The Fourth London Geothermal Symposium: The Launch of BritGeothermal

PRESENTATION ABSTRACTS

Monday 13th October 2014

10:00am – 8:00pm

The Geological Society,
Burlington House, Piccadilly,
London W1

Kindly supported by

1. Introductory Session

Deep Geothermal Energy in the UK: the View out to 2020

Michael Feliks, Cluff Geothermal

What can be said - if anything - about the sector's pathway out to 2020, considering the energy landscape both in the UK and abroad? We consider the biggest uncertainties: the future direction of energy policy, the UK's relationship with the EU, the confused debate on climate change nationally and globally; and (crucial for us) the changing shape of subsidy regimes for renewable energy. Accepting that the current outlook is particularly uncertain, what actions we can take to mitigate this? Do we have a vision for the industry in 2020? What are the optimum actions can we take, or lobby for, to help it materialise?

Stepping back to the present, we consider the largest barriers facing the UK deep geothermal industry at present, and consider how these are likely to change to 2020. Will heat networks, the ideal complementary heat customers for deep geothermal, start to be rolled out faster? How can we cope with the continuing scarcity of public sector grant funding? How can we educate public sector bodies to be better heat customers?

Lastly, we consider what the ideal outcome for deep geothermal in the UK would look like in 2020. What is our best case outcome?

2. BritGeothermal Research Challenges

Getting into Hot Water: The Geothermal Potential of Low Enthalpy Fluids

Jon Gluyas, Durham University

There are around 700 new geothermal power projects in 76 countries; so reports the 2014 edition of the annual Geothermal Energy Association. Growth of the market is around 5% annually and current installed capacity is a shade over 12,000 megawatts. The forecast for 2017 is around 13,500 megawatts. These figures are impressive but they do not bear comparison with any of the fossil fuels. Such a statement will surprise no one but few will realise that the global oil industry (as opposed to that for gas or coal) has a cryptic geothermal potential which is perhaps an order of magnitude greater than the output of the geothermal industry reported above.

The oil industry is ageing. Production from many provinces has reached or even surpassed middle age. This is true for much of the Middle East, the Caspian region, Alaskan North Slope, the North Sea and adjacent areas, Venezuela, Mexico, Indonesia, North Africa and parts of West Africa. That these areas still produce copious quantities of oil is also true but the oil comes with an unwanted byproduct - water. Indeed for most areas it is better described as water production with a valuable byproduct of oil. The water volume typically is ten to twenty times that of the oil; and it is hot, in some places very hot (>100°C).

A recent study by us (Auld et al, 2014) has shown that the power depleted oil platforms of the North Sea's North Viking Graben produced sufficient hot water to deliver around 60% of the power requirement for each field. In another of our studies we demonstrated that the discarded heat from co-produced water in a UK onshore field is some 40x greater than that delivered from an adjacent dedicated geothermal project.

The geothermal heat from co-produced water in oilfield operations is free and derivative power using Organic Rankine or similar systems would be low cost. An additional benefit from either heat use or power generation from such systems is the waste (now) cold water - all the better for oil sweep efficiency on reinjection.

A review of global oil and hence water production has enabled us to calculate that power production alone from waste water could be at least 100,000 megawatts.

Enigmatic Geothermal Fluids of Northern England

Paul Younger, Glasgow University

After a hiatus of two decades, geothermal exploration recommenced in the UK in 2004, with the drilling of the 995m-deep Eastgate No 1 Geothermal Borehole. This borehole was further tested in 2006 and in 2010, when a second borehole was added. In 2011 deep drilling at a second site (Science Central, Newcastle upon Tyne).

A fourth borehole near Gateshead (Bassett's Lookout) drilled in 2006 also accessed unusually warm strata. Hydrochemical appraisal of the fluids encountered in these drilling exercises reveal that the native warm groundwaters in the region are dominated by Na-Cl, with significant proportions of Ca. Although distinctly saline, stable isotope data for these and other, similar saline waters previously sampled in the region reveal a surprisingly 'fresh' meteoric water signature. This enigma is not easy to explain.

The only obvious explanation – evaporite dissolution – is ruled out by solute ratios and isotope signatures. Neither are these waters similar to North Sea oilfield brines. A complex origin involving accelerated rock-water interaction under the influence of elevated temperatures, plus a possible role for salinisation by subpermafrost "freeze-out" during Quaternary cold stages is suggested. These insights are important in erecting conceptual models for these geothermal reservoirs.

