

## UKRI GREENHOUSE GAS REMOVAL DEMONSTRATORS

### CALL FOR PROPOSALS

#### Summary timeline

Community Meeting	29 <sup>th</sup> April 2019
Launch date for Call for Proposals	30 <sup>th</sup> September 2019
Closing date for Expression of Interest	19 <sup>th</sup> November 2019
Assessment of Expression of Interest	w/c 27 <sup>th</sup> January 2020
Opening date for full proposals	24 <sup>th</sup> February 2020
Closing date for Full proposals (invitation only)	May 2020
Assessment of Full proposals	September 2020
Research grants awarded	November 2020
Projects start	14 <sup>th</sup> February 2021
Mid-term evaluation	August 2023

#### **SUMMARY**

This call is part of the interdisciplinary £31.5 million Strategic Priority Fund (SPF) Wave 2 Greenhouse Gas Removal Programme. The Programme is a UK Research and Innovation (UKRI) initiative involving the Arts and Humanities Research Council (AHRC), Biotechnology and Biological Sciences Research Council (BBSRC), Economic and Social Research Council (ESRC), Engineering and Physical Sciences Research Council (EPSRC), Natural Environment Research Council (NERC), and Innovate UK.

The programme will support sustainable routes for large-scale removal of greenhouse gases from the atmosphere, allowing the UK to take a major step towards achieving net-zero emissions, and placing the UK in a leading position to benefit from the £400 billion future global market in greenhouse gas removal.

The Strategic Priority Fund call will support up to five individual GGR Demonstrators as well as a central Directorate Hub. Information on the central Directorate Hub can be found here, <https://nerc.ukri.org/research/funded/programmes/ggrd/news/ao-ggrd-dhub/>. Applicants are advised to read both calls in order to understand the full scope of the programme. The Directorate Hub will provide an overarching coordination role across the suite of interdisciplinary programme activities, with specific focus on economic, social, cultural, risk perception and communication, ethical, legal and governance issues. The GGR Directorate Hub will be commissioned by NERC and the GGR Demonstrators will be commissioned by BBSRC on behalf of UKRI partners AHRC, ESRC, EPSRC and Innovate UK.

This call is for applications for GGR Demonstrators that will be responsible for exploring the effectiveness, cost and the limitations of large-scale methods of GGR. Potential interdisciplinary demonstrators could include, **but are not limited to**:

- **Direct air capture and carbon storage (DACCS)** – Research is required to integrate significant UK expertise, to develop and to test air capture materials and components, and to engineer a commercially viable solution for DACCS
- **Enhanced terrestrial weathering** – Research is required which should include field assessment of the co-benefits to soil/crop mineralisation kinetics and the fate of carbon and liberated elements in the environment (i.e. soil, surface water and ocean)
- **Bioenergy with carbon capture and storage (BECCS)** – Research should include minimising land use conflicts, improved accounting practices for sustainability and carbon, and biobased carbon capture technologies
- **Biochar** – Research should include studies on the efficiency of the pyrolysis process, the fate of its products and the biologically positive and potentially negative impacts of its addition to UK soils
- **Large scale-afforestation** – Research should include maximising carbon drawdown and storage per area of new forest, potentially combining afforestation with biochar and enhanced terrestrial weathering.

This programme brings together five Research Councils and Innovate UK to tackle an immediate problem in a challenging interdisciplinary space. It builds on investments made by the Research Councils, either individually or in partnership, but in an area where the urgent challenge of coordination across a wide range of disciplines has not yet been possible at the scale needed.

Up to £22.5 million is available to fund up to 5 demonstrators covering greenhouse gas removal technologies as outlined in the Royal Society report <https://royalsociety.org/topics-policy/projects/greenhouse-gas-removal/>. For this call, standard BBSRC eligibility rules apply, however it should be noted that PIs and CO-Is from **any discipline supported by UKRI** are welcomed and encouraged to apply.

