Written evidence from fsk technology research

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The author has been engaged in work on Direct Air Capture for more than a decade, initially in connection with research into the use of carbon dioxide to make carbon neutral synthetic hydrocarbon transport fuels such as Sustainable Aviation Fuel and subsequently with regard to climate change mitigation via carbon offsets. The author regularly reviews academic and other articles on DAC and contributes to the literature. The author declares that he has no financial interest in specific DAC technologies or projects mentioned below and that there is no breach of commercial confidentiality contained in this submission which primarily concerns DAC although reference is made to other NETs.

Preliminary observations:

Terminology

The Call for Evidence uses the term DACCS for the capture and storage of carbon dioxide (CO2) from air. Acronyms that include CCS (Carbon Capture and Storage) such as BECCS (Bio Energy with CCS) refer to the capture of concentrated forms of CO2 from point sources, which is a distinct set of technologies not to be confused with air capture. The correct term is DACS, for Direct Air Capture and Sequestration.

Comparisons between BECCS and DACS

BECCS is commonly described in discussion of the various forms of NET as an energy source, while DAC is said to require energy to operate. This is a common misconception arising from an incomplete framing of the whole system employed to create the NET.

Biomass is a stored form of solar energy that is collected by photosynthetic growth which converts CO2 into carbohydrates. That energy is subsequently released as heat in a furnace. The equivalent solar energy source for DAC can be a photovoltaic farm on a parcel of land which is in general much smaller than that used for BECCS for a given amount of captured CO2.

The reason for this is that photosynthetic capture and conversion of CO2 is much less efficient than engineered DAC per unit of solar energy and plant biology cannot survive in the high insolation sunbelt. That parcel of land can be arbitrarily large to allow for the DACS system to produce energy instead of consuming it, thus creating a carbon negative source of energy.

The energy demand for DAC and its sources has been the subject of much discussion in the scientific community in the context of its potential displacement of mitigation, ie that investment in DACS could be better used to eliminate fossil energy sources rather than remove their emissions. While this may appear to be true in the short term, there are two factors that must be carefully considered-

1. The amount of finance in the market that is available for investment in the clean energy scene is not strictly limited. It should be possible to invest in mitigation with renewable energy and NETs without one materially affecting the other
2. The need for NETs in the short, medium and long term is clear. Firstly to create offsets for hard to treat areas such as aviation and shipping, and second to remove excess cumulative emissions from the atmosphere in order to stabilise the climate at and then below the 1.5C limit. DAC is also the essential precursor to carbon neutral synthetic hydrocarbon electro-fuels which are made from CO2 and water. To scale NETS in an effective timescale, substantial investment is essential but this need not be at the expense of the mitigation effort for emission reduction.

Questions-

- What contribution could NETs (through DACCS, BECCS, and/or other NETs) make to achieving net zero by 2050?

At the global scale DACS should achieve more than 1 bn tons of CO2 Removal (CDR) by 2050. The UK should aim to create at least 1M tCO2 CDR using DACS by 2030, 5Mt by 2040 and 50Mt by 2050. These schemes need not all be geographically located in the UK.

- Which ‘hard to decarbonise’ sectors could benefit most from NETs, and which should be prioritised?

Sustainable Aviation Fuel (SAF) appears to be the key priority area. However, all transport solutions which currently use liquid fossil fuels (shipping, heavy goods) have a part to play in the transition to low carbon operation. Offsets using DACS offer what can be termed as “Energy Amplification” when combined with fossil fuel because the amount of energy produced by offset low carbon fossil fuel can be 4x greater than the renewable energy input to the DACS process. This is particularly important when renewables are being scaled up because electrically powered sustainable fuel production such as liquid synthetic hydrocarbons (electrofuels made from CO2 and water) and liquid hydrogen are energy intensive.

- At what technological stage are current NETs, and what is the likely timeframe that will allow NETs to be operational at scale in the UK

DACS is currently at a high Technology Readiness Level around TRL 8-9. The first fully supported DACS projects should be implementable in the UK before 2025 at the 10kton - 100kton CDR level.

- What, if any, are the links and co-benefits to other technological innovations, such as sustainable aviation fuel or sustainability in the energy sector?

DACS machines can be coupled optimally to thermal power stations which produce excess (waste) heat together with electrical power, by hybridisation. So nuclear or conventional gas power stations with CCS are prime candidates. Hinkley Point C is not well placed geographically for a sequestration pipe to remove the captured CO_2 but Sizewell C should be. A feasibility study should be carried out to discover how the plant could be modified and the cost of adding a linked CO_2 North Sea pipeline and other infrastructure. All new UK low carbon thermal power plants should be obliged to carry out feasibility studies and impact assessments for hybridisation with DACS.

