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June 18th 2025

Dear Dr Whitehead

Please find attached my submission to the Greenhouse Gas Removals (GGRs) Independent Review appended as a stand-alone document.

I welcome your review and hope that it may lead to a much more robust policy approach to GGR and CCS, based on the full and latest science.

Yours faithfully

Dr Andrew Boswell for Climate Emergency Science Law (CESL)

Contents

1 Cross-referencing to Dr Whitehead's questions 1 to 4

About you

1. What is your name?

As per covering letter, Dr Andrew Boswell

2. What is your email address?
As per covering letter, [redacted]

3. What is your organisation (if applicable)?
I represent my own consultancy - Climate Emergency Science Law[1] (CESL).

I am also the lead campaigner on the Scrap Carbon Capture (ScrapCC) campaign[2] which has two objectives:

- for the Government to commission an independent review of Carbon Capture; and
- for carbon capture based on fossil fuels (natural gas burning for electricity, or processing for blue hydrogen production) and bioenergy to be removed from the upcoming revised UK Climate plan (the Carbon Budget Delivery Plan).

This campaign is supported by a number of NGOs including MP Watch[3], Zero Hour[4] and the Campaign against Climate Change[5] who are key partner campaign organisations.

More information is given in the section "Transparency on campaigning position".

4. Disclaimer on data sharing: We may publish a summary of all responses. Would you be happy for your response to be published in full? (Options: Yes; Yes, but without identifying information; No, I want my response to be treated as confidential).

Yes.

[1] Previously Climate Emergency Planning and Policy (CEPP)

[2] https://scrapcc.org/FILM

[3] https://www.mpwatch.org/

[4] https://www.zerohour.uk/

[5] https://www.campaigncc.org/

2 Background

2.1 Brief Bio

Climate Emergency Science Law[6] (CESL) is a consultancy set up to promote the necessary rapid, and scientifically congruent, response to the climate crisis in mainstream institutions, such as local authorities and government, through the lenses of science, policy, and law.

I, Dr Andrew Boswell, established CESL (then CEPP) in 2017 following retirement from a scientific, computing and political career. I have a technical background in chemistry (first degree, Imperial College), structural biology (DPhil, Oxford), software engineering and Very Large Scale Integrated (VLSI) circuits, system management and scientific modelling including managing the high-performance and scientific computing service at the University of East Anglia for eleven years. I was a councillor at Norwich City Council and Norfolk County Council for twelve years.

As CESL (formerly CEPP), I have been an expert contributor to the Climate and Nature bill which is being progressed through this Parliament as a Private Member's Bill by Roz Savage MP. I have worked on a two-year fellowship from the Foundation for Integrated Transport on exposing the flaws in carbon assessment and transport modelling for road schemes. I have been an interested party and expert witness actively engaged in infrastructure planning examinations in the UK.

I have pro-actively participated in three DCO planning examinations for GGR/CCS projects:

(A) (Drax) Drax BECCS – conversion of the Drax Bioenergy power plant to CCS

(B) (BP & Equinor) Net Zero Teesside – a new gas-fired power station with CCS

(C) (BP) H2 Teesside – a new blue hydrogen plant with CCS

In each case, I have made major and substantive submissions on the project's GHG emissions. These are publicly available at the footnotes: Drax BECCS[7], Net Zero Teesside[8], H2 Teesside[9]. I have used my knowledge and experience from these DCO planning examinations and extending it with more recent science for my calculations in Appendices A, B and C which model these three technologies: BECCS bioenergy plants, gas-fired power stations with CCS, and blue hydrogen plants with CCS.

I give consent for my full and unredacted submission to be shared.

2.2 Personal position statement

I have followed the science and policy debate around Carbon Capture and Storage for many years, with concerns which have now matured into those as expressed in this submission. As above, I was an interested party at the planning examination for the Track-1 Net Zero Teesside gas fired (gas-CCS) power station, and following my submissions, the project promoters changed their

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[6] Previously Climate Emergency Planning and Policy (CEPP)

[7] https://scrapcc.org/DRAX-BOSWELL-SUBS

[8] See https://scrapcc.org/NZT-BOSWELL-SUBS

[9] See https://scrapcc.org/H2T-BOSWELL-SUBS

Environmental Statement to include an estimate of upstream emissions from the fuel supply chain. I believe this the first example where an environmental assessment of upstream emissions in a UK CCS project, though a very limited underestimate as explained later in this document, has been made.

This contributed to the Scottish Government requiring that an assessment of upstream emissions be made on the Peterhead gas-CCS scheme in the Scottish planning system. The revised Environmental Impact Assessment from the Peterhead developer SSE was published earlier this month, again a very limited underestimate of the real climate impact, as will be explained.

Other similar projects have either gained planning approval without any assessment of upstream greenhouse gas (GHG) emissions (eg: the HyNet Hydrogen Product Plant at Stanlow near Liverpool, and the Keadby 3 gas-CCS plant on Humberside).

I was the claimant in a legal case which challenged the previous DESNZ Secretary of State's decision to later approve the Net Zero Teesside (NZT) project for development consent. Although, I recently lost at the appeal, I submit that the information on the full scale of the upstream emissions was not available to the Court[10] and it, therefore, was beyond the Court's remit to consider whether a lawful decsion had been made on the full climate impacts of the project. My litigation was motivated by genuine concern for planning and policy decisions on UK infrastructure to be made based upon the latest and correct scientific understanding.

I continue here with that concern that policy decisions should be made on the latest scientific understanding. In this submission to the Whitehead review, I provide updated full lifecycle GHG assessment based on the science of upstream emissions, for bioenergy plants with CCS, gas plants with CCS, and CCS blue hydrogen plants. In each case, the GHG assessment is developed from data from the company's concerned, as explained later.

2.3 Transparency on campaigning position

I am the lead campaigner on the Scrap Carbon Capture (ScrapCC) campaign[11]. This campaign is supported by a number of NGOs including MP Watch[12] (who work alongside MPs and communities to champion evidence-based climate and nature policies), Zero Hour[13] (the campaign for a new UK law, the Climate and Nature Bill, that addresses the root causes of the climate-nature crisis) and the Campaign against Climate Change[14] (a UK-based campaign that aims to raise public awareness for the urgent action we need to prevent the catastrophic destabilisation of global climate) who are key partner campaign organisations.

Our campaign is evidence based and strongly supports a science-based approach to policy development. We are not ideological - the core principle of our work is to argue for rapid decarbonisation of our global society in the most effective way.

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[10] The recent science which I will present later was not available at the time of the Secretary of State's decision on Net Zero Teesside in February 2024 – the decision which was under challenge.

[11] https://scrapcc.org/FILM

[12] https://www.mpwatch.org/

[13] https://www.zerohour.uk/

[14] https://www.campaigncc.org/

And I should make it very clear that the ScrapCC campaign is **not** opposed to CCS for industrial emissions where genuine decarbonisation may be possible. However, we do note that the case for industrial CCS may not be that strong, and in some areas superior long-term options are rapidly developing, for example in steel production[15]. It is generally better to electrify processes, rather than trying to patch over 20th Century technology with very costly CCS technology.

That said, there may be a case for CCS in some industries where there isn't yet a scalable alternative: for example, cement production. We consider that the case for any such industrial decarbonisation should be made outside the current CCUS cluster models approach which promotes clusters around fossil fuel based anchor projects. As explained later, this locks in very high emissions at the outset before even any industrial emissions may be saved. Given very high upstream emissions from the gas based anchor projects when they are properly accounted, clusters may never even reach carbon neutrality.

The campaign is focussed on CCS based of fossil fuels (gas in the UK) and bioenergy.

The campaign has two objectives:

a. **for the Government to commission an independent review of Carbon Capture; and**

b. **for carbon capture based on fossil fuels (natural gas burning for electricity, or processing for blue hydrogen production) and bioenergy to be removed from the upcoming revised UK Climate plan (the Carbon Budget Delivery Plan).**

2.4 Position statement on Whitehead review

First of all, I welcome this review and hope that it may lead to a much more robust policy approach to GGR and CCS, based on the full science.

Dr Whitehead's forward to this consultation states "*the review will consider all GGRs, with a focus on engineered approaches, and I welcome information and evidence about all GGR technologies in this Call for Evidence.*"

I submit that the review should consider all technologies for capturing or removing greenhouse gas emissions. The distinction between GGR and CCS is somewhat arbitrary anyway. For example, I would argue that BECCS is a CCS technology capturing emissions at the point of combustion of biomass, rather than removing emissions already in the atmosphere. Despite semantics, there are, in any case, very good reasons to use the opportunity of the Whitehead review to review all available technologies – CCS and GGR, including:

(A) They may share common supporting technology. For example, DACCS may require use CO2 transport and storage technology developed for CCS applications. This is certainly the case for BECCS at Drax which would use off shore storage planned for east coast CCUS clusters.

[15] https://ieefa.org/resources/carbon-capture-steel

(B) Any removals should be looked at in the round as to how they might “assist the UK in meeting our net zero targets, out to 2050”. It is not coherent to review some or just part of the portfolio of proposed removal technologies.

As above, the ScrapCC campaign is proposing that the government commissions an independent review of carbon capture and storage. This follows from two letters from scientists to the Government in autumn 2024 raising very serious concerns about the Government’s CCUS which are appended in Appendices D and E.

Given my submissions that the review should consider all technologies for capturing or removing greenhouse gas emissions, I will respectfully submit relevant information on fossil fuel and biomass based CCS, and request that Dr Whitehead can accept and include these submissions as part of the review.

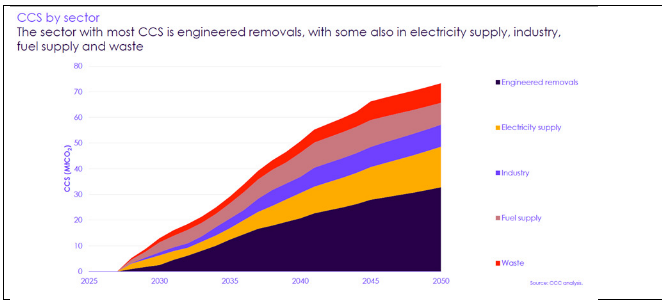
The review call for evidence also states that “the review will provide government with recommendations to consider and decide whether or not to accept. A form of government response to the review is likely.”. It is possible that the GGR Review will form input to the revised CBDP and that the Government response will come as part of the revised CBDP.

I request that Dr Whitehead has a direct meeting with a small group of scientists selected from the signatories of the autumn 2024 letters, and including myself (also a signatory on the letters). We would greatly appreciate expressing our concerns to Dr Whitehead and hope that our evidence is helpful in the review, and also to the government’s drafting of the CBDP.

3 Key background to submission

3.1 What is being advised by the CCC?

It is helpful to start with the proposals from the Climate Change Committee in its Seventh Carbon Budget report. The charts below are not in the report itself, but from a recent presentation by the CCC. I have reproduced the charts for overview – to help get an idea of the overall quantities of CCS and GGR being advised by CCC. (The reader is advised to look at the charts in the original presentation[16] for detail).



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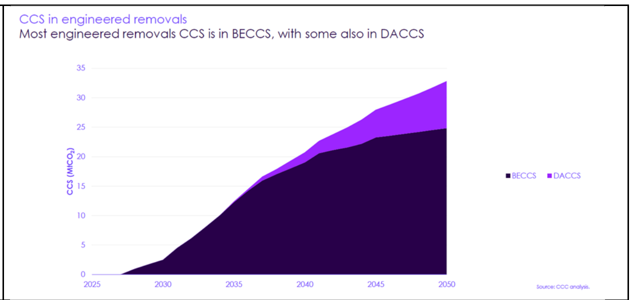

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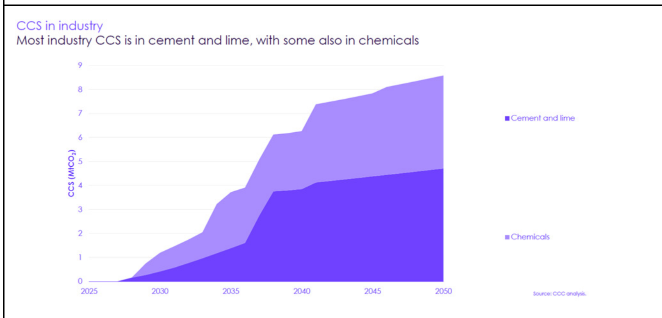

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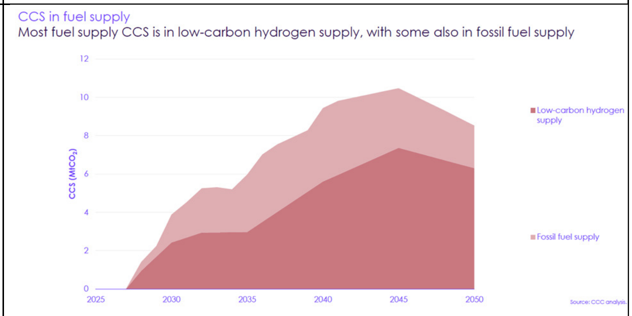

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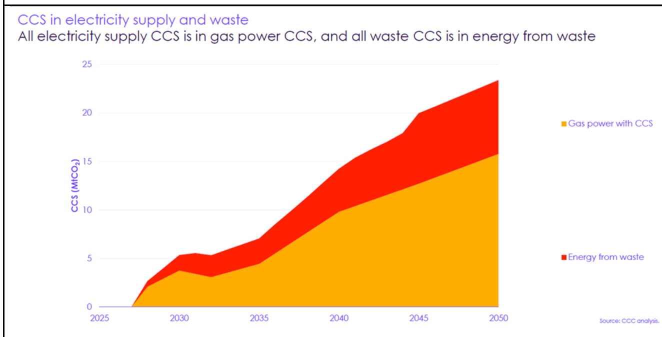

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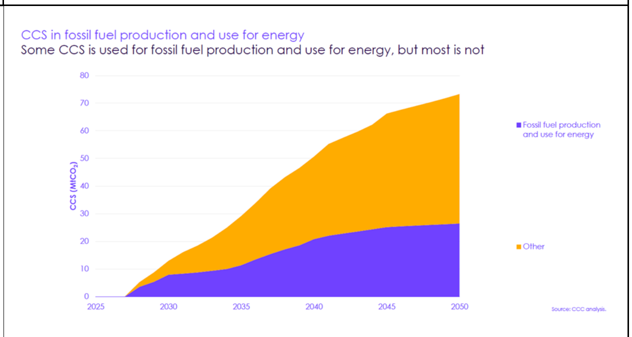

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I wish to draw attention to these key points:

- CCC advise that over 70MtCO2 should be captured and stored annually by 2050 (chart 1), of which
  - around 33MtCO2 in engineered removals, 25MtCO2 being by BECCS and 7MtCO2 DACCS (chart 2)
  - around 7MtCO2 from blue hydrogen production (peaking at 2045) (chart 4)
  - around 16MtCO2 from gas power with CCS (chart 5)

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[16] https://ukccsrc.ac.uk/wp-content/uploads/2025/04/Spring-2025-Conference-Closing-keynote-Jamie-Tarlton.pdf

- Around 4MtCO2 of chemical process decarbonisation, and 4MtCO2 of cement (chart 3)
- Around 7MtCO2 from incineration (chart 5)

- We can regroup these as:
  - around 48MtCO2 (69%) comes from gas based or biomass based CCS burning and processing: 25MtCO2 BECCS; 16MtCO2 gas power; and 7MtCO2 blue hydrogen.
  - 7 MtCO2 from DACCS
  - Around 15MtCO2 from industry and waste: 4MtCO2 chemicals; 4MtCO2 cement; and 7MtCO2 incineration.