Demonstrators will have a start date of no later than 14<sup>th</sup> February 2021 and will have the duration of 4.5 years (54 months) to cover the full duration of the programme.

# UKRI GREENHOUSE GAS REMOVAL (GGR) DEMONSTRATORS

## INTRODUCTION

There is overwhelming scientific evidence that the human release of greenhouse gases is changing the Earth's climate. In 2015, governments from around the world met to agree a framework that would minimise the negative consequences of climate change.

The Paris Agreement sets a goal to limit global average temperature increase to 'well below 2°C above preindustrial levels', and to 'pursue efforts' to limit it to 1.5°C

The role of rapid emissions reduction in meeting this target is widely understood. But it is increasingly clear that reducing emissions is not enough – we must also actively remove greenhouse gases from the atmosphere.

New technologies have emerged that show promise in removing CO<sub>2</sub> from the atmosphere but these are not well understood and mostly unproven at large scale.

The publication of two reports in 2018 The Royal Society report on Greenhouse Gas Removal (<https://royalsociety.org/topics-policy/projects/greenhouse-gas-removal/>) and the IPCC report Global Warming of 1.5 °C (<https://www.ipcc.ch/sr15/>) dramatically highlighted the need to evaluate at scale those technologies that would develop an effective greenhouse gas removal strategy for the UK.

Greenhouse gas removal (GGR) methods involve two main steps: the removal of greenhouse gases from the atmosphere and long term storage, a process best understood for carbon dioxide. Removal can be achieved through a wide variety of techniques, involving either bio-based approaches, accelerating natural inorganic reactions with rocks or engineered chemical processes. The carbon is then stored in land mass-based biomass or products derived from biomass, sub-surface geological formations, the oceans or the built environment.

Up to £22.5M has been allocated to this call for a world class research and innovation programme that will establish up to 5 greenhouse gas removal demonstrator facilities. These will demonstrate the effectiveness, cost and limitations of large scale GGR. This is part of the £31.5m UKRI Strategic Priorities Fund Programme on Greenhouse Gas Removal, a collaboration between BBSRC, AHRC, ESRC, EPSRC, NERC and Innovate UK.

Outputs from the demonstrators will be integrated by a Directorate Hub, administered by NERC in a separate call

(<https://nerc.ukri.org/research/funded/programmes/ggrd/news/ao-ggrd-dhub/>). The hub will provide underpinning research to address the business, environmental, social, ethical and governance issues.

## **BACKGROUND**

The Strategic Priorities Fund (SPF) has been set up to build upon the vision of a 'common research fund' set out in Sir Paul Nurse's [independent review](#) of the Research Councils. The fund will drive an increase in high-quality multi- and interdisciplinary research and innovation, ensure that UKRI's investment links up effectively with Government departments' research priorities and opportunities, and ensure that the system is able to respond to strategic priorities and opportunities. This programme is funded under Wave 2 of the Strategic Priorities Fund.

## **Greenhouse Gas Removal (GGR)**

Two reports were released on GGR in the autumn of 2018: one by The UK's Royal Society and Royal Academy of Engineering<sup>1</sup> (commissioned by BEIS) and another by the US National Academies of Sciences, Engineering and Medicine<sup>2</sup>. Both identified a diverse portfolio of GGR technologies at very different stages of readiness. No single GGR method can provide the scale of GGR required to meet the Paris Agreement, therefore a portfolio of approaches is needed. Research must address the potential and limitations of these technologies, including promising methods that will require significant development and testing at pilot level.

The existing [Greenhouse Gas Removal from the Atmosphere](#) strategic research programme ( supported by, NERC, EPSRC, ESRC and BEIS) provides a strong knowledge base on potential options for removing carbon dioxide and other greenhouse gases, giving attention to environmental, technical, economic, governance and wider societal aspects. However it does not incorporate large scale testing. This specific gap has now been identified in the recent Academy reports.