Newcastle Central No 1 – Progress in Geothermal Exploration in Newcastle

David Manning, Newcastle University; Andrew Phillips, Newcastle Science City; Cliff Jessett, Newcastle City Council

In March and April 2014, the 1820 m geothermal borehole at Newcastle Science Central was re-entered for completion as a well suitable for testing the aquifer properties of the Fell Sandstone Formation beneath Newcastle. The work was carried out by BDF Ltd, and the project managed and interpreted by Mott MacDonald.

The well was completed with 4½" casing beneath 910 m, including a perforated section from 1416m to 1651m that allows water to enter the well only from below a packer that seals the borehole at 1414m. Based on geophysical logging and cuttings logs from the original drilling exercise, this interval lies entirely within the Fell Sandstone Formation. The measured temperature gradient was 3.5°C/100m, identical to that of the well which is part of the Southampton city-centre CHP system. The hydraulic conductivity of the Fell Sandstone at Science Central could only be estimated from a recovery test, and was estimated by Mott MacDonald to be 8.1×10^{-10} m/s. Water samples taken from the well at 500, 1000 and 1500m are highly saline, with up to 136000 mg/l chloride, 60000 mg/l sodium and 19500 mg/l calcium.

These waters chemically resemble those reported from coal mines in North Tyneside. Overall, the Science Central well demonstrates that, very like Southampton, there is a high temperature gradient beneath urban Newcastle, and that waters of interest as a geothermal target also exist. The low hydraulic conductivity of the Fell Sandstone Formation at this location emphasizes the need before drilling to identify and target geological fracture systems.

Heat Mining: Exploiting the Legacy of Abandoned Mines

Charlotte Adams, Durham University and Jon Busby, British Geological Survey

The UK has a legacy of abandoned mineworkings most of which are now flooded resulting from a major period of colliery closures during the late 1980s and early 1990s. Environmental concerns associated with colliery closure include subsidence and uncontrolled discharges of contaminated groundwater at surface. Aside from the negative impacts of mine abandonment, opportunities exist to exploit the vast volumes of groundwater at temperatures of 12-20°C that lie a few hundred meters below surface within the subterranean plumbing network of the abandoned workings.

The temperature of these resources can be used directly for cooling or upgraded using heat pumps to provide space heating offering the opportunity for thermal storage with heat extraction taking place during the winter months and heat rejection during the summer. The benefit of using these ultra-low enthalpy resources is that they are located beneath many of our towns and cities and could benefit a wide range of energy users.

Minewater has been used as a source of thermal energy previously for individual developments in the UK and as part of district wide heating schemes at Heerlen in the Netherlands and Spring Hill Nova Scotia and the British Geological Survey have assessed the potential of abandoned mineworkings in Scotland to provide heating for the City of Glasgow.

GSHP Application for Heating and Cooling at City Scale: Study on the City of Westminster

Yi Zhang and Kenichi Soga, Cambridge University

Geothermal energy is an efficient low carbon solution for the heating and cooling of buildings. For many megacities, such as London, the amount of energy that can be stored in the urban local subsurface is greater than their annual heating and cooling demands. The ground source heat pump (GSHP) system, a shallow geothermal technology that provides heating and cooling for buildings by continuously replenishing the energy in the subsurface, has been used increasingly in recent years, but its application has been generally limited to single buildings.

In this study, a GIS-based simulation model was developed to estimate how many GSHPs could be installed at the city scale without losing control of the ground thermal capacity and to evaluate the degree to which such a system can contribute to the energy demands of the buildings in a city. The model was built by embedding a PYTHON-based GSHP design code into ArcGIS software and was trialled on the City of Westminster as a case study under the following two scenarios; (a) boreholes are 'under buildings' and (b) boreholes are 'around buildings'. Under both scenarios, the model produced borehole allocation maps and ratio of capacity to demand maps.

3. Powering the Future

Cornwall and the Isle of Scilly's Deep Geothermal Vision

Caroline Carroll, Cornwall Council

Cornwall is internationally recognised for its deep geothermal potential due to the world renowned Department of Energy research programme run at the Rosemanowes Quarry near Penryn in the 1970's and 1980's. During this period Cornwall developed local academic and industrial expertise.

The 2013 Atkins report suggests Cornwall's current potential, based on its existing heat demand, is approximately 100 MW of electricity, but could increase considerably as the sector matures, uncertainties are removed and costs reduce. The 2012 SKM report concluded that Cornwall's generating capacity could be as much as 4GW of electricity.

There are currently two deep geothermal projects with planning permission in Cornwall, both ready to go with the required investment. EGS Energy at the Eden Project site (4MW) and GEL at the United Downs site (7MW).