As a forward reference, I note that the 69% in biomass and gas based CCS is the grouping of most concern to my submission – this is because in each case, for every tonne of CO2 stored, there is a much greater quantities on new/additional emissions generated in the fuel/feed stock supply chain as will be explained.

3.2 The UK CCUS cluster model

Since 2018, the UK Government has developed its CCS policy around a model of industrial clusters (Carbon Capture Usage and Storage (CCUS) clusters). Each cluster is based around **first building new fossil fuel infrastructure** which is either a gas powered electricity station (gas+CCS) or a blue hydrogen plant. These are referred to as "anchor emitters" or "anchor" plants/projects. The CO2 transport and storage (T&S) system is implemented on the back of these anchor plants.

It is very relevant to the Whitehead review, that the Government has proceeded with massive investments of public money with no scientific review, despite the science of upstream emissions in the gas supply being much better understood than when the plans were formulated 2018, and being twice warned in letters by scientists to the Government on Sept 11 2024 (see Appendix D) and October 18 2024 (see Appendix E).

3.3 Full lifecycle GHG emissions have been systemically underestimated

Since the beginning of the new CCUS cluster programme in 2018, considerably more scientific and technical information is known about the full lifecycle carbon emissions of CCS enabled gas fired electricity generation and CCS enabled hydrogen production which comprise the known start-up projects for three of the four Track-1 and Track-2 clusters.

Key to the emerging issues is that these technologies use natural gas as their primary input or fuel, and their full lifecycle emissions have been underreported due to the systemic underestimation of 'upstream emissions' in the natural gas supply chain, especially for methane leakage, and other factors (see below).

Methane emissions are central, and the true extent of methane leakage has only become clearly apparent in recent years with the advent and rapid development of accurate methane detection by satellite and other remote imaging tools. And scientific papers, like the landmark 2024 paper from Professor Robert Howarth[17], which calculates upstream emissions from first principles.

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[17] **doi:10.1002/ese3.1934**

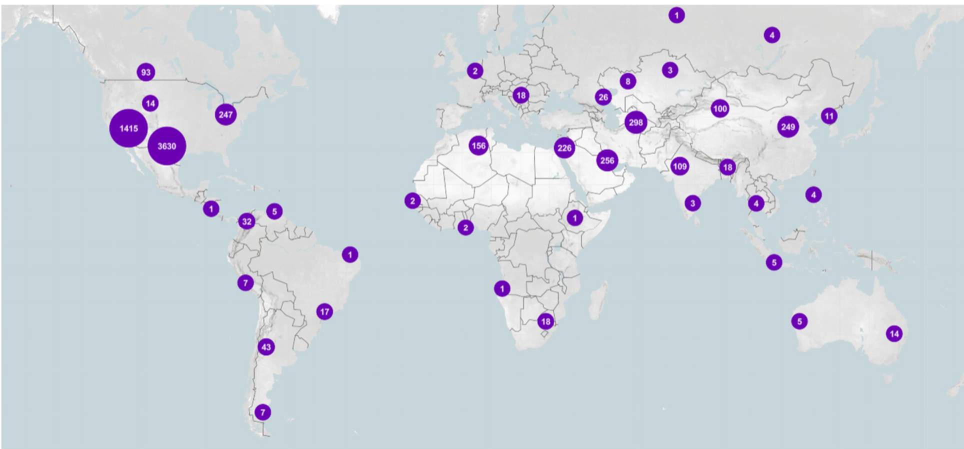


Figure 1: Recent map of methane leaks from new Tanager-1 satellite

The map from Carbon Mapper shows the first methane and carbon dioxide (CO_2) detections by the Tanager-1 satellite[18] launched in August 2024 which can detect individual leaks. Note the high density of leakage in the southern US, a large exporter of Liquified Natural Gas (LNG).

3.4 The four key ways of underestimating emissions

The four key ways that the carbon footprint is underestimated are now described.

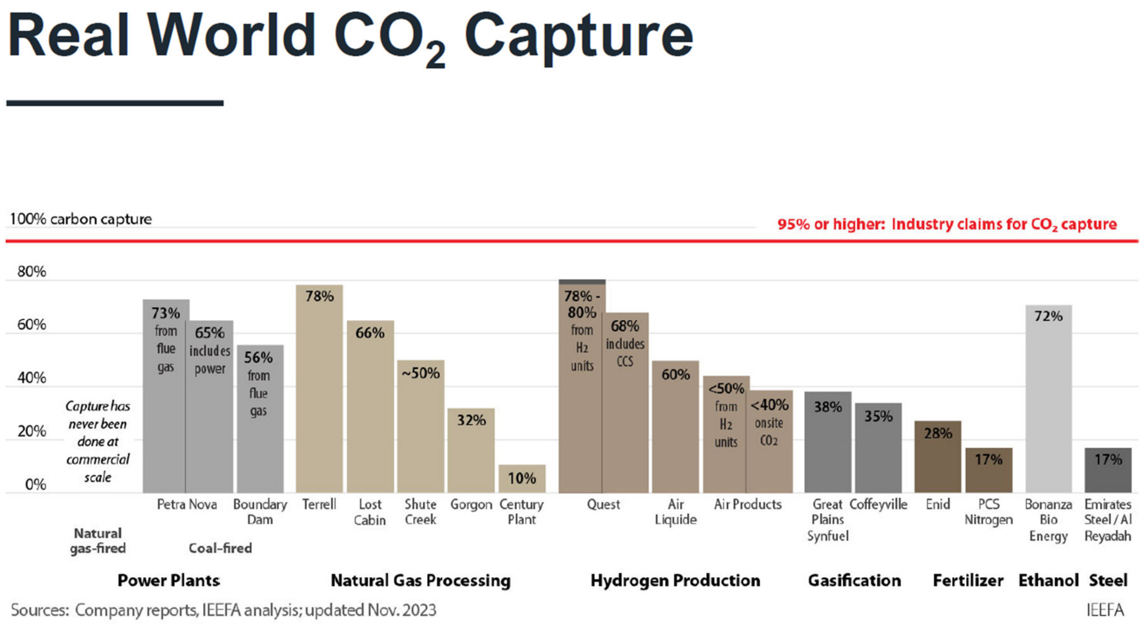
I. Overestimation of carbon capture rate

The schemes coming forward in the UK are claiming carbon capture rates which exceed those demonstrated by any commercial system today. For example under Track 1, the promoters of gas-CCS plant Net Zero Teesside Power claims 90% capture rate whilst the promoter of blue hydrogen plant H2 Teesside claims 95% capture rate.

However, CCS has a poor track record of capturing CO2 from combustion and hydrogen processing (known as Scope 1 emissions). The Institute of Energy Economics and Financial Analysis (IEEFA) have recently researched the CCS market and reviewed existing commercial projects[19], as below:

[18] More information: NASA, October 10th 2024, "Tanager-1 First Methane and Carbon Dioxide Plume Detections", https://www.jpl.nasa.gov/images/pia26416-tanager-1-first-methane-and-carbon-dioxide-plume-detections/ ; "Carbon Mapper Releases First Emissions Detections from the Tanager-1 Satellite", https://www.prnewswire.com/news-releases/carbon-mapper-releases-first-emissions-detections-from-the-tanager-1-satellite-302272245.html ; Dashboard, map https://data.carbonmapper.org/#1/30.8/50.5

[19] Institute of Energy Economics and Financial Analysis (IEEFA), Morrison, K, "The Good, the Bad, and the Ugly reality about CCS (Carbon Capture and Storage)", slide 12, https://ieefa.org/sites/default/files/2024-03/CCSpresentation4-MPCMarch24_CK.pdf



<u>Figure 2: IEEFA: Real World CO2 Capture (2024)</u>

Despite no gas-CCS system ever having been constructed at a commercial scale, 90% capture is nevertheless being promised for Net Zero Teesside (Track-1) and at Peterhead (Track-2). For blue hydrogen production, no more than 80% capture has ever been achieved, yet 95% is being promised for H2 Teesside (Track-1).

No satisfactory evidence has been provided why the projects in the UK CCUS programme should now considerably exceed what existing commercial projects are achieving.

The government should note that the provisional documentation for the Dispatchable Power Agreement gas-CCS plants only requires that plants will need to achieve a minimum capture rate of 70% in order to receive subsidy payments[20]. This strongly suggest that the Government and scheme promoters are not confident of reaching the much high capture rates which they promise.

The risk that these projects are unable to deliver on claimed capture rates must therefore be considered high, and appraisal of greenhouse gas impacts should be made on the basis of more precautionary capture rates in line with performance of existing commercial sites.

The risk from overstated carbon capture rates is compounded by a more fundamental problem. That is that the majority of greenhouse gas emissions associated with gas-CCS and blue hydrogen plants have now been demonstrated to occur in the upstream and downstream parts of the process and are therefore not subject to capture by the CCS equipment. These are described now.

[20] DESNZ (2024) - Dispatchable Power Agreement (DPA) Provisional Heads of Terms, https://assets.publishing.service.gov.uk/media/615b02b6d3bf7f55fe946b62/dpa-provisional-heads-terms-october-2021-annex-a.pdf

II. Venting of CO2 may not be included

When the CCS plants, or CO2 compressors, or the CO2 Transport and Storage network are being maintained, CO2 will be vented to the atmosphere. This is a downstream Scope 3 emission type. The promoters of Net Zero Teesside estimated that the availability of the CO2 transport and storage system would be 93.5% . NZT calculated that this amounted to 3,592,523 tonnes of CO2 over 25 years . This figure equates to an additional carbon intensity component of 25.0 gCO2/KWh in the power station footprint.

This is CO2 which is captured but is not stored. For this reason, my own calculations separate out captured emissions, and stored emissions.

III. Upstream emission factors: underestimated and don't reflect changes to natural gas supply

Upstream emissions relate to the supply chain emissions in the natural gas supply. They involve leakage of methane (natural gas) from extraction and pipelines. Where Liquified Natural Gas (LNG) is the supply, they also involve methane leakage from compressing the gas, and regasifying it, and also shipping emissions. These are upstream Scope 3 emissions, both CO2 and methane. To obtain an accurate measure of these emissions is a very complex area as it is dependent upon industry practices across many nations, and the changing nature of the UK natural gas supply.

The key message is that upstream emissions in the natural gas supply chain have been systemically underestimated, and this is now coming to light both from real-world evidence such as satellite methane detection, and academic analysis. **Of the latter, recent academic studies which have calculated both upstream methane and CO2 emissions from supply chains from first principles (for example, Zhu et al (2024)[21], Howarth (2024)[22], and a Carbon Tracker[23] 2024 report.**

The October 2024 paper by Professor Robert Howarth[24] is a landmark study which shows that due to the powerful warming impact of methane leaks and shipping emissions along the supply chain for LNG exported from the US, only a third of greenhouse gas emissions occur at the point of use (eg at a UK gas-CCS or blue hydrogen plant). So even if CCS were to achieve a high capture rate, around the 2/3rds of the carbon footprint arising elsewhere in the supply chain cannot be mitigated. Pre-publication drafts of this paper resulted in the Biden administration pausing new licences for LNG export from the US[25] in January 2024.

With respect to the Howarth paper, I request that Dr Whitehead considers the following. The paper has been fully peer reviewed and was revised to reflect review comments. The paper calculates

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[21] https://pubs.acs.org/doi/10.1021/acssuschemeng.4c07255

[22] https://scijournals.onlinelibrary.wiley.com/doi/10.1002/ese3.1934

[23] https://carbontracker.org/reports/kind-of-blue/

[24] Howarth, "The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States", Energy Science & Engineering, October 2024, https://scijournals.onlinelibrary.wiley.com/doi/10.1002/ese3.1934

[25] White House Fact Sheet, "Biden-Harris Administration Announces Temporary Pause on Pending Approvals of Liquefied Natural Gas Exports", https://www.whitehouse.gov/briefing-room/statements-releases/2024/01/26/fact-sheet-biden-harris-administration-announces-temporary-pause-on-pending-approvals-of-liquefied-natural-gas-exports/

upstream emissions from first principles – calculating emissions at every stage. Table 1 of the paper summarises this and includes stages for: Upstream and midstream methane and CO2; Downstream methane; Liquefaction for methane and CO2; Tankers for Methane slip, Fuel consumption, Boil-off using Cargo volume and Voyage times data. Each of the major parameter comes from the latest references in the literature. Howarth's methane emission factor is "derived from the very latest data set from a large body of independent observations from nearly one million aerial site measurements[26] and far better reflects the current state of the science". The Howarth paper is thorough and must be treated as the very latest science on LNG emissions.