The implementation of sustainable GGR solutions is broader than the development of technologies. GGR methods differ widely in terms of their potential costs, environmental risks, co-benefits, political and societal acceptability and trade-offs. Further research is required to understand the range of implications of each GGR solution, how they can be designed to take into account novel business operating models and appropriate governance that takes into account ethics, potential risks and public perceptions. Support is required to help progress the technologies towards readiness, to develop appropriate incentives for their ramp up, and to strengthen links to a range of business sectors.

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<sup>1</sup> Royal Society & Royal Academy of Engineering (2018) *Greenhouse Gas Removal*. <https://royalsociety.org/greenhouse-gas-removal>

<sup>2</sup> National Academies of Sciences, Engineering, and Medicine. 2018. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda*. Washington, DC: The National Academies Press. doi: <https://org/10.17226/25259>

## OBJECTIVES

Programme objectives are:

- To develop a suite of GGR technologies at demonstrator scale - £22.5m (led by BBSRC)
- To develop successful GGR solutions – understanding economics, governance, society and ethics (Directorate Hub) - £6.3m (led by NERC)
- To develop and support sustainable GGR solutions – supporting technologies towards commercial readiness: The Hub, in conjunction with Feasibility studies - £1.5m (led by Innovate UK in year three of the programme: 2022-23).

Through a world-leading research and innovation programme up to 5 GGR demonstrator facilities will be established and run over 4.5 years, to evaluate a suite of GGR approaches at a suitable scale.

### Development of a suite of GGR technologies at demonstrator scale

The GGR Demonstrators will research the effectiveness, cost, and limitations of large-scale GGR. Potential approaches include, **but are not limited to** the following:

- **Direct air capture and carbon storage (DACCS)** – Research is required to integrate significant UK expertise, to develop and to test air capture materials and components, and to engineer a commercially viable solution for DACCS
- **Enhanced terrestrial weathering** – Research is required which should include field assessment of the co-benefits to soil/crop mineralisation kinetics and the fate of carbon and liberated elements in the environment (i.e. soil, surface water and ocean)
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Each demonstrator will:

- Undertake a complete Life Cycle Analysis including a full carbon budget for the Demonstrator. (<https://www.iso.org/standard/37456.html>)
- Assess the environmental impacts of the chosen Demonstrator.
- Identify the key economic, financial, ethical, legal, social, cultural, behavioural and governance issues specific to the implementation of this approach to GGR, including public acceptability issues.
- Develop the technology to support implementation at scale, within the UK, that will eventually meet or exceed to UK's GGR 2050 targets as laid down in the Royal Society report, Greenhouse Gas Removal (<https://royalsociety.org/topics-policy/projects/greenhouse-gas-removal/>)

**Sustainable GGR solutions -supporting technologies to deployment: The Hub, in conjunction with Feasibility studies - £1.5m (led by Innovate UK in year three of the programme: 2022-23)**

Moving from the Demonstrators towards implementation will require identification of commercially viable and scalable business-led innovations, which can be developed for national and international markets. This will be delivered this by:

- The provision of Proof of Concept/ flexible funding through each Demonstrator to encourage business interaction at an early stage, linking a range of interdisciplinary networks allowing co-creation of evidence and outputs that meet users' needs.
- Support for UK business-focussed conferences on GGR involving innovator and early adopters of GGR e.g. larger businesses trying to be “net zero”, carbon accountancy firms and trade associations working together.
- Competitions, to be delivered by Innovate UK in year 3 of the programme to support Feasibility Studies or Collaborative R&D projects for business-led BECCS projects, and/or internationally-relevant GGR technologies;

## Development of successful GGR solutions – understanding economics, governance, society and ethics (Directorate Hub)

Findings will be integrated by a Directorate Hub which will co-ordinate the research across the programme, linking to relevant national and international activities. It will undertake and commission research to address the cross-cutting issues relating to GGR: environmental, economic, social, cultural, including risk perception and communication, ethical, legal and governance, towards establishing a GGR solution for the UK. It will engage with business communities, supporting innovation in GGR technologies and their progression to readiness for market.

