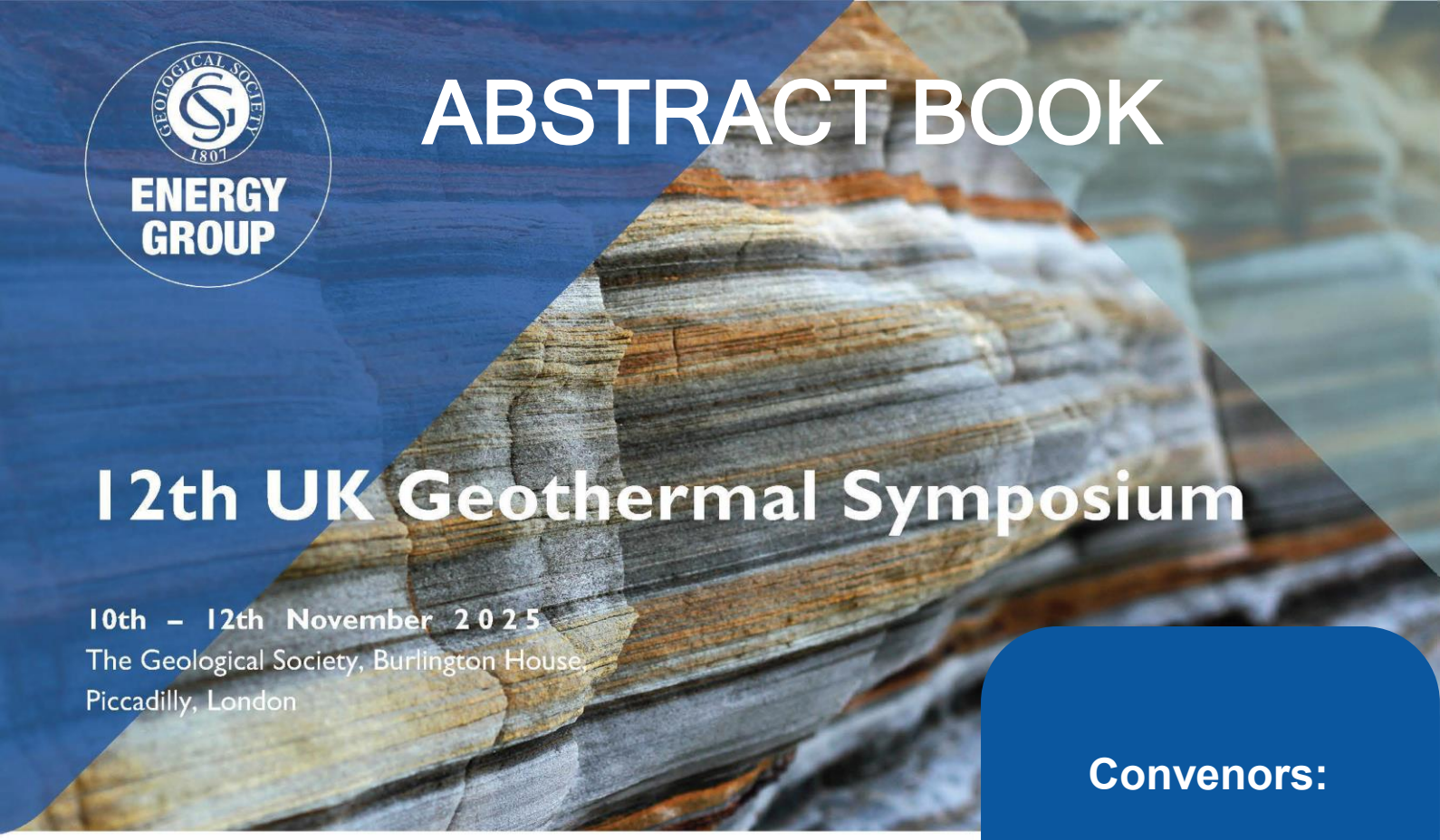

ABSTRACT BOOK

ENERGY GROUP

12th UK Geothermal Symposium

10th – 12th November 2025
The Geological Society, Burlington House,
Piccadilly, London

The 12th UK Geothermal Symposium will be dedicated to showcasing the latest advances in geothermal energy research, innovations, and projects, bringing together geoscientists, engineers, and decision-makers from industry, academia, and the public sector. The symposium will feature research presentations, poster sessions, and interdisciplinary discussions aimed at advancing the understanding and application of geothermal energy in the UK, with case studies and learnings from international partners. This two/three-day conference welcomes professionals and students from across the sector to present on key themes including:

- Subsurface geological and geophysical studies
- Ground source heat pumps
- Aquifer thermal energy storage
- Mine water heat recovery
- Deep geothermal heat and power production
- Local and international case studies and lessons learned
- Drilling practices and cost reduction
- Policy and regulation
- Investment incentives and strategies and project financing
- Technology advances and emerging research

This conference provides a platform for knowledge exchange and collaboration and is an essential event for anyone shaping the future of geothermal energy. We look forward to seeing you there!

Convenors:

Stephen Pink
(Rock N' Reef Consulting)

Holly-Marie Owen
(Sproule ERCE)

Chris Brown
(BGS)

Sean Watson
(Glasgow University)

Fiona Todd
(Coal Authority)

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The Geological Society

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#EGGS25

12th UK Geothermal Symposium

11-12 November

Burlington House and Zoom

Provisional Programme

Workshop - Modelling geothermal systems with FEFLOW

1pm-4pm, 10 November

This in person instructor-lead, hands-on workshop provides you with comprehensive training in geothermal modelling using FEFLOW. The program focuses on the modelling of shallow (near-surface) geothermal reservoirs.

Please note separate registration is required for the Workshop. This is in person attendance only and subject to availability.
https://www.geolsoc.org.uk/events/workshop-12th-geothermal-symposium/

Day One – 11 November

08.30	**Registration**
09:00	**Welcome**
09.05	**KEYNOTE: Mainstreaming geothermal: The power of collaboration** Anne Murrell, *Geothermal UK*
	Session One: Policy, Governance & Tools
09.20	**UK Geothermal Energy Review and Cost Estimations Report** Jordan Weddepohl, *Arup*
09.35	**The UK Geothermal Platform** Alison Monaghan, *BGS*
09:50	**Climbing the heat ladder: a strategic approach for urban geothermal governance** David Barns, *University of Leeds*
10.05	**Environmental and social impacts from co-location of net zero subsurface activities** Sian Loveless, *Environment Agency*
10.20	**BREAK – Poster Session**
	Session Two: Thermal Emergy Storage
11.00	**Investigating mixed circuit borehole heat exchangers for thermal energy storage and extraction** Christopher Brown, *BGS*
11.15	**Subsurface monitoring of thermal plumes at the UK Geoenergy Observatory in Cheshire** Mike Spence, *BGS*
11.30 Virtual	**Integrating Fibre-Optic Monitoring and 3D Numerical Modelling for Thermal Response Tests in the Sherwood Sandstone Group, UKGEOS Cheshire** Jafar Al Jawad, *BGS*

11:45	**Facilitating research and operational schemes to realise the geothermal potential of abandoned coal interests** Joanne Eynon & Helen Day, *Mining Remediation Authority*
12:00	**GEMINI: Geothermal Energy Momentum on the Island of Ireland** Michael MacKenzie, *BGS*
12.15	**LUNCH**
	Session Three
13.30	**KEYNOTE: The Most Righteous Heat Pump Time Machine Adventure** Dave Banks, *University of Glasgow*
13:45	**Quick Fire Talks**
Characteristics of Devonian Limestones in Plymouth, UK, and the prospects for geothermal energy Nicholas Harper, *University of Exeter (Virtual)*	
Expanding the UK's Geothermal Future: Power Generation from Low-Temperature Resources with Micro-ORC Technology Eren Gunuc, *London Geothermal Ltd*	
A simple probabilistic approach to assess the potential capacity of open-loop Ground Source Heating and Cooling and Aquifer Thermal Energy Storage systems Meissam Bahliali, *Imperial College London*	
	Session Three: Minewater Geothermal
14:20	**Techno-economic feasibility of using abandoned flooded mines for storage and transport of waste heat** Leah Victoria Swan, *TownRock Energy*
14:35	**Computational Analysis of the Thermochemical Impacts of Minewater Thermal Energy Storage on Scotland's Midland Valley Coal Mines** Samuel Graham, *University of Exeter*
14:50 Virtual	**Emerging research, collaboration and development of mine water heat at the Mining Remediation Authority** Rebecca Chambers, *Mining Remediation Authority*
15:05	**BREAK**
	Session Four: Deep Geothermal & Lithium
15.45	**An update on the development and commissioning of the United Downs Geothermal Power Plant, Cornwall** Thomas Olver, *Geothermal Engineering Limited*
16.00	**Geothermal fluids of the Carnmenellis Granite, Cornwall, UK** Chris Rochelle, *BGS*
16.15	**Photogrammetry-Based DFN Characterisation to Support Geothermal Lithium Exploration in Cornwall** Fiona McLean, *WSP UK*
16.30	**Selective Extraction of Lithium from Native Geothermal Brines Using Lithium-ion Sieves** Misagh Ghobadi, *University of Exeter*
16:45	**Reservoir Independent Deep Geothermal Technology for Heating** Mikey Van Mourik, *TownRock Energy*
17.00	**Closing Remarks**
17.05-18.05	**Drinks Reception**

Day Two – 12 November	
08.30	**Registration**
08.50	**Welcome**
09.00	**KEYNOTE: Supercharging UK Geothermal: Year One of the National Geothermal Centre** Charlotte Adams
	Session Five: Ireland
09.15	**Standing column well technologies in Northern Ireland, Part 1: Background, opportunities, barriers and forward potential** Simon Todd, *Causeway Geothermal (NI) Ltd*
09.30	**Standing column well technologies in Northern Ireland, Part 2: Borehole test design, execution, analysis and results** Huw Williams, *Agua Enodo*
09.45	**GeoEnergy NI – Results, Lessons Learned, and Forward Look** Sharon Clements, *Department for the Economy*
10.00	**Producing Subsurface Temperature Models from Joint Geophysical-Petrological Inversion** Emma Chambers, *Dublin Institute for Advanced Studies*
10.15	**BREAK – Poster Session**
	Session Six: Novel or O&G techniques for geothermal
11.00	**THERMOCAL – International thermogeological characterisation of Caledonian rocks** Sean Watson, *Glasgow University*
11.15	**Geothermal energy prospecting in radiothermal granites in the Cairngorms, Scotland, using an integrated magnetotelluric and petrophysical approach** Scott Innes Campbell, *Heriot Watt University*
11.30	**High-resolution geothermal exploration of the Muara Laboh geothermal system using Nodal Ambient Noise Tomography (NANT)** Michail Henry, *INVERT Sàrl*
11.45 Virtual	**A multi-perspective assessment of shallow geothermal energy potential for the city of Cambridge, UK** Nikolas Makasis, *University of Surrey*
12.00	**Reducing Subsurface Uncertainty in the Early Carboniferous Limestones: An Integrated Geophysical Approach to Geothermal Reservoir Characterisation** Mohamed Gouiza, *University of Leeds*
12.15	**The use of land gravity in UK geothermal energy exploration** Jon Watson, *Metatek*
12.30	**LUNCH**
13.45	**PANEL DICUSSION: From Margins to Mainstream: Growing Geothermal's Share of UK Energy** Lucy Cotton, *Eden Geothermal* (Chair) Richard Warren, *Kensa* Ryan Law, *Geothermal Engineering Ltd.* Geoff Smith, Stout Tony Pink, *Pink Granite* Neil McLoughlin, *REA*
	Session Seven: Novel or O&G techniques for geothermal

15.00	**The importance of pilot well programmes in geothermal projects: insights from Geothermal Campus Leeds** Arka Dyuti Sarkar, *University of Leeds*
15.15	**A pragmatic method for seismic hazard analysis for induced seismicity associated with geothermal developments in the case of limited a priori data** Mark Ireland, *Newcastle University*
15.30	**CO2 Fracturing in Preconditioned Reservoir Rocks: Maximizing Enhanced Geothermal System Extraction Potential While Minimizing Induced Seismicity** Lie Kong, *University of Manchester*
15.45	**BREAK**
	Session Eight: Resource Characteriastion
16.15	**Regional Mapping of Permo-Triassic aquifers in the Cheshire Basin, for direct use geothermal energy** David Johnstone, *University of Manchester*
16.30	**Hydrostratigraphy from thermal response: DTS-derived flow estimates for open-loop system design** Joseph Kelly, *University of Leeds*
16.45	**Multiparametric geophysical assessment of geothermal resources in the Dodecanese islands, Greece** Julien Sfalcin, *Invert*
17.00 Virtual	**Influence of Temperature and Heating Rate on Rock Thermophysical Behavior for Geothermal Applications** Fatemeh Tavanaei Sereshgi, *McGill University*
17.15	**GEOTHERMAL INM MINECRAFT _ REACHING FUTURE GENERATIOSNS** Simon Kendall, *EPDL*
17.30	**Closing Remarks**
17.45	**End of day two**

Posters – Day 1

Mine Water Heat Opportunity Mapping across Great Britain Dan Mallin Martin, *Mining Remediation Authority*
Rapid simulation of Aquifer Thermal Energy Storage (ATES) using Machine Learning Nok Hei Fung, *Imperial College London*
GeoGrid Leeds – modelling shallow aquifer thermal energy storage for the University of Leeds campus and upscaling storage at a national level Allegra Giblin Torlucci, *University of Leeds*
Using groundwater temperature data to reveal subsurface thermal and hydraulic processes Ashley Patton, *British Geological Survey/Cardiff University*
Optimising Urban Shallow Geothermal Systems Through Near-Surface Geophysical Characterisation Douglas Lansley, *The University of Manchester / Zetica*
Understanding the feasibility of Aquifer Thermal Energy Storage using numerical simulations Carlos Andres Rivera Villarreyes, *DHI*
An update on the development and commissioning of the United Downs Geothermal Power Plant, Cornwall Thomas Olver, *Geothermal Engineering Ltd*

Progress in assessing the feasibility for the installation of high temperature, mine thermal energy storage technologies in the Great Consolidated Mines, Cornwall Thomas Olver, *Geothermal Engineering Ltd*
Closed loop geothermal well solution drilled and completed in basement rocks Kim Gunn Maver, *Green Therma*

Posters - Day 2
Investigating the Potential of Geothermal Energy as a Sustainable Heat Source for Enhancing Waste Oil Properties in the Recycling Process of Waste Glass Kennedy Moranga Anyona, *University of Pisa*
The Role of Condensate Drainports Chemistry in steam Cleaning in Olkaria IAU Geothermal Power plant Melissa Nkapiani, *Kenya Electricity Generating Company LTD*
Micromechanics of Fluid-Induced Fault Reactivation From 4D X-Ray Microtomography Birhanmeskel Haddis Woldemichael, *Heriot-Watt University*
De-risking Geothermal Heat Extraction from Tight Hot Sedimentary Aquifers (GEOGUARD) Nathaniel Forbes Inskip, *Heriot-Watt University*
2D and 3D Geothermal Modelling of the Cheshire Basin: Implications for Geothermal Energy Exploration Harry Graveling, *Keele University*
Numerical investigation of onset of convection in heterogeneous porous media: implication for Geothermal reservoirs Aman Sharma, *IIT (ISM) Dhanbad*
Unlocking the geothermal energy potential of old sedimentary systems: Linking reservoir quality, geomechanics and flow Skye T. Tisdell, *Heriot-Watt University*

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POSTER ABSTRACTS	**pg 44**
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GROUND FLOOR PLAN OF THE GEOLOGICAL SOCIETY	**pg 65**

ORAL ABSTRACTS
(In Programme Order)

Day one

Keynote – Mainstreaming geothermal: The power of collaboration

Anne Murrell; Geothermal UK

There is momentum — finally! — in UK geothermal. After years of persistence, geothermal's huge potential is starting to be recognised in the UK.