Another recent report from Carbon Tracker "Kind of Blue"[27] sets out in detail the key issues which act together to compound the climate impact of gas-CCS or blue hydrogen production, including:

(A) The emission factors used for upstream emissions in the natural gas supply chain are underestimated. There are two compounding factors – underestimating the methane leakage in any particular source of natural gas and underestimating the effects of the changing balance of UK natural gas between UK and Norwegian gas (lower upstream emissions) and imported gas, especially LNG (higher upstream emissions).

(B) Although DESNZ publishes emissions factors annually, underestimating has been historically perpetuated by using data self-reported by fossil fuel companies, and based on unpublished estimated leakage rates from up to 40 years ago.

A 2023 paper[28] in the Royal Society of Chemistry journal *Energy & Environmental Science* ("RSC paper") reported on the likely substantial underestimation of reported methane emissions from United Kingdom upstream oil and gas activities. The paper found that the total UK methane CH4 emissions from flaring, combustion, processing, venting, and Oil & Gas transfer to be 289 Gg CH4 (0.72% of production). This figure is five times larger than the estimate from United Kingdom (UK) government's National Atmospheric Emissions Inventory (NAEI) is used to provide UK greenhouse gas emission data to the United Nations Framework Convention on Climate Change. NAEI estimated the equivalent figure for 2019 to be 52 Gg CH4, corresponding to the loss of 0.14% of production. The paper stated, "*The difference between current estimates used by NAEI and our estimates, which use more recent research findings, strongly suggests that the current methods of compiling national GHG inventories in the UK, and likely elsewhere, are outdated (oldest [Emission Factor] derived in 1982) and systematically underestimate emissions.*" The reason given was "*Most of the emission estimates are derived using a bottom up approach that takes 30 to 40 year-old [Emission Factor]s from available unpublished literature (flaring and loss in pipelines), unavailable unpublished literature (venting and offshore oil unloading) or expert opinion (fugitive emissions).*"

[26] Sherwin ED, Rutherford JS, Zhang Z, et al. US oil and gas system emissions from nearly one million aerial site measurements. Nature. 2024;627:328-334. doi:10.1038/s41586-

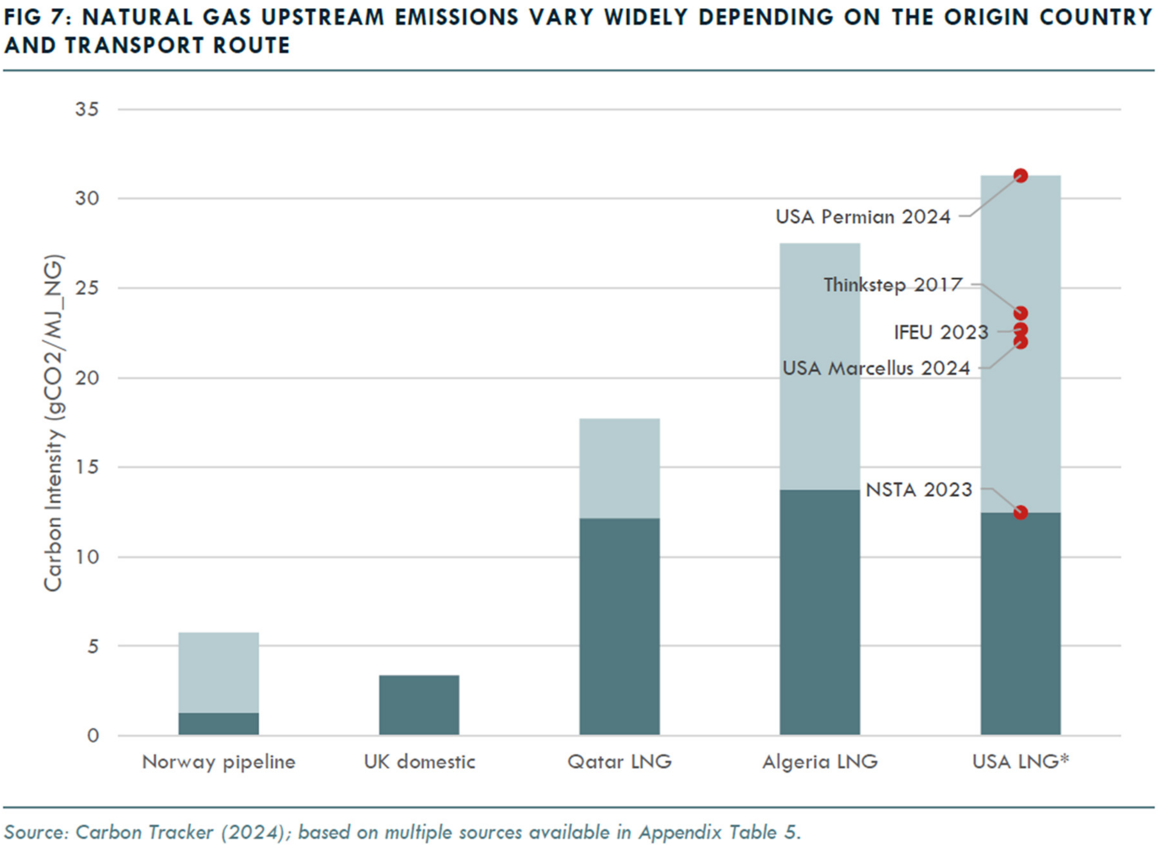
024-07117-5

[27] Carbon Tracker, "Kind of Blue", 2024, https://carbontracker.org/reports/kind-of-blue/

[28] Stuart N. Riddick, Denise L. Mauzerall. Likely substantial underestimation of reported methane emissions from United Kingdom upstream oil and gas activities. Energy & Environmental Science, 2023; 16 (1): 295 DOI: 10.1039/d2ee03072a, https://pubs.rsc.org/en/content/articlehtml/2023/ee/d2ee03072a

This is one example of how in recent years, satellite and remote sensing has achieved much a more accurate picture of upstream methane emissions, and that this is revealing this systemic underestimation[29].

(C) The source of the natural gas is important given the very different scale of emissions possible[30]. LNG imports have a much greater upstream emission footprint than UK domestic or Norwegian pipeline sources, see below.



<u>Figure 3: Carbon intensity for different Natural Gas supplies[31]</u>

(the lighter shading shows the range of carbon intensities)

(D) UK sources of natural gas are declining, and imports are growing[32].

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[29] Carbon Tracker, "Kind of Blue", page 14 "*Numerous independent reports have pointed out that there is still a large gap between the emissions self-reported by major fossil fuel companies and emissions estimated via satellites or remote sensing <footnote 26>. In particular, the IEA reports that most of the self-reporting is today based on reference values instead of measured emissions and that the difference between the two approaches could be massive.*"

[30] Carbon Tracker, "Kind of Blue", page 13, "Upstream emissions vary widely depending on the origin of natural gas, due to different extraction processes (conventional, fracking), transportation (pipeline, LNG shipping) and the leakages in the full supply chain."

[31] Carbon Tracker, "Kind of Blue", page 13,

[32] Carbon Tracker, Kind of Blue, page 14, "*Natural gas production in the UK has been in steep decline since the 2000s and, in the last ten years, it stabilised around half of the national supply with the rest being imported via pipeline (mostly from Norway) or LNG. Domestic production is expected to drop further in the coming decades while pipeline imports from Norway are also expected to decrease, though more slowly.*"

(E) LNG imports are predicted to grow, and DESNZ's December 2023 report "The role of gas storage and other forms of flexibility in security of supply"[33], notes:

> *"… the UK's import dependence for both LNG and interconnector gas supply is projected to rise from a predicted 13% in 2023 to around 32% by 2030. This is forecast to peak at around 58% in 2045, falling to 50% by 2050. It is likely that LNG will make up a significant proportion of these future gas imports."*

Although interconnector and LNG supplies are conglomerated in the above quote, based on DESNZ Statistics from March 2024, Carbon Tracker estimated that in 2023 LNG accounted already for 24% of the UK's total gas supply[34]

Critically, the DESNZ December 2023 report also identified that further research and analysis was required[35] on the methane emission intensity from the gas supply:

> *"As we import more gas, we are also mindful that the level of greenhouse gas emissions from overseas extraction, liquefaction and shipping of LNG varies considerably and is, in many cases, higher than UKCS[36] production. NSTA research shows that the production and transportation emissions of CO2 associated with LNG imports are on average over quadruple the global emission intensity of UKCS gas production. Further research and analysis is needed to develop our understanding of the methane emissions intensity of different sources of gas supply."*

The overall scale of CCUS planned in the UK will also become a driver for increased LNG imports. Carbon Tracker found that 4 GW of blue hydrogen and 9 GW of gas-CCS plants are planned by 2035[37], and report that:

> *"We estimate that if all the gas-based CCUS projects proposed by the UK's Net Zero strategy are built, by 2035 new gas demand could two times greater than the projected domestic production requiring an inevitable reliance on LNG imports."*

Carbon Tracker have also developed a model of a long-term gas outlook built on UK Government and other projections which broadly shows that, even assuming the unlikely development of new gas licenses in the 2030s, the 2030s the share of imported LNG could average around 50%[38].

The evidence is that imported LNG will play a significant role in meeting UK natural gas demand. Since cheaper pipeline gas will always be utilised first before turning to expensive LNG, any extra demand created by investing in new gas power stations or blue hydrogen production will, at a national level, be met entirely by imported LNG. **Life cycle assessments for new CCS-enabled**

[33] DESNZ, December 2023, "Role of gas storage and other forms of flexibility in security of supply", pages 19-20, https://www.gov.uk/government/publications/role-of-gas-storage-and-other-forms-of-flexibility-in-security-of-supply

[34] Carbon Tracker, "Kind of Blue", page 16

[35] DESNZ, December 2023, "Role of gas storage and other forms of flexibility in security of supply", pages 19-20, https://www.gov.uk/government/publications/role-of-gas-storage-and-other-forms-of-flexibility-in-security-of-supply

[36] UK Continental Shelf

[37] Carbon Tracker, "Kind of Blue", Pages 26-27

[38] Lorenzo Sani, Carbon Tracker, personal communication, Sept 2024

plants, such as the Track-1 and Track-2 start-up projects should therefore treat the methane gas input as 100% provided by LNG imports.

The DESNZ emission factors are mostly based on a 2015 report from Exergia[39]. The ten-year old report does not reflect the latest scientific findings on upstream emissions, particularly the more accurate measurement by satellites and remote sensing available now. The evidence base of this Exergia report is most likely outdated. It is imperative for DESNZ to update its methodology and assessment of emission factors.

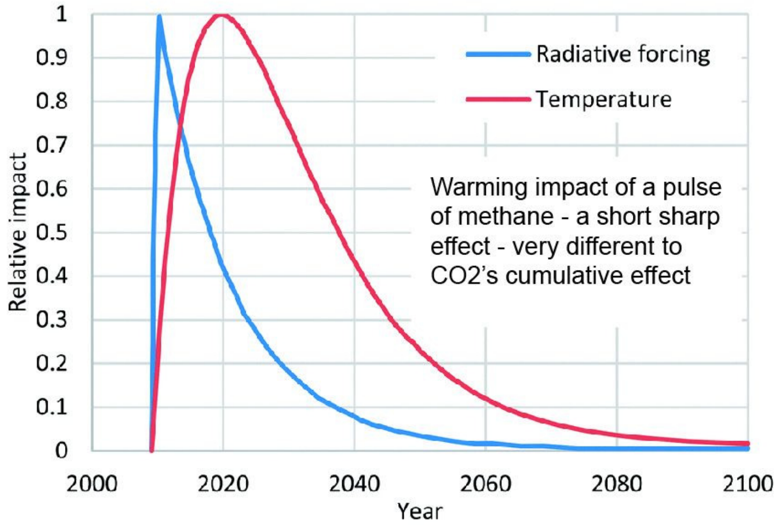
In summary, the upstream GHG footprint for the UK natural gas supply is underestimated by existing emissions factors, and the growth of high carbon intensity imports are overlooked in emission factors. In short, the emission factor(s) used by DESNZ is an out-of-date underestimate as shown by recent measurements by satellites or remote sensing, academic analysis, and does not reflect future scenarios of gas supply.

IV. The rapidly evolving science on methane emissions and their impact of the global climate

As described, the most significant carbon footprint for the Track-1 and Track-2 gas-CCS and blue-hydrogen plants comes from methane and other upstream emissions in the supply of the gas. A further issue is that methane has a half-life in the atmosphere of around 10 years which means that its effects on global heating is concentrated in the first 20 years from its release. This shown in the figure[40] below which shows the atmospheric effect, known a "radiative forcing" (blue line), of a methane pulse in 2010 being largely complete by 2030 (although actual physical temperature change trails in time).

[39] https://energy.ec.europa.eu/system/files/2015-08/Study%2520on%2520Actual%2520GHG%2520Data%2520Oil%2520Gas%2520Final%2520Report_0.pdf

[40] From: Balcombe etc al, 2018, "Methane emissions: choosing the right climate metric and time horizon", https://pubs.rsc.org/en/content/articlelanding/2018/em/c8em00414e



From Study: "Methane emissions: choosing the right climate metric and time horizon"

Figure 4: The short sharp effect of methane emissions

It is urgent to reduce methane emissions. This was recognised by global policy initiatives like the Global Methane Pledge[41] signed by over 150 countries[42] at the United Nations Climate Change conference in November 2021 (COP26), including the UK as COP26 host country. The UN said in 2021 that sharp cuts to methane (45% this decade) would avoid nearly 0.3° of warming by 2045[43]. Yet in September 2024, Carbon Brief reported that levels of methane in the atmosphere have soared by record-breaking amounts since 2020[44].

Urgent action on methane emissions is even more important following recent science finding that we are closer to crossing dangerous tipping points than previously thought. Of key concern is the abrupt collapse of the Atlantic Meridional Overturning Circulation (AMOC) ocean current which stops UK temperatures plunging to those seen in northern Canada—which several new studies now find could well start irreversibly within the next few decades on current emissions trajectories[45].

