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Energy Transition - Geosciences and the Energy Transition: Energy Transfer, Injection and Storage

Date: 07 - 08 June 2021

Event type: Conference, Virtual event

Organised by:

Geological Society Events, 2021 Energy Transition, Energy Group

With special thanks to our sponsor, Ernst & Young LLP.

Course Overview

Geosciences and the Energy Transition: Energy Transfer, Injection and Storage.

The second of a series of webinars and meetings to assess and highlight the role of Geosciences in the Energy Transition (ET). Two more webinars are scheduled for 2021 leading to a Discussion Meeting on the Energy Transition in April 2022 planned to be held in Burlington House.

This second event is focused on reviewing the status and progress on Energy Transfer, Injection and Storage via; CCUS, geothermal/heat, hydrogen, compressed air, radioactive waste and oil/gas stewardship during the Energy Transition.
The meeting format will include breakout sessions for attendees to participate in critical issue discussions and with time to report back to the general meeting.

A recording of the first Webinar in this series on 'Geosciences and the Energy Transition', held in April 2021, will soon be available via this website.

Series Overview and Purpose

An overview of Energy Transition and Geoscience contributions with an aim to cover science progress and achievements in critical areas, the context of geosciences in society awareness, Government policy, finance, insurance, and economic communities.

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The series of meetings will provide updates and discussions on the geological science needed to underpin future energy changes and to promote the systems approach for the collaborations needed for efficient integration of geosciences into the ET.

The series of Webinars/Meetings is aimed at addressing the following questions:

1.What are the recent advances and future needs in geoscience areas critical to the Energy Transition?
2. How can Geosciences contribute more effectively to the Energy Transition?
3. What advances in Geoscience integration into societal needs and public awareness of the Energy Transition are possible?
4. How well is the Geosciences community integrated with other sciences and engineering, and how can a more multidisciplinary, systems approach be achieved?

The outcomes of the series are aimed at:

- Increased and accelerated awareness of the role, contribution and importance of the geosciences to the Energy Transition.
- Highlighting the need for rapid and robust planning and action on responsible resource usage and the use of geoscience skills in the Energy Transition.
- Generating a platform for multi-disciplinary engagement and collaboration across the geosciences and with other sciences as a foundation for future interdisciplinary meetings/engagement on the ET.
- Publications in the online open access journal; Earth Science, Systems and Society (ES3).

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Co-convenors

- **Rob Knipe (University of Leeds)**
- Jon Gluyas (University of Durham),
- Stuart Haszeldine OBE (University of Edinburgh)
- David Reiner (University of Cambridge)
- Frances Wall (University of Exeter)
- Nick Gardiner (St Andrews University and Geological Society Theme Leader)
- Jen Roberts (University of Strathclyde)
- Mike Stephenson (BGS)
- Jo Coleman OBE (Shell).
- David McNamara (University of Liverpool).

CCUS – The Blueprint for Delivery.

Graham Beal (Partner EY Corporate Finance – Government and Infrastructure)

In December 2020 and in May 2021, BEIS published updates to its delivery plans for the stand up of 2 operational CCUS clusters and associated capture projects by the mid 2020's with the explicit aim of capturing and storing 10m tons of CO_2 per annum. The EY team is supporting BEIS in the development of the financial and regulatory regime that will underpin the Government's plans. The presentation will review the key aspects of the Business Model Blueprint and the potential commercial arrangements which are being developed.

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Perceptions of permanence in carbon storage - what is a long time?

Niall MacDowell (Imperial College, London), Stuart Haszeldine (Edinburgh University), and Jon Gibbons (Sheffield University).

Protecting the atmosphere against excess CO2 means reducing emissions and attempting to reduce the already-emitted. Climate models are very clear that temperature is driven by atmospheric concentration, and that atmospheric concentration is decreased by dissolution into the upper ocean> That produces timescales of 10,000 years to return close to (but not actually at) pre-industrial CO2 concentrations. Storage (not capture) of CO2 is being offered by a range of technologies : dense phase injections, aqueous dissolution and mineralisation, biochar and soil carbon, forest biomass, bigger tomatoes, or fizzy drinks. Which is short and which is long? Is nature superior to technology? How do policy makers reconcile the abundant offers of offsets in some technologies, with perceived cost of others. Can equable markets be created to attract and reward investment for reliable purposes?

