FEBRUARY 7, 2025

Post

expert reaction to Public Accounts Committee report on Carbon Capture, Usage, and Storage (CCUS) Technologies

Scientists comment on the Public Accounts Committee (PAC) report on Carbon Capture, Usage and Storage (CCUS) technologies.

Prof Stuart Haszeldine, Professor of Carbon Capture and Storage, University of Edinburgh, said:

“The IPCC is very clear that CCS is essential for all future pathways to Net Zero to safeguard global climate. The UK and many other rich industrial nations are very slow on delivering CCS. Decarbonisation of UK industry will preserve and improve tens of thousands of industrial jobs, and is expected to pay back financially at 5%/year or more. These benefits have not been recognised by the PA Committee.

“Many of the comments in this PAC report are based on sparse evidence, and several comments are based on no evidence. There is no recognition that CO2 storage injection in Norway has been monitored and verified to the highest standards by independent regulators for nearly three decades Geophysics and Geosequestration , pp. 209 – 234 DOI: https://doi.org/10.1017/9781316480724.014

“Requesting annual reporting for large expenditure projects is reasonable, but should not be onerous to delay delivery of the projects.

“The Contracts for Difference style of financial support is very well established as an innovation mechanism in the UK. The CfD greatly decreases risk to Government – as payment is by results. That was spectacularly successful as an incentive for wind power in the UK and

injection of CO2 into underground geology has been safely and securely operating worldwide since 1972.

"Although these CCS projects are delayed, all participants are clear that there are no technical or scientific obstacles. Delivery will reach the forecast storage of up to 30 million tonnes CO2 per year – but soon after 2030, rather than before. Future projects should aim to agree in less than half the time, like Denmark, now that the pathways have been created and agreed."

Professor Geoffrey C Maitland CBE FREng FIChemE, Professor of Energy Engineering, Imperial College London, said:

"Whilst the PAC CCUS report does make a number of useful recommendations regarding the need to update targets for UK carbon capture and storage to achieve future carbon budgets and assessment for value for money of projects going forward, it does make a number of assertions which do not reflect the current readiness level of CCS technology and its critical role in ensuring the UK achieves its 2050 net-zero target. It asserts that DESNZ 'is taking a high-risk approach by backing first-of-a-kind (FOK), unproven technologies with large amounts of taxpayer and consumer funding'. This is completely untrue – CCS has been deployed commercially and safely since 1996 in the North Sea and across the world, with more than 40 such operations currently operating and successfully storing more than the UK plans to store by 2050. Assertions that Norway's experience suggests that projects may not capture and store as much carbon as projected fly in the face of the available evidence; the Sleipner North Sea field continues to store CO2 at the 1Mt pa scale expected for the subsurface geology and injection rates, as it has for 20 years.

"CCS within the current cluster projects may be FOK in the UK, because of government false starts and obfuscation over the last 20 years, but it is proven technology across the world and we should benefit from that experience and learning to kick-start our own projects rather than feeling we need to start from scratch and re-evaluate risks – technology is global. In fact the UK's business models for implementing CCUS are world-leading and are doing much to lower the risks for private investors. Much of the value of the government investment is in enabling an equitable sharing of the business risks. The PAC report questions that the government 'has not established mechanisms to make sure that taxpayers and consumers will benefit financially should the programme be successful', whilst not considering the risk of not facilitating commercial CCUS, without which the decarbonisation of industrial processes and provision of low-carbon dispatchable power (for when renewables generation is low or insufficient) would

replacement technologies emerge later in the century.