Despite, these very significant concerns about methane emissions, the emissions factors (such as the DESNZ ones) used to model and assess upstream emissions from CCS plants use an outdated model of the radiative effects and climate impacts. This is due to a historical quirk from international standards developed in the 1990s which model methane's climate impact over 100 years rather than over the much more realistic 20 years. By effectively spreading the radiative forcing effect over 100 years, this approach significantly underestimates methane's impact over the

[41] https://www.globalmethanepledge.org/

[42] Now signed by over 150 countries, Carbon Brief, https://www.carbonbrief.org/qa-why-methane-levels-are-rising-with-no-hint-of-a-decline/

[43] UNEP, May 2021, "Global Assessment: Urgent steps must be taken to reduce methane emissions this decade, https://www.unep.org/news-and-stories/press-release/global-assessment-urgent-steps-must-be-taken-reduce-methane

[44] Carbon Brief, 10 September 2024, "Q&A: Why methane levels are rising with no 'hint of a decline'", https://www.carbonbrief.org/qa-why-methane-levels-are-rising-with-no-hint-of-a-decline/

[45] Rahmstorf, Oceanography, April 2024, "Is the Atlantic Overturning Circulation Approaching a Tipping Point?", https://tos.org/oceanography/article/is-the-atlantic-overturning-circulation-approaching-a-tipping-point

20 years in which most of its global heating impact is originated, and is the timescale in which we need decisive action to avoid runaway global heating.

Technically, this is described as the emission factor being based on a 100-year Global Warming Potential (GWP) called GWP100 rather than a 20-year GWP called GWP20.

Recently Professor Robert Howarth of Cornell University who has advised the US Government and given evidence to the Senate Climate Change Task Force published a landmark paper[46] in which he explains the issue with the different GWPs as in the footnote. Note, also that Professor Howarth states that the use of US exported LNG always has a larger greenhouse gas footprint than coal. Professor Howarth also identifies in the footnote quote that methane has been responsible for around 2/5ths of the global heating temperature rise to date.

3.5 Where does the natural gas supply chain fit in the UK carbon budget regime

Natural gas may be sourced either from UK fields, or by pipeline from Norway, or as Liquified Natural Gas (LNG) shipped from far afield places such as Qatar or the US. But whatever private contracts the operators of new CCUS projects enter into, at a UK national level, all the extra demand will have to be satisfied by LNG imports. The fact that UK is already importing expensive LNG, the share of which is set to grow, provides evidence that cheaper pipeline gas output is already maxed out.

The very high carbon footprint from natural gas supply occurs both within UK territories as covered under UK carbon budgets (under the Climate Change Act 2008) and ex-territorially when the gas comes from other countries.

With LNG, the ex-territorial LNG supply chain emissions then form part of UK consumption emissions and ex-territorial greenhouse gas emission inventories: for example, GHGs international shipping inventories and for other countries. The UK-territorial emissions for natural gas supply fall under the Fuel Supply sector in the carbon budgets under the Climate Change 2008.

As the majority of upstream emissions generated by UK demand for natural gas occur outside UK territory, making policy on the basis of UK territorial emissions only does not make sense. However, this is what the Government and CCC do, by just considering UK territorial emissions. So policies to tackle climate change and reduce emissions are being created without consideration of most of the emissions being generated.

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[46] "The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States", Energy Science & Engineering, October 2024, https://scijournals.onlinelibrary.wiley.com/doi/10.1002/ese3.1934 :

"While the 100-year time frame of GWP100 is widely used in lifecycle assessments and greenhouse gas inventories, it understates the extent of global warming that is caused by methane, particularly on the time frame of the next several decades. The use of GWP100 dates to the Kyoto Protocol in the 1990s, and was an arbitrary choice made at a time when few were paying much attention to the role of methane as an agent of global warming. As the Intergovernmental Panel on Climate Change stated in their AR5 synthesis report, "there is no scientific argument for selecting 100 years compared with other choices" (IPCC 2013). The latest IPCC AR6 synthesis reports that methane has contributed 0.5° C of the total global warming to date since the late 1800s, compared to 0.75° C for carbon dioxide (IPCC 2021). The rate of global warming over the next few decades is critical, with the rate of warming important in the context of potential tipping points in the climate system (Ritchie et al. 2023). Reducing methane emissions rapidly is increasingly viewed as critical to reaching climate targets (Collins et al. 2018; Nzotungicimpaye et al. 2023). In this context, many researchers call for using the 20-year time frame of GWP20 instead of or in addition to GWP100 (Ocko et al. 2017; Fesenfeld et al. 2018; Pavlenko et al. 2020; Balcombe et al. 2021, 2022). GWP20 is the preferred approach in my analysis presented in this paper, as was the case for our earlier lifecycle assessment of blue hydrogen (Howarth & Jacobson 2021). Using GWP20, LNG always has a larger greenhouse gas footprint than coal."

3.6 ***Where does the biomass supply chain fit in the UK carbon budget regime***

Large scale bioenergy producers like Drax import the vast majority of their wood feedstock. Despite, the wood being combusted within UK territory, and the emissions being huge, the convention has been to account the combustion emissions as zero. This "zero rating" principle falsely accounts for the biomass combustion emissions as being offset by instant forest regrowth in the feedstock source country. There are a number of serious issues with this:

(A) Burning wood to generate electricity emits as much or more CO2 per megawatt-hour as burning coal[47].

(B) Treating these bioenergy combustion emissions as actually having "zero" emissions, rather than acknowledging this is simply a convention, can obscure large impacts and the IPCC is thus clear that bioenergy should not be considered carbon neutral based on its zero-rating in the energy sector[48].

(C) The zero-rating convention assumes that loss of forest carbon stock for fuel stock and combustion is instantly replaced with forest carbon stock elsewhere in the global carbon cycle. However, forest carbon sink is declining (becoming less negative) in the US, one of the main suppliers of UK biomass, with a decline since the wood pellet industry started really growing in recent years[49]. This indicates that forest growth, and critically associated carbon sinking, is not happening instantly.

(D) Given this, it is no surprise that scientists are concerned that the net carbon impacts of increased forest harvests for bioenergy are rising. And academic studies are showing where a reduction is in forest carbon stocks associated with increased use of forest biomass relative to the counterfactual scenario with lower harvests, as it often takes considerable periods of time until forest bioenergy actually provides net carbon savings in comparison to fossil-based reference systems. The analysis of Sterman et all (2022)[50] provides evidence that the impact of harvesting biomass fuel in 2025 is to increase forest emissions until around 2040 because "*the carbon sequestered by regrowth is initially less than the carbon the forest would have stored had it not been harvested*". Examining Figure 2 in the Sterman paper would suggest that there is no net carbon payback until 2050 (starting from 2025). Given the horizon considered here for the Whitehead review is 2050, zero sequestration from forest regrowth should be accounted for in full-lifecycle analysis and policy making.

(E) The CCC's and DESNZ's treatment of biomass CO2 as "zero" contradicts IPCC guidance. Please see the detailed discussion including discussions at the March 2025 hearings by Parliament's Public Accounts Committee where officials from DESNZ tried to explain, and

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[47] Comments to the UK Subsidies Advice Unit on the proposed subsidy to Drax Power from the Partnership for Policy Integrity and The Lifescape Project, page 6, https://forestlitigation.org/wp-content/uploads/2025/06/PFPI-Lifescape-comments-on-Drax-subsidy-June-12-2025.pdf

[48] Comments to the UK Subsidies Advice Unit on the proposed subsidy to Drax Power from the Partnership for Policy Integrity and The Lifescape Project, page 7, https://forestlitigation.org/wp-content/uploads/2025/06/PFPI-Lifescape-comments-on-Drax-subsidy-June-12-2025.pdf

[49] Comments to the UK Subsidies Advice Unit on the proposed subsidy to Drax Power from the Partnership for Policy Integrity and The Lifescape Project, page 9, https://forestlitigation.org/wp-content/uploads/2025/06/PFPI-Lifescape-comments-on-Drax-subsidy-June-12-2025.pdf

[50] Sterman, J., Moomaw, W., Rooney-Varga, J. N., & Siegel, L. (2022). Does wood bioenergy help or harm the climate? *Bulletin of the Atomic Scientists*, *78*(3), 128–138. https://doi.org/10.1080/00963402.2022.2062933

failed to do so, the rationale behind treating "sustainable" biomass as actually having zero emissions in the footnote[51].

3.7 *CCC and DESNZ policy making on gas and biomass imports do not follow Treasury Green Book guidance*

The CCC and DESNZ has not followed Treasury Green Book guidance on treatment of CO2 emissions[52]. Supplementary guidance to Treasury's Green Book provides guidelines to government analysts for quantifying GHG emissions. The main document[53] explains that policies and projects can affect GHG emissions "*directly through changes in energy use, or indirectly through planning, land use change, construction or the introduction of new policies that use energy*." The guidance states that proposals can have "*a significant impact on emissions produced abroad*". Critically, the Green Book guidance calls for **counterfactual modelling of emissions**, stating at 3.34 *"A policy or project that increases or decreases GHG emissions domestically or internationally relative to a 'business as usual' scenario is required to quantify the change in emissions"* and that emissions should be assigned a monetary value by using carbon cost values provided in an associated spreadsheet.

This should apply both to biomass imports and also LNG imports. This guidance is for assigning a monetary value to carbon emissions using Treasury carbon cost values, and it is clear that ex-UK emissions generated by from UK activities (eg: creating electricity from biomass and gas burning, or CCS blue hydrogen from gas) should be accounted for in monetary terms. It follows that such emissions should be accounted for in policy making.

However, CESL have seen no evidence that CCC and DESNZ are following these guidelines – either for monetary and value for money appraisal, or for greenhouse gas and climatic impacts – in policymaking. In fact, a recent FoI (see Appendix F) shows that calculations for the CCC Sixth Carbon budget report on upstream emissions from natural gas were made in line with "territorial emissions accounting". My understanding is that the same assumptions has been made in the Seventh Carbon Budget report.

This Nelson's blind eye approach appears to extend to for upstream emissions associated with biomass combustion.

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[51] **Please read pages 10-12** from - Comments to the UK Subsidies Advice Unit on the proposed subsidy to Drax Power from the Partnership for Policy Integrity and The Lifescape Project, , https://forestlitigation.org/wp-content/uploads/2025/06/PFPI-Lifescape-comments-on-Drax-subsidy-June-12-2025.pdf

[52] **Please read pages 12-15** from - Comments to the UK Subsidies Advice Unit on the proposed subsidy to Drax Power from the Partnership for Policy Integrity and The Lifescape Project, , https://forestlitigation.org/wp-content/uploads/2025/06/PFPI-Lifescape-comments-on-Drax-subsidy-June-12-2025.pdf

[53] https://assets.publishing.service.gov.uk/media/65aadd020ff90c000f955f17/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.pdf ; full list of relevant docs at https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

3.8 UK policy making only sees a small part of the full GHG footprint

There is a very severe concern above that UK policy making has predominantly been concerned only those emissions which come under the UK territorially based Climate Change Act 2008.

And as confirmed above, a recent FoI (see Appendix F) shows that calculations for the CCC Sixth Carbon budget report were made in line with "territorial emissions accounting". My understanding is that the same assumptions has been made in the Seventh Carbon Budget report.

In other words, the UK has developed its own climate policy incorporating CCUS without concern for the international climate impacts from the natural gas demand inherent in the policy.

I later develop calculations to demonstrate these climate impact issues for developing gas-CCS and blue hydrogen in the UK.

GHG reporting for blue hydrogen production also shares the same issues of overstated carbon capture rates, CO_2 venting, underestimate emissions factors for upstream emissions and not being consistent with up-to-date modelling of methane impacts. Leakage of hydrogen, itself a powerful indirect GHG, is also an issue for blue hydrogen although I am not calculating in this submission.

4 Evidence from CESL on full lifecycle GHG emissions

4.1 Case studies of three GGR/CCS technologies with high upstream emissions

As stated in my "Brief Bio" and "Personal position statements" sections, I have engaged pro-actively in three DCO planning examinations for GGR/CCS projects across the three key technologies which share the issues raised above of high upstream emissions in the fuel / feed stock supply chains:

(A) BECCS bioenergy plants,

(B) gas-fired power stations with CCS, and

(C) blue hydrogen plants with CCS.

Since these DCO planning examinations, new science has become available. I have updated my analysis for a case study of each of these technologies using real examples actively under consideration. The case studies are given in the Appendices listed. I am happy to make my full spreadsheet models available to Dr Whitehead's team, should they be interested. For this submission, I have summarised the analysis into simple Tables, and I have sourced/referenced my assumptions as fully as possible.

(A) BECCS bioenergy plant. **Drax BECCS** as planned post-2031. See Appendix A.

(B) gas-fired power station with CCS. SSE's **new Peterhead gas plant with CCS**. Funding pledged in the June 2025 Comprehensive Spending review. The Peterhead project is still active in the Scottish planning system, and therefore is of particular interest. See Appendix B.

(C) blue hydrogen plant with CCS. **BP's H2 Teesside**. Funding pledged in October 2024. See Appendix C.

In each case, I start with data provided by the developer for its Environmental Impact Assessment at planning. I then make sensitivity tests on two key factors:

(A) **upstream emissions.** In the case of BECCS, this relates to relates to treating emissions generated by combustion in the UK <u>as UK emissions</u>, and treating carbon stock emissions in wood exporting countries (such as the US) <u>**not**</u> as instant offsets. Recent science suggests the replenishment of carbon stocks from forest regrowth can take decades, and may not even become positive until after 25 years: therefore, no offset emissions are included.

In the case of natural gas (for new fossil fuel based infrastructure), the <u>extra demand</u> for gas for the new infrastructure will, at a national level, be met entirely by imported LNG, with cheaper UK gas or Norwegian pipeline gas always being utilised first in the existing market demand. Therefore, the upstream emissions are based upon imported LNG supplies meeting the demand created by the new CCS infrastructure.

(B) **Realistic CO2 capture rates.** See the previous section "Overestimation of carbon capture rate". As providers can claim subsidies if 70% capture is achieved, this sensitivity test models 70% capture rate.

The figures show that upstream emissions are by far the major effect, and yet they are not picked up by the CCC advice to DESNZ which is based purely on UK territorial emissions.

