



The
Geological
Society

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Geosciences and the Energy Transition: Resources on a Finite Planet.

Meeting: Sept 6th (Afternoon) and 7th (Morning).

The Geological Society of London,

In association with the Mineral Deposits Studies Group and the Critical Minerals Association.

Sponsored by Ernst and Young



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1 Background to Geosciences and the Energy Transition Series

Geosciences and the Energy Transition: Resources on a Finite Planet

This September event is focused on the resources needed for future energy systems. Contributions are requested on the challenges, future technologies and advances in responsible recovery and stewardship of key resources (including strategic minerals, hydrocarbons, water and soil health) that will all under-pin a successful energy transition. In addition, presentations linked to the investment, circular economies, public awareness and policy needs associated with the future use of earth resources, are all welcome. The virtual meeting will run on the afternoon of the 6th Sept and the morning of the 7th Sept. Presentations will include an introduction and scene setting from Mike Daly (President of the Geological Society) and Julian Kettle, (Senior Vice President, Metals and Mining, Wood Mackenzie).

The aim is to cover science progress and achievements in critical areas, the context of geosciences in society awareness, Government policy, finance, insurance, and economics linked to the Energy Transition.

This webinar is the third of a series in 2021 leading to a Discussion Meeting on the Energy Transition in April 2022.

Series Overview and Purpose

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).*

2 Webinar Co-convenors

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

Additional Co-ordinators for '**Resources on a Finite Planet**':

- Dan Smith (Mineral Deposits Studies Group)
- Jeff Townsend, Kirsty Benham (Critical Minerals Association)

3 Programme

September 6th 12pm to 4.15pm

Introduction (12pm - 12.45pm)

Mike Daly, President Geological Society.

Julian Kettle, Senior VP, Wood Mackenzie. '*The Implausibility of a 2^o Pathway*'

Discussion Q/As (12.30-12.35)

Frances Wall, (Camborne School of Mines, University of Exeter). (10mins)

Outline of the Energy Transition Webinar Series and Meeting Objectives.

Murray Hitzman (Irish Centre for Applied Geosciences) (12.45pm - 1.10pm)
Resources on a finite planet: An Overview. (20mins)
Discussion Q/As (5mins)

Hydrocarbon Stewardship 1.10pm – 2.35pm

Chair: Jo Coleman (Shell)

Iman Hill (IOGP) 1.10pm – 1.25pm

Enablers of the energy transition: the role of oil and gas in a low carbon future.

Paul de Leeuw (Robert Gordon University) 1.25pm – 1.40pm

Building a better and greener world.

Discussion Q/As 1.40pm – 1.50pm

Mike Simmons (Halliburton) 1.50pm – 2.05pm

Demand for 'Advantaged' Hydrocarbons during the 21st Century Energy Transition.

Sian Loveless (Environment Agency) 2.05pm – 2.20pm

Environmental regulation for the Net Zero agenda.

Discussion Q/As 2.20pm – 2.35pm

BREAK 2.35pm – 2.55pm

Water and Soil Resources (2.55pm – 4.00pm)

Chair: Murray Hitzman (Irish Centre for Applied Geosciences)

Alan MacDonald (BGS) 2.55pm – 3.10pm

Groundwater resources in a net zero economy.

Helen Gavin (Ricardo) 3.10pm – 3.25pm

The UK water industry and Net Zero.

Christian Davies (Shell) 3.25pm – 3.40pm

The many roles of microbes in soil and their importance for increasing soil carbon in nature.

Discussion Q/As 3.40pm – 4pm

General Discussion and Close 4pm – 4.15pm

September 7th 9:30 am to 1.15pm

Chair: Introduction/Announcements 9.30am – 9.50am

Frances Wall (Camborne School of Mines, University of Exeter)

Minerals and the Energy Transition. 9.50am – 11.10am

Dan Smith (University of Leicester) 9.50am – 10.05am

Barriers to sustainability in metal supply.