But momentum alone is not enough. To drill more wells and make geothermal a visible, viable part of the UK's energy system, we must work together — not just within our own sector, but with everyone who shares our vision of a cleaner, more resilient future.

As geothermal experts gather for the 12th Geothermal Symposium, let's use these two days to build bridges, share knowledge, and strengthen our UK geothermal sector. Then – together – with a strong, unified voice, we can engage more effectively beyond our community to make UK geothermal happen.

Geothermal UK provides the platform for our collaboration. Formed in early 2025 by key industry stakeholders, more than 50 companies and many talented, passionate individuals have already joined; the network is growing fast. Combining the commercial imperative and professional expertise with our impatience for positive change, Geothermal UK is working proactively with partners across sectors to deliver solutions to the challenges we have all been talking about for too long.

Join us! Anne Murrell will present the work which is underway within the Geothermal UK community and explain how you can participate.

Collaboration within the geothermal sector is vital; collaboration beyond it is transformative. Together, we can make geothermal mainstream.

Session One: Policy, Governance & Tools

UK Geothermal Energy Review and Cost Estimations Report

Jordan Weddepohl, Arup; Melanie Thrush (Arup), Jason Boddy (Arup), Daniel Percy (Arup), Sarah Robinson (Department of Energy Security & Net Zero, DESNZ), Jenny Inwood (DESNZ, now NESO)

Research plays a vital role in delivering technical advice and building robust evidence bases for policy, enabling effective and sustainable governance. This presentation will showcase a research project funded by the Department for Energy Security and Net Zero (DESNZ), commissioned to Ove Arup & Partners Limited (Arup), aimed at updating the Levelised Cost of Electricity (LCOE) and Levelised Cost of Heat (LCOH) estimates for geothermal energy in the UK.

Released in August 2025, this report marks a significant milestone as DESNZ's first publication of geothermal LCOH estimates and the first revised LCOE estimates since 2016. The presentation will:
• Discuss key findings from the report, including cost breakdowns and technology-specific insights.
• Outline the methodology used to gather data across geothermal technologies, applications, and geological contexts.
• Explain the cost assessment approach, including assumptions and outputs for both LCOE and LCOH.
• Address international relevance, noting the applicability and limitations of the research for global stakeholders.
• Guide users on how to use the report, including next steps for revisions and how industry can contribute to the next levelised cost revision.

The estimates include pre-development costs, capital expenditures for equipment installation, operating costs, and maintenance. The research also assessed thermal capacities across UK locations to determine potential energy generation. Results reveal the levelised costs for various geothermal technologies, emphasizing the influence of upfront investment and the role of heating and cooling revenues in reducing overall costs.

Understanding the cost of low-carbon technologies is essential for informed decision-making, budget planning, and evaluating economic feasibility. This research supports policy, market competitiveness, and innovation, especially in regions with limited geothermal deployment, by providing indicative costs that can inform strategies for renewable electricity generation and heat decarbonisation.

The UK Geothermal Platform

Alison Monaghan, BGS; Sarah Robinson (DESNZ), Russell Lawley (BGS), Darren Beriro (BGS), Carl Watson (BGS), with a large BGS science/informatics team and DESNZ SICE and heat network teams

Geothermal technologies have the potential to decarbonise heating and cooling, playing a role in the energy transition to net zero emissions in the UK. The ability to identify which parts of the subsurface have the necessary conditions to realise this potential is an important first step.

BGS has launched the UK Geothermal Platform, which provides openly-accessible national- to local-scale information on geothermal potential across shallow and deep technology options. This first release has been funded by the UK Government's Department for Energy Security and Net Zero (DESNZ) through the Net Zero Innovation Portfolio.

The UK Geothermal Platform allows users to explore and assess the geothermal potential of an area and make more informed decisions. It draws together diverse information and synthesises it to deliver the information needed by heat policy, heat networks, national zoning model and planning specialists. The platform can be used by regulators, developers and researchers.

Included in the platform is an overview of geothermal energy potential for four geothermal technologies (Great Britain coverage):
• shallow, vertical closed-loop with ground-source heat pump
• shallow open-loop with ground-source heat pump
• deep, hot sedimentary aquifers (hydrothermal)
• deep, engineered geothermal systems in granites (petrothermal)
• as well as an overview layer, including levelized costs from Arup/DESNZ 2025

Ninety layers are included in the user-friendly map explorer, making available a wide range of more detailed geoscientific information such as temperature and resource potential maps. Together with a data access page and accompanying metadata, the hub of information enables viewing of information from several organisations, including BGS, the Mining Remediation Authority, Environmental Agency, Natural Resources Wales, Scottish Environmental Protection Agency, North Sea Transition Authority and the UK Onshore Geophysical Library.

A short demo will be given showing how the platform might be used at pre-feasibility stage to consider geothermal options for heating of a school.

Climbing the heat ladder: a strategic approach for urban geothermal governance

David Barns, University of Leeds; James Van Alstine, Fleur Loveridge, Mohamed Gouiza, Catherine S.E. Bale, Emma Bramham, Nick Shaw,.

The Geosolutions team at the University of Leeds have been exploring how urban geothermal energy can be strategically integrated into local heat planning and governance. Using an interdisciplinary approach combining subsurface modelling, spatial demand analysis, stakeholder engagement, and collaborative planning exercises, the project identified multiple shallow aquifers beneath a UK city with varying thermal characteristics. These offer significant potential for low-carbon heating but highlight the need for new institutional models to manage geothermal resources fairly and efficiently.

To communicate these results, we developed a visual ‘heat ladder’ of optimal solutions for decarbonising heat in urban areas. At the top of the ladder are multi-source heat networks that incorporate geothermal energy, valued for their ability to support local decarbonisation as well as offer system-wide benefits and cost savings through energy storage and grid balancing. However, multiple barriers, particularly at the commercial scale, impede progress up the ladder, including fragmented data, unclear ownership, and regulatory gaps.

We propose place-based approach to subsurface governance to enable equitable allocation, long-term sustainability, and wider system integration. Our aim is to develop a replicable framework for other UK cities seeking to unlock geothermal potential through coordinated governance and strategic planning. By climbing the ladder, cities can move toward resilient, low-carbon heat systems that are both locally grounded and nationally scalable.

Environmental and social impacts from co-location of net zero subsurface activities

Sian Loveless, Environment Agency; Lucy Abel (BGS), Katie Dow (EA), Harry Morris (BGS), Hazel Napier (BGS), Ceri Vincent (BGS), Jim White (BGS) with support from Gary Edwards (EA), Jon Ford (BGS), Alison Futter (EA), Ian Martin (EA), Lucy Snape (EA), Glenn Watts (CEH)

As the geothermal industry gathers momentum, so do other net zero related technologies that will use the subsurface, such as energy storage and carbon capture and storage (CCS). At the same time, demand for existing subsurface resources (water, minerals, ecosystem services) continues. This could lead to increasing competition for use of the subsurface, overcrowding, or interactions between technologies that could potentially:

• affect our ability to meet net-zero targets,
• reduce technology efficiency,
• result in harm to environment and society.

The British Geological Survey and the Environment Agency have partnered on a project to address these challenges. We brought together existing mapping of regions suitable for subsurface net zero technologies including geothermal, CCS, energy storage and geological disposal facilities, to identify subsurface environments of greatest interest for net zero technologies. We conducted a literature review and hosted a workshop for experts and stakeholders from different sectors to better understand possible interactions and environmental or social concerns.

There are likely to be areas of greater focus for net-zero subsurface technologies. While we have a reasonable understanding of generic environmental risks and social implications from individual subsurface net zero technologies, we know much less about the risks when these technologies are co-located, such as the impacts from cumulative changes to pressures and temperatures or interaction of infrastructure. The work has highlighted a need to work in partnership, across sectors, with the public, decision-makers, industry and planners to use the subsurface effectively, benefit from opportunities and mitigate for environmental and social harm.

Session Two: Thermal Energy Storage

Investigating mixed circuit borehole heat exchangers for thermal energy storage and extraction

Christopher Brown, BGS; Isa Kolo (University of Glasgow), Gioia Falcone (University of Glasgow), Daniel Friedrich (University of Edinburgh), Sean Watson (University of Glasgow)

Underground Thermal Energy Storage (UTES) is an emerging yet underutilised technology with strong potential to support the UK's decarbonisation strategy. It enables excess heat to be stored in the ground during periods of high cooling demand and later extracted for heating, providing a flexible means of balancing energy supply and demand. This is particularly relevant for applications such as data centres, where large and continuous cooling requirements produce significant volumes of waste heat that are typically rejected into the atmosphere. This study focuses on developing and testing novel mixed-circuit borehole heat exchanger (BHE) arrays that combine energy storage and exchange within the same system. The aim is to align the steady cooling loads of data centres with the variable heating demands of local networks by using the subsurface as a thermal buffer.

The work centres on two complementary methods of investigation. Firstly, ground-based experiments were carried out at the UK Geoenergy Observatory in Cheshire. Short-duration trials tested simultaneous heat injection and extraction in a shared array, capturing borehole fluid temperatures and subsurface response which allowed the prediction of bulk thermal properties. Secondly, numerical modelling was applied to scale these findings beyond the field trials. Models were calibrated using observed data and then extended to explore long-term performance, optimal system design, and operational strategies at larger scales. By coupling empirical and numerical approaches, the study will generate robust insights into the scalability of mixed-circuit BHE arrays, supporting the wider deployment of UTES using mixed circuit arrays as a cost-effective solution for low-carbon, integrated heating and cooling.

Subsurface monitoring of thermal plumes at the UK Geoenergy Observatory in Cheshire

Mike Spence, BGS; Magret Damaschke, Elisabeth Steer, Mark Fellgett, David Hetherington, Rachel Dearden, Oliver Kuras, Jason Ngui, Mihai Cimpoiasu, Philip Meldrum, James Boyd, Jack Croft, David Boon, Bruce Napier, Catherine Cripps, Joanna Thompson, Edward Hough, Carl Watson, Daniel Burgess, Lynn Coppell, Simon Gregory, Megan Barnett, Jess Mackie, Kaye Parker, Humphrey Wallis (all British Geological Survey)

Pathways and barriers to the advective transport of heat present both challenges and opportunities to developers of geothermal energy and underground thermal energy storage (UTES) systems. For example, flowing fractures may increase the radius of influence of a heat recovery well. Conversely, fractures connecting hot and cold heat reservoirs in an aquifer thermal energy storage (ATES) system may lead to mixing of the reservoirs and a reduction in energy storage performance. Research highlights are presented from the construction, commissioning and first operation of the UK Geoenergy Observatory in Cheshire. The Observatory, which entered into operation in April 2024, provides broad-spectrum capabilities for monitoring the transport of heat and associated environmental effects in the Triassic Sherwood Sandstone. The Observatory samples a range of interesting geological features that may be important for the commercial storage of heat including high angle faults, flowing horizontal fractures and a divide between unconfined and semi-confined aquifers. The influence of the sandstone structure on its physical and chemical properties is being explored using a 3D virtual reality model that can also be used to display time- series subsurface monitoring data. Electrical resistivity tomography images of thermal plume development can be viewed alongside rock property data to investigate how geological heterogeneity influences in-situ flow and transport processes. The Observatory comprises 21 vertical boreholes drilled to 100 m depth and permanent surface equipment for heating, cooling and groundwater flow control. Boreholes are equipped with a high-resolution array of electrical resistance tomography electrodes, hybrid fibre- optic distributed temperature and acoustic sensing (DTS & DAS) cables and multilevel groundwater monitoring to allow subsurface change to be observed in close to real time. For further information on Observatory capabilities and access please visit the UKGEOS website (www.ukgeos.ac.uk) or contact BGS at ukgeosenquiries@bgs.ac.uk.

Integrating Fibre-Optic Monitoring and 3D Numerical Modelling for Thermal Response Tests in the Sherwood Sandstone Group, UKGEOS Cheshire

Jafar Al Jawad, BGS; David Boon, Edward Hough, Andres Gonzalez Quiros - (British Geological Survey) for all additional authors

Aquifer Thermal Energy Storage (ATES) presents a significant but underexploited opportunity to decarbonise large-scale heating and cooling. The Triassic Sherwood Sandstone Group (SSG), a major dual-porosity aquifer in the UK, represents an important ATES resource close to areas of high energy demand. Understanding its thermal properties is essential for optimising heat pump design and evaluating deep geothermal potential. This study draws on Thermal Response Tests (TRTs) conducted within the fluvial Chester Formation of the SSG at the UK Geoenergy Observatories (UKGEOS) site in Cheshire. Fibre-optic distributed temperature sensing (FO-DTS) was applied alongside conventional TRTs to provide high-resolution monitoring of heat transfer through research boreholes.

Three-dimensional COMSOL models were developed for two boreholes to evaluate parameter estimation and model validation. Model inputs, including U-pipe configuration, boundary conditions, aquifer properties, and porous-media flow, were derived from laboratory measurements, commissioning reports, and DTS-based estimates of ground and grout thermal conductivity. The modelling framework coupled heat transfer in solids, non-isothermal pipe flow, and Darcy's law to capture borehole–ground interactions.