4.2 Results for BECCS

A number of points are summarised in Appendix A. For the discussion here, I bring forward these points:

(A) Drax does not achieve "*an overall reduction in greenhouse gas emissions*", either:

  a. in continued operation of Drax under the proposed 2027-2031 transition subsidy (capped at 27% generation), or

  b. in future (post-transitional) operation of Drax with BECCS

(B) Point b is crucial. In this example, **Drax with BECCS is not negative-emissions infrastructure.** I estimate the proposed BECCS at Drax to operate with a carbon intensity in the range 341-564 gmCO2e/KWh. Note that carbon intensity of unabated gas CCGT (Combined Cycle Gas Turbine) in the UK is generally quoted as being around 360 gCO2eq/kWh[54].

(C) Running as BECCS, every tonnes of CO2 stored comes with a positive carbon footprint of additional emissions to the atmosphere:

  a. After CO2 venting (T & S unavailability), the total emissions are 0.38 tCO2 for every tCO2 stored, **overall net positive**.

  b. After CO2 venting (T & S unavailability), the total emissions are 0.74 tCO2 for every tCO2 stored, **overall net positive**.

Then developing these points further with the CCC projections for energy at 2050:

(D) The data[55] under Figure 7.12.1 of the CCC's Seventh Carbon Budget report[56] ("7CB") indicates that at 2050 CCC project "negative emissions" of 9.63 MtCO2 from "BECCS – power", 5.37 MtCO2 from "BECCS – energy-from-waste", and 9.82 MtCO2 from "BECCS – other". This gives a total of 24.82 MtCO2 from BECCS and corresponds to the overall 25MtCO2 which I identified in my introductory section "What is being advised by the CCC?".

(E) For the range above of net positive emissions of 0.38 tCO2 - 0.74 tCO2 for every tCO2 stored, the 9.63 MtCO2 stored from "BECCS – power" comes with a cost to the carbon budget in 2050 of 3.7 MtCO2 to 7.15 MtCO2.

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[54] Note that this figure is an underestimate as the upstream emissions in the gas supply chain are currently not accounted correctly. I have written about this much elsewhere. However, I use this figure as a comparator in common usage for the purpose of this submission.

[55] https://www.theccc.org.uk/wp-content/uploads/2025/02/The-Seventh-Carbon-Budget-Charts-and-data-in-the-report.xlsx

[56] https://www.theccc.org.uk/wp-content/uploads/2025/02/The-Seventh-Carbon-Budget.pdf

(F) **The key point here is that, on the basis of zero rating the combustion emissions of burning biomass in the UK, the CCC project 9.63 MtCO2 of "negative emissions" from "BECCS – power" at 2050. However, once the combustion emissions are included correctly, the policy for "BECCS – power" is actually net positive and comes with a comes with a cost to the carbon budget in 2050 of 3.7 MtCO2 to 7.15 MtCO2.**

(G) **It is only possible to see "BECCS - power" as net negative by ignoring the carbon footprint generated outside of UK territory (from forest carbon stock depletion). This is currently done by zero rating the combustion emissions generated in UK territory in UK carbon budgets. This is scientifically false.**

(H) This is the point being made in the previous section "UK policy making only sees a small part of the full GHG footprint"

4.3 Results for new gas with CCS

A number of points are summarised in Appendix B. For the discussion here, I bring forward these points:

(A) Using data from the 2024 Howarth paper, the upstream are over 10 times greater than those in the SSE Reference case for Peterhead based upon the 2024 UK Govt emissions factor. **This is important showing that the UK emissions factors are out-of-date and severely underestimate upstream emissions** as discussed in the section "Upstream emission factors: underestimated and don't reflect changes to natural gas supply".

(B) The impact of this is **only 35.7% of the full life-cycle emissions are capturable**. Leading to the maximum possible storage of emissions as 31% (at 90% capture) or 23% (at 70% capture, adjusted for T&S unavailability (CO2 venting)).

(C) The overall footprint of the Peterhead CCS gas plant is up to 80MtCO2 over 25 years when running is dispatchable mode at the levels specified in the data provided by SSE itself in its Additional Information Report[57] ("AIR") 2025 – dated 16 May 2025 (ie very recent).

(D) **The key point here is that this is being put forward as an "anchor" emitter project for the Acorn CCUS cluster. For the Acorn cluster to ever become carbon neutral over its lifetime, savings from third party emitters need to first offset the huge footprint of the power plant, even when it is running in dispatchable mode. I am aware of no evidence which demonstrates how the Acorn cluster can become carbon neutral over its lifetime when the full impacts of upstream emissions are calculated with the latest science.**

(E) **It is only possible to see that a CCUS cluster anchored with a gas plant as overall net negative by ignoring the carbon footprint generated outside of UK territory (from upstream gas supply chain emissions). This is currently done by using emissions factors that severely underestimate upstream emissions and only reporting impacts in UK carbon budgets. This is scientifically false.**

[57] Downloaded from https://www.energyconsents.scot/ApplicationDetails.aspx?cr=ECU00003433 (under Documents, Additional Information).

(F) This is the point being made in the previous section "UK policy making only sees a small part of the full GHG footprint".

4.4 Results for new blue hydrogen plants with CCS

A number of points are summarised in Appendix C. For the discussion here, I bring forward these points:

(A) Using data from the 2024 Howarth paper, the upstream are over 10 times greater than those in the than those in the BP supplied data based upon the UK Govt emissions factor. **This is important showing that the UK emissions factors are out-of-date and severely underestimate upstream emissions** as discussed in the section "Upstream emission factors: underestimated and don't reflect changes to natural gas supply".

(B) The impact of this is only 36.0% of the full life-cycle emissions are capturable. Leading to the maximum possible storage of emissions as 30.3% (at 95% capture) or 23.6% (at 70% capture, adjusted for T&S unavailability (CO2 venting)).

(C) The overall footprint of the H2 Teesside blue hydrogen plant is up to 140MtCO2 over 25 years.

(D) The project is being put forward as the second emitter project in the Net Zero Teesside cluster. **For the Net Zero Teesside cluster to ever become carbon neutral over its lifetime, savings from other third party emitters need to first offset both the huge footprint of the Net Zero Teesside power plant (similar argument apply as to the Peterhead gas CCS plant in the previous section), even when it is running in dispatchable mode, and the H2 Teesside blue hydrogen plant running at full production.**

(E) Currently, there is only one further emitter project being considered in Net Zero Teesside with relatively small emissions savings.

(F) **I am aware of no evidence which demonstrates how the Net Zero Teesside cluster can become carbon neutral over its lifetime when the full impacts of upstream emissions of its first two projects – Net Zero Teesside Power plant and H2 Teesside blue hydrogen plant - are calculated with the latest science.**

(G) This is the point being made in the previous section "UK policy making only sees a small part of the full GHG footprint".

5 Other evidence from CESL

5.1 On projected costs of GGR/CCS

The data[58] under the CCC's Seventh Carbon Budget report[59] ("7CB") provides Capex and Opex data (public and private investment) for GGR and CCS. I have analysed the data to see how it allocated to different sectors, GGR and CCS technologies. No overview, such I generate below, is given by the CCC and the graphs below have been generated by bringing together data from different sections and charts of the 7CB report.

In some area, the underlying data aggregate costs: for example, blue and green hydrogen production are aggregated under "low carbon hydrogen". (NB: blue hydrogen is very definately not "low carbon", as evidenced by the previous section, and the aggregated "low carbon hydrogen" grouping is misnomer.)

Despite, problems with not being to disaggregate the data as clearly as I would like, the evidence below can provide some useful observations on value for money, and misplaced priorities in the CCC advice and Government policies.

The graphs below summarise how the money would be spent each year, across all GGR/CCS technologies[60], first by Capex (essentially construction) and then by Opex (operation).

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[58] https://www.theccc.org.uk/wp-content/uploads/2025/02/The-Seventh-Carbon-Budget-Charts-and-data-in-the-report.xlsx

[59] https://www.theccc.org.uk/wp-content/uploads/2025/02/The-Seventh-Carbon-Budget.pdf

[60] The CCC projections are for six main sectors: "dispatchable low carbon energy" (gas with CCS), biomass with CCS (BECCS), Direct Air Capture (DACCS), "Low carbon hydrogen**" (green and blue hydrogen), EfW (waste incinerators with CCS), CCS for industry.

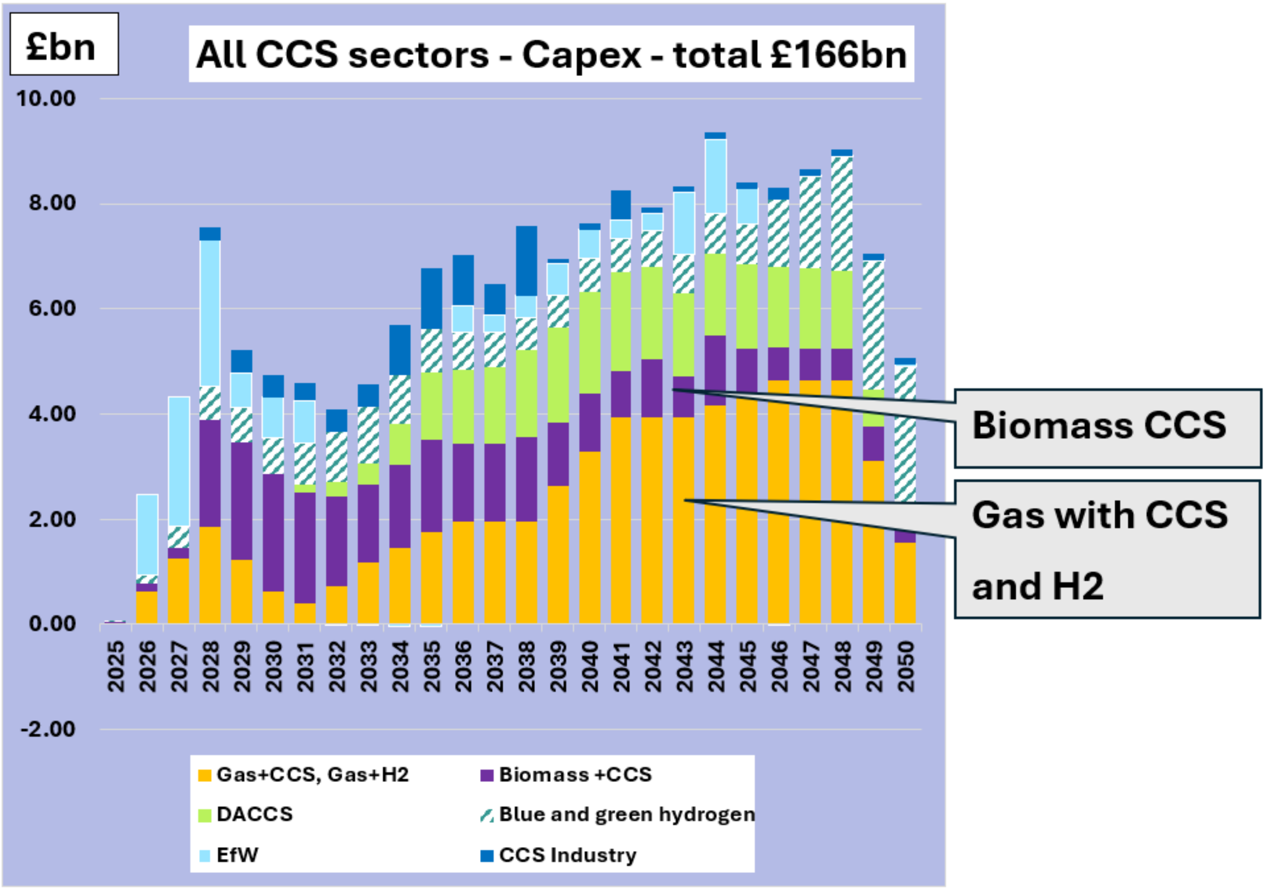

Figure 5: GGR/CCS projected Capex costs to 2050

The capital costs of gas with CCS, or gas co-fired with hydrogen, will be up to £4.5bn annually into the late 2040s indicating that gas fired electricity plants will still be under construction even then which will operate well into the second half of the century.

Whilst technically, co-firing gas with hydrogen could include burning green hydrogen for electricity, I suggest that the CCC is over-optimistic about the uptake of green hydrogen production. Leading analysts have predicted that "Green hydrogen prices will remain stubbornly high for decades"[61]. So gas may be being co-fired with blue hydrogen with its very high production carbon footprint.

I suggest that the Whitehead review needs to get to the bottom of projections around green and blue hydrogen – both in production (the "low carbon hydrogen" category) and is use in co-firing with gas (the "Gas+CCS, Gas+H2" category on the chart, "Dispatchable low-carbon electricity" in the 7CB). The CCC conflate and aggregate data which make it impossible to know what they are projecting.