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Building a social license: subsurface technologies and carbon dioxide removal.
Emily Cox, Elspeth Spence, Nick Pidgeon, Steve Westlake & Conor John, Cardiff University

Meeting decarbonisation objectives may require novel technologies, as well as the considerable scaling up of existing ones. In particular, the emergence of 'net zero' objectives puts the decarbonisation challenge into sharp focus, because certain sectors (e.g. aviation, agriculture) cannot be completely decarbonised within the next few decades. Therefore alongside steep emissions reductions, there will be a need to remove some CO2 from the air using Carbon Dioxide Removal (CDR) techniques. Many proposed techniques interact with the subsurface in some way – either because they require geological storage or mineralisation to sequester the CO2, or because they require mining. We know from past experience that building a 'social license to operate' will be crucial. Developing safe, effective, scalable techniques is not just about getting them to work in a lab or a field; it's also about using them in the 'real world', in ways which will interact with people and everyday lives. To get them right, it is important that we listen to people's opinions and their concerns.

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This presentation describes 3 years of work by our team on building a social license for carbon dioxide removal. We explore public attitudes towards geological storage of CO2, mining of materials, and implications for CO2 mineralisation. We explore the key factors underpinning public attitudes, so that we can gradually build an idea of how people are likely to respond to novel technologies, and important lessons learned for public engagement and communication. Finally, we discuss recent work on attitudes towards deep geothermal energy, and our hypothesis that controversies around fracking have spilled over to negatively impact public perceptions of other subsurface techniques.

Hydrogen and CCS – the opportunities in the future energy system

Nilay Shah, Department of Chemical Engineering, Imperial College London.

The role of hydrogen and CCS in decarbonisation, with a focus on industrial clusters and heat will be reviewed. Recent examples of a study looking at Great Britain and the potential evolution of the system over time will be presented. We shall look at two geographical scales – the whole island and an industrial cluster. The value of geological storage of hydrogen will be quantified. The wider implications for the energy system will also be described.

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Geothermal: Examples and Key Learnings.
Lucy Cotton, and Peter Ledingham, GeoScience.

Geothermal is an established global provider of heat and power with very good environmental credentials but it is under-utilised, particularly in non-volcanic regions. Today, more than ever, geothermal can contribute to regional, national and global targets for carbon reduction and it has the potential to supply significant amounts of decarbonized heat. In the UK the resources exist, we know how to harness them and we have the skill set to deliver deep geothermal wells and grow the industry. In support of the Energy Transition theme, this talk will draw on examples from two deep geothermal developments in Cornwall to highlight the synergies and differences between the oil and gas and geothermal industries.

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CO_2 storage through carbon mineralisation.

Sandra Snæbjörnsdóttir and Bergur Sigfússon, Carbfix, Iceland.

CO_2 storage through mineral carbonation extends the applicability of carbon capture and storage by enabling storage in areas previously not considered feasible: Dissolved CO_2 can be injected into reactive rocks such as mafic or ultra-mafic rocks, promoting carbon mineralisation for CO_2 mineral storage. By mineralising the injected CO_2, it is permanently fixed and there is a negligible risk of it returning to the atmosphere. Recent advances have enabled this method as an industrial scale solution – however, considerable efforts are needed to accelerate the deployment of CO_2 mineral storage including more widespread operation in diverse conditions.

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Power production from CO_2 plume geothermal (CPG) systems

Masoud Babaei, University of Manchester
Jon Gluyas, Durham University.

In order to limit emissions of the greenhouse gas to the atmosphere, a proposed option is to bury CO_2 underground in a process called carbon capture use and storage (CCUS). The U is a recent addition to what was CCS. Until now a large scale industrial process which both uses carbon dioxide and liberates energy was lacking. However, the geo-storage of tens of millions of tonnes of CO2 provides a unique opportunity to monetise the CO2 as the power fluid within geothermal systems. CO2 plume geothermal (CPG) can be used to harvest heat from the Earth more efficiently than can brine geothermal. CO2 as a supercritical fluid is circulated from deep in the Earth (bottom hole temperature needs to be above about 100 degree C), heat extracted to drive a turbine and generate power. The cooled and now denser fluid is returned to the subsurface. No carbon dioxide is emitted to atmosphere and no parasitic power load is required to return the carbon dioxide to the sub-surface. Heat and thus power is extracted via the thermosiphon effect. There are technical challenges but if overcome CPG could become a major source of carbon negative power within a decade.

Here we discuss about current state-of-the-art knowledge on electricity generation from CPG, using different power cycles. The application of realistic heterogeneous CPG models is also discussed where potential implications of simplifying such systems have been largely overlooked in literature.