The experimental programme included a 3-day conventional TRT with 9 kW heating and a 14-day step-test with incremental inputs of 3, 6, 9, and 12 kW applied over 2, 3, 3, and 7 days, respectively. Results indicate that regional groundwater flow had negligible impact on model calibration due to borehole grouting, whereas small variations in U-tube flow rate significantly affected inflow temperature adjustment. During step-test recovery, a temperature breakthrough was observed approximately 3 m from the borehole after ~9 days, a response absents in the conventional test.

These findings highlight the value of step testing with FO-DTS for resolving subsurface thermal behaviour, reducing uncertainty in formation properties and fracture effects, and improving the design, optimisation, and risk assessment of ATES and borehole thermal energy storage (BTES) systems within the Sherwood Sandstone Aquifer.

Lessons from battery energy storage: how regulation and investment incentive learnings from BESS can help scale geothermal

Nicolette Salazar, National Grid

The rapid scale-up of battery energy storage systems (BESS) over the five years demonstrates how regulation and market incentives can transform a fringe technology into a core component of the power sector. Once considered niche and uneconomic, batteries are now integral to grid reliability, renewable integration, and wholesale market operations globally. This transformation was not purely technological—it was driven by carefully designed regulatory frameworks and incentive structures that reduced risk, created predictable revenue streams, and aligned private investment with system needs.

Policy measures such as the UK's Clean Power 2030 Action plan and Australia's frequency performance payments reform enable batteries to participate more fully in ancillary and wholesale markets, while incentive programs like the US IRA investment tax credit and UK cap and floor scheme create early demand signals. Together, these mechanisms accelerate cost declines through scale, attract private capital, and encourage the entry of new developers, integrators, and financiers.

Geothermal energy faces a parallel challenge: despite its reliability and low-carbon profile, the technology has struggled to reach cost competitiveness with other fuels. High upfront exploration costs, long development timelines, and uncertain revenue models remain persistent barriers. Geothermal stakeholders should use BESS learnings as a blueprint for overcoming these hurdles. By pairing regulatory reforms that appropriately value geothermal's baseload, clean capacity with targeted incentives that de-risk early-stage development, policymakers can unlock the same cycle of investment, scale, and innovation that propelled BESS forward.

As grids increasingly adopt variable renewable energy, it will also require firm, low-carbon resources, of which geothermal has the potential to play a vital role. Lessons from battery storage's policy-enabled growth show how thoughtful market design and incentives can move geothermal from the margins to the mainstream.

Geothermal resource modelling in NE England

Zhenni Sun, University of Manchester; David Johnstone (University of Manchester), Jonathan Watson (MetaTek), Mads Huuse (University of Manchester)

Urban decarbonisation requires reliable and scalable low-carbon heat sources. This work evaluates the medium-depth geothermal potential beneath the University of Manchester (Cecil Street area) by integrating two approaches: (i) probabilistic doublet simulations using DoubletCalc for three target formations; the Collyhurst Sandstone, Millstone Grit Group; and Carboniferous Limestone, and (ii) the acquisition and processing of a high-resolution land gravity survey to image fault systems that may enhance fracture permeability or cause seismicity during geothermal operations. Corrected bottom-hole temperatures indicate a geothermal gradient of ~28 °C/km with a 10 °C surface constraint. Sensitivity analyses on temperature, permeability, netto-gross ratio, and salinity were performed to quantify uncertainty in thermal power output. The results suggest that: (1) the Collyhurst Sandstone has high permeability but limited temperature contrast, making it better suited for heat-pump-assisted schemes, incl heating and cooling; (2) the Millstone Grit can sustain direct-use heating with outputs of several MW where connected channel belts or fracture corridors are encountered, but permeability is a key uncertainty; and (3) the fractured Carboniferous Limestone at 2-3 km depth shows the highest potential, with outputs potentially exceeding 10 MW under favourable fracture or karst conditions.

Gravity modelling and simulated survey workflows demonstrate that ±2–2.5 mGal anomalies associated with faulted basin geometries are detectable with 200 m station spacing, significantly improving on public BGS map coverage. Collectively, these findings support the potential feasibility of geothermal development beneath Manchester and provide a framework for appraisal drilling, well design, and integration into future district heating networks.

To further support a geothermal source of heat for the university and the city of Manchester as a whole, further geophysical acquisition could include extending the gravity survey and acquisition of new 2D seismic profiles. Geomechanical analysis of fault trends encountered would help ascertain their potential impact on seismic hazards and whole-rock permeability.

Session 3

Commented [RM1]: Page needs finalising

Keynote: The Most Righteous Heat Pump Time Machine Adventure

Dave Banks; University of Glasgow

Dave “bogus” Banks takes you on a brief, but most bodacious, tour through time, to document the highlights of ground source heat pump (GSHP) development in the UK. The stops on the tour will include Miriam Griffith’s and John Sumner’s pioneering work on heat transfer between soils and ground collector pipes (and their possible environmental effects) [1,2,3,4], the world’s first operational closed loop GSHP in Swansea {5], Charles Parsons’ Hellfire Exploration Company [5,6] and Dr TGN (“Graeme”) Haldane’s early domestic (ground?)water-sourced heat pump in Auchterarder, Scotland [7,8]. The tour will close with a consideration of the state of the GSHP industry in the UK today – a recent report [9] reckoned that there may be 30,000-38,000 GSHP systems operating in the UK as of 2021 - and the policies that might further stimulate take-up of the technology.

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GEMINI: Geothermal Energy Momentum on the Island of Ireland

Michael MacKenzie, BGS

Launched in November 2024, GEMINI is a €20m cross border geothermal demonstration project that aims to support and accelerate geothermal market growth across the island of Ireland.

The project, supported by the PEACEPLUS Programme, is being delivered by 15 partners from a wide range of sectors, including local and national governments, research organisations, and community engagement groups, North and South of the border.

With four demonstration sites, GEMINI will showcase diverse applications of geothermal technologies, across a range of subsurface environments. Works include delivery of operational shallow and deep geothermal systems, data acquisition and modelling to characterise key geological settings, and economic analyses of different geothermal prospects.

The project will use results to provide guidance on technical solutions, cost insights, legislation and planning systems, informing stakeholders and support the long-term growth of a sustainable, geothermal sector in Ireland.

Additionally, in order to expand the critical skills base required for sector growth, the project will develop joint education, skills and training frameworks. This will ensure that accreditation of geothermal professionals, such as businesses and installers, drillers is recognised throughout the geothermal market on the island of Ireland.

Activities over the past year have included feasibility studies, system design development, and geophysical survey campaigns, with some acquisitions completed and analyses underway.

Characteristics of Devonian Limestones in Plymouth, UK, and the prospects for geothermal energy.

Nicholas Harper, University of Exeter; Bailey, M. T.; Andrews, B. J. (University of Plymouth); Birks, D. (Worley); Smith, R. (John Grimes)

The city of Plymouth, Southwest England, has ambitious decarbonisation plans including delivering on a Government heat network pilot for space heating and cooling (DESNZ, 2025). Early investigations, as part of the preceding EU funded HeatNet project, explored the potential for Aquifer Thermal Energy Storage (ATES) as part of a heat network (Plymouth City Council., 2019). Initial findings were promising and studies are ongoing. The target aquifer comprises the Middle-Late Devonian, coral- and stromatoporoid-bearing, Plymouth Limestone and Torpoint formation (Braithwaite, 1967), which lie beneath large parts of the city and surrounding areas.

These Devonian limestones are structurally complex and heavily karstified, with evidence of groundwater discharge at the coastal fringe, within Plymouth Sound, in the form of submarine springs (Roxburgh, 1984). High flow rate groundwater abstraction tests in proximity (<100m) of the coast found that, due to high transmissivity of karst/structural features, water quality rapidly became saline due to sea water intrusion. The complex flow pathways and the aquifers interaction with seawater demonstrate the need for a greater understanding of flow pathways within the limestone, if it is to be targeted for ATES or geothermal energy.

Here we present structural and geochemical data of the Plymouth Limestone and Torpoint Formation and, discuss hydrogeological properties and groundwater pathways within the subsurface. Our data provides new insights into the geothermal potential of Plymouth and considers what analogies can be drawn from case studies elsewhere such as the Middle-Late Devonian ‘Massenkalk’ limestones, Germany, which formed on the same southern Avalonian paleo-margin as the Plymouth limestone and are currently being explored for geothermal resources (Lippert et al., 2022).

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Expanding the UK's Geothermal Future: Power Generation from Low-Temperature Resources with Micro-ORC Technology

Eren Gunuc, London Geothermal Ltd;

Geothermal energy in the UK has historically been applied to heating, with strong growth in ground source heat pumps, mine water schemes, and aquifer thermal storage. More recently, deep Enhanced Geothermal Systems (EGS) projects such as United Downs have demonstrated that geothermal electricity production is possible in the UK. However, the broader opportunity lies in the abundant low-temperature resources 70–150 °C that remain underutilised.

This presentation highlights the role of micro-scale Organic Rankine Cycle (ORC) systems, specifically designed for distributed power generation from lower-temperature fluids. QBivio UK Energy Limited has developed modular units in the 30–300 kWe capacity range, optimised for integration with deep aquifers, mine water projects, and repurposed oil and gas wells. These compact systems can be deployed as stand-alone electricity producers or as combined heat and power (CHP) solutions, enhancing the efficiency and viability of geothermal developments.

The study will:

- Assess the technical potential for low-enthalpy power generation across UK geological settings.
- Present design and performance characteristics of micro-ORC systems in the 70–150 °C operating window.
- Demonstrate the synergies between electricity generation and heating applications in district networks and industrial clusters.
- Explore the economic, carbon, and policy impacts of enabling power generation from geothermal resources previously considered viable for heat-only.

By bridging the gap between deep EGS power plants and conventional geothermal heating, micro-ORC systems offer a scalable and replicable pathway for unlocking the UK's wider geothermal potential. This approach can diversify renewable energy generation, reduce emissions, and accelerate the role of geothermal in the UK's net zero strategy.

A simple probabilistic approach to assess the potential capacity of open-loop Ground Source Heating and Cooling and Aquifer Thermal Energy Storage systems

Meissam Bahlali, Imperial College London; Matthew Jackson (Imperial College), Yixuan Yan (Imperial College)

Open-loop Ground Source Heating and Cooling (GSHC) and Aquifer Thermal Energy Storage (ATES) can provide large capacity (of order MWth to 10s MWth), low carbon heating and cooling to large buildings and building complexes, or district heating/cooling networks. Early appraisal of system capacity is important to inform scoping studies. However, data to characterize system operation at the appraisal stage are scarce or missing, so predictions are uncertain. It is common for scoping studies to include just a few example calculations of predicted capacity, which are highly dependent on the chosen input values and fail to capture the range of possible system outputs.

Here we report a simple probabilistic approach to assess the potential capacity of GWHC and ATES systems. The equations characterizing ATES and GWHC system operation are recast to express production temperature, which is usually determined using numerical simulation, in terms of the thermal recovery factor. A thermal recovery factor of zero corresponds to a GWHC system. The approach allows rapid prediction of ATES and GWHC system performance in a deterministic or probabilistic framework, and identifies the most likely (P50), upside (P90) and downside (P10) system performance. The sensitivity of predicted performance to input parameter ranges is also determined to guide future data acquisition. The approach is implemented in open-source software to facilitate widespread uptake.

Facilitating research and operational schemes to realise the geothermal potential of abandoned coal interests

Joanne Eynon & Helen Day, Mining Remediation Authority

Abandoned coal interests represent, a compelling and underutilised opportunity to contribute towards achieving net-zero.

In Great Britain the majority of coal mines and unworked coal is owned and managed by the Mining Remediation Authority. With 25% of properties in Great Britain located on the coalfield, the Mining Remediation Authority can facilitate both research to better understand the potential for the thermal properties of mine water to provide low carbon heating and cooling, and operational schemes to realise this potential through proving permissions to access to the coal mines and unworked coal. Opportunities exist for both open loop and closed loop research and schemes utilising boreholes and in some cases mine shafts.

The Mining Remediation Authority can also facilitate permission for the purpose of accessing deeper geothermal resources.

A technical overview into how the Mining Remediation Authority can support and facilitate these permissions will be provided. This will include guidance of the submission information required and the risks that are considered to support and inform the licensing and permissions process along with an overview of the current stages in securing permissions. An outline of how ongoing research and information from the operation of schemes is identifying efficiencies and refining a regulatory framework for the permission application and process, to better support innovation to realise geothermal potential.

The Mining Remediation Authority is a non-departmental public body, created by the 1994 coal Industry Act, which owns and manages the majority of coal mines and unworked coal in Great Britain. Permission from the Mining Remediation Authority is required to enter, intersect or disturb this property which includes a review of potential risks and identification of appropriate monitoring and mitigation.

Session Three: Minewater Geothermal

Techno-economic feasibility of using abandoned flooded mines for storage and transport of waste heat

Leah Victoria Swan, TownRock Energy; Sam Smith (TownRock Energy), Sean Watson (University of Glasgow), Alejandro Perez Silva (University of Edinburgh), David Townsend (TownRock Energy)

Galleries to Calories (G2C) is a £ 2.6 million collaborative research project involving industry and academic partners which aims to demonstrate, for the first time, the use of abandoned flooded mines to store and transport industrial waste heat. The legacy mines will act as a subsurface “geobattery”, highlighting the potential for recycling waste heat to provide sustainable recharge of geothermal resources to supplement the existing low-carbon heat source for district heat networks (DHN).

As part of the G2C project, TRE are leading a techno-economic study to assess the feasibility of using the legacy mines to store and transport waste heat from the University of Edinburgh’s Advanced Computing Facility (ACF) to potential heat customers downstream. This involves conceptual design and economic assessment of both the minewater cooling system at the ACF and the minewater heating system identified downstream. The economic benefit of the geobattery will be determined based on this design, with revenue obtained from both “coolth” sales (heat disposal rate from ACF to the mines) and “heat” sales (heat extraction rate from mines to DHN), using a bespoke minewater heating and cooling cashflow model.

This presentation will give an overview of the design methodology including quantification of the waste heat resource and downstream heat demand, followed by design of a suitably sized minewater geobattery system. We will highlight how key parameters impact the economic feasibility (NPV, IRR and payback) of the geobattery system and present levelized cost of heating and cooling for at least one commercially viable case.

