL) to design, install and test a deep co-axial heat exchanger (Law et al., 2014). Following an assessment of various potential locations and a review of different design approaches, a 1,800 metre coaxial heat exchanger will be deployed in autumn 2014 in one of the original deep boreholes at the site of the Rosemanowes HDR project in Cornwall. The heat exchanger uses polypropylene pipework, and will have a pump chamber at 300 m. Significant attention has been paid to the challenge of deploying a heat exchanger of this length with GEL working with members of the original team responsible for the drilling and operation of Borehole RH15 at Rosemanowes in the 1980's. A mobile thermal testing rig is being built to allow the heat exchanger to be tested for a meaningful period of operation with a simulated building thermal load. It is hoped that successful testing of this replicable prototype will lead to deployment of these systems in deep boreholes elsewhere that have been drilled for other purposes.

3.4 EGS / HDR projects

EGS Energy Limited is proposing to develop 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 4,500 m in granite, to obtain a downhole temperature of at least 175°C. The plant will primarily supply the electricity and heat demand of the facilities at Eden but may 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 identified 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 planning 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. Limited preparatory site work has recently been undertaken on the proposed site in order to extend the planning permission, while the search continues for funding to undertake the drilling of EP-1, the first well at the Eden Project.

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 10MWe of electricity and up to 55MWt of renewable heat for local use, utilising three wells (two production and one injection) drilled to approximately 4,500 m. At this depth the temperature of the granite host rock is expected to be approaching 200°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 300 MW of capacity in the region. GEL has a drilling site and all the necessary planning and environmental permissions necessary to proceed. It 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 secured during 2015 after which drilling can proceed.

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 5 ROCs 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.

3.4 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 in 1995 to several thousand per annum in 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 Programme incentive schemes. In a period of fifteen years, installations went from the very small 3-5 kW 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 (~5 MW closed loop lake installation), One New Change, a mixed office/commercial development next to St Paul's Cathedral in London, (~2.4 MW combination of thermal piles and open loop), and Churchill Hospital at Oxford, the largest closed loop borehole installation to date in the UK (~3 MW).

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), one on vertical closed loop boreholes and one on thermal piles. Three more standards, one on shallow collectors, one on open loop systems, and one on thermal transfer fluids will be released during 2014. 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). Since then, DECC have initiated one of the largest ever monitoring schemes of domestic ground and air source heat pump installations. Initial results from this programme (the RHPP scheme) were released in early 2014, and will continue to emerge during 2014/15. Reading Borough Council was a participant in the EU wide GeoPower programme (http://www.geopower.ee/eng/). 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 (www.thermomap-project.eu), 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, several 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 significantly 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 has been undertaken. New (increased) tariffs for qualifying non-domestic GSHPs have been announced in the spring of 2014. The domestic RHI proved to be even more difficult to resolve, and was finally enabled in May 2014. This has a retrospective element and allows qualifying installations since 2009 to receive the tariff.

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 0.6 million domestic heat pumps by 2020, rising to 2.6 million by 2025 and 6.8 million 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. It is hoped that the newly released RHI tariffs for both domestic and non-domestic GSHP installations will lead to a significant uptake, and a turnaround for the industry. As has been remarked on before by other European countries, extreme care needs to be taken in the deployment of incentivisation schemes. It remains to be seen whether lessons have been learned in the development and operation of the novel RHI scheme.

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 1,000 m 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. 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. A conference on the use of minewater for heat pump applications was held at the National Coal Mining Museum in February 2010 (NCM 2010).

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, as mentioned elsewhere in this paper.

5. MEETINGS AND PUBLICATIONS

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

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 and 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.

As part of a series of EU wide events, the Intelligent Europe GeoDH programme held a national workshop at the Geological Society in London in October 2012 to promote Geothermal District Heating Systems in Europe.

In September 2013 the Institution of Mechanical Engineers published a brief report on the Geothermal Potential of the UK (IMechE 2013). In the GSHP sector, the UK Ground Source Heat Pump Association now routinely holds both an annual AGM/Seminar, and has held specialist Technical seminars at various UK locations.

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, one or more of the proposed deep heat schemes in the north east will have come to fruition, and the Deep Coaxial Heat Exchanger Project will have been completed.

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STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (wind/solar/biomass)		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 December 2014	0	0	61764	219798	1392	3609	9906	64134	9026	46519	77268	334060
Under construction in December 2014	0	0	~1000	~7884	0	0	0	0	~3000	~13000	~4000	~21000
Funds committed, but not yet under construction in December 2014	0	0	0	0	0	0	~2500	~19800	unknown	unknown	unknown	unknown
Estimated total projected use by 2020	10	75	~50000	~200000	1392	3609	8000	~63000	~15000	~40000	~74400	~306680

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Southampton Western Esplanade ***	D	15	72	28			2.761	12.5	72.5	0.83
Bath Spa (Avon)	B	13	46.5	~26.5			~1.0	13	~34	0.95
TOTAL										

*** at time of writing – downhole pump being replaced; D = district heating, B = bathing and swimming (including balneology)

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2014

Locality	Ground or Water Temp. (°C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)]	COP[3)]	Heating Equivalent Full Load Hr/Year[4)]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Tthroughout UK	~10-12	Domestic ~6-12kW Nondomestic 50-500kW	~16000	V+ H	3.2 - 4.0	1800-2400	~1800	~400
TOTAL			~16000				~1800	~400

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2014

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]			
District Heating [4)]	2.761	72.5	0.83
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5)]			
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]	~1.0	~34	0.95
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps	280	1800	~0.23
TOTAL	283.8	1906	

4) Other than heat pumps, 7) Includes Balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2010 TO DECEMBER 31, 2014 (excluding heat pump wells)

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration	(all)		1			1.82
Production	>150° C					
	150-100° C					
	<100° C					
Injection	(all)					
Total			1			1.82

Table 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	2	0	4			10
2011	2	0	5			12
2012	2	0	6			14
2013	2	1	7			14
2014	2	1	8			18
Total	10	2	30	0	0	70

(1) Government, (2) Public Utilities, (3) Universities, (4) Paid Foreign Consultants, (5) Contributed Through Foreign Aid Programs, (6) Private Industry.

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development Incl. Million US$	Field Development Including Production Million US$	Utilization		Funding Type	
			Direct Million US$	Electrical Million US$	Private %	Public %
1995-1999						
2000-2004						
2005-2009						
2010-2014	0.2	1	0.25	0.25	50	50