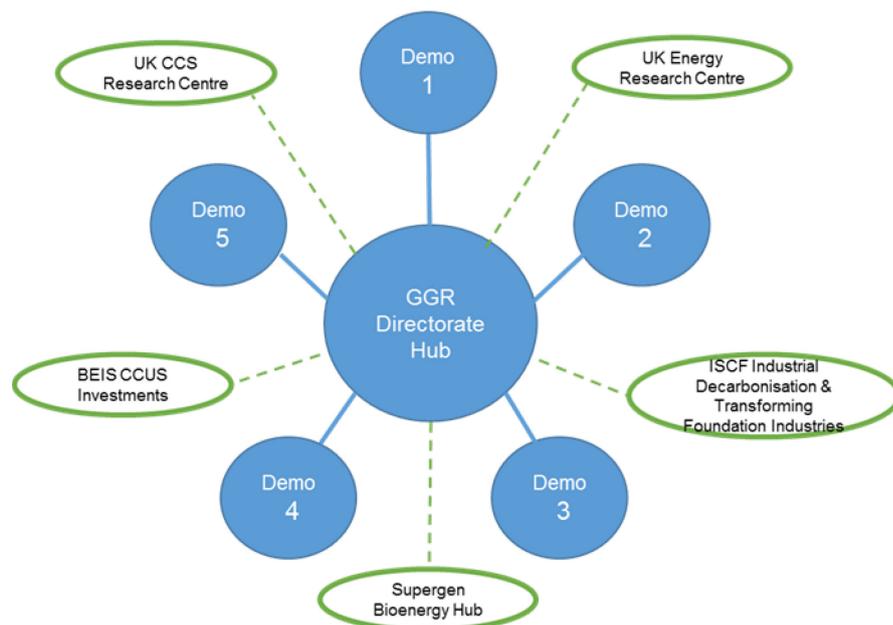


Figure 1: Structure of Greenhouse Gas Removal Demonstrators concept, with up to 5 demonstrators co-ordinated by a Directorate Hub, which also links to existing relevant UK research and innovation projects

The success of GGR solutions will rely on understanding of their full implications for different groups across society, and assessment of how they can best be governed. This needs to be considered at scales from the individual to community, national and international, and across generations. It also needs to account for the full range of perspectives including cultural, societal, political, and corporate.

Moving from the demonstrators to implementation will require identification of commercially viable and scalable business-led innovations, which can be developed for national and international markets. To develop a “pull” from the commercial sector, strong links will also need to be made to industries and to sources of finance interested in the opportunities of a large new international market.

The Directorate hub and Demonstrators will commit to working collaboratively, and to identify and exploit potential opportunities to work with other existing UKRI investments, where appropriate, to maximise impact. A plan for investment engagement should be

included in the application. Other investments include but are not limited to

- Present UKRI [Greenhouse Gas Removal from the Atmosphere programme](#)
- Strategic Priorities Fund [Landscape Decisions: Towards a new framework for using land assets](#)
- Strategic Priorities Fund [Clean Air: Analysis & Solutions](#)
- [Valuing Nature](#)
- Centre for Climate Change and Social Transformations ([CAST](#))
- Centre for Climate Change Economics and Policy ([CCCEP](#))
- Centre for the Evaluation of Complexity Across the Nexus ([CECAN](#))
- [Supergen](#)
- [UK Energy Research Centre](#)

Each Demonstrator will co-operate and engage with the Directorate hub. The hub will be responsible for integration of findings and research and a co-ordinate options for a balanced suite of GGR technologies that could provide a successful GGR solution for the UK. This will require understanding of each demonstrator's implications for different groups across society and assessment of how they can best be governed. This needs to be considered at scales from the individual to community, national and international, and across generations. It also needs to account for the full range of perspectives: cultural and societal, political, and corporate.