Computational Analysis of the Thermochemical Impacts of Minewater Thermal Energy Storage on Scotland's Midland Valley Coal Mines

Samuel Graham, University of Exeter; Ruby Smith (University of Edinburgh)

Re-using flooded coal mines as a geothermal resource is gaining traction. In addition to providing a geothermal resource, we need to consider thermal energy storage in order to provide for a balanced energy storage system. Much research was done in the post closure years to understand the geochemical challenges associated with mine water pollution, impacts on water quality in mine water aquifers relating to the thermal energy storage are not well understood, with implications for how such schemes may be granted permission, and regulated during operation.

This study takes a computational approach to simulate impacts on the geochemical state of mine waters under various operationally relevant conditions. In order to place our work in the wider context of a regional roll-out of mine water thermal energy storage we make use of a large data set that comprehensively characterises the geochemical make-up of shallow mine waters sampled at discharge points covering the Scottish central belt. Various PHREEQC scenarios are developed to look at impacts of thermal energy storage.

We look at the baseline variation of geochemical saturation with respect to key indicator minerals relating to host rock geology and the generation of acid mine drainage across the central belt and assess the direction that equilibrium could shift if MTES was employed for the long term. We consider perturbations in mine water temperature up to 60oC from present day case. This is scoped in terms both rock forming minerals, and in terms of acid generating salts to understand implications for rock stability, and for potential negative impacts on water quality arising from vestigial acidity due to fluctuations in shallow water tables. The use of large regionally expansive dataset allows us to present this in a probabilistic framework.

Emerging research, collaboration and development of mine water heat at the Mining Remediation Authority.

Rebecca Chambers, Mining Remediation Authority; Fiona Todd (Mining Remediation Authority)

Research into mine water heat, storage and cooling is a key priority for the Mining Remediation Authority, in order to support evidence-based decision making and drive the wider uptake of mine water heat networks in the UK. As set out in our newly published 2025-2028 Business Plan and our Mine Heat Opportunities Framework, there are several key research and development priorities, which include: contributing to net zero and energy security, working with partners, supporting external R&D, and raising awareness of mine water heat. This presentation will offer insights into the cutting-edge monitoring network established between operational mine water heat schemes at our Gateshead 'Living Lab' and will outline our current and future research into mine water heating and cooling.

The Gateshead mine water Living Lab is a pioneering research initiative that was officially launched in January 2025 in order to facilitate addressing these key research areas. At the Gateshead Living Lab, cutting edge research has been undertaken, including the first use of Borehole Magnetic Resonance (BMR) in a Mining Remediation Authority borehole. The use of such novel geophysical techniques has allowed us to establish porosity and permeability values for the first time in mine workings within the Walker block. Other emerging research includes investigations into increased thermal gradients within the Walker block, the potential for heat storage within mine workings, and collaborative research into heat resource estimate calculations. This presentation will also outline how the Mining Remediation Authority supports complementary research with our external collaborators within the mine heat sector and how we continue to work with partners to support mine water heat schemes in Great Britain.

Session Four: Deep Geothermal & Lithium

An update on the development and commissioning of the United Downs Geothermal Power Plant, Cornwall.

Thomas Olver, Geothermal Engineering Limited; Ryan Law (Geothermal Engineering Limited), Poppy Edgecombe (Geothermal Engineering Limited)

Geothermal Engineering Ltd (GEL) has developed the UK's first geothermal electricity project at its United Downs site in Cornwall. The power plant is now complete and is undergoing commissioning. Export to the national grid is expected to start during 2025.

Commissioning of the plant followed a bespoke, staged process, planned in conjunction with Exergy ORC. The process included further testing and the commissioning of the geothermal doublet (a 5,275 m production well and 2,393 m injection well within a fractured granitic reservoir) and installed production and injection pumps, as well as all plant infrastructure at the surface. The process also involved extensive discussions with the National Grid. The lessons learned throughout commissioning are important for the planning of additional sites in Cornwall, for which GEL already has planning permission.

The United Downs site acts as proof of concept for geothermal power projects in the UK, providing key insights into all stages of development, including initial site selection and financing, the UK planning and regulatory processes, drilling, well testing and stimulation, as well as construction, commissioning and early operation. It is therefore a flagship for further development of the geothermal sector in the UK.

Geothermal fluids of the Carnmenellis Granite, Cornwall, UK

Chris Rochelle, BGS; Tom Olver (Geothermal Engineering Ltd), Chris Yeomans (Formerly Cornish Lithium Plc, Now at Neo Geo Consulting Ltd, Andy Marriott (British Geological Survey), Ali Salisbury (Formerly Cornish Lithium Plc), Keith Bateman (British Geological Survey) and Poppy Edgecombe (Geothermal Engineering Ltd)

Geothermal development in Cornwall has seen a major step forward recently, with both the UK's first geothermal power plant by Geothermal Engineering Ltd, and the successful planning application for a Direct Lithium Extraction plant at Cross Lanes Farm (Cornish Lithium Plc) – both targeting deep groundwaters and dissolved minerals held within fractures in c. 290 Ma old thermogenic granite. Recent industry projects and scientific studies, coupled with information from the 1980s UK Hot Dry Rock geothermal project, provide a compelling dataset of fluid chemistry within the upper 5 km of the northern boundary of the Carnmenellis granite.

These projects access water between 1-5 km, targeting an area around the Porthtowan Fault Zone, a system of NNW-SSE trending fractures, of which many are known across SW England. Data from the United Downs Deep Geothermal Project confirms a NaCl-dominated water at about 185°C, with a TDS of c. 35 g/L and lithium concentrations c. 280+ mg/L.

Fractures allow circulation of the deep groundwater to shallower levels, creating mixing zones with local surface groundwaters and intermediate water chemistries. These carry a deep geothermal signature and can still have commercially attractive Li concentrations (c. 100 mg/L) at 1-2 km depth, as is the case at Cross Lanes Farm.

We present a summary of current understanding of the geochemistry of these thermal waters, and how they interact with the host rocks.

Photogrammetry-Based DFN Characterisation to Support Geothermal Lithium Exploration in Cornwall

Fiona McLean, WSP UK; Will McKenzie (Cornish Lithium), Edward Cox (WSP UK) and Mark Cottrell (WSP UK)

Characterising subsurface fracture networks is essential for modelling fluid flow and resource extraction in structurally complex geological settings. This study presents a methodology that integrates high-resolution photogrammetry data with Discrete Fracture Network (DFN) modelling workflows to reduce subsurface uncertainty and support Cornish Lithium's exploration for geothermal lithium.

Cornwall's lithium-rich geothermal waters offer a unique opportunity for sustainable resource development through Direct Lithium Extraction (DLE). Unlike conventional mining methods, DLE delivers a low-carbon, energy-efficient approach that significantly reduces land and water usage, making it a more environmentally responsible solution for lithium recovery. These geothermal systems, hosted in fractured granitic and metasedimentary rocks, also offer the potential to supply heat energy to local industries and communities. Identifying and characterising the fracture networks that control geothermal water circulation is therefore critical.

For its ability to assess larger scale (>1m) structural discontinuities over wide areas, the use of high-resolution photogrammetric survey data offers a significant complement to traditional geological mapping. Photogrammetry data from multiple outcrops across Cornwall were processed in FracMan DFN modelling software. Observable fractures were interpreted and statistically characterised to generate static DFNs capturing fracture orientation, intensity and length, and the reproducibility of these models validated using a Monte Carlo approach. Incorporation of well-established aperture-length relationships, as observed in naturally fractured rocks, allowed for quantitative metrics on volumetric intensity (P32), fracture porosity (P33), and network connectivity index (NCI) to be derived. These metrics enabled site-specific assessment of geothermal potential. The geomechanical response of modelled fractures to in-situ stress conditions was analysed to identify fracture orientations that are anticipated to be critically stressed, and to ground-truth the DFN models generated.

This study demonstrates that photogrammetry-informed DFN modelling offers a data-constrained approach to fracture characterisation which may supplement traditional field mapping. This approach aids geothermal exploration, optimises well planning and reduces subsurface uncertainty.

Selective Extraction of Lithium from Native Geothermal Brines Using Lithium-ion Sieves

Misagh Ghobadi, University of Exeter; Rich Crane [University of Exeter], Karen Hudson-Edwards [University of Exeter], Clemens Vinzenz Ullmann [University of Exeter]

Lithium, often termed “white gold,” is regarded as the critical energy metal of the 21st century, paralleling the role of coal in the 19th century and oil in the 20th. Global demand, estimated at 0.95–0.98 million metric tons (Mt) of lithium carbonate equivalent (LCE) in 2024, is projected to reach 1.87 Mt by 2027 and 3.06 Mt by 2030. Meeting this forecast will require an additional 1.42 Mt of annual LCE capacity—beyond current planned and ongoing developments—despite short-term stability in supply and demand. Brine resources account for nearly 65% of global lithium reserves, highlighting the potential of underutilized sources such as geothermal brines. However, conventional brine extraction is hindered by long processing times, low recovery rates (30–50%), inefficiency with low lithium concentrations (<300 mg/L), and significant environmental impacts. Direct lithium extraction (DLE) technologies have emerged as promising alternatives, capable of economically recovering lithium from brines with concentrations as low as 50 mg/L, achieving recovery rates of 75–98%. Yet, about 70% of existing studies focus on synthetic brines, with limited real-world or industrial applications. This study addresses that gap by examining a geothermal brine sample from a UK case study site. A manganese-based lithium-ion sieve (LIS) adsorbent was synthesized for selective lithium extraction. Adsorbents with a Li:Mn molar ratio of 1:1 showed superior selectivity and adsorption capacity. Further enhancement was achieved through transition metal doping, which improved lithium selectivity and capacity. The modified adsorbent achieved separation factors exceeding 200 over co-existing cations such as Ca, Mg, Na, and K. Adsorption behavior followed the Langmuir model, indicating monolayer adsorption, while kinetics conformed to a pseudo-second-order mechanism, suggesting chemisorption. Thermodynamic analysis revealed negative ΔG° values and positive ΔH° and ΔS° values, confirming the process is spontaneous and endothermic.

Reservoir Independent Deep Geothermal Technology for Heating

Mikey Van Mourik, TownRock Energy; David Townsend, Mike Schiltz, Sam Smith and John Naismith (TownRock Energy)

Deep, reservoir independent geothermal technologies are typically investigated for the purposes of electricity generation. TownRock Energy recently completed a feasibility study for NHS Grampian investigating the viability of three deep technologies to supply a large hospital heat demand rather than electricity. The technologies were Coaxial Systems, Advanced Geothermal Systems (AGS) and Engineered Geothermal Systems (EGS). Using numerical modelling (CMG Stars) paired with engineering concept designs and techno-economic modelling, the case for each technology was assessed. The study concluded that where heat demands are high enough (e.g., large building complexes such as hospitals or heat networks) and / or where there are insurmountable electrical grid constraints, deep geothermal options were the preferred source of heat versus other low carbon heat pump technologies.

Out of the three options, EGS was found to be the most attractive for supplying large heat demands (30 MW +) and provided the lowest levelised cost of heat (< 6 p/kWh) which is competitive with present-day gas, biomass and heat pump alternatives. The technique of using stimulation to create a synthetic geothermal reservoir also provides a scalable technology that can be installed where geothermal gradients are sufficiently elevated – most typically in granite plutons.

There are challenges to such a technology, especially in an urban setting such as Aberdeen, most significantly upfront capital cost and public acceptance. However, the upside is low-cost baseload heat at a city scale with relatively low technology risk (thanks to rapid innovation in EGS technologies) and associated net-zero geothermal energy ‘anywhere’.

This presentation will discuss the findings of TownRock’s feasibility study and how EGS technology is not only a renewable electricity solution, but also a renewable heating solution.

Day Two

Keynote: Supercharging UK Geothermal: Year One of the National Geothermal Centre
TBC

Session Five: Ireland

Standing column well technologies in Northern Ireland, Part 1: Background, opportunities, barriers and forward potential

Simon Todd, Causeway Geothermal (NI) Ltd; Huw Williams (Agua Enodo), Kevin Mallin (Geolorn Ltd)

Standing Column Wells (SCWs) are a Geothermal application that has been applied to 500m depth in North America, but negligibly in the UK and Ireland. SCWs are a hybrid between open loop and closed loop Geothermal Heat Exchangers (GHEs), where aquifer water is circulated around the open hole well and heat is drawn by both conduction (like closed loop) and advection (like open loop) through fractures in the bedrocks.

Large parts of Northern Ireland are underlain by low to modestly productive bedrock aquifers like the ones in the United States and Canada that have historically hosted SCWs. This project illuminates the potential for SCW application and proliferation in Northern Ireland (and similar geologies in Ireland and Great Britain) through pre-commercial pilot testing of existing boreholes drilled for water, but with the borehole piping geometry temporarily reconfigured into a SCW geometry. The results clearly demonstrate that the SCW application can indeed perform in two different bedrock aquifers – and by inference the others – to the expected levels of thermal performance observed in North America.

Available aquifer productivity data for Northern Ireland has allowed the development of a series of probability of success maps for the region, which developers and customers can start to consider opportunities for the application in pre-feasibility reviews. A preliminary outline SCW appraisal and design methodology has been formulated to begin the development of a best practice in managing risks and uncertainties in construction and operation.

Standing column well technologies in Northern Ireland, Part 2: Borehole test design, execution, analysis and results

Huw Williams, Agua Enodo; Simon Todd (Causeway Geothermal (NI) Ltd, Kevin Mallin (Geolorn Ltd), Ric Pasquali (Terra GeoServ), Josepth Ireland (Terra GeoServ), Paul Wilson (Geological Survey of Northern Ireland), Rob Raine (Geological Survey of Northern Ireland)

Standing Column Wells (SCWs) can be considered as under-utilised in the UK and Ireland. The Department for the Economy have funded research into their applicability in Northern Ireland.

As part of this research two sites were selected, based on borehole suitability and representative target aquifers for Northern Ireland, of modest open loop potential, but geographically extensive; 1) Anacramp, south Tyrone with limestones of the Carboniferous Maydown Formation, and 2) Tievenny, west Tyrone with metamorphic psammites and psammitic schists of the Dalradian Dart Formation.

A Thermal Response Testing programme was conducted at both sites over 5 days at each location. Two methodologies for analysis of the thermal response test were used; traditional closed loop thermal response test (line source theory) and finite element modelling.

