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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

Devon Platt [a], Mark Workman [a, *], Stephen Hall [b]

[a] Energy Futures Lab, Imperial College London, London SW7 2AZ, UK
[b] Sustainability Research Institute, University of Leeds, Leeds LS2 9JT, UK

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ABSTRACT

In the UK the development of greenhouse gas removal (GGR) technologies at scale by 2050 is seen as an increasingly urgent imperative; necessary to ensure alignment of the UK's carbon targets with international efforts to limit the global temperature increase to 2 °C or less. As such, GGR is an increasingly critical topic for UK climate policy. So far, GGR research has focused on top-down assessment of techno-environmental potential and carbon abatement costs - an approach which aids integrated assessment modelling but does not provide the commercially relevant analysis necessary to understand potential routes to market for this sector. This research reduces this knowledge gap by employing a novel bottom-up perspective to determine the financial opportunities available to GGR business models in Biomass heavy UK energy scenarios. This delivers results relevant to national and sectorial policy and decision making, by quantifying revenue opportunities from future GGR value chains, as well as business model performance. It also informs the innovation, policy, and regulatory environment required to ensure market development and resilience of different revenue streams. The work concludes that energy market policy - specifically access to a carbon credit mechanism - has by far the greatest near term opportunity to drive the negative emissions technologies we assess. This is because the values in this market far outweigh those in related supply chains such as: enhanced oil recovery, afforestation payments, biochar markets, and industry and commercial uses of captured carbon. This data shows that negative emissions technologies in the UK, should not be led by agricultural and land use policy, but should be integrated with energy policy. To do this, the development of a carbon storage credit mechanism analogous to the existing carbon price floor is key. As a proof of concept for a novel method to generate commercially relevant insights for GGR scale up, the research clearly demonstrates that the value pool method provides critical insights to assist GGR development and could form the basis of further work.

1. Introduction

1.1. The international challenge ahead: negative emissions

Despite significant attempts to advance progress towards global greenhouse gas (GHG) emissions reduction, there is unequivocal evidence that more substantial action will be necessary in order to meet internationally agreed climate targets. This is observed in the disparity between the emissions pathways compatible with keeping global temperature change to well below 2 °C such as the RCP 2.6 emissions pathway relative to other scenarios (Rogelj et al., 2016) - see Fig. 1.

Eighty seven percent (101 of 116) models consistent with the 2 °C target require net-negative emissions - the net withdrawal of CO_2 from the atmosphere - in the second half of this century (Fuss et al., 2014). Central projections suggest that 600 $GtCO_2$ need to be removed. This can only be achieved by the deployment of greenhouse gas removal (GGR) technologies on a scale equivalent to today's largest industries, such as the Oil and Gas sector, to capture and permanently store CO_2. To achieve this goal within an adequate time frame, these technologies will require development at an unprecedented rate of diffusion through research, policy support, and commercial investment at a global scale.

* Corresponding author.
E-mail address: mark.workman07@imperial.ac.uk (M. Workman).

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Abbreviations

BECCS	bioenergy carbon capture & storage
BEIS	Department for Business, Energy and Industrial Strategy
BM	business model
CCS	carbon capture & storage
DAC	direct air capture
DECC	Department for Energy & Climate Change
GGR	greenhouse gas removal
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
NERC	National Environmental Research Council
PPM	parts per million
VI	vertically integrated
VP	value pool

1.2. Greenhouse gas technologies: the UK perspective and the significance of firms and investment

The prominence of greenhouse gas removal for UK policymakers reached a significant milestone in 2017. A report by the Parliamentary Office of Science and Technology (2017) concluded that net zero emissions may be difficult and more costly to achieve without GGR, whilst also underlining the absence of specific policy in this area. In addition, the Committee on Climate Change (2017) emphasised the requirement for further climate strategy development by the UK government, as a necessity for deeper emissions reduction beyond 2030. Greenhouse gas removal, as well as related areas of carbon capture and storage (CCS) and sustainable bioenergy, were highlighted as key areas requiring substantial and immediate progress to achieve the 2050 target of 80% reduction in emissions below 1990 levels - which require a reduction from 466 MtCO2e in 2016 to 120 MtCO2e in 2050.