Brett Grist (Critical Mineral Association) 10.05am – 10.20am

The UK and mining: the opportunity to support the Green Industrial Revolution through domestic production.

Erika Faigen / Gavin Bridge (Durham University) 10.20am – 10.35am.

The battery mineral production network.

Discussion Q/As 10.35am – 11am.

BREAK 11.00am to 11.30am.

Circular Economies, Investment and the Energy Transition 11.30am – 12.55pm

Chair: Dan Smith (University of Leicester)

Peter Hopkinson (University of Exeter) 11.30am – 11.45am

Circular economics and energy futures.

Andy Samuel. (Oil and Gas Authority) 11.45am – 12pm

The North Sea: Energy Transition in action.

Discussion Q/As 12pm – 12.10pm

Jon Clark (Ernst and Young) 12.10pm – 12.25pm

Fuelling the Future – different energy pathways and investment.

Frances Wall (University of Exeter) 12.25pm – 12.40pm

The Circular Economy Centre for Technology Metals

Discussion Q/As 12.40pm – 12.50pm

General Discussion 12.50pm – 1.10pm

Future Meetings – Nick Gardiner

Close 1.15pm.

4 Abstracts

Resources on a finite planet: An Overview.

Murray W. Hitzman, School of Earth Sciences, and Director iCRAG, University College Dublin, Belfield, Dublin 4, IRELAND

Even as we (hopefully) move out of the global pandemic, 2021 has seen decided market movement indicating that the Energy Transition from fossil to renewable fuels is well underway. This talk will examine what is happening in this transition, its historical context, and the implications for geoscience and geoscientists. The ways in which Geoscience not only plays a part in, but is actually fundamental to achieving the United Nations Sustainable Development Goals, which include Affordable and Clean Energy.

Enablers of the energy transition: the role of oil and gas in a low carbon future

Iman Hill (IOGP) City Tower, 40 Basinghall St. London, EC2V 5DE.

Oil and gas will continue to play a critical role to meet the world's energy demand. The global oil and gas industry is committed to help meeting the energy demand while also playing a significant role in achieving a lower carbon future and supporting the Paris Agreement goals: by reducing the carbon footprint of its operations, by providing cleaner energy, and by developing low carbon technologies.

The oil and gas workforce will be instrumental in the push for lower carbon operations – and a diverse and inclusive workforce will ensure that the industry has the skills to address the challenge of continuing to supply clean, affordable, and reliable energy around the world. The International Association of Oil & Gas Producers (IOGP) is supporting its global membership in all these efforts.

Building a better and greener world

Paul de Leeuw, Director, Energy Transition Institute, Robert Gordon University | Garthdee Road | Aberdeen AB10 7QB | UK

As each year has its own unique challenges, 2021 will probably be defined by the global response to COVID-19 and the climate emergency. The global vaccination programme, the upcoming United Nations COP26 conference and the prospect to build a better and greener society will provide the opportunity to tackle some of the world's greatest challenges. COVID-19 has helped to unite the world against a common cause and has demonstrated that the global community can step up to do remarkable things. Against this backdrop, the talk will review the role of the subsurface community to build on this positive momentum, to help manage the energy transition and to ensure the sustainability of our planet.

Demand for 'Advantaged' Hydrocarbons during the 21st Century Energy Transition

Mike Simmons & Andy Davies, GeoSciences, Halliburton, Abingdon.