Analysis demonstrated that convection of heat from the SCW accounted for the major difference in the thermal evolution of both SCW verses conventional closed loop systems. Conductive heat properties were designed to be as similar as possible in both sets of analysis. Comparison of expected thermal performance of closed loop BHE, at 70 W/m borehole, and a SCW design in the test sites, 16 KW for 74 m or 216 W/m, shows that SCWs are around 3 times more powerful. This may mean a reduction in well count of ~70% at most, but will likely be tempered to 35% because of the need to have twin bleed wells. A robust methodology for future testing and design of SCW systems will be presented.

GeoEnergy NI – Results, Lessons Learned, and Forward Look

Sharon Clements, Department for the Economy

In recognition of a nascent geothermal sector, and a growing need to decarbonise the heating sector in the region, GeoEnergy NI was launched in March 2023 in line with the NI Executive's Energy Strategy.

Informed by published research into the sector, the project was designed to address key barriers to sector growth in Northern Ireland, with aims that included de-risking the subsurface, increasing public awareness of geothermal energy, and informing future policy development in the region.

Over two years, the project undertook feasibility studies at two sites, exploring both shallow and deep geothermal potential, alongside a bespoke communications campaign.

The recently published results of these feasibility studies have provided valuable insights into the delivery of geothermal in Northern Ireland, highlighting both new opportunities, but also challenges, for the sector.

In 2025, the Department for the Economy commissioned the British Geological Survey to conduct an independent review of GeoEnergy NI, evaluating the effectiveness of outcomes against project objectives. Included in the scope of this review is a summary of 'Lessons Learned' and assessment of remaining research gaps.

The results of the studies, as well as the BGS review, are being used to inform future actions that will further support geothermal uptake in Northern Ireland; on a systems level at each of the sites, and at a national level for the development of a geothermal regulatory regime.

Producing Subsurface Temperature Models from Joint Geophysical-Petrological Inversion

Emma Chambers, Dublin Institute for Advanced Studies; Javier Fullea (Department of Physics of the Earth and Astrophysics, Universidad Complutense de Madrid), Duygu Kiyan (Dublin Institute for Advanced Studies), Bernard Owusu (Dublin Institute for Advanced Studies), Christopher J. Bean (Dublin Institute for Advanced Studies)

Determining the nature of the crust and upper mantle is essential for geothermal resource assessment, resource exploration, hazard assessment and understanding tectonic processes. Focussing on geothermal resource assessment, variations in subsurface lithology and the associated thermal parameters will modify subsurface thermal structure, a parameter useful for geothermal exploration. Given subsurface temperature signals are intertwined with other variables, we require ways to separate the individual contributions in overlapping datasets. One way to do this is using a joint geophysical-petrological inversion to invert different complimentary datasets directly for subsurface temperature.

We use Ireland and Iceland as two case studies to test the methodology at the crustal scale, for full island and local scale approaches. The output from the inversion includes the lithospheric geotherm, lithospheric thickness and Moho depth, as well as crustal structure (seismic velocity, density and radiogenic heat production). The lithospheric geotherm is useful for determining heat in place and the geothermal potential of an area. The additional outputs, besides temperature, can provide insights into the lithological and compositional variations in the crust. We further develop the workflow by introducing lithological boundaries from detailed 3D subsurface models. Additionally, gravity data, magnetotelluric and melt information will be integrated to refine the 3D crustal structure, and consequently the subsurface temperatures.

Session Six: Novel or O&G techniques for geothermal

THERMOCAL – International thermogeological characterisation of Caledonian rocks

Gioia Falcone, Sean Watson, Glasgow University

The bilateral UK-Norway THERMOCAL (THERMOphysical properties of CALedonian rock materials to de-risk geothermal development) project aims to compile a new set of empirical thermogeological data across the lithologies associated with the Caledonian orogeny (and associated plutons and Precambrian basement) in Northern Ireland, Scotland and Norway. The parameters that the project will focus on will be (i) internal heat generation from natural radionuclides, (ii) thermal conductivity and (iii) volumetric heat capacity. These parameters are relevant to the design of both shallow (ground source heat pump) and deep geothermal systems. The last two properties are determined in the laboratory, while internal heat generation is derived from airborne, downhole and hand-held field nuclide-specific gamma-ray spectrometry. The project will undertake interlaboratory quality control, ring-testing and method harmonisation, together with consideration of anisotropy, state of weathering and state of saturation of samples.

THERMOCAL has commenced with the compilation of existing thermogeological data in the three participant nations. The range of thermal conductivities in Caledonian granites, Silurian wackes (Southern Uplands), Dalradian and Moinian metamorphics and Devonian sandstones is presented using graphical non-parametric statistical techniques. The importance of anisotropy in Caledonian metamorphic rocks is demonstrated, and the significance (or lack thereof) of metamorphic grade is considered.

Geothermal energy prospecting in radiothermal granites in the Cairngorms, Scotland, using an integrated magnetotelluric and petrophysical approach

Scott Innes Campbell, Heriot Watt University; Nathaniel Forbes Inskip (Heriot Watt University), Juliane Huebert (British Geological Society), Andreas Busch (Heriot Watt University), Michael van Mourik (TownRock Energy)

The Cairngorm Pluton granites in NE Scotland emit among the highest heat-production values in the UK. While past geothermal exploration had been stifled by low heat-flow estimates, recent palaeoclimate-corrected models predict significantly higher temperatures at depth. Key uncertainties persist regarding geothermal reservoir permeability, fluid pathways, and the overall pluton structure - critical factors for achieving economical geothermal flow rates at strategically placed drill sites. Hydrothermal alteration, recognised within the Cairngorm granite, may also affect reservoir quality. Studies from analogous granitic systems suggest that hydrothermal processes along fracture networks can enhance porosity and permeability through mineral alteration and microstructural modification at depth. The effects of hydrothermal alteration in the Cairngorm granites remain unquantified.

To address these uncertainties, we conducted a broadband magnetotelluric (MT) survey, a geophysical deep-sounding technique with the capability to image structures in the subsurface at several kilometres depth. We collected data from ~50 sites in the central Cairngorms south of Glenmore during summer 2024 and 2025. The 3D inversion of the MT data reveals north-south trending conductive zones extending to ~2.5 km depth, potentially imaging fluid-bearing fracture systems and zones of hydrothermal alteration. Our integrated approach combines 3D resistivity modelling using advanced inversion techniques with laboratory measurements of altered and unaltered granite samples to evaluate the effects of alteration on porosity and permeability. These measurements will be correlated with the MT-derived resistivity structure to identify viable geothermal fluid pathways. This work directly contributes to de-risking Scotland's geothermal development and develops transferable methodologies for characterising crystalline geothermal reservoirs worldwide.

High-resolution geothermal exploration of the Muara Laboh geothermal system using Nodal Ambient Noise Tomography (NANT)

Michail Henry, INVERT Sàrl; Adriano Mazzini [University of Oslo, Geoscience Department, Oslo, Norway; Institute for Energy Technology, 2007 Kjeller, Norway], Elliot Amir Jiwani Brown [Department of Earth Sciences, University of Geneva, Switzerland], Iván Cabrera-Pérez [Department of Earth Sciences, University of Geneva, Switzerland], Julien Sfalcin [INVERT Sàrl, Switzerland], Herwin Azis [Supreme Energy, Jakarta, Indonesia],Indra Nugroho [Supreme Energy, Jakarta, Indonesia], Takashi Zaizen [Supreme Energy, Jakarta, Indonesia], and Matteo Lupi [Department of Earth Sciences, University of Geneva, Switzerland]

The Muara Laboh geothermal system, located in central Sumatra along a heavily faulted zone of the Great Sumatra Fault, is characterised by widespread surface manifestations of fluid migration. In this tectonic environment, the movement of geothermal fluids is expected to be controlled by complex lithological and structural discontinuities within the subsurface.

To effectively map these fluid pathways and reservoirs, we deployed a large network of 212 seismic nodes to conduct a Nodal Ambient Noise Tomography (NANT) survey. This non-invasive and cost-efficient method uses the dense network to acquire high-density data, which is then processed to extract cross-correlation functions and Rayleigh wave group-velocity dispersion curves. Subsequently, a high-resolution 3D S-wave velocity model of the upper crust was computed using non-linear multiscale inversions, providing unprecedented detail for mapping subsurface fluid pathways and reservoirs

The resulting S-wave velocity model successfully delineates distinct fast and slow velocity domains, which are indicative of different subsurface features. We identified fast-velocity anomalies matching with cooled intrusive bodies located directly beneath the main Muara Laboh geothermal system. The sharp transitions between these zones and adjacent low-velocity regions are likely to exhibit high fracturing and enhanced permeability, which are ideal targets for geothermal exploitation. This further demonstrates the capability of NANT to precisely map the boundaries of these critical geothermal features.

This study firmly establishes NANT as an ideal method for geothermal exploration. Its ability to produce high-resolution 3D subsurface images makes it perfectly suited for identifying and characterising the tectonic discontinuities that control hydrothermal fluid migration in seismically active regions. This approach is a powerful tool for greenfield exploration, as its non-invasive nature, cost-effectiveness, and extensive coverage make it a crucial first step for targeting new areas with geothermal energy potential.

A multi-perspective assessment of shallow geothermal energy potential for the city of Cambridge, UK

Nikolas Makasis, University of Surrey; Monika J Kreitmair (University of Surrey), Kecheng Chen (University of California Berkeley), Kenichi Soga (University of California Berkeley), Ruchi Choudhary (University of Cambridge)

Ground-source heat pump (GSHP) systems offer highly efficient heating and cooling, making them a key technology for urban decarbonisation. However, city-scale adoption remains limited due to challenges in planning, data availability, and subsurface characterisation. This work presents an expanded framework for assessing shallow geothermal potential in urban environments, using the city of Cambridge, UK, as a case study.

Building on a recently proposed methodology for subsurface thermal state quantification, this expanded framework combines numerical modelling, statistical clustering, and analytical methods to derive geothermal potential archetypes. It incorporates natural and built environment data, considers subsurface urban heat island effects, and includes heating and cooling demand, which is often neglected in large-scale assessments.

The results are presented through various geothermal potential maps, each tackling a different perspective on geothermal energy usage. These include capacity-only estimates, giving a percentage of local demand met using typical GSHP installations, net supply-demand ratios, indicating opportunities for heat sharing, and holistic utilisation maps, understanding the impacts of utilising the subsurface at a city scale.

The study highlights how different urban areas can play distinct roles in contributing to net-zero goals, depending on supply capacity, local demand, and spatial constraints. The framework enables a holistic approach to geothermal planning, supporting effective integration of shallow geothermal systems into city-wide energy strategies. Importantly, it is shown that shallow geothermal potential is not a unique value, but can vary, depending on the application and scope of investment, and as such clarity is needed in communicating these values to stakeholders.

Reducing Subsurface Uncertainty in the Early Carboniferous Limestones: An Integrated Geophysical Approach to Geothermal Reservoir Characterisation

Mohamed Gouiza, Imperial College London; Dave Healy (Geosolutions Leeds, University of Leeds)

The Early Carboniferous Limestones (ECL) represent a promising deep geothermal target in the UK, owing to their regional extent, burial depth, and fracture-controlled permeability. However, uncertainty in mapping their thickness and continuity at depth—primarily due to sparse well penetration and seismic resolution—remains one of the key challenges for geothermal reservoir characterisation.

This study presents an integrated geophysical workflow to better constrain the depth, geometry, and structural framework of the ECL. Legacy 3D seismic reflection and borehole data from the Gainsborough Basin were used to map key stratigraphic horizons and derive depth-dependent density trends for the main lithostratigraphic units. These inputs were incorporated into a 3D voxel-based geological model of the subsurface and used to perform gravity modelling.

Preliminary results show that gravity modelling provides valuable constraints in areas where seismic or well data are limited, improving confidence in the geometry of deeper formations such as the ECL. The resulting model will support further work to quantify fluid flow and assess the thermal performance of the reservoir. This work highlights the value of integrated geophysical approach in reducing subsurface uncertainty and enhancing geothermal resource evaluation in the UK.

Session Seven: Novel or O&G techniques for geothermal

The importance of pilot well programmes in geothermal projects: insights from Geothermal Campus Leeds

Arka Dyuti Sarkar, University of Leeds; Emma Bramham, Richard Collier, Nicholas Shaw, Joseph Kelly, Fleur Loveridge, David Barns

Schemes are being announced across the country targeting both shallow and deeper aquifers for geothermal heating and cooling, to address UK emissions linked to heating. De-risking approaches are thus imperative to advance geothermal energy uptake nationally. University of Leeds Geothermal Campus is one such Net Zero programme with a reversible open loop doublet system targeting a shallow Carboniferous sandstone aquifer, alongside a network of monitoring thermal response test wells and pilot wells, which were fully cored, geophysically logged and instrumented with fibre-optic cable. Such integrated data collection is atypical for shallow schemes. However, this enabled key insights that would not be available via legacy data-based models alone. While legacy and fieldwork data-based pre-drill models allowed for generalised estimation of key aquifer intervals, it cannot accurately account for regional variabilities arising from depositional architecture differences for example. Core analysis, coupled with the wireline logs, demarcated the interbedded nature of the target Elland Flags aquifer in this region, along with an assessment of the fracture networks through it. With limited primary porosity, fracture flow is key to producing from this aquifer. Such information allowed for prudent placement of submersible pumps and well screens in the open loop doublet, accounting for likely geological heterogeneity. In the absence of a pilot well campaign, operational issues could arise further down the line impacting the overall project success, emphasising the importance of front-loading investment on such de-risking. Pilot well drilling from phase 1 can provide the necessary data to de-risk the entire geothermal play, reducing the need for expensive testing for future phases. While not requiring coring, later phases can benefit from pilot drilling coupled with image logging to ascertain localised fault and fracture patterns, all of which will support lower risk, more reliable well casing design and aquifer assessment.

A pragmatic method for seismic hazard analysis for induced seismicity associated with geothermal developments in the case of limited a priori data

Mark Ireland, Newcastle University; Sam Graham (Camborne School of Mines, University of Exeter)

Perturbing the stress state, and thereby induced seismicity, is an inevitable consequence of any intervention with the subsurface, and its presence and consequence need to be managed adequately. In the UK context, the topic of induced seismicity is a fraught topic and the development of nascent domestic geothermal energy poses an additional source of induced seismicity. Such seismicity poses a potential risk to safe operations and adjacent property, and also to an energy extraction or energy storage project itself, as the "social license" to operate may be subject to any induced seismicity being kept to a minimum.

