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Greenhouse gas removal technologies: A focus on the commercial opportunity

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A discussion paper

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Grantham Institute discussion papers use evidence to present thought-provoking reflections on topical issues.

These opinion pieces are intended to inspire action and provide ideas for further research.

What is the role of greenhouse gas removal in meeting climate change targets?

Building on previous scientific evidence, the most recent report from the Intergovernmental Panel on Climate Change (IPCC) highlights the importance of rapidly cutting net emissions of greenhouse gases from human activities to zero, to avoid the worst impacts of climate change[1]. The challenges of achieving this pace of change globally, plus meeting targets in certain significant sectors, makes it increasingly likely that greenhouse gases will need to be deliberately removed from the atmosphere. Estimates of the quantity vary broadly, but are substantial. Approximately 12 Gigatonnes of carbon dioxide ($GtCO_2$) will need to be removed globally per year by 2100, to tally with the IPCC scenarios that have greater than 66% chance of limiting global warming to 1.5°C[2]. Scenario models such as these often use greenhouse gas removal (GGR) by Bioenergy from Carbon Capture and Storage (BECCS) as a proxy for all negative emissions technologies (NETs), because many NETs are only at a very early stage of development. The UK's Climate Change Committee notes that the UK must remove 0.06-0.1 $GtCO_2$ per year by 2050 to meet its national targets as cheaply as possible[3]. However, currently less than a few thousand tonnes of emissions are being artificially removed globally each year, and none of these in the UK[4]. One recent study estimates that 0.13 $GtCO_2$ per year by 2050 is feasible but challenging for the UK[5]. As such, it is increasingly critical for UK policymakers to to fully investigate the role that GGR could play, and to consider how government policy would actively promote GGR, as part of the wider set of greenhouse gas reduction policies. Substantial research and development; support for testing and deploying technologies; and market development policies are needed to add incentives along the whole value chain for greenhouse gases, effectively creating a market for greenhouse gas removal[6].

Realising and scaling greenhouse gas value chains: The market information gap

Developing a GGR sector of a sufficiently large scale to address climate change will require the co-evolution of policy, regulation, innovation and investment[7]. The private sector will also need to be harnessed to deliver innovation and investment at sufficient scale.

In the UK's liberalised market, private companies can decide how to engage in new opportunities like GGR. By understanding the relative size of the market, and the potential revenue streams in the prospective GGR sector, it is possible to understand the drivers for private companies to compete for a share of the profits[8].

Innovation by companies is driven by an expectation of profit, which is a function of the size of the market and how competitive it is[9]. However, detailed discussion of market size, revenue pathways, potential policy support and business models is currently absent from the discourse about GGR in the UK[10], acting as a barrier to innovation.

Early analysis indicates a £39 billion market

One study indicates that GGR value chains could have a cumulative value of between £35.3-38.8bn in 2050[11], spread across a wide range of technologies. These pathways often used biological plants to remove carbon dioxide (CO_2) from the atmosphere, and then employed a range of pathways downstream to use the biomass and eventually store the CO_2 permanently. These pathways featured techniques such as pyrolysis, afforestation, biofuels, electricity production etc. as part of that chain. In this study, the highest value market was found in a distributed biomass pathway that encompassed biochar, wood construction, biofuels, afforestation and associated payment for ecosystem services[11,12]. The largest single source of this value came from the electricity generation component. Diversifying revenue and accessing existing markets such as electricity, fuels and construction, reduces the financial risk that would come with a single pathway or market.

1 V.Masson-Delmotte et al., 2018 Global warming of 1.5C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change. 2018. IPCC, Geneva Switzerland.R.

2 Fajardy, M., Koberle, A., MacDowell, N., and Fantuzzi, A. 2019. BECCS deployment: a reality check. Grantham Institute Briefing Paper No 28 January 2019.

3 Committee on Climate Change. *Reducing UK Emissions, 2018 Progress Report to Parliament* June 2018.

4 See: http://carbonengineering.com/ and http://www.climeworks.com/

5 Royal Society and Royal Academy of Engineering 2018. *Greenhouse Gas Removal* pp 136.

6 BEIS, 2017. Clean Growth Strategy.

7 Geels, F.W., 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental innovation and societal transitions,* 1(1), pp.24-40.

8 Wegner, M.S., Hall, S., Hardy, J. and Workman, M., 2017. Valuing energy futures; a comparative analysis of value pools across UK energy system scenarios. *Applied Energy,* 206, pp.815-828.

9 Grant, R.M., 1991. The resource-based theory of competitive advantage: implications for strategy formulation. *California management review,* 33(3), pp.114-135.

This first estimate of market size indicates that, in the appropriate policy environment, GGR markets, and the associated commercial opportunity, might be substantial.

Keeping it sustainable

It is vital that the development of GGR does not unintentionally damage the environment through land-use change, impacts on water use and biodiversity. Recent analysis suggests that the maximum global sustainable biomass is around 100 Exajoules (EJ) per year, with a potential to remove 3-4 $GtCO_2$[5] annually, and constraining the upper limits of a biomass-based GGR market. This figure indicates that the required 12 $GtCO_2$ is not yet achievable and the commercial opportunity is likewise constrained. Strong governance processes would be needed to ensure compliance with sustainability criteria, confirm the removal of greenhouse gases and safeguard environmental benefits overall.

Further commercial insights are required

Evidently, the technical feasibility of a large-scale, commercially-viable GGR market still needs further testing. In addition to understanding the market size and value chains for GGR, it is also important to consider how business models – even in a smaller market – would operate from a human-centred design (HCD) perspective i.e. viability, desirability and feasibility[13].

Some example questions include:

- How can GGR products meet individuals' or business's needs?
- What are the transactional relationships between stakeholders?
- How ready are GGR technologies?
- What market frameworks would stimulate a GGR sector whilst adhering to sustainability constraints?

Working with users builds trust

To answer these questions, as with all climate change mitigation approaches, GGR advocates need to engage directly and openly with a range of stakeholders[14]. This dialogue can build shared value and trust between society and the actors who will capture the value from GGR. The development of shared values is fundamental to allowing the expansion of these technologies in a socially-inclusive and environmentally-beneficial manner.

Policy recommendations

To help stimulate GGR, think tanks, policymakers, regulators, researchers and business developers should consider the commercial aspects of this growing area as well as the human-centred perspective.

It is time to complement the techno-environmental analysis and start designing socially-acceptable, testable business approaches.

10 Wegner, S.,M. et al, 2017 p.816 Ibid.

11 Platt et al., 2018. A novel approach to assessing the commercial opportunities for greenhouse gas removal technology value chains: Developing the case for a negative emissions credit in the UK. In Journal of Cleaner Production 10.1016/j.jclepro.2018.08.291.

12 The sustainable biomass is within the sustainable estimates cited in Fajardi et al., 2019. Pp14.

13 Tim Brown 2009. Change by Design: How Design Thinking Transforms Organisations and Inspires Innovation. Published by Harper Collins.

14 Hall, S., et al, 2019. Utility 2050 – Electricity Futures and the 'Third Wave of Systems Innovation'. Energy Systems Catapult Report.

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