At present, oil and gas comprises ~54.3 % of the global energy supply. Rapidly replacing this with lower carbon sources is challenging, resulting in oil and gas forming a significant part of the energy mix in future predictions, even in scenarios that strive to meet the goals of the Paris Agreement. An analysis of recently published, rapid energy transition scenarios suggests around 950 Bbbl of oil and 4,750 Tcf of gas will be required in the next three decades, with around 280 Bbbl of oil and 2,200 Tcf of gas needing to be found to complement existing recoverable reserves. To place this in context, that is an oil demand equivalent to ~62 % of all of oil we have so far consumed and ~108 % of all the gas we have thus far consumed. A key consideration for the industry will be the emphasis that should be placed on 'advantaged hydrocarbons', those with a relatively low carbon/energy intensity to discover and produce. The concept of 'advantaged hydrocarbons', provides a focus on how the nature of the subsurface and the hydrocarbon fluids impacts on carbon/energy intensity of exploration and production operations. In combination with significant carbon sequestration activity, this will help ensure that demand for hydrocarbons is met in the most environmentally responsible manner.

Environmental regulation for the Net Zero agenda

Sian Loveless, Alwyn Hart (Environment Agency) Danielle Ashton (Environment Agency)
Xiaoqing Wang (WSS Energy)

Low carbon energy technologies that use the subsurface could begin to contribute to the Net Zero 2050 target in the next few years. The drive towards Net Zero and a Green Economy presents significant opportunities but also challenges for environmental regulators. The growth of low carbon technologies will support Net Zero goals and associated Environment Agency objectives, yet even well-intentioned/green technologies can cause environmental harm. We therefore need to be aware of possible unintended consequences from green technologies. However, delays in granting permits due to a lack of knowledge about the technologies and environmental risks could present a barrier to their development, hindering Net Zero ambitions. In addition, we recognise that there could be competition for finite resources and space. Environmental regulation thus requires an evidence and risk-based approach. The Chief Scientist's Group in the Environment Agency is embarking on an ambitious phase of work to provide evidence to support the Net Zero agenda to understand the potential environmental and health impacts of the deployment of different technologies. Topics will include possible unintended consequences and cumulative impacts on the environment of technologies at local, regional and national scale, and the use of already stretched resources. A recent project to assess the potential environmental impacts of low carbon subsurface technologies (e.g., Carbon Capture and Storage, geothermal, Compressed Air Energy Storage, Underground Hydrogen Storage...) has identified some of

the key environmental challenges that we face in England. Existing regulation and use of Best Available Techniques will mitigate many of these challenges, however, we have identified some knowledge and policy gaps that we need to address. In this talk we will outline key environmental challenges and discuss the evidence needs that we have identified.

Groundwater resources in a net zero economy

Alan MacDonald, Principal Hydrogeologist, BGS Edinburgh.

The availability, storage and distribution of water resources is a key component for economic growth and the development of sustainable livelihoods. Water is, however, unevenly distributed across the globe and is often available only seasonally, with climate change leading to more extremes of flood and drought. As the world moves to a net zero carbon economy, the availability of reliable water for emerging industries, food and domestic consumption cannot be taken for granted. Groundwater resources offer great potential for current and future economies, with natural storage, widespread availability, and the ability to buffer short term changes in climate. However, competing demands on the subsurface for infrastructure and mining, to assimilate waste, capture carbon and store heat will all need to be managed to ensure the benefits of groundwater can be accrued to future generations. Similarly, the planting of trees and changes to landcover to help capture carbon also has a knock-on impact on hydrology, and both hydrology and carbon capture will need to be considered to maximise benefits and manage trade-offs.

The UK water industry and Net Zero

Helen Gavin, Associate Director, Ricardo Energy & Environment, UK.

This talk will focus on the water-energy nexus and summarise the way energy is used in the UK water industry, and how this dominates its carbon footprint. The different ways in which energy is consumed to produce clean drinking water, and process wastewater, as well as the generation of electricity and gas by water companies will be covered. The issues and opportunities in reducing energy use will be reviewed and what may be possible for the industry to achieve its voluntary goal of net zero emissions by 2030 outlined.

The many roles of microbes in soil and their importance for increasing soil carbon in nature.

Christian Davies, Principal Science Expert for Shell's Nature Based Solutions, Houston.