[61] https://www.bloomberg.com/news/articles/2024-12-23/green-hydrogen-prices-will-remain-stubbornly-high-for-decades

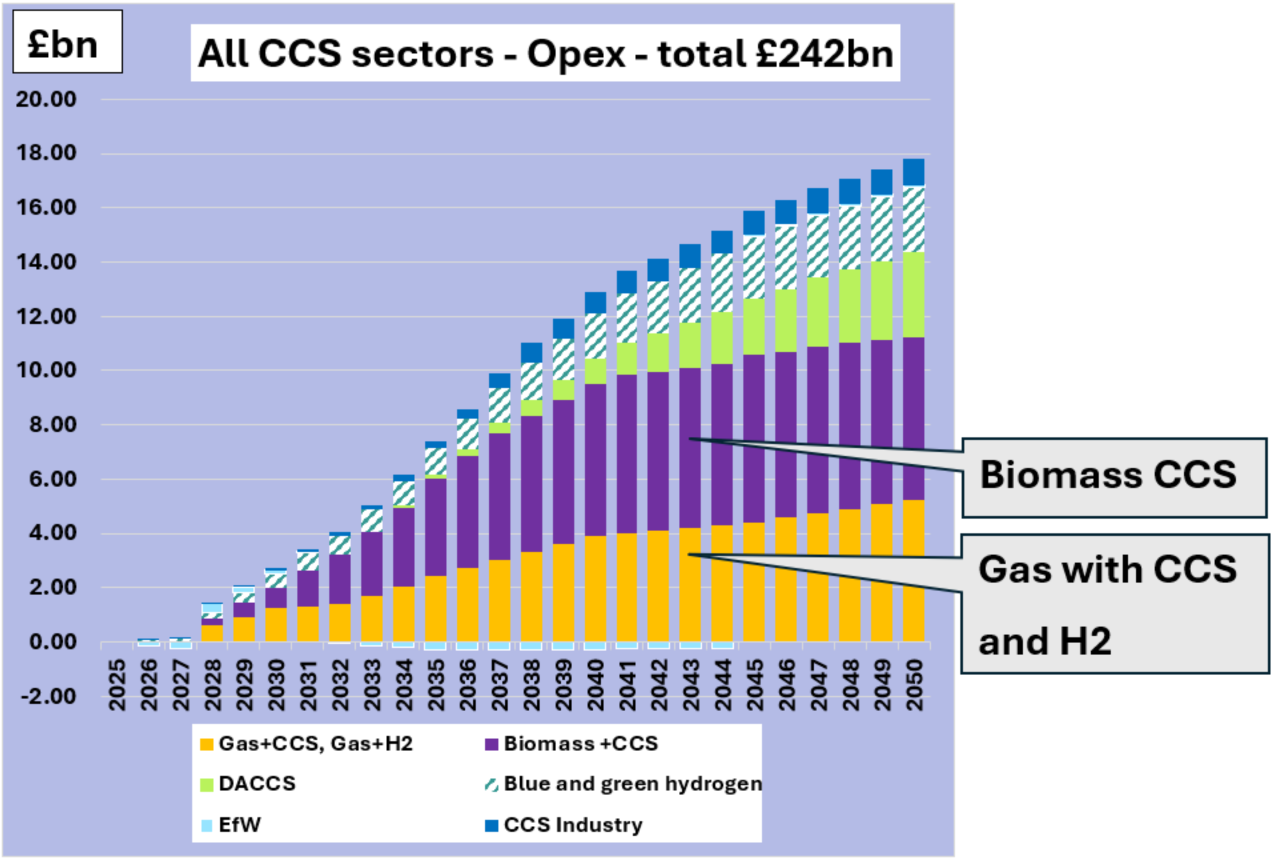

Figure 6: GGR/CCS projected Opex costs to 2050

Operating all the planned CCS technology will cost £18bn a year by 2050 with the operational costs for burning gas and biomass with CCS being around £10bn a year.

I. Key points

£264bn of the above figures is recommended for continuing to burn gas (as gas with CCS, or gas cofired with H2) and biomass. Up to £136bn for building and operating power stations burning gas[62] and £128bn for burning biomass with CCS (BECCS).

The previous sections and the GHG case studies for BECCS, gas power with CCS, and blue hydrogen production all show that the "UK policy making only sees a small part of the full GHG footprint" and that these technologies are all high emitters in a full lifecycle GHG analysis which include ex-UK upstream emissions. **In each case, they increase overall emissions rather than save them.**

This is paying to make climate change worse. It is paying to do with huge sums of money. Even as investment into electricity generation (if we did not care about climate change impacts), it does not make sense. The CCC data predicts that at 2050, the investment of £136bn into gas with CCS, and co-firing gas with hydrogen, will provide 5.5% of electricity generation whilst an investment of

[62] Either with CCS or with hydrogen produced predominantly with CCS before 2040 as green hydrogen uptake is expected to be slower than the CCC's optimistic projections.

£360bn into renewables and energy storage will provide 81.8% of electricity generation. In other words, investment in renewables and storage generates 5.6 times more electricity in 2050 per £1 investment into these gas-based technologies.

On the other hand, only £22bn is recommended by CCC for decarbonising hard-to-abate industry—just 5 to 6% of all CCS sectors. The government has promoted CCS as a means to industrial decarbonisation; however, the overall investment is dominated into gas and biomass based CCS which in the full lifecycle analysis is net positive and makes climate change worse.

5.2 Limits to scaling up clusters

It is also very uncertain that the CO2 storage for CCUS clusters can be expanded to support capture of industrial emissions at the rates being claimed. If industrial emissions cannot be expanded, then this would accentuate further the front-loading of very high fossil fuel emissions into each cluster (as described above for the combination of a gas power plant and a blue hydrogen plant into the Net Zero Teesside cluster). For example, analysis of the Teesside Endurance site in an academic paper[63] funded by the developers themselves[64] suggests an initial storage capacity of 4 million tonnes per year (Mtpa) for 25 years is within safe pressure limits. However, expanding beyond this rate to accommodate more annual CO2 storage requires further "dynamic appraisal" of early storage performance to manage pressure dissipation—a process still underway with no certainty of success. The paper actually states that expansion growth beyond Endurance Phase 1 (4 Mtpa) is highly uncertain[65], despite policy being based on being able to rapidly expand the rate of CO2 storage.

6 Discussion

The UK has declining oil and gas reserves, and we are projected to increase imports of LNG going forward. Even with some gas piped from Norway, any new gas burning or processing infrastructure is going to create a new and marginal demand for gas which may only be met by LNG imports. US LNG has one of the highest carbon footprints, and we can be expected to use increasing amounts of US LNG as production and export is ramped up under the current US administration.

The latest science on LNG supply chain emissions shows that the majority of the full lifecycle emissions are before the point of combustion or processing. So that gas-based CCS technology using LNG, such as gas power with CCS and blue hydrogen production, will to be able to capture most of their full lifecycle emissions: these technologies have an overall very high footprint.

When BECCS is correctly accounted with combustion emissions attributed to the UK, it also has a high footprint and is not net-negative.

Policy for these technologies has only been able to proceed to this point because the UK Government and its advisers the CCC have systematically ignored emissions from UK activity which fall outside UK territory, and applied zero rating to biomass combustion emissions.

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[63] https://www.lyellcollection.org/doi/abs/10.1144/egc1-2024-23

[64] The funding statement on page 25 (25/75) of the above paper states "*This research was funded by the commercial partners of the Northern Endurance Partnership (bp, Equinor and TotalEnergies).*"

[65] The figure legend for Figure 32 of the above paper states "*Fig. 32: Notional NEP CO2 injection profile including expansion via future development options. Expansion growth beyond Endurance Phase 1 (4 Mtpa) is highly uncertain.*"

It is for these reasons that the ScrapCC campaign is calling for the gas and biomass based CCS technologies – by which we mean BECCS, gas power with CCS, and blue hydrogen production – to be removed from the Climate plan (CBDP).

The Climate plan has twice been found to be unlawful already because its policies to reduce emissions and meet the carbon budgets had not been properly risk-assessed. The CCS policies for gas and biomass based CCS are high risk, and their delivery have not been risk assessed. This aligns with the conclusion of the recent Public Accounts Committee report[66] into CCUS which identified CCS as a high risk to meeting carbon reduction targets.

7 Recommendations

(A) The Whitehead review should consider all technologies for capturing or removing greenhouse gas emissions ie both GGR and CCS technologies.

(B) That Dr Whitehead and his team has a direct meeting with a small group of scientists selected from the signatories of the autumn 2024 letters (in Appendix D and E), and including myself (also a signatory on the letters). This would go far beyond the evidence presented in this submission. We would greatly appreciate expressing our concerns to Dr Whitehead and consider that receiving this wider evidence would be helpful in the review.

(C) That gas and biomass based CCS technologies - BECCS, gas power with CCS, and blue hydrogen production – are recommended to be removed from the upcoming Climate plan (CBDP).

(D) That the accounting of biomass emissions is reviewed so the full impacts of UK activities is properly accounted.

(E) That the emissions factors used for upstream emissions in the gas supply chain are reviewed against the latest science, and take into account projections of LNG imports.

(F) That methane emissions are properly represented, in policy making, for their climate impact over a twenty year period ie calculations of the climate impact of methane emissions should be based on GWP20.

(G) As gas based technologies are used as anchor projects in the CCUS cluster model, that the CCUS cluster programme is halted pending further review.

(H) That the government look to much greater investment in renewables and energy storage technologies to decarbonise the grid and deliver energy security.

[66] https://committees.parliament.uk/committee/127/public-accounts-committee/news/205139/carbon-capture-high-degree-of-uncertainty-whether-risky-investment-by-govt-will-pay-off/

8 Appendix A: Full lifecycle emissions for BECCS at Drax

I calculate below a summary of the full lifecycle emissions for Drax in three scenarios:

- Running unabated up to 27% of generation capacity in the recently proposed subsidy[67] proposed to transition (see the document "Transitional support mechanism ("**TSM**") for large-scale biomass generators: government response"[68] ("**TSM response**") which is the Government response to a previous consultation[69]) to BECCS at Drax.

- Post transition to BECCS at 90% capture

- Post transition to BECCS at 70% capture, a sensitivity test for a more realistic capture rate[70]

The calculations are based on the data provided by Drax itself at the DCO examination for Drax BECCS (references in the footnotes) and subsequently approved by the Secretary of State in approving the DCO consent.

For each scenario, I fully account the combustion emissions. It is not scientifically coherent to "zero rate" biomass combustion at the point of combustion. Such a position assumes that loss of forest carbon stock for fuel stock and combustion is instantly replaced with forest carbon stock elsewhere in the global carbon cycle. This is highly contested scientifically.

In fact, scientists are concerned that the net carbon impacts of increased forest harvests for bioenergy are rising. There is a reduction in forest carbon stocks associated with increased use of forest biomass relative to the counterfactual scenario with lower harvests, as it often takes considerable periods of time until forest bioenergy actually provides net carbon savings in comparison to fossil-based reference systems. The analysis of Sterman et al

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[67] https://www.gov.uk/cma-cases/referral-of-the-proposed-subsidy-to-drax-power-limited-by-the-department-for-energy-security-and-net-zero

[68] https://www.gov.uk/government/consultations/transitional-support-mechanism-for-large-scale-biomass-electricity-generators/outcome/transitional-support-mechanism-for-large-scale-biomass-generators-government-response-html

[69] See https://www.gov.uk/government/consultations/transitional-support-mechanism-for-large-scale-biomass-electricity-generators

[70] CCS has a poor track record of capturing CO2 from combustion and hydrogen processing (known as Scope 1 emissions). No known commercial system has exceeded 80% and much lower capture rates are prevalent. See the research from the Institute of Energy Economics and Financial Analysis (IEEFA) who have recently researched the CCS market and reviewed existing commercial projects, see (IEEFA), Morrison, K, "The Good, the Bad, and the Ugly reality about CCS (Carbon Capture and Storage)", slide 12, https://ieefa.org/sites/default/files/2024-03/CCSpresentation4-MPCMarch24_CK.pdf

(2022)[71] provides evidence that the impact of harvesting biomass fuel in 2025 is to increase forest emissions until around 2040 because "*the carbon sequestered by regrowth is initially less than the carbon the forest would have stored had it not been harvested*". Examining Figure 2 in the Sterman paper would suggest that there is no net carbon payback until 2050 (starting from 2025). Given the horizon considered here is 2050, I apply zero sequestration from forest regrowth in the full-lifecycle analysis below.

The data is derived from the Environmental Impact Assessment (EIA) as agreed by the DESNZ Secretary of State in approving Drax BECCS on 16th January 2024. Details in the notes.

	Units	**TWh**	**tCO2**	**tCO2**	**tCO2e**	**tCO2**	**tCO2**	**tCO2e**	**gmCO2e /KWh**
		Generation	**Supply Chain**	**Combustion**	**CH4/N2 O**	**Captured**	**CO2 venting**	**Total Carbon**	**Carbon Intensity**
Data from DCO	Units 1, 2, 3 & 4 (8760 hrs/yr)	16.31	2,447,446	19,383,134	48,948			21,879,528	1,342
Subsidy	Running at 27%	4.40	660,810	5,233,446	13,216			5,907,473	1,342
BECCS-90%	Units 1 & 2 (8760 hrs/yr) @90% capture	8.15	1,223,723	9,691,567	24,474	- 8,722,410	566,957	2,784,310	341
BECCS-70%	Units 1 & 2 (8760 hrs/yr) @70% capture	8.15	1,223,723	9,691,567	24,474	- 6,784,097	440,966	4,596,633	564

Notes:

1. On all scenarios, "Additional Scope 1 and 2 emissions from operation" are not included[72].
2. Combustion[73]. and supply chain emissions agreed by Secretary of State[74].

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[71] Sterman, J., Moomaw, W., Rooney-Varga, J. N., & Siegel, L. (2022). Does wood bioenergy help or harm the climate? *Bulletin of the Atomic Scientists*, *78*(3), 128–138. https://doi.org/10.1080/00963402.2022.2062933

[72] REP-028, PDF p35 - https://nsip-documents.planninginspectorate.gov.uk/published-documents/EN010120-000912-8.6.2%20Summary%20of%20Oral%20Case%20at%20Issue%20Specific%20Hering%201%20and%20Open%20Floor%20Hearing%201-13932-1.pdf

[73] REP-028, PDFp34 give combustion emissions as 19,383,135 tCO2 across Unit 1-4 operating at 8760 hours. 9,691,567 tCO2 is half this for Units 1 &2.

[74] Appendix 15.2 https://nsip-documents.planninginspectorate.gov.uk/published-documents/EN010120-000268-6.3.15.2%20Drax%20BECCS%20ES%20Vol%203%20Appendix%2015.2%20Proposed%20Scheme%20GHG%20Emissions%20Calculation.pdf

3. For the BECCS full lifecycle emissions, annualised construction emissions, CCS solvent emissions, CO2 Transport and Storage are not included.
4. CO2 venting emissions are based on 93.5% availability of the CO2 Transport and Storage infrastructure.
5. Combustion emissions are accounted to UK. Forest re-growth is not expected offset the combustions within the lifetime of the analysis until 2050.

A number of points arise from the Full Lifecycle emissions calculations provided in the Table above:

(I) The annual full lifecycle GHG emissions for the proposed subsidy the transition period 2027-2031 as unabated bioenergy, running up to 27% load, are calculated at around 6 million tonnes of CO2.

