Written evidence from Carbon Technology Research Foundation (ENB0031)

Introduction

The Carbon Technology Research Foundation (CTRF) seeks to invest in discovery research which will be able to scale up swiftly. This is important as our focus is on solving the climate crisis through greenhouse gas removal by utilising the power of engineering biology. Though we are UK based, we fund globally; climate change is a global challenge, and it is only right that the science with the best chance of success is funded, regardless of its location. It is from these perspectives that we will provide our evidence.

What are the key applications for engineering biology?

When discussing engineering biology, there is a tendency to focus on health and clinical applications, and on bacteria. Often the next application considered is the development of a sustainable chemical industry. These areas are extremely important, yet CTRF focuses on an area that is rarely discussed – the removal of greenhouse gases including carbon dioxide and methane from the air and water.

To achieve net zero it is implicit that greenhouse gas removal will be needed, and not just decarbonisation. This leads to the requirement for removals of the scale of 10Gt/year by 2050. This will need a $1 trillion industry to be developed, which is larger in terms of volumes moved than the oil and gas industry is today. This is an extreme challenge, but one that remains possible.

Conceptually speaking direct air capture, where carbon dioxide is chemically absorbed from air, is the simplest to appreciate. There is also the argument that nature has provided us with an excellent method of removing carbon dioxide from the air – a tree – and we should simply plant more to restore the atmosphere to its pre-industrial revolution status. The vision that CTRF has is to augment existing natural systems using engineering biology (as defined by the UK government) and allied research disciplines across the biological sciences, instead of relying upon methods such as direct air capture.

To give some specific examples:

- Metabolic engineering in plants and algae – enhancing specific enzymes related to photosynthesis, novel carbon fixing pathways or otherwise enhancing photosynthetic efficiency.
- Soil carbon sequestration – adapting the root-soil ecosystem and exploring the sequestration potential of archaea.

- Engineering of photosynthetic organisms – engineering faster growing strains of algae, bacteria or fungi and new strains producing a higher proportion of carbon within their biomass.
- Ocean carbon removal – development of new kelp and seagrass
- Biotech enhanced weathering – the use and enhancement of various microorganisms to increase the rate of rock weathering.

We are agnostic on the precise route that researchers propose, meaning that they produce a wide array of suggestions. What is common to all of them is that they must propose the use of engineering biology to achieve their goals. This might be synthetic biology or metabolic engineering; it might be something completely different. The target might be bacteria, plant or even animal or archaea as their proposal may warrant.

The range of engineering biology options that are proposed to us means that we would advocate for a holistic vision of the area, which integrates across into other fields such as agriculture, health and the chemical industry. The UK is renowned for its strong academic sector, and engineering biology is no exception. Equally though, the broad challenges of interdisciplinary research, maintaining a pipeline from academia into industry, and recruiting a skilled workforce, remain present.

In the area of greenhouse gas removal, engineering biology can have a truly transformative impact. The principal reason for this is scale. Even a very modest improvement on carbon sequestration in crops would have an extremely significant impact if applied across all crops grown in the UK. A similar case can be made for any of the routes we consider, which is part of the reason we seek not to pick a winner among the methods but seek to develop a portfolio of different engineering biology approaches which all remain sufficiently funded.

The current challenge is to address scientific and technological issues, which are different across the different strands. This is because to scale up the carbon removals industry to the necessary scale by 2050 requires a significant and sustained increase every year. Current methods are being used in the kiloton scale per year, with initial deployments in the megaton scale. We require 10Gt/year, and preferably more, by 2050. Over the next five to ten years the most promising routes to scale up need to be identified and funding prioritised for these areas to move them from lab scale to pilot scale and demonstration scale deployment.

How can Government policy support the development of engineering biology?

It is obviously welcome that there has been significant investment into engineering biology, but there will be a danger that this investment will be seen as sufficient. Though £2 billion is a large sum of money, compared to other investments in scientific research by Government, if it is believed that this investment is sufficient and at the end of the ten years attention moves to another area of science, then the benefits of engineering biology may not be realised. It is imperative to maintain investment, adjusting focus from one cycle to the next, and not to lose focus on the end goal being sought. At the very least this level of investment needs to be maintained, if not increased over time.

At the academic end of investment, UKRI was established to assist in the development and progression of interdisciplinary research. It continues to make strides in the right direction, but more work remains to be done. Engineering biology desperately requires a fully connected and interdisciplinary approach, but it is unclear whether UKRI would be able to maintain progress during the current period of reorganisation, in part sparked by the Grant Review. Engineering biology has benefited from the Government's focus on this area, which is reflected in the number of recent funding announcements, but this level of engagement is unsustainable over the medium to longer term. It is also noticeable that there is a focus on delivery rather than delivery at the most appropriate time, leading to significant fatigue within the academic community.

Moving forwards investment needs to be carefully managed, without rapid changes and fluctuations which makes it difficult to work with. UKRI and the research councils should absolutely be central in maintaining the academic disciplines and promoting an interdisciplinary way of working. A mission orientated investment model which targets end goals rather than specific niches would be a good approach. This can then provide investment to move towards whichever goal that engineering biology could solve, whether agricultural, medical or climate related.

How can the UK maximise the economic potential of developments in engineering biology?

One of the most significant challenges that we have noted is that start up access to funding is not functioning very well. It is important that investors have confidence in the science that they are funding, and there is a substantial amount of misinformation or even complete lack of information on scientific underpinnings of start-ups. Equally there are many start up opportunities, and larger organisations, which are not able to access funding at all. It is not clear who is benefiting from this dysfunction, but it is not in the best interests of anyone involved. There is clearly a need for more scientifically informed investors who understand the nature of the area.

Given the scale of the industry required for greenhouse gas removal through the use of engineering biology and the high level of expertise that exists in the UK at a range of academic and non-academic organisations, there is a tremendous opportunity for the UK to place itself at the forefront of this tidal wave. With sufficient funding and technological progress there is no reason there could not be UK based companies in this area on the FTSE 100 over the next two decades – this is the level of ambition that is needed, and which is achievable.

What are the risks posed to society by engineering biology?

It would be as equally valid to ask what the risks are to engineering biology from society. There are valid concerns about, for example, growing a gene edited crop across dozens or hundreds of farms. However, each risk should be considered on its merits and the public needs to be engaged at every stage to ensure that there is not a backlash similar to genetic engineering. A social licence to operate needs to be maintained, particularly for the most contentious issues such as ocean-based work. More needs to be done in this area, with many concerned that irreversible damage will be done to the oceans.

What are the possible barriers and limitations to good and effective use of engineering biology?

In addition to the above-mentioned licence to operate, other risks include expertise – not just for investors as previously mentioned, but maintaining a pipeline of highly trained scientists, engineers, technicians and other experts to carry out the necessary work. Particularly on the academic side there is also a need to bring in existing expertise from adjacent areas such as agriculture. Government could facilitate more interdisciplinary and cross-disciplinary work to raise awareness of the potential of applying expertise from other fields and sectors.

Feedstocks are an incredibly significant barrier to longer term scale up, and therefore a fundamental area of scientific investigation. The same biomass that might be used to produce biochar or be sequestered underground, for example, might also be used as food. There is already competition for land, including the food versus fuel debate of years past. Scaling up a land-based greenhouse gas removal system to the level necessary would increase these existing tensions.

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