In many intraplate settings or tectonically quiescent settings there are often limited data from which to base statistical forecasts. In this talk we provide a workflow that takes pragmatic approach to quantifying the potential seismic hazards from induced seismicity in the absence of detailed, or spatially extensive pre-existing data. We incorporate open-source geospatial data sets with calibrated ground motion models based for low-magnitude, short-distance seismic events on learning from hydraulic fracturing and long-wall retreat coal mining. The workflow takes major divisions of the Ordnance Survey national grid as regions of influence. The model outputs allow mapping of the number of potentially impacted buildings in response to a given depth-magnitude input, or as a probability number of buildings exceeding a given ground velocity in accordance with BS 7385-2:1993. These are taken as a baseline from which an initial risk framework and stakeholder engagement strategy could be devised, with modifications to the initial baseline estimate able to be refined once a scheme is operational.

CO2 Fracturing in Preconditioned Reservoir Rocks: Maximizing Enhanced Geothermal System Extraction Potential While Minimizing Induced Seismicity

Lie Kong, University of Manchester; Junlong Shang (University of Manchester)

Enhanced Geothermal Systems (EGS) offer a promising route for decarbonizing energy by providing continuous renewable power from deep, low-permeability crystalline rocks. EGS effectiveness relies on successful reservoir stimulation, typically via hydraulic fracturing, which creates flow paths to improve permeability and fluid circulation. However, challenges remain in controlling fracture geometry and induced seismicity due to limited understanding of fracture mechanics and fluid–rock interactions. Advanced approaches, such as CO2-based fracturing fluids and rock pre-conditioning that introduces pre-existing damage, have recently gained attention. Here, we use a coupled Hydro-Grain-Based Model (Hydro-GBM) to simulate fluid-driven fracturing of granite, explicitly incorporating grain-scale heterogeneity. We examine different stimulation scenarios combining fluid types (high-viscosity water versus low-viscosity CO2) with rock conditions (intact versus pre-conditioned) to understand the underlying mechanisms. Results show that low-viscosity CO2 reduces breakdown pressures and promotes a more distributed fracture network. Rock pre-conditioning accelerates crack initiation, increases fracture complexity, and lowers micro-seismic energy. The hybrid approach, which combines low-viscosity CO2 injection with pre-conditioning, produces the most extensive fractures and lowest peak micro-seismic magnitudes, with a 69% increase in crack numbers and approximately 25% reduction in micro-seismic energy compared to conventional water fracturing. The enhanced fracturing is primarily driven by activation of grain boundaries and pre-existing damage, with stress redistribution and fluid leak-off as key mechanisms. This hybrid stimulation strategy and the mechanistic insights gained provide guidance for safer and more efficient EGS deployment.

Session Eight: Resource Characteriastion

Regional Mapping of Permo-Triassic aquifers in the Cheshire Basin, for direct use geothermal energy

David Johnstone, University of Manchester

This study is a play-based exploration assessment of two siliciclastic aquifers in the Cheshire Basin, northwest England, the Triassic Sherwood Sandstone Group and the Permian Collyhurst Sandstone Formation. The geothermal aquifers in this study form part of a sedimentary sequence deposited in a Permo-Triassic extensional half graben.
This study has utilised four interlinked workflows that combine to determine aquifer presence, temperature, quality, and hence geothermal potential using a play fairway mapping approach.

1. Aquifer presence, depth, and thickness. Well-seismic tie, Seismic TWT interpretation and depth conversion.
2. Aquifer temperature. Data gathering, temperature calibration and mapping.
3. Aquifer quality. Core analysis data from Cheshire Basin and the adjoining East Irish Sea Basin (EISB) has been used to identify porosity-depth and porosity-permeability trends in the aquifers of interest. Transmissivity maps are the product of permeability and thickness maps.
4. Play Mapping. Identifying Target areas for further exploration based on relevant cut-off criteria

By integrating the predicted temperature and transmissivity maps for both aquifers, a target zone is defined which meets the cut-off criteria. Firstly, a minimum temperature of 40°C, and secondly, a minimum transmissivity of 4Dm. Values of domestic heat demand greater than 5kWh/m2 have been extracted from the heatflow dataset of Taylor et al., (2014b), and overlaid onto this target area to indicate areas of significant domestic demand.
Core data From the EISB wells shows that depositional facies, and a variable diagenetic overprint strongly control aquifer quality. The actual net thickness of suitably permeable aquifer within the plays of interest across the Cheshire Basin is therefore unknown at present but is estimated using a net:gross ratio derived from analogue wells in the adjacent East Irish Sea Basin. The prediction of the porosity and permeability at the depths required for direct use heat remains a key area of uncertainty.

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Hydrostratigraphy from thermal response: DTS-derived flow estimates for open-loop system design

Joseph Kelly, University of Leeds; Fleur Loveridge (University of Leeds), Simon Rees (University of Leeds), Adam Booth (University of Leeds)

Characterising the thermohydraulic properties of the ground is critical for the design of sustainable open-loop geothermal systems. However, most in-situ testing approaches deliver effective aquifer-averaged design parameters that miss insight into which horizons may contribute to coupled heat and water flow. This study presents a methodology for estimating depth-discretised key parameters from distributed thermal response test (DTRT) data, using distributed temperature sensing (DTS) and a moving infinite line source (MILS) model.

Temperature data were collected over time at 0.5 m depth intervals during DTRTs at the University of Leeds Campus (Coal Measures sandstone) and Trumpletts Farm (Chalk) sites, using grouted and open boreholes respectively. The DTS data were pre-processed to align depth values and calculate temperature change (ΔT) during the tests. The MILS model was used to simulate ΔT over time, accounting for heat conduction, advection, and borehole thermal resistance. An optimisation process was then implemented that minimises the error between the experimental and modelled ΔT values, producing estimates of effective Darcy velocity (vD) of the groundwater, thermal conductivity (λ), and the temperature difference between fluid and optical fibre sensor as the product of borehole thermal resistance and thermal power (Rb*q).

The results are visualised through plots of the objective function error, as well as comparisons of the modelled and experimental ΔT curves over time. Early results indicate that this methodology generates good fits between the modelled and experimental data, while giving reasonable agreement with lab-measured λ values. This approach requires further validation of estimated parameters but shows promise for producing high-resolution indications of the hydrostratigraphy of open-loop systems that would not otherwise be possible from traditional pumping test approaches. Further work will validate the methodology across additional borehole sites and compare the validity of assumptions in open and grouted boreholes.

Multiparametric geophysical assessment of geothermal resources in the Dodecanese islands, Greece

Julien Sfalcin, Invert; Monika Przeor (Invert), Michaïl Henry (Invert)

In the framework of the DEMETRA project 2025, a multiphysics and multiscale study will be conducted in a geothermal field of the Greek Dodecanese archipelago.
The 40 km2 area will be investigated with Deep Electrical Resistivity Tomography (DERT) and Nodal Ambient Noise Tomography (NANT), two deep-reaching geophysical methods that have successfully imaged high- and low-enthalpy systems.

The DERT survey will involve the deployment of 60 independent dipoles and will result in a 3D resistivity model reaching one thousand meters depth. Our first objective is to distinguish the boundary between volcanic deposits and the underlying sedimentary-metamorphic basement, which hosts a shallow hydrothermal aquifer. In addition caldera ring faults controlling fluid flow and responsible for surface manifestations would show resistivity contrast, providing a good overview of the upper part of the system. Its deeper part will be explored in a second stage with NANT, designed to image the subsurface down to 3km using hundreds of geophones recording natural seismic noise. Surface-wave tomography has proven to perform very well in the basement, allowing to identify high fracturing zones in magmatic and metamorphic rocks; boundary with sedimentary cover; plutonic rocks and their associated alterations. Additionally, Remote Sensing (RS) study will focus on the analysis of ground surface deformation using the DIfferential Interferometric Synthetic Aperture Radar with Small BAseline Approach (DInSAR-SBAS) with Sentinel-1 dataset, and multispectral analysis using Sentinel-2 imagery. The DInSAR time series will allow us to detect subtle ground movements, and characterize the source of hydrothermal manifestations. Meanwhile, Sentinel-2 optical imagery will enable observation of the hydrothermal alterations on the surface.

The combination of these three datasets will provide a unique insight into the geology of the Greek Dodecanese archipelago through the application of geophysical and RS methods specifically designed for deep geothermal exploration at low cost and with low environmental impact.

Influence of Temperature and Heating Rate on Rock Thermophysical Behavior for Geothermal Applications

Fatemeh Tavanaei Sereshgi, McGill University; Adel Ahmadihosseini [Department of Mechanical Engineering, Université de Sherbrooke], Fatemeh Tavanaei Sereshgi [Department of Mining and Materials Engineering, McGill University], Ferri Hassani [Department of Mining and Materials Engineering, McGill University]

In geothermal energy systems, the thermal response of surrounding rock directly governs heat extraction efficiency, structural integrity, and long-term reservoir performance. Accurate knowledge of rock thermophysical properties under realistic heating conditions is therefore essential—not only for predicting behavior during operation but also for evaluating the potential of adjacent cooler rock zones as natural thermal storage. This study examines how temperature and heating rate jointly influence the thermal behavior of two compositionally distinct rocks, basalt and serpentinite, both relevant to subsurface engineering. Over 80 laboratory experiments were conducted using thermogravimetric analysis, differential scanning calorimetry, thermomechanical analysis, and laser flash analysis to measure thermal stability, specific heat capacity, thermal diffusivity, and thermal conductivity across temperatures up to 400 °C and heating rates from 3 to 120 °C/min. Results show that both rock types exhibit pronounced temperature–rate dependence, with distinct endothermic events occurring near 100–150 °C for basalt and 350–400 °C for serpentinite. Heating rate significantly altered the onset, magnitude, and progression of these thermal transitions, as well as derived properties such as conductivity coefficients. These effects were especially marked at elevated temperatures, where faster or slower rates revealed phenomena—such as delayed reactions, thermal lag, and microstructural changes—that would be overlooked under standard testing protocols. By quantifying these coupled effects, the study provides a robust dataset and practical framework for improving geothermal reservoir models. Incorporating both temperature and heating rate into simulations enables more accurate predictions of heat transfer and mechanical stability, while also informing strategies to harness colder peripheral rock volumes as supplementary thermal storage. This integrated understanding supports the design of more efficient, reliable, and sustainable geothermal energy systems.

GEOTHERMAL INM MINECRAFT _ REACHING FUTURE GENERATIOSNS

Simon Kendall, EPDL; JAY EGG MIMI EGG

The geothermal industry faces a critical challenge: a significant decline in public awareness and a shrinking pipeline of future talent in the geosciences. To secure the future of our industry, we must engage the next generation in a medium they understand and embrace.

That medium is Minecraft.

With over 100 million active players, Minecraft is more than a game; it is a digital world where children learn, create, and solve problems. This project will leverage the Minecraft Education platform, which reaches 5 million students annually, to deliver engaging, scientifically sound lessons on the full spectrum of geothermal technologies. The ultimate goal is integration into the main "Bedrock" version of the game, offering unprecedented exposure for geothermal energy.

Project Overview & Status
This initiative is not just a concept; it is a project already in motion.

● Microsoft Partnership: Simon Kendall has secured the enthusiastic support of Justin Edwards, the head of Minecraft Education. The project aligns perfectly with their key themes of sustainability and governance and is endorsed by their partner, UNESCO, as part of its global commitment to sustainability education.
● Developer Selected: A Microsoft-approved third-party creator, i2e Build Studio, has been selected to develop the modules and has already produced a compelling video demonstration.
● Content Vision: The modules will be designed for children aged 7-13 and will cover:
○ Low-enthalpy heating and cooling
○ Thermal Energy Networks (TENs)
○ High-enthalpy power generation
○ Sustainable mineral extraction (e.g., lithium)
● Funding Status: The total budget to create a full suite of initial modules

Heterogeneity in public attitudes and preferences for the deployment of aquifer thermal energy storage

Liu Ting, Imperial College London; Richard Hanna (Centre for Environmental Policy, Imperial College London), Ioannis Kountouris (Centre for Environmental Policy, Imperial College London)

Aquifer thermal energy storage (ATES) can contribute to decarbonising heating and cooling by utilising the thermal capacity of natural aquifers. Securing acceptance and support for deploying ATES at scale requires acknowledging public perceptions and designing systems in a manner compatible with public preferences and expectations. Here we characterise attitudes and preferences for the deployment of ATES in public buildings in the UK. Using data from a social survey and a discrete choice experiment, we find evidence of substantial heterogeneity in public attitudes and support for ATES installations. Latent Class Analysis identifies four distinct attitudinal segments, ranging from cautiously negative to enthusiastically supportive. Estimating mixed multinomial and hybrid choice models, we find strong preferences for quicker deployment of ATES infrastructure, with larger CO2 emissions reduction capacity, that can be accessed by private households. Results point to the need for tailored communication strategies and people-oriented design for achieving socially favoured sustainable energy transitions.

Mine Water Heat Opportunity Mapping across Great Britain

Dan Mallin Martin, Mining Remediation Authority; Watkinson, Katie, Fox, Matthew; Parker, Keith; Wyatt, Lee; Farr, Gareth; – Mining Remediation Authority

Establishing the high level potential for mine water heat schemes over a wide area of interest, can be challenging and time consuming. Simple to use mapping tools are required to support decision makers and energy managers who need to determine whether mine water heat should be considered or not as part of heat network planning strategies.
Mine water heat opportunity mapping is one such way to provide high level screening, producing usable 2D maps based on a simplified set of criteria. Assessing the most impactful criteria to the technical feasibility of a mine water heat scheme, the outputs have been made easy to integrate into mapping systems and simple to digest for non-technical specialists. They can guide decision makers and developers to higher potential areas for further detailed investigation, potentially saving time assessing regional prospects on a site by site basis.

This presentation outlines our approach to opportunity assessments and how it has been used and developed to assess mine water heat opportunities across England, Wales, and Scotland. The presentation will illustrate how opportunity mapping can used, the challenges of making it accessible to audiences, how our methodology has evolved and the future trajectory for refining the assessment method.