Heating the Future with Abandoned Coal Mines
Charlotte Adams (The Coal Authority)

The UK has over 23,000 abandoned coal mines formed following the extraction of 17 billion tonnes of coal over the past two centuries. The coal has long since been mined, traded and burned yet the voids that remain following its removal offer many opportunities for supplying resources.
No longer viewed as a liability, the abandoned mining infrastructure is now seen as an asset of strategic national importance that could help to decarbonise heat demands whilst offering a host of other opportunities.
This presentation will outline some of the work being undertaken by the Innovation Team at The Coal Authority with a particular focus on the mine energy opportunity. The Coal Authority also works closely with the British Geological Survey, Durham Energy Institute and the North East Local Enterprise Partnership on developing this innovative approach.

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Hydrogen storage and net-zero.

Katriona Edlmann (The University of Edinburgh)

To meet the UK commitment to reach net zero carbon emissions by 2050 our energy mix must transition from fossil fuels. Hydrogen can support this transition by replacing natural gas for domestic and industrial heat; replacing coal and natural gas for power generation; decarbonise transport and facilitate increased renewable energy by acting as an energy store to balance supply and demand. For the deployment at scale of green hydrogen, (produced from renewables) and blue hydrogen (produced from steam reformation of methane with carbon capture and storage) large-scale storage is required. Our initial studies show that underground storage in porous rocks is essential to facilitate hydrogen as a low carbon energy pathway and that the required storage capacity exists in depleted gas fields within the UK North Sea. **Hydrogen storage and net-zero.** Katriona Edlmann (The University of Edinburgh)

Using Salt Caverns to store Hydrogen

Alan Leadbetter – Technical Director Storengy UK Ltd

The North-West of England is seen as an ideal location for the world's first net-zero carbon industrial cluster. To support this ambition Storengy is looking to develop a salt cavern capable of storing bulk hydrogen on its Stublach site near Northwich.
Over the last 18 months Storengy has carried out two studies covering the repurposing of existing salt caverns and the development of a new cavern. Working with key equipment suppliers an outline development plan has been defined that looks at the design, manufacture, and testing of subsurface and wellhead equipment. The studies have helped define the technical issues, cost, programme, and next steps.
The conclusion is that although repurposing caverns is feasible it brings with it significant technical challenges and a higher risk of unacceptable leakage rates. Creating a new cavern is more expensive and takes longer but greatly reduces the risk of unacceptable leak rates. Storengy is therefore seeking government funding to solution mine a new salt cavern that will be fitted with equipment specially designed for a hydrogen environment to prove the technology ahead of investing in a national scale hydrogen storage solution.

Shale fail: what can we learn for the energy transition?

Richard Davies[1] (richard.davies@ncl.ac.uk), Miles Wilson[2], Lawrence Williams[3], Rachel Brown[1]

[1] Newcastle University [2] Durham University

[3] University of Sussex.

We consider the reasons why gas has not been produced from shale using hydraulic fracturing in the UK and the implications for meeting net zero targets. These reasons include factors both above and below ground. Above ground, shale developments had inherent properties that provoked controversy from the start; there was a rapid online dissemination of a negative version of the US experience; there was a government policy commitment to develop an industry based on expert risk assessment with a lack of early community consultation. This led to mistrust between communities and operators, as well as conflict between councils and government.

Furthermore, the planning system was slow and development plans continued whilst many organisations declared a climate emergency, with shale advocates failing to convince stakeholders that shale gas was aligned with net zero. Below ground, the Science not well enough understood, for example induced seismicity dogged the UK shale gas industry from the beginning. In addition, the geoscience community and media provided poor quality communication to the public on the technical details of shale gas hydraulic fracturing. So how do we avoid repeating history so that the subsurface can be used for geothermal energy and CO2 and H2 storage as part of an energy transition?

*We acknowledge the contributions of the wider UK Unconventional Hydrocarbons Team of 61 researchers (www.ukuh.org)

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Subsurface test laboratories and sites for net zero applications: Dirty hands and Clean Energy.

Linda Stalker (CSIRO) and In-Situ Laboratory Project Team.

Subsurface test labs and observatories are important catalysts for research and technology development. Activities at field sites around the world have driven understanding of geological CO_2 storage processes and impacts, tested monitoring tools and unlocked new research challenges. But to maximise progress from these field sites, it is useful to consider the 'whole picture'. For example, as a scientific community, we are quick to report the successes at these sites, but it is also important to share the set-backs, too. Likewise, though the emphasis of the research may be technical, the non-technical benefits are many.

