



Editorial: Earth Sciences and the Race to Net Zero

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Editorial on the Special Issue

Earth Sciences and the Race to Net Zero

The race to net zero emissions, where greenhouse gas emissions match removals, is underway as part of the global response to the threat of climate change. To achieve net zero, change is required at pace and scale across all sectors of the global economy to first drastically reduce anthropogenic greenhouse gas emissions, and then to offset remaining outputs through carbon removals. Transformative action is required to deliver net zero in a sustainable way, as systems transitions alone are insufficient (Schipper et al., 2022).

The global goal is to limit the rise in global mean surface temperatures to well below 2°C and preferably below 1.5°C above pre-industrial levels by 2100 (United Nations Framework Convention on Climate Change, 2015). When this Special Issue “*Earth Sciences and the Race to Net Zero*” launched in early 2019, the goal of 1.5°C was still within our reach. In the 2 years since, it has become increasingly likely that global temperatures will overshoot this, at least temporarily (World Meteorological Organisation, 2023). Net zero may no longer be enough: to rebalance the carbon budget and ensure a safe climate, net negative global emissions (where greenhouse gas removals outsize emissions) may become necessary beyond 2050 (Riahi et al., 2022). The finish line of the race may be moving but the goal remains the same: a healthy planet Earth.

The past decade has seen a decoupling between emissions and economic growth in some countries (Hubacek et al., 2021). However global energy-related CO₂ emissions reached an all-time high in 2022 (IEA, 2023a). Reducing emissions from the heating and cooling sector has proven particularly challenging and is becoming increasingly complicated by demand spikes associated with more extreme weather events across the globe and the global energy crisis and related risks to energy security (IEA, 2023b). It is perhaps not surprising then that five articles in this Special Issue examine the role that Earth Science could play in providing low-carbon heat. Three Original Research articles explore repurposing of coal mines for heating and cooling (Walls et al.) and associated monitoring (Monaghan et al.; Chambers et al.), with a Perspective outlining the importance of putting place and context at the heart of these geoenery developments for sustainable transition (Roberts et al.). A fourth Original Research paper on low-carbon heat provision examines the concept of a geothermal circular heat network (Fraser-Harris et al.).

A second theme within this Special Issue is the role of the subsurface for energy storage and waste disposal, including geological CO₂ storage. Original Research articles include exploring CO₂ storage prospects (Lloyd et al.), co-locating developments for wind energy and CO₂ storage offshore UK (de-Jonge Anderson and Underhill) and developing workflows to identify regions

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with high hydrogen storage potential in Australia (Walsh et al.). In their Review, Kaminskaite et al. explore the importance of understanding physiochemical processes to ensure efficient and sustainable use of the subsurface and outlines key knowledge gaps that need to be addressed.

During the timeframe of this Special Issue, the importance of Earth Science for climate action has risen up the global agenda. There is now increased awareness of the interconnections between raw materials such as critical minerals for low-carbon technologies (Jowitt, 2022), circular economy, energy storage and waste disposal, as well as strengthened calls for decreased reliance on hydrocarbons for energy supply accompanied by no new oil and gas developments (IEA, 2021). The range of ways that Earth Science contributes to a sustainable energy transition—directly or indirectly—is explored in Gardiner et al., and spans across geoscience sectors, skills, knowledge, data, and infrastructure. In their Review, Velenturf et al. focus on the offshore wind energy sector, and the role of geoscience for sustainable offshore wind energy developments. Stephenson et al. review the importance of pilot and demonstration facilities for understanding and upscaling subsurface technologies, providing a particularly critical role for enabling low carbon solutions given the pace and scale of technology development required for net zero. Working across sectors and stakeholders is a theme across all articles in this Special Issue.

Collectively, the twelve articles in this Special Issue *Earth Sciences and the Race to Net Zero* demonstrate the critical role Earth Science research is playing—and will continue to

play—in climate action. The articles identify opportunities and challenges across different applications, systems and scales, they issue calls of caution and calls to action, for geoscientists and society, and raise emerging and cross-cutting issues. Multiple authors identify potential conflicts and challenges in the potential future uses of the subsurface and resources. Several future research directions are given, all with a shared destination: securing a safe climate. The challenge now is to translate research into action to improve progress and performance that will deliver the essential acceleration required in the race to—and beyond—net zero.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

CONFLICT OF INTEREST

Author CY is employed by the company Cornish Lithium Plc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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