"The report challenges DESNZ to 'consider the impact of up-to-date scientific understanding of CCUS', without apparently taking account of significant expert advice to the inquiry on the advances made across the world in the ability of CCUS to safely take CO2 out of the system as an essential tool for meeting carbon mitigation targets. Mention is made of problems with methane emissions from the production of natural gas and LNG but such fugitive emissions can be made minimal by operation of best engineering practice and are no reason not to replace unabated gas power by gas + CCS as the primary mechanism for avoiding the lights going out. The systems are not yet, and will never be, perfect but let not perfection be the enemy of invention on this challenging energy transition journey where we are already way behind schedule by ruling out imperfect solutions. The concern that BECCS might not be a viable technology for achieving high volume negative emissions because of concerns that some of the biomass used by Drax may not have met required sustainability standards is no reason to abandon that route; sourcing appropriate low carbon footprint biomass in sufficient quantities is a challenge which needs addressing but meanwhile the foundations for BECCS through building our CCS infrastructure remains a no regrets option.

"The report questions why some of the difficult to decarbonise industries like cement are not included in the Track 1 clusters. The aim of the clusters is to provide the backbone transport and storage networks into which other industrial sites can feed CO2 for safe removal. In fact several Energy from Waste facilities (in the Runcorn area for instance) are in well-advanced discussions with the government about contracts for feeding into the Track 1 clusters. As more clusters form and their CO2 transport networks expand, more and more facilities will have access to CO2 storage; connection of the UK's cement facilities should be a high priority for the next stages."

Prof Hannah Chalmers, Personal Chair of Sustainable Energy Systems, Institute for Energy Systems, School of Engineering, University of Edinburgh, said:

"CCUS technologies can play a unique role in tackling carbon dioxide emissions. They can be used at large industrial sites to ensure that most of the carbon dioxide produced by activities like iron and steel production is not emitted to the atmosphere. Instead, the carbon dioxide is permanently stored in geological formations (rocks). In the UK, CCUS projects are developing plans to store carbon dioxide in layers of rock that are deep underneath the sea.

"There is also ongoing work to develop and deploy cost-effective approaches to remove carbon

dioxide emissions will be the most cost-effective way to address climate change. Several large-scale projects have been operating in other countries for many years. Experience from these projects is being used to ensure that the CCUS projects that are being developed in the UK are designed to be reliable and cost-effective."

Dr Stuart Gilfillan, Reader in Geochemistry, University of Edinburgh, said:

What is CCUS technology, how does it work, does it have limitations?

"CCUS stands for Carbon Capture, Utilisation, and Storage, which is a developing technology which reduces the amount of carbon dioxide (CO_2) released into the atmosphere. It works by capturing CO_2 at the point source, transporting it and then burying it for safe storage in rocks over a kilometre below the ground surface. Like any technology, it has pros and cons, and costs more than simply releasing the CO_2 directly to the atmosphere, which is currently free. CCUS is the only currently available technology that can directly reduce CO_2 emissions from sources like power plants and industrial processes. Given that global temperature records are now being broken on an almost daily basis and yesterday's announcement of the hottest January on record, it is essential tool in the urgent fight against runaway climate change.

What is the existing evidence around the efficacy of CCUS?

"CO_2 capture technology has proven successful in capturing up to 90-95% of CO_2 emissions from point of sources from power stations and industrial facilities. Successful examples include the Boundary Dam power station in Saskatchewan, Canada, where a large-scale CCUS unit has been operational since 2014, capturing about 1 million tonnes of CO_2 per year.

"The long-term storage of CO_2 is proven by natural CO_2 reservoirs around the world and engineered projects like Sleipner in the North Sea, which have been injecting CO_2 beneath the seabed since 1996 without significant issues. Research over the past two decades has developed monitoring technologies that can detect and mitigate potential leakage and to ensure that CO_2 remains securely buried in rocks deep underground.

What more evidence may be needed to be confident in its applications?

"No more evidence is required, as exemplified by the UK's Climate Change Committee (CCC), which is an independent body established under the Climate Change Act who advise the

"CCUS is not only as a standalone technology but is an essential part of a broader strategy to reach net-zero emissions by 2050. It compliments energy efficiency, renewable energy deployment, and electrification. CCUS is a clear driver for regional economic development, particularly in regions with suitable geological storage sites and industrial bases, such as the East Coast of Scotland, the Humber region, and North East England, areas that have been 'left behind' in recent times."