Here, I will share the 'whole picture' lessons learned from developing CSIRO's In-Situ Laboratory in Western Australia. The world-first experiment injected 38 tonnes of CO_2 into a fault zone at ~300 m below ground. The (re)development of came in part through a setback: land access was lost only days before the deployment of the bottom-hole-assembly for testing reservoir and potential seal formations at the South West Hub CCS Project

With a new site rapidly identified, new research questions were developed, and new permits and approvals obtained to allow wellbore infrastructure to be completed in November 2018, ready for CO_2 injection in Feb 2019, and the site decommissioned in April 2019.

Completed at sprint-pace, the project was successful but not without challenges, which I will share, as well as the key technical outcomes. Further, like other field sites, pilots and demonstrators, the CSIRO In-Situ Lab has stimulated partnerships for knowledge sharing and innovation, and provided upskilling and learning-by-doing opportunities. The project also brought key stakeholders (regulators, industry, research, publics) together. Not only has this enabled broader engagement in energy transition solutions, establishing and maintaining a communication framework amongst key stakeholders brings longer term value around further projects in the region, which is a prospective decarbonisation hub.
In short, field experiments drive progress by getting us out there, getting our hands dirty, together.

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Tracking injection in the subsurface: insights into CO_2 storage security with implications for public confidence.

Gareth Johnson (Strathclyde University).

Carbon dioxide (CO_2) storage is widely acknowledged as an essential part of the net zero transition; enabling decarbonisation of industry, power and providing pathways for engineered CO_2 removal. However, public confidence in the technology is low, particularly in Europe. Multiple factors contribute to public concern, and insights from the 2020 UK Climate Assembly provide a window into the technological concerns held by UK publics. Assembly members expressed concerns around leakage and ‘escape’ of CO_2, stating that there is a lack of understanding of what happens to the injected CO_2 and the potential for ‘uncontrolled disaster’. Monitoring and Verification (M&V) methodologies are a key requirement to satisfy a wide range of stakeholders from regulatory authorities to the investment and insurance communities and the publics

Aims of M&V include assurance of containment of CO_2 and conformance with model predictions as well as the lack of environmental impact. Within these aims the demonstration of robust understanding of the storage processes that take place in the subsurface is critical. The phase of the CO_2 in the reservoir and CO_2-water-rock reactions determine the type of trapping that occurs which in turn influences the storage security. Geochemical monitoring approaches have been shown to be able to determine the trapping mechanisms operating and in some place quantify the contribution of different trapping mechanisms.

Here, we present a number of examples from global field studies of engineered CO_2 storage that show the current state of the art in quantifying trapping mechanisms and highlight where further research is required. The demonstration and communication of monitoring of CO_2 storage and the associated verification of safe and secure storage is critical to informing the societal deliberation around the appropriate deployment of CO_2 storage.

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Deep geological disposal of UK higher activity nuclear waste.

Jonathan P Turner (Chief Geologist, Radioactive Waste Management Ltd.).
Twitter: @JPTgeologist

The deep geological disposal programme will remove the cost of radioactive waste storage and the security burden it imposes on future generations, with enduring socio-economic benefits for the community that will host the Geological Disposal Facility (GDF). A GDF needs to meet two principal requirements: contain radionuclides deep underground for hundreds of thousands of years such that they cannot harm people and the environment; and isolate the waste from surface processes (such as glaciations) and future generations mining into it.

Some twenty years before construction start and thirty years until commencement of operations seems long and stakeholders sometimes pick up on anecdotal comparisons with the oil & gas and mining industries along the lines that they can characterise and de-risk sites in only a few years

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Direct application of these timescales to the GDF programme can however reveal a lack of understanding of its unique context, particularly the challenges of finding and retaining a willing community and safely delivering a first-of-a-kind major infrastructure project in a highly regulated environment that is likely to be contested.

The GDF programme is presently focusing on building strong relationships with communities and concurrently evaluating multiple sites. Comparative assessments of sites will result in a recommendation on which two should be taken forward for site characterisation, including 3D seismic data and deep boreholes. Site characterisation aims to deliver the following outcomes.

- One willing community
- A suitable site
- Organisational and supply chain capability, capacity and resilience
- A balanced national, and supportive regional, environment
- Designs and safety case sufficiently mature to demonstrate the inventory for disposal can be managed, and that risks to disposal are understood and their impact adequately accounted for in the decision to proceed to GDF construction.

This talk will focus on the role of geoscience and geoscientists in delivering this ambitious work programme.

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End of Abstract booklet.

Talks will be uploaded after the event and a link shared with all registered persons.

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