Applicants for Demonstrators are required to consider carefully how best to build links and contacts with potential beneficiaries and users of the research at the earliest possible stages of research design and development, and to work towards co-production of knowledge with research users where appropriate. In addition to knowledge exchange and impact strategies that focus on particular user groups or specific named beneficiary organisations. It is envisaged that research from the programme will underpin both the Government's **Clean Growth Strategy** and support several relevant **Industrial Strategy Challenge Fund (ISCF) programmes**.

This programme fully aligns with the UK Government's Clean Growth Strategy (2017), (<https://www.gov.uk/government/publications/clean-growth-strategy>) specifically No. 7 of the Key Policies and Proposals in the strategy 'Develop our strategic approach to greenhouse gas removal technologies, building on the Government's programme of research and development and addressing the barriers to their long term deployment'. The programme aligns with the UK Government's 25 Year Environment Plan (2017), (<https://www.gov.uk/government/publications/25-year-environment-plan>) specifically its goal to manage pressures on the environment by mitigating and adapting to climate change, which in the context of greenhouse gas removal encompasses policies on using and managing land sustainably, recovering nature and enhancing the beauty of landscapes. It also aligns with the focus on woodland to maximise its many benefits, which was supported in the 2018 budget with £60m for planting trees in England.

## EXPECTED OUTPUTS OF THE GGR DEMONSTRATORS

Each Demonstrator:

- Will demonstrate the overall capability of the technology in relation to UK GGR targets as outlined in the Royal Society Report.
- Will provide a quantitative assessment of the technology's effectiveness in CO<sub>2</sub> removal, its costs and its limitations if deployed at large scale.
- Will outline potential routes for sustainable scalability. This should include scientific, technological, environmental, economic and social issues that may need to be taken into account for full scale deployment of that particular technology. This should be undertaken in cooperation with the Directorate Hub.
- Will commit to working collaboratively with the other demonstrators in the programme as well as with the Directorate hub, and to identify and exploit potential opportunities to work with other existing UKRI investments, where appropriate, to maximise impact and to meet UK Government GGR targets for 2050. Other investments include but are not limited to:
  - SPF Landscape Decision making
  - SPF Clean Air
  - Valuing Nature
  - CAST
  - CCCEP
  - CECAN
  - Supergen
  - UKERC

## FUNDING

Up to £22.5million is available for this call and is expected to support up to 5 demonstrators to test and pilot a suite GGR approaches at a suitable scale, moving towards TRL3-4. Up to a maximum of £4.5million (at 80% FEC) per demonstrator will be available dependent on the number of demonstrators funded. Each grant will be for a maximum of 4.5 years and ending financial year 2025/2026. BBSRC expects all grant to be completed by August 2025 where extension will only be granted in accordance with compliance with the Equality Act.

Proposals should demonstrate clear strategic relevance to GGR and address most or all of the following requirements:

- A portfolio of existing grant support relevant to the Demonstrator research area (including UKRI and other sponsors).
- Evidence of a clear route for the implementation of the technology at a scale commensurate with the ability to meet GGR targets by 2050.
- A track record of successful translation of relevant research with business (from TRL 1 to TRL 4).
- A critical mass of researchers (academic and potentially business based) involved in the Demonstrator research area.
- Well established international links.

### **Capacity building.**

UKRI will be looking for evidence that each demonstrator has a strong commitment to support the development of researchers at all stages of their career. The capacity-building element of proposals should include, but not be limited to, early career stage researchers; applicants are encouraged to consider how they can support the career development of *all* members of the team. The focus should be on the quality and impact of the research, and how increasing capacity of the team contributes to this. Examples of building capacity include:

- support and mentoring
- studentships based in the UK (eligibility requirements below)
- training events
- networking opportunities

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