Barriers to Sustainability in Metal Supply

Dan Smith, University of Leicester, Leicester.

A move away from fossil fuels is a move towards a more metal-intensive global economy. The increasing demands for industrial metals (Fe, Cu, Al) and specialty metals (REE, Li, etc.) cannot be met without mining. Environmental and social impacts of mining are thus a key concern in the energy transition. More sustainable mining is a challenge. Mining is a complex industry with public and private sector involvement, at scales from cottage industry to multinational corporations. Many metals are extracted from low grade ores with considerable waste production, energy demands, and water consumption. Mines often have indirect and cumulative impacts which extend their footprints beyond the remit of operators.

Corruption and weak governance undermines local laws, and so increasingly, market and investment-based controls are the frameworks in which mining is monitored and regulated. Better tracking of materials through complex supply chains will be needed to empower consumers to purchase ethically.

The UK and mining: the opportunity to support the Green Industrial Revolution through domestic production

Brett Grist, Co-Chair, UK Mining Group, Critical Minerals Association, and Exploration Manager, Cornwall Resources Limited) and James Blight, Senior Geologist, Cornwall Resources Limited.

'The UK's Green Industrial Revolution cannot be delivered without significant use of raw materials. Products of mineral extraction such as copper, tin, rare earth elements (REEs) and lithium are needed to build the low carbon technologies required to reduce our reliance on fossil fuels.'¹

The UK as a nation now has a choice; it may encourage best practice mining in its backyard, and thereby achieve security of supply of critical and strategic metals, ranging from lithium through rare earth elements to tungsten, or it may instead elect to 'offshore' production, to countries where standards may, at times, be unevenly applied; reducing the gain from green changes to, for example, transport, energy generation and storage.

The UK as recently as the 19th Century accounted for a large proportion of global copper and tin production. These metals and others are now required for the Green Industrial Revolution. UK supply did not stop due to a lack of metal, but due to a short-term drop in metals prices. With metals prices approaching modern-day highs and increasing interest in the range of metals that the UK (and in particular SW England) is endowed with, now is the time for the UK to develop a renewed metals industry to deliver secure local supply.

There are, however, a number of legal and social barriers, some unique to the UK, that have limited the range of activity and modern-day competitiveness of the UK in this area. These include an antiquated mineral rights system, a lack of centralised government support, and challenges in attracting capital.

This presentation summarises examples of current activity in the UK minerals space, covering lithium, tungsten, tin, and copper, as case studies of effective modern exploration of UK mineral potential, and then asks what else the UK could be doing to stimulate activity to the level that its geological prospectivity warrants.

¹ *Critical Minerals Association publication, July 2021 'Enabling the UK's Green Industrial Revolution; A blueprint for responsible sourcing of Critical Minerals'*

Financing resource projects for the Energy Transition

Simon Gardner-Bond, Chief Technical Officer, TechMet, 20 Lower Baggot Street, Dublin 2, D02 X658, Ireland

Historically the majority of early-stage resource development has been equity investors, as banks are normally worried about the volatility of the underlying commodity price that drives the returns for a new project. With the energy transition requiring a change in energy systems, and a change to the mix of metals and commodities required, will the funding structures change? Are governments and banks willing to back their own rhetoric with

financial support? Do equity investors look at technology metals projects in a different way to more traditional resources? What are the key attributes of a critical mineral project that make it attractive to an equity investor? How important is ESG to the consideration of financing a project?

Towards a lithium-ion battery production network: Thinking beyond mineral supply chains

Erika Faigen and Gavin Bridge, Department of Geography, Fellow, Durham Energy Institute, Durham University.

In this presentation we outline a 'global production network' (GPN) for lithium-ion batteries, highlighting the intersections of battery manufacturing with the automotive and power sectors. Our approach augments conventional mineral supply chain accounts of battery manufacturing in two ways: by identifying the economic and non-economic actors, network relations and multiple locations that constitute the GPN for lithium-ion batteries; and by focusing on strategies of innovation, cooperation and competition through which this network acquires its organisationally and geographically dynamic character. We offer some concluding reflections on the anticipated effects of these battery network dynamics for energy transition.