Dr Tim Dixon, IEA Greenhouse Gas, Director and General Manager, said:

"Carbon Capture and Storage (CCS) is a necessary technology for the UK and other countries to achieve net-zero, and we need all low-carbon energy technologies. The science case for the role of CCS is provided by the UK's Climate Change Committee, the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) and cannot be disputed if climate change is to be taken seriously. The key aspect of CCS is the secure long-term retention of CO2 in deep geological formations, and we have decades of experience in this from around the world. With over 40 large scale projects in operation injecting millions of tonnes every year and many pilot-scale projects, this has allowed us to test the science, the monitoring and the practicalities of geological storage of CO2. Hence CO2 geological storage is a proven technology and the regulations to enable and to ensure that it is safe and secure are based upon this sound science and experience. "

Professor Paul Fennell FIchemE, Professor of Clean Energy, Imperial College London, said:

"The idea that Carbon Capture and Storage is an unproven technology is simply untrue. There are projects ongoing around the world, and millions of tonnes of CO2 have been safely stored over the last couple of decades. This has not happened in the U.K. because of our sclerotic inability to develop public infrastructure, not because the technology is unproven."

Dr Greg Mutch, Researcher in Carbon Capture and Storage, Newcastle University, said:

"Carbon capture and storage is a technology that prevents carbon dioxide from entering the atmosphere, by capturing it and storing it underground in 'empty' oil & gas reservoirs or saline

several billion pounds in terms of gross value added per year by 2050,[2] and enable other important technologies (hydrogen production etc) that will come with further jobs and economic value."

[1] *IPCC, 2018: Global Warming of 1.5 °C. An IPCC Special Report on the impacts of global warming of 1.5 °C 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, sustainable development, and efforts to eradicate poverty*, ed. V. Masson-Delmotte, P. Zhai, H.-O. Portner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Pean, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor and T. Waterfield, Cambridge University Press, 2018.

[2] *Energy Innovation Needs Assessment Sub-theme report: Carbon capture, utilisation, and storage*, Vivid Economics, Carbon Trust, E4tech, Imperial College London, Frazer-Nash Consultancy, Energy Systems Catapult. Commissioned by the Department for Business, Energy & Industrial Strategy, 2019.

Professor Peter Styring, Director of the UK Centre for Carbon Dioxide Utilization, Professor of Chemical Engineering & Chemistry, University of Sheffield, said:

What is CCUS technology, how does it work, does it have limitations?

"CCUS is carbon capture and storage. This has been primarily focused on CCS as the main driver. It aims to capture carbon dioxide from emitters such as power stations and industries. The current technology temperature swing absorption (TSA) using a chemical reaction with an aqueous amine solvent to capture the CO2 from the mixed waste gas and then to release it in a purified form by increased temperature chemical desorption and then further drying and purification to get a gas that can be in theory transported to a site where the gas can be stored underground. It works but at a high energy cost and the production of amine decomposition products that need to be removed and more amine added. It costs a lot!

"Limitations are the energy and financial costs, permitting regulations on solvent disclosure and the large physical footprint. Full system lifecycle analysis is required but this is not always reported."

funded projects use old technologies to achieve CCS and what is actually needed is a step change to new, lower cost more efficient processes such as solid based pressure swing adsorption (PSA). The whole system tends to be simpler and the energy costs and land use is significantly reduced."

What more evidence may be needed to be confident in its applications?

"Full evaluation of new technologies and rapid acceleration from proof of concept to capture at scale. The Innovate UK funded Flue2Chem project is a good example of how this is being addressed using mid-TRL technologies. The UK also needs to move away from a single minded storage approach to adding value through the use of CO2 in the production of chemicals that would otherwise be sourced from virgin fossil carbon. SUSTAIN project is making synthetic fuels from captured CO2 and Flue2Chem is making FMCG components, including surfactants and precursors from the CO2."