Rapid simulation of Aquifer Thermal Energy Storage (ATES) using Machine Learning

Nok Hei Fung, Imperial College London; Issac Ju (Stanford University), Carl Jacquemyn (Imperial College London), Meissam L. Bahlali (Imperial College London), Matthew D. Jackson (Imperial College London), Gege Wen (Imperial College London)

Aquifer Thermal Energy Storage (ATES) offers a sustainable, low-carbon heating and cooling solution for the built environment. However, maintaining ATES system efficiency requires careful optimisation of both design and operation, involving computationally expensive numerical simulations of groundwater flow and heat transport in heterogeneous aquifers. High spatial resolution is essential to capture flow and temperature fields. Advanced numerical simulators, such as the open-source Imperial College Finite Element Reservoir Simulator (IC-FERST) can deliver this by employing dynamic unstructured mesh optimisation (DMO) that increases solution accuracy and reduces computational cost compared to fixed-grid methods. Nonetheless, even these advanced approaches can require run times of order hours to tens of hours. Machine Learning (ML) provides a rapid modelling alternative to conventional numerical simulations of complex subsurface flow and transport processes.

Here, we introduce the Adaptive Physics Transformer (APT), a transformer-based ML model employing an auto-regressive approach with native support for DMO. Unlike conventional ML models such as Convolutional Neural Networks (CNNs), Graph Neural Networks (GNNs), or Neural Operators, which require interpolation onto fixed grids, APT seamlessly handles arbitrary gridding schemes that adapt dynamically at each timestep throughout the simulation rollout. The native support of adaptive mesh data in APT eliminates the need for interpolation, reduces potential sources of error, and enables the model to directly learn the underlying physics and transport processes. Our experiments with a synthetic ATES dataset produced using IC-FERST demonstrate that the APT model significantly accelerates simulations, reducing the runtime of a 10-year ATES scenario from tens of hours to mere seconds, while generally maintaining high accuracy ($R2 > 0.99$).

GeoGrid Leeds – modelling shallow aquifer thermal energy storage for the University of Leeds campus and upscaling storage at a national level

Allegra Giblin Torlucci, University of Leeds; Fleur Loveridge, Simon Rees, Arka Dyuti Sarkar, Joseph Kelly, Emma Bramham, Nicholas Shaw, David Barns (University of Leeds)

Data from the University of Leeds's 2024 geothermal drilling campaign is being used in the GeoGrid project, an Ofgem Strategic Innovation Fund Alpha Phase project in partnership with Northern Powergrid, LCP Delta, Star Renewables, Eon and Leeds City Council. This project is using the University's geothermal living lab as a case study for long duration underground thermal energy storage to address particular challenges in heat electrification. These include minimising grid demand, reducing renewable energy curtailment, and supporting low-carbon heat networks develop to meet 20% of UK heat demand. The project aims to deliver a replicable solution for heat networks across the UK, offering system balancing, resilience, and reduced heating costs.

This study evaluates the feasibility of geothermal seasonal storage using site-specific data to model storage capacity for the campus and extrapolate findings to Leeds and the wider UK. The campus well data, pumping test and thermal response test results provided updated aquifer characteristics, hydrogeological characterisation, and derived groundwater flow estimates. These were integrated into a dynamic model in MODFLOW 6, the USGS's modular groundwater flow simulator, with periods of heat injection and extraction defined as seasonal operation. The system was constrained by a maximum injection temperature to manage environmental impacts and a peak flow rate based on pumping tests. Simulations were run over a five-year period to allow thermal plume stabilization and assess the maximum heat storage potential of a single doublet on campus. The results were compared with analytical and other case study data showing that there is a strong case for a viable geothermal storage system on the campus, with a conservative mid–range analytical outcome of 1500 MWhr ± 500 MWhrs. These results show meaningful useable storage that also increases the efficiency of the ground source heat pumps in the system.

Using groundwater temperature data to reveal subsurface thermal and hydraulic processes

Ashley Patton, British Geological Survey/Cardiff University; Peter Cleall (Cardiff University), Mark Cuthbert (Cardiff University)

Awareness of subsurface heat transport processes is vital for heat-flow modelling and geothermal development. Previously, research into subsurface thermal regimes has largely focused on repeat temperature-depth profile analysis. The use of groundwater temperature time-series data from loggers installed in boreholes to characterise thermal and hydraulic processes has been under-explored.

Here, repeat temperature-depth profile analysis and modelling of the subsurface Urban Heat Island (sUHI) effect are combined with analysis of an unusually rich set of half-hourly groundwater level and temperature time-series data from 48 boreholes in the Cardiff Geo-observatory (UK) between 2014-2018. These data are used to explore the interrelationships between subsurface hydraulic and thermal processes. Time-series curve shape categories have been identified in annual temperature records and are shown to be indicative of distinct flow and heat transport mechanisms. Sinusoidal curves indicate conduction-dominant settings, while 'right-leaning' time-series reveal faster cooling than warming, associated with localised recharge resulting in the influence of advection of heat. Short-lived temperature events discovered on the cooling limbs of right-leaning curves coincide with sharp groundwater level rises, indicative of recharge events. Temperatures rebound within hours of events but do not return to pre-event levels, therefore cooling groundwater faster in winter than it is warmed in summer. Boreholes located close to rivers display more complex behaviours indicating recharge responses coupled with the influence of changes in stream-aquifer interactions which co-occur with heavy rainfall.

The results demonstrate that groundwater temperature time-series interpretation may be a cost-effective way of providing new insights into the characteristics of subsurface hydraulic and thermal processes with implications for geothermal exploration. Recharge-driven advection is seen to a depth of 8mbgl suggesting shallow ground source heat pumps targeting the sUHI effect may be better installed below this depth to ensure system efficiency whilst still utilising enhanced subsurface temperatures, which in Cardiff are seen to 80mbgl.

Optimising Urban Shallow Geothermal Systems Through Near-Surface Geophysical Characterisation

Douglas Lansley, The University of Manchester / Zetica

Urban deployment of ground-source heat pumps (GSHPs) faces challenges from complex subsurface conditions. This work demonstrates how near-surface geophysical methods can optimize shallow geothermal systems for decarbonization. We focus on electrical resistivity tomography (ERT), ground-penetrating radar (GPR), and electromagnetic induction (EM) for site characterization, borehole placement, and thermal feasibility assessment.

ERT effectively predicts thermal conductivity in low-enthalpy systems, showing strong correlations (R^2>0.8) with lithology in clay-sand sequences (Hermans et al., 2015). GPR and EM surveys reduce installation risks by mapping utilities and anthropogenic features, preventing cost overruns of 20-30% in urban areas (Cardarelli et al., 2014). Case studies demonstrate practical benefits: 3D ERT improved borehole efficiency by 40% in Belgian urban sites (Robert et al., 2020), while GPR identified undocumented obstructions in London (Porsani et al., 2012).

These methods show broader potential in aquifer thermal energy storage (ATES) and mine-water systems, where geophysics-guided designs achieve 15-25% energy savings (Fleuchaus et al., 2018). Our analysis advocates integrating infrastructure geophysics with energy transition planning to overcome urban subsurface challenges. This cross-disciplinary approach enhances feasibility while reducing costs and risks in renewable thermal energy projects.

Assessment of common hypotheses adopted in borehole sizing for Ground-Source Heat Pump (GSHP) systems

Fabien Bez, Centre Géosciences Mines Paris; Centre Efficacité Énergétique des Systèmes

The growing demand for renewable energy is driven by the urgent need to mitigate climate change, reduce greenhouse gas emissions, and transition from fossil fuels to sustainable energy sources. Ground source heat pump (GSHP) systems offer an efficient and sustainable heating and cooling solution that is a perfect alternative to meet this demand. The main limiting factor in the development of GSHP is its higher initial cost compared to other heating systems. This work presents a numerical evaluation of the common hypotheses that are frequently used in standard borehole heat exchanger (BHE) sizing for GSHP. To ensure a representative baseline for evaluating the impact of each hypothesis, this study introduces a reference case where parameter values are adjusted based on literature-documented ranges. After validation, the methodology to assess the consequences of each hypothesis on the final BHE sizing is presented. The results quantify the over- or underestimation of borefield length, providing insights into the potential economic implications. For the specific case studied, modeling the pipes as line heat sources, neglecting the influence of groundwater or ignoring the pipe's geometry appear to significantly impact the BHE behavior resulting in non-optimal sizing recommendations. Finally, compared to the Finite Line Source model—widely used in common standard design procedures—the numerical model–based approach resulted in a required BHE length up to 45% shorter.

Understanding the feasibility of Aquifer Thermal Energy Storage using numerical simulations

Carlos Andres Rivera Villarreyes, DHI

The challenge of promoting the application of renewable energy is the seasonal mismatch between the thermal energy supply and demand. To resolve this issue, the technology of thermal energy storage (TES) has been introduced to balance the mismatch, to achieve the efficient usage of renewable energy, and to realize waste heat/cold recovery. The selection of an appropriate storage method depends on several factors such as storage capacity, storage duration, and supply and demand temperature. Underground Thermal Energy Storage (UTES) is a sensible TES method, characterized by high storage efficiencies and high storage capacities and is therefore the preferred choice for long-term TES. UTES can be further subdivided into open-loop or closed-loop systems. In open-loop systems, also referred to as Aquifer Thermal Energy Storage (ATES), sensible heat and cold is temporarily stored in the subsurface through injection and withdrawal of groundwater.
In the present study, we focus on the understanding of performance and efficient of the ATES system via numerical simulations. The finite-element simulator FEFLOW is used to model the subsurface flow and heat transport conditions. The typical operations of ATES system usually contain two stages: a summer stage and a winter stage. Multiple scenarios combined with operation cycles (injection, storage, abstraction) were tested with FEFLOW to evaluate the efficiency and the subsurface thermal impact of the ATES system. Here, we present our most recent simulation results.

An update on the development and commissioning of the United Downs Geothermal Power Plant, Cornwall

Thomas Olver, Geothermal Engineering Ltd; Ryan Law (Geothermal Engineering Ltd.), Poppy Edgecombe (Geothermal Engineering Ltd.)

Geothermal Engineering Ltd (GEL) has developed the UK's first geothermal electricity project at its United Downs site in Cornwall. The power plant is now complete and is undergoing commissioning. Export to the national grid is expected to start during 2025. Commissioning of the plant followed a bespoke, staged process, planned in conjunction with Exergy ORC. The process included further testing and the commissioning of the geothermal doublet (a 5,275 m production well and 2,393 m injection well within a fractured granitic reservoir) and installed production and injection pumps, as well as all plant infrastructure at the surface. The process has also involved extensive discussions with the National Grid. The lessons learned throughout commissioning are important for the planning of additional sites for which GEL already have planning permission.

The United Downs site acts as proof of concept for geothermal power projects in the UK, providing key insights into all stages of development, including initial site selection and financing, the UK planning and regulatory processes, drilling, well testing and stimulation, as well as construction, commissioning and early operation. It is therefore a flagship for further development of the geothermal sector in the UK.

Progress in assessing the feasibility for the installation of high temperature, mine thermal energy storage technologies in the Great Consolidated Mines, Cornwall

Thomas Olver, Geothermal Engineering Ltd; Andres Gonzalez Quiros (British Geological Survey), Mylene Receveur (British Geological Survey), Christopher Rochelle (British Geological Survey), Andy Marriott (British Geological Survey), Poppy Edgecombe (Geothermal Engineering Limited)

The Horizon 2020 funded PUSH-IT project (Piloting Underground Seasonal Heat Storage in Geothermal Reservoirs) aims to develop and test high temperature underground thermal energy storage technologies. The selected technologies are mine water (MTES), aquifer (ATES) and borehole (BTES) thermal energy storage, and are being developed across six European sites. A lead and follower site were selected for each technology.

The follower site for the development of MTES technologies is in Cornwall, UK. Geothermal Engineering Ltd (GEL) and the British Geological Survey (BGS) are investigating the feasibility for MTES alongside the United Downs Geothermal Power Plant. The concept is to store excess thermal energy produced from the geothermal plant in flooded mine workings to aid the seasonal miss-match in demand for heating. The study is assessing, in particular, the suitability of the Great Consolidated and United Mines for MTES. Both mines consist of an extensive network of flooded, interconnected workings, including vertical shafts (≤ 500 m), horizontal workways and stopped sub-vertical mineral lodes.

Conceptual and numerical hydrogeological models are being developed to evaluate various MTES operational scenarios. To aid the formation of the hydrogeological model, a database of historic mine plans and maps has been compiled and georeferenced to key shafts and structures identifiable in the present day. Level loggers have been installed in 7 locations to enable monitoring of water levels and down-shaft temperature profiles have been measured to assess cross flow and mine water stratification. Mine water samples have been collected and analysed to enable the assessment of variations in mine water composition between key shafts. Initial numerical simulations of MTES scenarios have been completed.

Poster Abstracts – Day 2

Deep Geothermal in Practice: Lessons Learned from German Flagship Projects for UK Stakeholders

Stephanie Ostermaier, Roedl & Partner

Germany has already advanced numerous deep geothermal (DG) projects from early concept to full implementation, creating a unique pool of experience for regions aiming to accelerate their heat transition. For the UK, where DG deployment is still in its early stages, these real-world lessons offer valuable insights into how ambitious strategies can be translated into successful projects with practical relevance and clear implementation pathways.

Roedl & Partner has supported multiple German municipalities in delivering flagship DG projects, guiding clients across the entire project lifecycle. Our work does not involve technical planning itself, but focuses on evaluating planning results from an economic perspective and developing proposals to improve overall project viability. In many cases, this also included assessing district heating network integration and heat pricing implications to ensure affordability and long-term competitiveness. Beyond the economic dimension, we also provide legal and tax assessments, enabling municipalities to make sound and compliant investment decisions.

In our proposed presentation, we will present selected lessons learned from these flagship projects, covering governance and permitting processes, financing approaches, business case development and stakeholder engagement. Rather than promoting a single model, we will highlight the elements that have proven effective under varying local conditions, and outline where flexibility and adaptive solutions were critical to project success.

We will also reflect on how these insights feed into ongoing exchanges with policymakers and regulators, including contributions to the EU Geothermal Action Plan, and how they may support UK stakeholders in scaling up DG deployment effectively. The session will provide inspiration, concrete recommendations and a realistic perspective on how deep geothermal can become a cornerstone of sustainable and affordable heat supply.