Why we need a circular economy for a resilient and secure energy transition.

Peter Hopkinson, Co-Director for the Centre for the Circular Economy, Stella Turk Building University of Exeter, Penryn Campus, Penryn, TR10 9FE.

The circular economy is a systems framework that provides a set of principles to move away from the current dominant 'take, make, waste' linear economy to a high value industrial economy that designs at waste at the outset, keeps products and materials in use at the highest value for the longest time and rebuilds natural capital. In doing so it reduces demand for virgin materials, dramatically increases resource productivity and drives down greenhouse gas emissions at all stages of the value chain. Many aspects of the circular economy are not new, people have been thinking about the pressures on the planet for 40-50 years, but the urgency to take meaningful action to reduce climate change and mitigate biodiversity loss is growing and circular economy has a key role.

A circular economy is about much more than recycling. In fact recycling is sometimes called the 'loop of last resort' wherever products and materials are degraded and downcycled. Whilst traditional resource efficiency has a role to play in reducing material demand, this will not by itself achieve the step-change required to meet net zero or allow for continued economic growth within planetary boundaries. To create superior value in a circular economy and achieve non-linear gains in resource productivity requires attention to four simple building blocks; the way we design products and services; the business models we use to connect producers and users; the logistics networks needed to circulate and cascade materials at their highest value and a series of system enablers including policy, regulation, finance, innovation and collaboration. Taken together these building blocks requires a collective change in mind set from cradle to grave to cradle to cradle.

Geologically derived materials are fundamental to a future regenerative circular economy. Critical materials with their lower volumes and often high diversity of uses pose particular challenges to track, re-use and recover. To address the current very low rates of recovery of embedded critical materials within many products there is a pressing need for systemic innovation and investments across the entire value chain to maintain, reuse remanufacture and upcycle materials at their highest value.

Whilst it is scientifically impossible to fully close material loops and avoid losses of materials across the value chain, there are many technologies, innovations and solutions to radically increase the retention of materials at a profit throughout the whole value chain and in doing so reduce the materials environmental burden and address the multiple pressures and stresses on global planetary systems. The circular economy offers a compelling, proven business case but requires collaboration and co-ordinated action amongst all agents and actors. The alternative is continuing biophysical of planetary life support systems and increasing brittleness of economic and industrial systems.

The North Sea: Energy Transition in action.

Andy Samuel, *Chief Executive*, Oil and Gas Authority, 48 Huntly Street, Aberdeen, AB10 1SH.

Dr Andy Samuel will provide the UK's Oil and Gas Authority's perspective on the role of the oil and gas industry in helping deliver net zero, as well as the personal perspective of a geologist highly alarmed by the climate emergency. He will discuss the significance of the North Sea Transition Deal – designed to ensure a managed transition away from fossil fuels by investing in alternatives – and the vital role of the OGA in holding industry to account on their emissions reductions. Dr Samuel will also outline his vision for the future of the UKCS, including energy integration, CCS and the leadership that's required.

Fuelling the Future – Different energy pathways and investment.

Jon Clark, Oil and Gas Strategy and Transactions Leader, Ernst and Young, UK.

There are multiple paths for energy transition. This presentation will discuss some of the key variables shaping the future energy landscape, and organisations' strategic responses to navigating investment decisions in this diverse and uncertain environment.

The Circular Economy Centre for Technology Metals.

Frances Wall (University of Exeter).

This talk will review a project that brings together world-leading researchers to maximise opportunities around the provision of technology metals from primary and secondary sources, and lead materials stewardship (Met4Tech). A planned National Technology Metals Circular Economy Roadmap aims to accelerate us towards a circular economy.