The Cornwall and Isles of Scilly Local Enterprise Partnership's (C&Ios LEP) vision for deep geothermal sets out the aspirations around maximising the social, economic and environmental benefits associated with exploiting the resource. Geothermal energy will form the cornerstone of Cornwall's Local Energy Market, its flexible base load power and heat will form part of the Smart Cornwall Vision and a Centre of Excellence will be established in Cornwall supported by the International Energy Agency. Further benefits include; GHG savings equivalent to c.18% of Cornwall's emissions, affordable heat and power that will reduce fuel poverty, safe guard job and attract new businesses and the provision of some high value jobs through direct employment and indirectly, through 'spin off' industries.

International Geothermal Power Development: Case Study from the Ngatamariki Geothermal Field, New Zealand.

Catherine Coutts, Parsons Brinckerhoff

Most operating geothermal power plants are located in parts of the world with favourable tectonic conditions. One such area is New Zealand with c. 900MW installed geothermal capacity, equivalent to 14% of the country's electricity generation. Much of the recent commercial development here was preceded by government funded exploration in the 1970's and 1980's which served as a catalyst for future development and private sector investment.

The Ngatamariki Geothermal Field case study describes development of a geothermal resource from initial investigations to power to the grid over a period of three decades. Development of deep geothermal in the UK, where commercial uptake of the technology is arguably more challenging, can learn much from overseas experience.

The Ngatamariki Geothermal Power Station is an 82MW ORMAT binary cycle plant commissioned in 2013. Initial exploration by the New Zealand government was undertaken in the mid 1980's followed by a hiatus in activity until development rights were jointly secured by Mighty River Power Ltd and Tauhara North No. 2 Trust in 2000. From here, development of the field took over ten years, with further exploration in 2004, resource consent approval in 2010, and construction of the plant between 2011 and 2013. Investment in pre-development exploration drilling and resource monitoring, and the utilisation of both local and international expertise were key factors in the successful development of the field, and provide a solid foundation for the on-going sustainable management of the resource.

The Eden Deep Geothermal Plant, a First Step Towards the Birth of New Technology in Cornwall

Roy Baria, Tony Bennett & Guy Macpherson Grant, EGS Energy Ltd

Cornwall's history is embedded in mining of valuable economic commodities going back to the Roman times. However, the rising cost of mining operations in the UK and cheaper alternative resources worldwide makes mining uneconomical in Cornwall. Fortunately there is "a hidden treasure" which can be exploited using deep geothermal plants (Engineered Geothermal System) over a long period of time based on a vast resource of stored heat in the granite of the Cornubian Batholith. Some estimates indicate that it can deliver up to 20% of the current electricity generating capacity of the UK for 200 years by accessing hot rocks at 5,000m depth and significantly more if one goes to 10,000m as proposed in the MIT report (2004).

At present, the take-up of "deep geothermal" is constrained by the unfamiliarity of this type of development in the UK, but once a power plant has been installed at the Eden Project, the take-up of such plant will change dramatically. The aim is that this will be followed by a number of individual plants that will generate between 4 to 12 MWe. The long-term aspiration is that large scale geothermal power plants, with a power output of 50 MWe can be constructed. Geothermal plants will provide baseload energy for high tech industries with large demand for power, such as computer server centres, and will provide direct heat for uses including fish farming, high value agricultural and horticultural products and balneology.

This development will need to be supported by trained scientists, engineers and supporting technologies and services. The opportunity arises for the creation of a Centre of Excellence and the generation of higher education facilities. All this leads to high value employment which can be exported worldwide, bringing prosperity to Cornwall and making it a world leader in this technology sector.

4. Plumbing the Depths for Heat Delivery

The Geothermal Prospects for the South-East Cheshire Basin: A Geological, Sociological and Economic Overview

Peter Styles, Keele University and Michael Jones, Cheshire East Council

Geothermal water is naturally heated by the escape of heat from the cooling of the Earth and in the UK at a depth of 4 km usually exceeds a temperature of 100 degrees Celsius. The British Geological Survey has identified the Cheshire Basin near Crewe as one of six major deep geothermal resources in the UK.

This major resource lies in a region bounded by the Wem-Bridgemere, Red Rock Fault to the east and by the Llanelidan-Peckforton Fault, which bounds the Peckforton Hills to the west between which the very permeable, Permian and Triassic red sandstones, which characterise Cheshire, lie at depths between 2 to 5 kilometers. An initial trial site has been identified near Leighton, Crewe and it is estimated that there are around 100 Gigawatt hours a year of heat demand from public and private sector customers within 2.5km of the proposed site, and an additional 50GWh a year from two sites within 1km and other excellent prospects in a region extending for some 40 km.