Investigating the Potential of Geothermal Energy as a Sustainable Heat Source for Enhancing Waste Oil Properties in the Recycling Process of Waste Glass

Kennedy Moranga Anyona, University of Pisa; KENYATTA UNIVERSITY

Geothermal energy is one of the clean, sustainable, and renewable resources, which provides heat energy that is derived from radioactive decay elements within the earth's crust. The non-electric utilization (direct use) of geothermal heat has been reported in various domains that have a need for a sustainable supply of heat energy. Adoption and direct use of geothermal energy in Kenya is one way that can enable waste control to enhance environmental protection and optimize the use of this resource. In this research, heat energy from the geothermal well was simulated using an experimental model in which polyethylene terephthalate (PET) pieces were melted and moulded into usable products under suitable pressure conditions. The objective of this study was to investigate the potential of geothermal energy as a sustainable heat source for enhancing waste oil properties in the recycling process of PET plastics. The ground PET material was exposed to heat, and the resulting molten medium was subjected to selected polymer processing techniques to obtain desired products. The suitability of geothermal conditions in enhancing waste oil properties in the recycling process of PET was investigated through an experimental model and numerical analysis. In the design, the study performed experiments on three controlled factors: temperature, velocity and pressure. The data collected was analyzed by use of MATLAB. This study established, through an experimental model, that the least intrinsic melting temperature for recycling PET was 180 0C, the study further noted that the maximum recycling pressure for PET through experimentation was 1 bar and for effective velocity flow of molten plastic viscosity index of 0.1 to 0.8 was needed. All these conditions are attainable at Olkaria after steam has been used for the generation of electricity before reinjection to the ground. The study recommends that the Kenyan government should explore the utilization of geothermal energy as a sustainable heat source for enhancing waste oil properties in the recycling process of PET plastics.

Keywords: experimental model, geothermal fluid pressure, waste oil, recycling and polyethylene terephthalate

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The Role of Condensate Drainports Chemistry in steam Cleaning in Olkaria IAU Geothermal Power plant

Melissa Nkapiani, Kenya Electricity Generating Company LTD

Steam purity is a significant factor in ensuring availability, reliability and efficiency in geothermal power plants. Geothermal fluid mined in high temperature geothermal fields for electricity is usually two phase at least at the well discharge. Steam turbines are design to take pure steam to generate power and therefore separation is necessary to obtain pure steam from the two-phase fluid. Cyclone separator stations separate steam from water from individual wells or combinations of wells. At ideal situation, 100 % steam separation should occur at the separator station. The steam lines delivering steam from the separator stations have condensate drain ports along the line to get rid of any steam condensate that occurs along the steam line. The first sets of the drain ports near the separator station are the first line of defence against water (brine) carry over and they should remove this carry over such that at the drain ports near the power plant, only steam condensate with no dissolved components is obtained. At times when 100% separation is not occurring, traces of water from the two-phase fluid will be carried into the steam. This can be detected by analysis of water discharged at the drain ports. Continuous monitoring of steam purity is therefore essential in maintaining the power plant operation and to detect changes in steam purity that need intervention.

Closed loop geothermal well solution drilled and completed in basement rocks

Kim Gunn Maver, Green Therma; Camille Hanna (Green Therma), Matus Gajdos (GA Drilling) and Dusan Kocis (GA Drilling)

United Kingdom has a limited sedimentary cover that in many areas are either absent and only in a few areas are in excess of 2 km. Furthermore, the geothermal temperature gradient is only on average 26-28 degrees C/km but with significant higher gradients in Eastern and the very Southern parts of England. It is therefore limited where hydrothermal solutions can be successfully implemented.

A closed loop co-axial solution can be installed at any depth as the heat transfer is conduction and requires no fluid circulation in the geological formations. To achieve a sufficient thermal output a horizontal section is added to the well with the inner pipe being a vacuumized pipe-in-pipe solution minimizing the heat loss of the returning fluids.

To achieve a sufficiently high temperatures for harvesting geothermal energy, basement rocks have to be drilled in United Kingdom. But with ROP in basement rocks in Europe being as low as in 2-5 m/h range, geothermal projects have not been commercially viable.

To substantially increase the drilling speed and especially for the horizontal section an innovative anchoring tool is proposed that is attached behind the PDC bit and mud motor. The tool consists of two or more modular anchoring units that operate in an “inchworm” pattern—gripping the wellbore and pushing/pulling the drillstring. This eliminates reliance on surface weight on bit and torque, decouples the bit from drillstring dysfunction, and substantially increase the ROP especially in abrasive rocks.

This approach will make it possible to implement geothermal solutions much more widely in United Kingdom and for possible direct usage for district heating, district cooling and industrial applications.

Micromechanics of Fluid-Induced Fault Reactivation From 4D X-Ray Microtomography

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Key words - Geothermal Systems, induced seismicity, Faulting, Rock deformation, Fluid injection, Micromechanics

Abstract

Most deep geothermal energy systems involve extracting hot fluids and reinjecting cooler fluids into the subsurface. This process alters subsurface stresses through hydro-mechanical and thermal effects and can induce seismicity. For example, projects in Pohang, South Korea, and Cerro Prieto, Mexico, have produced seismic events of magnitude 5.5 and 5.0, respectively. Such events have raised concerns about the commercial viability of deep geothermal projects, particularly regarding economic and geological risks, as well as social acceptance related to hydraulic stimulation and fluid extraction. Safe stimulation strategies require effective planning and operational management to minimise the risk of induced seismicity, in an ideal case including monitoring of fluid flow, seismic events and ground deformation.

Currently, induced seismicity is regulated using a ‘traffic light’ system based on the maximum magnitude of recorded seismic events. However, management of induced seismicity requires more advanced systems, such as varying the injection protocol continuously instead of waiting for the thresholds to be exceeded when it may be too late. To better manage induced seismic risk, it is crucial to understand small-scale processes like strain and damage evolution during fault reactivation, and spatial-temporal dynamics which inform models predicting catastrophic events.

We present results from fluid injection experiments that combine in-situ fast synchrotron x-ray microtomography with micro-seismic monitoring and control. We show how micro-seismicity and rock microstructure evolve during fluid-induced fault reactivation. Preliminary results show that dilation dominates. We quantify the fault-normal volumetric strain evolution – a key parameter that determines whether rupture continues to runaway failure.

Next-generation geothermal technologies: unlocking Europe's untapped energy potential

Kate Adie, Wood Mackenzie

A wave of emerging geothermal technologies is being developed with the potential to significantly expand resource accessibility across Europe, offering pathways beyond the limitations of conventional hydrothermal systems. The drivers for the growth of these technologies are clear: energy systems require decarbonised baseload power sources – a technological gap exacerbated by the growth and expansion of data centres – and net energy importers are looking to develop native energy sources to reduce reliance on volatile global markets. This presentation examines commercialisation trajectories of breakthrough innovations that could transform the sector's role in Europe's energy mix.

Our research actively tracks the progress and development of emerging geothermal projects and companies across Europe. This analysis includes a specific focus on Enhanced Geothermal Systems (EGS), Advanced Geothermal Systems (AGS), and Geothermal Co-location, such as pairing energy production with lithium extraction or carbon capture and storage (CCS). By analysing the emerging project pipeline, examining both pilot demonstrations and commercial-scale developments, we identify the most promising pathways to deployment.

By combining technical analysis with market intelligence, this research offers a comprehensive framework for understanding the future of geothermal energy in Europe, addressing the critical questions: can technological innovation drive substantial market penetration for geothermal in Europe's energy mix? What opportunities and barriers exist for commercial scale-up of next-generation technologies? How do different technological approaches compare in terms of resource potential, development timelines, and economic competitiveness?

De-risking Geothermal Heat Extraction from Tight Hot Sedimentary Aquifers (GEOGUARD)

Nathaniel Forbes Inskip, Heriot-Watt University; Andreas Busch (Heriot-Watt University), Amy Gough (Heriot-Watt University), Uisdean Nicholson (Heriot-Watt University), Florian Doster (Heriot-Watt University), David Townsend (Townrock Energy), Mayur Pal (Kaunas University of Technology), Tom Manzocchi (University College Dublin))

Many major European population centres lie above Hot Sedimentary Aquifers (HSAs) that contain water at temperatures suitable for direct-use heating. Cities like Paris and Munich already harness low-carbon heat from HSAs, but many regions remain untapped. A major challenge is that many target formations lack sufficient permeability to sustain economic flow rates. Techniques to enhance flow are costly, not well understood, and face low public acceptance.

To help address these challenges, the GEOGUARD project aims to develop a toolbox for assessing technical and economic options to improve flow rates. It will also prepare stakeholders for necessary dialogue on induced seismicity and other manageable risks. The project will focus on three country case studies: Lithuania, Scotland, and Ireland.

Another key theme of GEOGUARD is managing uncertainty in subsurface data, including seismic, well logs, and rock properties. The three case studies differ significantly in data quality: Lithuania has abundant seismic and well data; Scotland has poor-quality seismic and minimal well control; Ireland has almost no relevant seismic and only limited well data from target formations.

High-quality models from Lithuania's data-rich case study will be used to develop an exploration and development strategy for geothermal heat production. This will then be adapted for the more data-limited settings in Scotland and Ireland. Through GEOGUARD, we aim to create methodologies and workflows that help manage key risks linked to uncertainties in subsurface data, ultimately supporting the expansion of geothermal heat projects across Europe.

2D and 3D Geothermal Modelling of the Cheshire Basin: Implications for Geothermal Energy Exploration

Harry Graveling, Keele University; Dr Stuart Egan (Keele University)

As a result of the 2016 Paris Climate Agreement, it was agreed that global hydrocarbon usage needs to be reduced to achieve net neutrality for carbon emissions. Deep geothermal energy has been highlighted as one of the most promising green energy alternatives to help bridge the energy gap that has emerged as a result of the energy transition. The high viability of deep geothermal energy within the UK has been suggested since the 1980s with Permo-Triassic sedimentary basins being highlighted as promising areas for geothermal exploration. Geothermal reservoirs within these basins attain temperatures exceeding the commercial geothermal energy target temperature of 35C.

The focus of this research is the Cheshire Basin, a Permo-Triassic basin predominately composed of aeolian-fluvial and marine sediments located in the northwest of England. This area holds significant geothermal interest within the UK. The main aim of the research has been to provide novel insights into the geothermal potential of the Cheshire Basin, with a particular emphasis on elucidating the thermal structure of the lithosphere to identify the depths to target temperatures within sedimentary geothermal reservoirs.

Regional 2D and 3D geothermal models of the Cheshire Basin based on the finite difference method have been created within the MATLAB 2023a coding environment to assess the geothermal energy output of potential reservoirs within the basin. The main parameters used in the construction of the models are the thermal conductivity and radiogenic heat production values for the lithologies present in the basin. Model results have shown that the basin achieves the commercial geothermal energy target temperature at a depth of 1.6km placing it within the desired geothermal reservoir of the Sherwood Sandstone Group. Furthermore, the 35C target temperature is attained across the entire basin, with the highest temperatures of 83C located within the Sandbach-Knutsford and Wem-Audlem sub-basins.

Numerical investigation of onset of convection in heterogeneous porous media: implication for Geothermal reservoirs

Aman Sharma, IIT (ISM) Dhanbad; Tirtha raj Barman (IIT (ISM) Dhanbad, India) and Prof. Swarandeep Sahoo (IIT (ISM) Dhanbad, India)

Convection is ubiquitous in nature, governing the transport of heat and fluids from the Earth's interior to the atmosphere. In geothermal reservoirs, fluid migration is strongly influenced by spatial variations in porosity and permeability. Recent investigations at the Los Tres Virgenes geothermal field reveal alternating high- and low-porosity rock layers, highlighting the importance of understanding how heterogeneity affects convective processes. In this study, we employ a plane-layer convection model to systematically investigate instabilities in porous media under both homogeneous and heterogeneous conditions using numerical simulations. In both cases, the onset of convection is determined by the critical Rayleigh number and wavenumber, but axial variations in porosity in the heterogeneous case modify these stability thresholds. Our analysis indicates that heterogeneity significantly reduces the critical Rayleigh number and alters the characteristic size of convection cells, with instabilities developing preferentially in fluid-rich zones. Beyond these fundamental insights, the findings suggest that heterogeneity can enhance fluid migration pathways, improving connectivity and the efficiency of geothermal reservoirs. This work also emphasizes the value of developing novel modeling approaches for a deeper understanding of complex geothermal dynamics. By integrating spectral analysis with numerical simulations, this study provides a data-driven framework to evaluate convective processes, which is crucial for optimizing sustainable energy extraction and guiding effective geothermal reservoir design.

Keywords: geothermal reservoirs, convection, porous media, heterogeneity, Rayleigh number, numerical modelling

Unlocking the geothermal energy potential of old sedimentary systems: Linking reservoir quality, geomechanics and flow

Skye T. Tisdell, Heriot-Watt University; Nathaniel Forbes Inskip (Heriot-Watt University), Amy Gough (Heriot-Watt University), Sean O'Neill (Shell)

Hot Sedimentary Aquifer [HSA] systems present an opportunity to harness geothermal energy in areas where traditional hydrothermal heat sources are not available. The Midland Valley of Scotland [MVS] which is home to the major cities of Edinburgh and Glasgow, and approximately 3.5 million people hosts a promising HSA. Despite having a firm technical foundation to develop HSAs, there are still fundamental questions remaining related to the interplay of reservoir quality and hydro-mechanical properties, particularly in diagenetically complex sedimentary sequences, like that in the MVS.

The MVS was initially considered as a source of geothermal energy in the 1980's, but it was concluded that geothermal resources in the region are limited by the aquifer properties of prospective intervals (e.g., Brereton et al., 1988). Despite this, a recent regional-scale estimation of the HSA 'Heat-In-Place' values for the region recognised potential opportunities of 44-116°C hosted by Upper Devonian/Carboniferous stratigraphy (Kearsey et al., 2024). These investigations are limited by a high level of geological uncertainty derived from limited data, summarised input parameters – such as porosity – and coarse resolutions. Furthermore, studies into the sedimentology, diagenetic cements, porosity, and permeability of this stratigraphy imply a high level of heterogeneity (e.g., Ballantyne, 2024).

Using the Upper Devonian/Carboniferous clastic stratigraphy of the MVS as an example, this study aims to investigate the heterogeneity of sedimentological and hydro-mechanical properties and determine the controls upon hydraulic properties in diagenetically complex settings. This study will begin by investigating the variability of the sedimentology, porosity, and permeability of target formations using sedimentary logging and architectural analysis. This will be complemented by fracture analysis and new laboratory data (porosity, permeability, mechanical properties, and thin-section analysis). This study will improve our understanding of the viability of deep geothermal energy in the MVS.

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