A particularly good candidate is the Whitetail Energy gas power plant with 100% CCS that is being built at Teesside, using new technology invented by the British engineer Rodney Allam. The Allam Cycle has been implemented by the US company Netpower with R&D funding from the UK government energy and climate department DECC in 2012. This machine produces waste heat that is removed using air movement via a heat exchanger in order to cool the turbine fluid (liquid CO_2). It is ideally placed as a DACS hybrid machine because it will have low parasitic losses. (a low temperature DACS process requires a source of waste heat and air movement together with a waste CO_2 disposal pipeline) The 300MW electrical output Netpower power plant will capture and dispose of around 850ktonCO_2 per year from burning gas and has the potential to remove up to a further 1MtonCO_2 using a coupled DACS machine in order to become a source of negative carbon power. A feasibility study into this hybrid should be carried out asap.

- How should the UK Government support the further development of NETs?

By creating a support system such as the recently proposed CarbonFIT policy by Luxembourg MP Sven Clement who aims to modify and apply the ***Feed-in-Tariff (FIT)*** model to carbon dioxide removal technology. First implemented in Europe by Germany two decades ago the FIT helped catalyse global renewable energy growth and cost reduction more than any other single policy. This should apply to DACS and exclude BECCS which has its own support arrangements.

This demand-pull proposal may initially require a high level of support at around £500 per tonCO_2 captured together with matching capital support for the construction of DACS machines at the 10ktonCO_2 per year CDR level. Specific quantified goals for CDR should be set every 5 years starting with 2025.

UKRI should fund at least one new university based department dedicated to DACS which should have at least one chair and 2 senior lecturers (no such department currently exists in the UK). The aim should

be to carry out co-operative research and train postgraduates in DACS technologies. The academics should preferably not be drawn from the existing UK CCS community which has not risen to the DAC challenge.

NETs need not necessarily be geographically based in the UK and government should examine as a matter of urgency international co-operation and the implementation of DACS at scale, ie greater than 1MtonCO2 CDR per year. The EU Commission and the Gates supported Breakthrough Energy Catalyst have earlier this year announced a new partnership to support investments in clean technologies for low carbon technologies, including DAC. Government should seek to join with this effort asap whether through the EU Horizon R&D programme or otherwise.

All UK power supply arrangements should be required to state their suitability for negative carbon power production. For example, the XLINKS UK-Morocco solar and wind power project (which intends to supply 3.6GW of firm power to the UK via an undersea cable before 2030) could additionally provide a CDR service using their solar and wind power at competitive rates, providing that the CO2 so produced can be safely sequestered in the region.

- What policy changes, if any, are needed to ensure the UK gains a competitive advantage and remains at the cutting edge of this sector?

Sweden's climate policy framework from 2017 states that by 2045, Sweden is to have zero net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions.The UK should in this Parliament commit by statute to a net negative carbon pathway which will operate before 2050. That policy will motivate research organisations, companies, NGOs and enterprises generally to base their NET operations in the UK.

Consideration of the large range of NETs and their relative merits will need a concerted effort at a level that has not yet been undertaken. A large combined Institute of Carbon Removal (ICR) similar to the US NREL is an essential part of any attempt to look at the wide variety of NETs and their consequences. Managing various CDR projects will take a substantial expert effort and only an expert staff working essentially under one roof will be able to view the whole span of scientific, engineering, techno-economic, legal governance and equity issues etc across the piece.

This will involve at least hundreds of staff and a budget of $100M+ per year. (NREL has 2600 international staff and a $500M budget). The tech billionaires and their companies should be induced to finance this effort on a like for like basis. For example, Jeremy Grantham (who funds the relatively small university based Grantham Institute in London which is split into 2 separate climate science and economic branches at Imperial College and LSE) has said that he is willing to devote most of his substantial resource to climate issues Companies like Amazon, Google, Microsoft etc will want to see a level playing field for the various CDR technology options that policy should provide through an independent agency and it is in their interest to provide matching finance.

Apart from anything else, the huge nascent carbon offset market announced by Mark Carney will be valued in $100s of bns and the various financial instruments that will be created (which will undoubtedly be subject to some form of taxation) will have to be independently assessed and verified to ensure that endemic fraud is minimised. A small levy on the London and other carbon offset markets should be used to fund the validation of permanence and verifiability of various NETs as an activity within the new Institute.

Each major jurisdiction (EU, US and China) is likely to need its own ICR and the UK should seek to form a co-operative alliance with at least one of these, preferably with the EU. A large UK based office would be part of that arrangement and would manage the UK CDR effort to ensure that it remains competitive.

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