The government response to the Committee on Climate Change report outlined a UK GGR strategic approach with two main elements (BEIS, 2017):

- A research programme, enabled through £8.6 million of funding for the National Environmental Research Council (NERC); coupled with a commitment to develop estimates of sustainable biomass resource available to the UK; and
- A study to consider the scope for removing barriers, strengthening incentives and introducing a policy framework to support GGR deployment, with the ambition for the UK to become a sector leader. Areas of interest include development of a carbon offset market and UK timber for construction.

It is in the context of these recent publications, and most specifically the second element of the government strategy that this work looks to advance: A better understanding of prospective GGR policy in the UK, and question whether more immediate measures can be taken using existing policy tools in established markets.

1.3. The implications of greenhouse gas removal technology development in de-carbonisation

The development of negative emissions in the UK emissions reduction policy mix provides much flexibility to where decarbonisation innovation needs to be directed, and the allocation of energy carriers – especially biomass (Committee on Climate Change, 2011). In conjunction with Carbon Capture and Storage (CCS) development, biomass would be allocated very differently in 2050 compared to a future without CCS development – see Fig. 2, below.

In a 2050 UK future without CCS and negative emissions, biomass is allocated to the production of liquid transport fuels for aviation and shipping. There would also be the requirement for substantial breakthroughs in low carbon technology development in bioenergy such as biofuels from algae or changes in consumer behaviour e.g. diet and or travel behaviour. Whereas with CCS and negative emissions, biomass is instead allocated to electricity and heat production as well as hydrogen surface transport with as well as an allocation to biofuels for aviation and shipping. Thus the

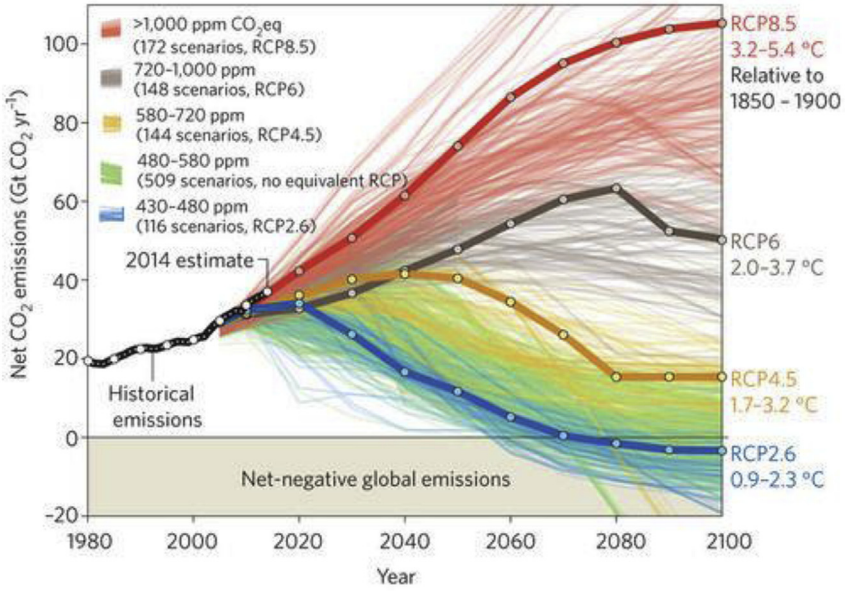

Fig. 1. Graph showing IPCC Integrated Assessment Models (IAMs) and the requirement for net-negative global emissions to limit CO^2 equivalent to 480 ppm to keep temperature change to 2 °C or less (Fuss et al., 2014).