Dr Stuart Jenkins, Net Zero Fossil Fuel Fellow, University of Oxford, said:

"The Public Accounts Committee are wrong to have labelled CCUS as 'unproven', there are many commercial scale projects around the world, but they are right to question the current model for funding it. We need to make sure the CCUS industry becomes self-sustaining, without the need for major taxpayer funding. One option — asking fossil fuel suppliers to contribute to these costs via a carbon storage mandate — is a fair and responsible approach going forward.

In a recent report we published working with researchers at the University of Oxford and Carbon Balance Initiative [1] we looked at the use of Carbon Storage Mandates, which place an obligation on fossil fuel producers to capture and store a rising fraction of the CO2 they produce, to support the UK's CCUS industry.

Carbon storage mandates, in tandem with carbon pricing and other mechanisms, could deliver subsidy-free CCUS to the UK and provide investment certainty for companies."

[1]- https://www.carbon-balance.earth/briefs-reports/report-markets-and-mandates

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Declared interests

Dr Stuart Jenkins Our report was funded by the Carbon Capture and Storage Association, and consulted regulators, fossil fuel companies, capture and storage entities, UK Government, and academics on models for CCUS sector support packages.

Professor Paul Fennell: No conflicts other than being involved in CCs research.

Dr Tim Dixon: "Tim is a Director of IEA Environmental Projects Ltd (UK), a Non-Executive Director on the Board for The International CCS Knowledge Centre (Canada). He is also proud to be an Honorary Senior Research Fellow at the Bureau of Economic Geology, University of Texas in Austin, and an Honorary Lecturer at the School of Geosciences at University of Edinburgh. He was an original Board Member of the UK CCS Research Centre. Previously he worked in CCS, emissions trading, clean energy technologies and related areas for AEA Technology (ETSU), for the UK Government's Department of Trade and Industry (DTI) and for the Global CCS Institute. He was the EU's Lead Negotiator for getting CCS in the CDM in UNFCCC in 2011, and a UK negotiator for getting CCS in the London Convention 2004-7, in OSPAR 2006-7, in the EU Emission Trading Scheme 2004-8, and inputting to the EU CCS Directive 2007-8. He gives talks on climate and CCS to schools and public organisations and supported the start of Oxford Climate Society at the University of Oxford. He is a Fellow of the UK Energy Institute, and member of the UK Institute of Physics and the UK Environmental Law Association."

Dr Stuart Gilfillan "I have received funding from TotalEnergies in the past, for research related to CO2 origins in the subsurface and reservoir connectivity and Equinor on CO2 dissolution in natural CO2 reservoirs. I currently receive funding from the Natural Environment Research Council and Carbfix on CO2 mineralisation."

Prof Hannah Chalmers "I work collaboratively with industrial partners who are developing CCUS projects in the UK (e.g. as a member of the Advisory Board for the Industrial Decarbonisation Research and Innovation Centre). I currently receive no funding from industry, but have received funding from industrial partners who are actively developing CCUS projects in the UK in the past (e.g. SSE plc)."

Fellowship, and the Engineering & Physical Sciences Research Council [grant numbers: EP/V047078/1, EP/W03395X/1, EP/Y034961/1]. I am also an academic member of the UK Carbon Capture & Storage Research Centre, and I sat on the UK Government's Department for Business, Energy, & Industrial Strategy Carbon Capture, Utilisation, and Storage Early Career Professional's Forum."

Prof Stuart Haszeldine: Stuart Haszeldine is funded for CCS research by UK research councils EPSRC and NERC

Professor Geoffrey C Maitland:

– Worked as a research director for Schlumberger 1985-2005

– Have carried out research at Imperial on CCS for past 20 years, funded by Shell and Qatar Energy

– Submitted evidence to the PAC report on CCS.

For all other experts, no response to our request for DOIs was received.

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