(J) If and when Drax is transitioned to BECCS on 2 of its 4 units (as per the consented DCO), then the annual full lifecycle GHG emissions are calculated in the range 2.7-4.6 million tonnes of CO2.This assumes the two BECCS units run at full-load, and that the two unabated units cease from operation. Should the unabated units continue generation at this point, then they would produce electricity at the extremely high carbon intensity of 1,342 gmCO2e/KWh.

(K) The key bottom-line points are that Drax does not achieve "*an overall reduction in greenhouse gas emissions*", either:

a. in continued operation of Drax under the proposed subsidy (capped at 27% generation), or
b. in future (post-transitional) operation of Drax with BECCS

(L) A further crucial point is that Drax with BECCS is not negative-emissions infrastructure. I estimate it to operate with a carbon intensity in the range 341-564 gmCO2e/KWh. Note that carbon intensity of unabated gas CCGT (Combined Cycle Gas Turbine) in the UK is generally quoted as being around 360 gCO2eq/kWh[75].

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[75] Note that this figure is an underestimate as the upstream emissions in the gas supply chain are currently not accounted correctly. I have written about this much elsewhere. However, I use this figure as a comparator in common usage for the purpose of this submission.

9 Appendix B: Full lifecycle emissions for gas with CCS at Peterhead

I calculate below a summary of the full lifecycle emissions for the proposed gas with CCS plant at Peterhead in Scotland in three scenarios:

- The "Reference" case, as submitted by developers SSE in its recently revised EIA report which reports a full lifecycle operation only emissions of 17,070,241 tCO2e over 25 years.
- A sensitivity test "Howarth High" based upon upstream supply chain emissions data from the recent paper by Prof Robert Howarth for LNG supplied natural gas from Texas, transported on a 9070 km journey from Sabine Pass, TX to the UK.
- A further sensitivity test on "Howarth High" which (1) uses a 70% CO2 capture rate, a more realistic capture rate[76] (2) corrects SSE's data to use the T&S Unavailability at 6.5% (rather than 3% in SSE's calculations) used for Net Zero Teesside[77] and H2 Teesside[78], and (3) use the dispatchable model where Peterhead would run for 135,000 hours[79] over 25 years instead of 200,000 hours over 25 years (in the Reference case).

The calculations are based on the data provided by SSE itself in its Additional Information Report[80] ("AIR") 2025 – dated 16 May 2025.

[76] CCS has a poor track record of capturing CO2 from combustion and hydrogen processing (known as Scope 1 emissions). No known commercial system has exceeded 80% and much lower capture rates are prevalent. See the research from the Institute of Energy Economics and Financial Analysis (IEEFA) who have recently researched the CCS market and reviewed existing commercial projects, see (IEEFA), Morrison, K, "The Good, the Bad, and the Ugly reality about CCS (Carbon Capture and Storage)", slide 12, https://ieefa.org/sites/default/files/2024-03/CCSpresentation4-MPCMarch24_CK.pdf

[77] See section 3.3.4 of https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010103/EN010103-002075-NZT%20DCO%209.29%20-%20Cumulative%20GHG%20Onshore%20and%20Offshore%20Assessment%20August%202022%20(D6).pdf

[78] See section 19.5.66 of https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN070009/EN070009-000254-H2T%20DCO%20-%206.2.19%20ES%20Vol%20I%20Chapter%2019%20Climate%20Change.pdf

[79] See AIR 2025, p109, Table 18-23 Downloaded from https://www.energyconsents.scot/ApplicationDetails.aspx?cr=ECU00003433 (under Documents, Additional Information).

[80] Downloaded from https://www.energyconsents.scot/ApplicationDetails.aspx?cr=ECU00003433 (under Documents, Additional Information).

25-year whole lifecycle tCO2e (SSE Peterhead)	Combustion (Not Captured)	Other Scope 1	CO2 venting	CO2 Captured	Upstream	TOTAL Emitted	CO2 Stored	% Capturable	% Captured & Stored	Upstream /combustion	
SSE "Reference case" - AIR 2025, p109, Table 18-23	5,630,940	618,337	1,520,354	50,678,460	9,300,610[81]	17,070,241	49,158,106	83.1%	72.6%	17%	
SSE AIR + Howarth High (90% CCS)	5,630,940	618,337	1,520,354	50,678,460	99,125,020[82]	106,894,651	49,158,106	35.7%	31.2%	176%	
SSE AIR + Howarth High + CCS@70% + Venting at 6.5% + Dispatchable	11,402,654	417,378	1,729,402	26,606,192	66,909,389	80,458,822	24,876,789	35.5%	23.2%	176%	

Notes:

1. The "Howarth High" sensitivity test uses a Global Warming Potential of 20 years ("GWP20") for methane. This is scientifically correct for capturing the real climate impacts of methane which has a half-life in the atmosphere of around 10 years. Professor Howarth explains the issue with the different GWPs as in the footnote[83].

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[81] The upstream emissions are calculated using an emission factor from Department of Energy Security and Net Zero (2024), Greenhouse Gas Conversion Factors for Company Reporting. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2024

[82] The upstream emissions are calculated from the recent paper by Prof Robert Howarth using data and emissions factors from "Supplemental Table B. Full lifecycle greenhouse gas emissions for LNG for 4 different tanker-transport scenarios, using shortest voyages (21.4 days round-trip)." – this is data for an LNG trip 9070 km each way from Sabine Pass, TX to the UK. Paper: Howarth RW. The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States. *Energy Sci Eng*. 2024; 12: 4843-4859. **doi:10.1002/ese3.1934** , Supplementary materials: https://scijournals.onlinelibrary.wiley.com/action/downloadSupplement?doi=10.1002%2Fese3.1934&file=ese31934-sup-0001-On_line_supplemental_materials.docx

[83] "The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States", Energy Science & Engineering, October 2024, https://scijournals.onlinelibrary.wiley.com/doi/10.1002/ese3.1934 :

"While the 100-year time frame of GWP100 is widely used in lifecycle assessments and greenhouse gas inventories, it understates the extent of global warming that is caused by methane, particularly on the time frame of the next several decades. The use of GWP100 dates to the Kyoto Protocol in the 1990s, and was an arbitrary choice made at a time when few were paying much attention to the role of methane as an agent of global warming. As the Intergovernmental Panel on Climate Change stated in their AR5 synthesis report, "there is no scientific argument for selecting 100 years compared with other choices" (IPCC 2013). The latest IPCC AR6 synthesis reports that methane has contributed 0.5º C of the total global warming to date since the late 1800s, compared to 0.75º C for carbon dioxide (IPCC 2021). The rate of global warming over the next few decades is critical, with the rate of warming important in the context of potential tipping points in the climate system (Ritchie et al. 2023). Reducing methane emissions rapidly is increasingly viewed as critical to reaching climate targets (Collins et al. 2018; Nzotungicimpaye et al. 2023). In this context, many researchers call for using the 20-year time frame of GWP20 instead of or in addition to GWP100 (Ocko et al. 2017; Fesenfeld et al. 2018; Pavlenko et al. 2020; Balcombe et al. 2021, 2022). GWP20 is the preferred

2. The "Howarth High" sensitivity test attributes all gas supply to LNG from Texas as modelled by Professor Howarth. This is because any extra demand created by investing in new gas power stations or blue hydrogen production will, at a national level, be met entirely by imported LNG, with cheaper UK gas or Norwegian pipeline gas always being utilised first. It is acknowledged that the sensitivity case is a worst case because some LNG may be sourced from other countries such as Qatar, but we expect US LNG to be increasingly prevalent as an import to the UK[84].
3. Construction emissions and also cumulative emissions for the construction and operation of the offshore CO2 storage system are not included in the full lifecycle calculation, making it a conservative estimate. By contrast, these were included in the analysis agreed by the Secretary of State for Net Zero Teesside[85].

A number of points arise from the Full Lifecycle emissions calculations provided in the Table above:

(A) The upstream emissions in the Howarth High sensitivity test are over 10 times greater than those in the SSE Reference case based upon the 2024 UK Govt emissions factor. This is important showing that the UK emissions factors are out-of-date and severely underestimate upstream emissions as discussed in main text.

(B) The impact of this is only 35.7% of the full life-cycle emissions are capturable. Leading to the maximum possible storage of emissions as 31% (at 90% capture) or 23% (at 70% capture, adjusted for T&S unavailability (CO2 venting)).

(C) In the latter 70% capture sensitivity test, less than one quarter of emissions are captured, and three quarters escape to the atmosphere accelerating global heating.

(D) The key bottom-line point is that Peterhead does not achieve "*an overall reduction in greenhouse gas emissions*", either running at full baseload (in the Reference case) or in dispatchable operation.

approach in my analysis presented in this paper, as was the case for our earlier lifecycle assessment of blue hydrogen (Howarth & Jacobson 2021). Using GWP20, LNG always has a larger greenhouse gas footprint than coal."

[84] The evidence is that imported LNG will play a significant role in meeting UK natural gas demand. Since cheaper pipeline gas will always be utilised first before turning to expensive LNG, any extra demand created by investing in new gas power stations or blue hydrogen production will, at a national level, be met entirely by imported LNG. Life cycle assessments for new CCS-enabled plants, such as the Track-1 and Track-2 start-up projects should therefore treat the methane gas input as 100% provided by LNG imports.

[85] This was after a detailed exchange of letters and submissions between CESL (CEPP) and the NZT promoter, which included a severe double counting error of over 50 million tonnes of CO2 by the promoter, and leading to the Secretary of State agreeing with CESL in the final decision letter, see paragraph 4.48, SoS Decision Letter, 16th February 2024, https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010103/EN010103-002914-Decision%20Letter_Net%20Zero%20Teesside%20Project.pdf

10 Appendix C: Full lifecycle emissions for blue hydrogen at H2 Teesside

I calculate below a summary of the full lifecycle emissions for the proposed blue hydrogen plant at H2 Teesside in three scenarios:

- Based on full lifecycle construction and operation EIA data, submitted by developers BP to the planning examination over 25 years. Using Government data for upstream emissions gives 20,009,374 tCO2e[86] over 25 years.
- A sensitivity test "Howarth High" based upon upstream supply chain emissions data from the recent paper by Prof Robert Howarth for LNG supplied natural gas from Texas, transported on a 9070 km journey from Sabine Pass, TX to the UK.
- A further sensitivity test on "Howarth High" which uses a 70% CO2 capture rate, a more realistic capture rate[87].

25-year full lifecycle tCO2e	**ATR Process Not Captured**	**Construction & Decommissioning**	**LCHS Other Scope 1,2&3**	**Other Scope 1,2&3**	**CO2 venting**	**CO2 Captured**	**Upstream**	**TOTAL Emitted**	**CO2 Stored**	**% Capturable**	**% Captured & Stored**
Blue H2Teesside @95%CCS – BP's submitted EIA	3,399,000	180,699	1,004,175	6,650	4,197,775	64,581,000	11,221,075	20,009,374	60,383,225	80.4%	71.4%
submitted EIA + Howarth High + 90%CCS	6,798,000	180,699	1,004,175	6,650	3,976,830	61,182,000	115,945,273	127,911,627	57,205,170	36.0%	30.3%
Howarth High- 70% CCS	20,394,000	180,699	1,004,175	6,650	3,093,090	47,586,000	115,945,273	140,623,887	44,492,910	36.1%	23.6%

[86] This is based on 25 years operation of Phase 2 of the plant. It is slightly different value to BP's figure of **19,133,421 tCO2e** which is based on Phase 1 and Phase 2 operation over 25 years.

[87] CCS has a poor track record of capturing CO2 from combustion and hydrogen processing (known as Scope 1 emissions). No known commercial system has exceeded 80% and much lower capture rates are prevalent. See the research from the Institute of Energy Economics and Financial Analysis (IEEFA) who have recently researched the CCS market and reviewed existing commercial projects, see (IEEFA), Morrison, K, "The Good, the Bad, and the Ugly reality about CCS (Carbon Capture and Storage)", slide 12, https://ieefa.org/sites/default/files/2024-03/CCSpresentation4-MPCMarch24_CK.pdf

Notes:

1. The "Howarth High" sensitivity test uses a Global Warming Potential of 20 years ("GWP20") for methane. This is scientifically correct for capturing the real climate impacts of methane which has a half-life in the atmosphere of around 10 years. Professor Howarth explains the issue with the different GWPs as in the footnote[88].
2. The "Howarth High" sensitivity test attributes all gas supply to LNG from Texas as modelled by Professor Howarth. This is because any extra demand created by investing in new gas power stations or blue hydrogen production will, at a national level, be met entirely by imported LNG, with cheaper UK gas or Norwegian pipeline gas always being utilised first. It is acknowledged that the sensitivity case is a worst case because some LNG may be sourced from other countries such as Qatar, but we expect US LNG to be increasingly prevalent as an import to the UK[89].

A number of points arise from the Full Lifecycle emissions calculations provided in the Table above:

(A) The upstream emissions in the Howarth High sensitivity test are over 10 times greater than those in the BP supplied data based upon the UK Govt emissions factor. This is important showing that the UK emissions factors are out-of-date and severely underestimate upstream emissions as discussed in main text.

(B) The impact of this is only 36.0% of the full life-cycle emissions are capturable. Leading to the maximum possible storage of emissions as 30.3% (at 95% capture) or 23.6% (at 70% capture, adjusted for T&S unavailability (CO2 venting)).

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[88] "The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States", Energy Science & Engineering, October 2024, https://scijournals.onlinelibrary.wiley.com/doi/10.1002/ese3.1934 :

"While the 100-year time frame of GWP100 is widely used in lifecycle assessments and greenhouse gas inventories, it understates the extent of global warming that is caused by methane, particularly on the time frame of the next several decades. The use of GWP100 dates to the Kyoto Protocol in the 1990s, and was an arbitrary choice made at a time when few were paying much attention to the role of methane as an agent of global warming. As the Intergovernmental Panel on Climate Change stated in their AR5 synthesis report, "there is no scientific argument for selecting 100 years compared with other choices" (IPCC 2013). The latest IPCC AR6 synthesis reports that methane has contributed 0.5^{o} C of the total global warming to date since the late 1800s, compared to 0.75^{o} C for carbon dioxide (IPCC 2021). The rate of global warming over the next few decades is critical, with the rate of warming important in the context of potential tipping points in the climate system (Ritchie et al. 2023). Reducing methane emissions rapidly is increasingly viewed as critical to reaching climate targets (Collins et al. 2018; Nzotungicimpaye et al. 2023). In this context, many researchers call for using the 20-year time frame of GWP20 instead of or in addition to GWP100 (Ocko et al. 2017; Fesenfeld et al. 2018; Pavlenko et al. 2020; Balcombe et al. 2021, 2022). GWP20 is the preferred approach in my analysis presented in this paper, as was the case for our earlier lifecycle assessment of blue hydrogen (Howarth & Jacobson 2021). Using GWP20, LNG always has a larger greenhouse gas footprint than coal."