Cheshire East Council is committed to tackling energy poverty as well as reducing carbon emissions and sees Geothermal energy as part of that process and earlier this year, was awarded a grant of £200,000 to undertake detailed feasibility into the opportunity in Crewe. The Council intends to deliver a borehole to around 5km which will be the deepest drilled onshore UK and hopes to begin extraction with a suitable partner within the next 12 months.

The Manchester Deep Geothermal Heat Project – Challenges and Lessons Learnt

Riccardo Pasquali, GT Energy

The development of deep geothermal energy resource at the Devonshire Street site in Manchester provides an example of the practical aspects of exploring and planning the development of deep geothermal heat plants in a dense urban environment. The presentation reviews the key project milestones achieved to date, including the development of a subsurface model and presents the objectives and next steps to reduce the risk of drilling the first deep geothermal well in the Cheshire Basin and the UK.

Heat Networks – Characteristics of Success

Mike Smith, Cofely

The development of viable district heating networks is likely to be an essential part of the delivery of successful deep geothermal heating projects over the coming years. District heating networks have been slower to develop in the UK than in other European countries but there is now a broad consensus at both a national and local level that such networks have the potential to support the deployment of large scale renewable energy and heat in particular, in the future.

However, it is important to note that district heating schemes are not necessarily suitable in all situations. This session will explore the characteristics of successful schemes with reference to existing networks both in the UK and elsewhere and help to define situations where such networks stand a high chance of achieving viability. Issues of energy density, diversity, investment risk and engineering compatibility will all be discussed along with details of the typical development cycle for such schemes.

A Local Authority Approach to Developing a Deep Geothermal sourced DHN

Andrew Briggs, Stoke-on-Trent City Council

Stoke-on-Trent City Council aims to become more energy self-sufficient in the future with a desire to provide resilient and secure sources of low carbon energy. To support this aim the City Council took part in a LEP bid to City Deal Wave 2 titled Powerhouse Central with the core proposal for the delivery of a city-wide District Heat Network (DHN) enabling private sector investments in low carbon heat sources and to sell heat around the city.

Local research identified a deep geothermal heat source as one of the potential options to feed the DHN. This was soft market tested and attracted strong private sector commitment which was fed into the business case being prepared.

A Strategic Business Case including the option for a geothermal heat source was subsequently submitted to DECC, DCLG and Cabinet Office for the delivery of the network seeking to address investment issues in the delivery of low carbon DHN's in the UK. Following a successful negotiation the City Deal was signed by the Rt Hon. Nick Clegg MP, Deputy Prime Minster and the Rt Hon. Greg Clark MP, Minister for Cities and the Constitution securing £19.75m capital funding support for the development and delivery of the scheme.

Deep Geothermal Heat Production in Cornwall

Ryan Law, Geothermal Engineering Ltd

Geothermal Engineering Ltd (GEL) is involved in the development of heat and power projects in the United Kingdom. As part of the development of deep geothermal heat, GEL was awarded an £800,000 Grant from DECC to install and test a deep geothermal single well heat system in Cornwall. This trial also required the design, development and construction of a 0.5MW Thermal Response Test unit – again a first for the UK.

The equipment has now been installed and has recently produced deep geothermal heat in Cornwall – the first for 25 years. The system has been designed to provide renewable heat directly to buildings that are not yet connected or might never be connected to district energy networks and, as such, GEL is now actively seeking partners for commercial roll out.

5. Exploration and Endeavour

Integrating Multiple Data Streams to Understand Magmatic and Hydrothermal Systems in the Main Ethiopian Rift

William Hutchison[1], Juliet Biggs[2], Matthew Wilks[2], Tamsin Mather[1], David Pyle[1], Michael Kendall[2], Andy Nowacki[2], Gezahegn Yirgu[3], Elias Lewi[3] and Atalay Ayele[3],

[1]Oxford University, [2]Bristol University and [3]University of Addis Ababa

Ethiopia hosts a number of young silicic volcanoes that hold significant untapped geothermal resources. However, a number of these volcanoes are also showing signs of unrest (e.g. ground deformation), many have undergone caldera forming eruptions and in all cases they are located close to densely populated areas and are un-monitored. Despite the demands for geothermal and infrastructure development on these active volcanic complexes there is a critical lack of understanding of the current activity of the magmatic and hydrothermal systems, and the potential volcanic hazards.

To address this we are undertaking a multi-disciplinary investigation of two young volcanoes, Aluto and Corbetti, involving geophysical characterisation of the subsurface (using seismic, geodetic networks and MT measurements) as well as surface mapping using high-resolution airborne imagery and volcanic degassing measurements. In this talk we will outline the data sets we have acquired, what we are learning about the state of the magmatic and hydrothermal systems and how fluids (such as gas, geothermal fluids and magma) move from the deep reservoirs to the surface. This project offers the potential for a step change in our understanding of the magmatic and hydrothermal systems of these active rift volcanoes and has clear implications for geothermal exploitation and volcanic hazard assessment in East Africa.

The Tellus SW Airborne Geophysical Data: Insights into Heat Production and Deep Structure in SW England

Dave Beamish and Jon Busby - British Geological Survey

The recent TellusSW airborne geophysical survey acquired over 60,000 line-km of high-resolution magnetic and radiometric data over SW England. The data were obtained at a line-spacing of 200 m and at a mean survey altitude of 91 m. The radiometric data provide ground concentration estimates of the three main radioelements Potassium, Thorium and Uranium. These data may then be converted to a highly detailed map of radiogenic heat production. High value locations are largely confined to granite outcrops providing a mean and maximum of 2.58 and 6.17 $\mu W.m^{-3}$, respectively, across all five exposed granites. The spatial distribution obtained is then compared with historical borehole information obtained across the granites. Heat production values for 22 locations (all granites) provide a mean and maximum of 3.1 and 6.5 $\mu W.m^{-3}$, respectively.

The most spatially extensive zone of high production occurs towards the NE margin of the Dartmoor granite. Highly localised zones are also associated with the Land's End granite. Current research concerns the correction of the airborne data, which are biased to low values by soil attenuation effects, to provide more robust estimates of the bedrock radiogenic heat production. The aeromagnetic data provide a considerably enhanced resolution image of the magnetic field. The granites are magnetic quiet zones, but major and minor features are evident across the region.

A Frontier Exploration Story: Hot Sedimentary Aquifers as Renewable Heat Sources Fringing the Firth of Forth

David Townsend, Town Rock Energy Limited

Town Rock Energy is Scotland's first deep geothermal energy consultancy company. We specialise in evaluating the geothermal potential of Hot Sedimentary Aquifers (HSA) and abandoned mines, and bringing together the key partners and stakeholders to facilitate projects.

We are applying hydrocarbon exploration techniques, combined with appropriate thermal, reservoir and geomechanical modelling, to locate, evaluate and de-risk an economically viable Hot Sedimentary Aquifer play fringing the Firth of Forth. Successful test drilling of a target aquifer will lead to development and sustainable provision of carbon-free baseload renewable heat to customers via a district heating network.

The talk will give an overview of our exploration work to date, including how field analysis was used to identify the target interval; and will report upon the porosity and permeability analysis undertaken for relevant cores. The talk will also cover petrophysical analysis of onshore well wireline data. Gross depositional environment mapping of the target intervals from the integration of literature review and seismic interpretation for structural and depositional controls will also be described.

All of these elements will be drawn together through a common risk mapping technique which will highlight areas of highest prospectivity. Our analysis can then be used to seek investment in both the private and public sector to drill and exploit the resource, or be published as an example of the high quality technical work we are capable of performing.

Atomic Dielectric Resonance: A New Geophysical Tool For Geothermal Exploration

Thomas Harley, Adrok Ltd

The greatest barrier to development of geothermal energy is the risk associated with drilling exploratory boreholes in each new prospect. Applying established geophysical tools and methods to subsurface imaging can de-risk early-stage exploration but often has limited effectiveness due to depth and resolution constraints. Adrok already operates worldwide, applying Atomic Dielectric Resonance (ADR) scanning technology to exploration for hydrocarbons, minerals, and metal ores. This project, funded through the UK government's Knowledge Transfer Partnership (KTP) scheme, linking universities (in this case the University of Glasgow) and industrial partners (Adrok), is developing ADR technology for use in exploration for geothermal resources.

The ADR scanner transmits a pulsed, coherent, beam within the radio wave band of the electromagnetic spectrum, which passes through the subsurface, returning a reflected signal at the interface between rock types. Every material has a different relative dielectric permittivity, meaning the return signal is altered by each layer and can be analysed to identify rock type and material characteristics. This presentation will outline Adrok's ADR scanning technology and discuss its ability to resolve deep subsurface targets relevant to the production of geothermal energy. Results will be presented from UK field trials on mid-enthalpy radiothermal granites