[89] The evidence is that imported LNG will play a significant role in meeting UK natural gas demand. Since cheaper pipeline gas will always be utilised first before turning to expensive LNG, any extra demand created by investing in new gas power stations or blue hydrogen production will, at a national level, be met entirely by imported LNG. Life cycle assessments for new CCS-enabled plants, such as the Track-1 and Track-2 start-up projects should therefore treat the methane gas input as 100% provided by LNG imports.

(C) In the latter 70% capture sensitivity test, less than one quarter of emissions are captured, and three quarters escape to the atmosphere accelerating global heating.

(D) The key bottom-line point is that BP H2 Teesside plant does not achieve "*an overall reduction in greenhouse gas emissions*".

11 Appendix D: Scientist's letter, September 11th 2024

Right Hon Ed Miliband MP
Secretary of State for Energy Security and Net Zero
Department for Energy Security and Net Zero
55 Whitehall
London
SW1A 2HP

Cc: Rt Hon Lord Hunt of Kings Heath, Minister of State (Minister for Energy Security and Net Zero)
Sarah Jones, MP, Minister of State (Minister for Industry)

11 September 2024

Dear Secretary of State

We warmly welcome your commitment to decarbonising the UK's power supply and our industrial processes. As you take investment decisions which will have consequences for the UK for decades to come, we are writing to urge you to ensure that these important decisions are based on accurate information about technologies' climate impact and whether they will actually help or hinder the UK reaching net zero. Putting the UK on the wrong pathway could be catastrophic.

In the Track 1 carbon capture (usage) and storage (CCUS) programme which you have inherited from the previous government, final investment decisions are expected in September for the Net Zero Teesside Power, bpH2Teesside and Teesside Hydrogen CO2 Capture in the East Coast Cluster, and HyNet Hydrogen Production Plant 1 in the HyNet Cluster in Liverpool Bay. These are gas-CCS power stations and facilities to produce 'blue' hydrogen from natural gas with carbon capture.

We strongly urge you to pause your government's policy for CCUS-based blue hydrogen and gas power, and delay any investment decision into the Track 1 programme until all the relevant evidence concerning the whole-life emissions and safety of these technologies has been properly evaluated.

Currently, this policy would lock the UK into using fossil fuel based energy generation to well past 2050. In particular given declining North Sea gas supplies it would lock the UK into increasing Liquefied Natural Gas (LNG) imports.[1] This raises serious concerns, which we have set out below:

1. **Upstream emissions**

It seems certain that methane leaks from the UK's North Sea oil and gas operations have been significantly under-estimated. The UK's National Atmospheric Emissions Inventory

[1] DESNZ (2023) The role of gas storage and other forms of flexibility in security of supply: Energy security plan update

(NAEI) reports these at 52 Gg in 2019. However an independent analysis[2] using the best available data to estimate methane emissions from flaring, combustion, processing, venting, and transfer found a total of 289 Gg (uncertainty range 112 to 1181 Gg). The emissions for venting alone, as taken from oil and gas operators' own reports to the North Sea Transition Authority, were 112 Gg.[3]

Even more concerning are the very high upstream emissions, from methane leaks, transport and processing, from LNG imported from the USA and other countries given the increased imports of LNG which would be required to meet demand under current proposals. Most natural gas production in the United States is shale gas, with energy intensive extraction and high methane emissions as revealed by satellites or remote sensing. Based on these estimates of methane leakage, blue hydrogen produced in the US from shale gas was estimated to have a greenhouse gas footprint greater than burning gas or coal, due to the increased demand for natural gas to power the carbon capture.[4] This does not include additional emissions from liquefaction and shipping to the UK.

The recent report from Carbon Tracker "Kind of Blue" examines the impact of these upstream emissions on whether gas projects can claim to be low carbon.[5] It concludes that the proposed blue hydrogen production at H2 Teesside would have lifetime's emissions of around 15 to 25 million tonnes of CO2e, much higher than the 10 million tonnes reported by the developer in its environmental statement for planning. The report finds that "*even with the best technology, blue hydrogen from imported LNG could emit up to 2.5 times more than the UK's low carbon hydrogen standard*".

2. Short term impact of methane emissions

Comparing methane emissions to their CO2 equivalent is traditionally done by averaging both out over 100 years, but this was an arbitrary decision when the contribution of methane (responsible for around 30% of current warming)[6] was not well understood. Since almost all of methane's impact occurs within the first couple of decades, a 20 year timescale is now widely considered to be a more appropriate comparison. Limiting greenhouse gas emissions during this timeframe is crucial to avoid triggering climate tipping points. Over 20 years, methane has a global warming potential around 84 times that of CO2.[7] Recalculating the Carbon Tracker figures on this basis would nearly triple the climate impact of methane leaks.

3. Hydrogen leakage

Potential leaks of hydrogen during production and distribution are currently excluded from climate impact calculations. But hydrogen is a potent indirect greenhouse gas. Over the

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[2] Riddick & Mauzerall (2022) Likely substantial underestimation of reported methane emissions from United Kingdom upstream oil and gas activities Energy Environ. Sci., 2023, 16, 295-304
[3] Uncertainty range 78-146 Gg allowing for inaccuracy in measurements of gas volume released
[4] Howarth & Jacobson (2021) How green is blue hydrogen? Energy Science and Engineering 9(10) 1676-1687
[5] Sani (2024) Kind of Blue Carbon Tracker
[6] IEA (2022) Global Methane Tracker
[7] European Commission EU Energy Policy website: Methane emissions

crucial 20-year timeframe it is estimated to cause around 37 times more warming per tonne than CO2.[8] The inevitability of some leakage should clearly be taken into account.

4. Carbon capture's track record

Carbon capture projects have a consistent track record of over-promising and under-delivering. The majority of current CCUS capacity is within natural gas processing facilities, where CO2 must be separated from hydrocarbons to produce marketable products. Almost 80% of the CO2 captured is re-injected into oil fields to facilitate oil extraction.

The track record of adding carbon capture to power generation is much worse, with the vast majority of projects abandoned. Just two commercial-scale coal-fired power plants are operating with CCUS: Boundary Dam in Canada and Petra Nova in the US. Both have experienced consistent underperformance, recurring technical issues and ballooning costs.[9] Notably, the challenge of capturing CO2 at lower concentrations from the flue gases of gas turbines is even greater than for coal-fired power plants.

5. Storage and transport

The assumption is that there will be no leakage of CO2 from transport and storage. This is an unsound position to take with an emerging technology where difficulties have already been documented. There are only two undersea storage sites in the world (the Norwegian Sleipner and Snohvit fields). Both these projects are far smaller than the UK proposals, with 1.45 to 1.7 million tonnes of CO2 per annum (mtpa) injected combined,[10] while the Northern Endurance Field is expected to reach 23mtpa and the Viking Field 10mtpa. They are also far less complex since the CO2 is from only one source (gas refining). However, both have run into problems:[11] the CO2 in the Sleipner field has leaked from the rock stratum where it was expected to be sealed, and the Snohvit one turned out to have far smaller capacity than geological modelling predicted. However well studied the undersea geology is, there is no certainty that CO2 will not leak, with the risk of ocean acidification, ecosystem harms, and accelerating global heating.

6. Health and safety

CO2 is an asphyxiant, heavier than air, which may not disperse readily in the event of a leak. Any pipeline leak would be a serious health risk, potentially fatal. In Satartia, Mississippi, in 2020, at least 45 people were hospitalised due to a CO2 pipeline leak.[12]

Regulations and standards for safe pipeline transportation of CO2 are underdeveloped, as acknowledged by the Health and Safety Executive.[13] In the case of projects such as the East

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[8] Parkes (2023) Hydrogen is a more potent greenhouse gas than previously reported, new study reveals Hydrogen Insight
[9] Sani (2024) Curb Your Enthusiasm: Bridging the gap between the UK's CCUS targets and reality Carbon Tracker
[10] Hauber (2023) Norway's Sleipner and Snøhvit CCS: Industry models or cautionary tales? IEEFA
[11] Hauber (2023) Norway's Sleipner and Snøhvit CCS: Industry models or cautionary tales? IEEFA
[12] Simon (2023) The U.S. is expanding CO2 pipelines. One poisoned town wants you to know its story NPR website 25/9/23
[13] Health and Safety Executive Pipeline design codes and standards for use in UK CO2 Storage and Sequestration projects

Coast Cluster, having multiple sources of CO_2 with varying pressures and contaminants is a factor which is acknowledged to increase the risk of pipeline corrosion, or other system failure caused by wear and tear.

There is also uncertainty about the extent to which technology developed for burning methane can control the higher levels of nitrogen oxides (NOx) produced when burning hydrogen or blended hydrogen/natural gas. NOx pollution is a well recognised public health issue, increasing the risk of respiratory conditions.

Questions have also been raised about the cumulative impact of the release of amines from multiple carbon capture operations in the same locality and how safe levels will be determined.

7. Monitoring and enforcement

At almost every stage in the process there is uncertainty about the technology and consequent emissions: the accurate assessment of upstream emissions, the reliability of carbon capture, the security of long-term geological storage, the safety of pipelines and the management of air pollution. Developers will inevitably give optimistic forecasts for all of these, but how will these processes and consequent emissions be independently monitored?

Safety precautions and measures to reduce emissions have a financial cost. Can we trust companies to operate to the highest standards and transparency when doing so has a direct impact on profits? We might consider UK water companies and their failure to prioritise controlling pollution over profit. However, unlike raw sewage, these emissions are invisible and occur over an immense and often inaccessible area.

When government funding is used to support large-scale private enterprise with significant risk of failure to achieve the intended outcome (in this case, genuinely low-carbon energy generation) questions need to be asked about who bears the risk if things go wrong.

8. Better alternatives for investment

A wide range of uses have been promoted for hydrogen, but not all are practical or competitive. The claim that hydrogen should have a significant role in heating buildings has been comprehensively disproved,[14] while direct electrification is increasingly emerging as a better solution for industrial process heating.[15]

While not denying that both carbon capture and green hydrogen may be needed for specific uses in a zero carbon economy, we have concerns about the harms that could be done by locking the UK into a fossil-fuel based pathway with inevitable upstream emissions, displacing genuinely zero or low-carbon electricity generation.

Instead of investing billions in large scale versions of unproven technologies, we urge your Government to prioritise funding for alternative flexibility technologies to enable a more rapid transition to renewables. There is increasing evidence that energy security can be achieved from a grid that is almost 100% supplied by renewable energy with a range of storage

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[14] Rosenow (2023) A meta-review of 54 studies on hydrogen heating Cell Reports Sustainability 1(1)
[15] Agora Industry (2024) Direct electrification of industrial process heat

technologies alongside demand reduction measures such as insulation and low energy heating systems.[16]

In summary we ask you to (1) review UK CCUS and hydrogen policy (2) delay any investment decision on Track 1 CCUS projects (3) expand funding for flexibility, grid storage technologies and retrofit of homes.

Yours sincerely

Professor Kevin Anderson, Tyndall Centre, University of Manchester
Dr Keith Baker, Research Fellow, Department of Civil Engineering and Environmental Management, Glasgow Caledonian University
Professor Tom Baxter, Visiting Professor, University of Strathclyde and Chemical Engineering Consultant
Professor Mike Berners-Lee, Lancaster Environment Centre, Lancaster University
Dr Andrew Boswell, Climate Emergency Planning and Policy
Professor David Cebon, Professor of Mechanical Engineering, Cambridge University
Mike Childs, Head of Science, Policy & Research, Friends of the Earth England, Wales and Northern Ireland
Dr James Dyke, Associate Professor in Earth System Science, University of Exeter
Ruby Earle, Just Transition Campaigner, Platform
Catherine Green, HyNot
Professor Joanna Haigh, Imperial College London, former co-director, Grantham Institute
Professor Charles Harvey, Professor of Civil and Environmental Engineering, Massachusetts Institute of Technology
Professor Robert Howarth, Professor of Ecology and Environmental Biology, Cornell University
Tahir Latif, Secretary, Greener Jobs Alliance
Alex Lee, Campaigner, Friends of the Earth Scotland
Professor Mark Maslin, Professor of Earth System Science, University College London
Dr Amy McDonnell, Zero Hour
Dr Stuart Parkinson, Scientists for Global Responsibility
Emeritus Professor Rupert Read, University of East Anglia
Ellen Robottom, Secretary, Campaign against Climate Change
Pascoe Sabido, Researcher and Campaigner, Corporate Europe Observatory
June Sekera, Senior Research Fellow, Global Development Policy Center, Boston University
Professor Peter Strachan, independent researcher, Energy Transition & Public Policy

[16] Breyer et al (2022) On the History and Future of 100% Renewable Energy Systems Research IEEE Access, 2022, p78176-78218.

12 Appendix E: Scientist's letter, October 18th 2024

Right Hon Ed Miliband MP
Secretary of State for Energy Security and Net Zero
55 Whitehall
London
SW1A 2HP

Cc:

Rt Hon Lord Hunt of Kings Heath, Minister of State (Minister for Energy Security and Net Zero);
Sarah Jones MP, Minister of State (Minister for Industry)
Michael Shanks MP, Parliamentary Under-Secretary of State, DESNZ

18 October 2024

Dear Secretary of State

We write in response to a letter of 27th September, referred to in The Times,[1] from a group led by Professor Stuart Haszeldine. Since that letter, the government has announced its intention to press ahead with almost £22 billion of investment in carbon capture and storage. The first projects lined up to benefit from this funding are primarily new fossil fuel infrastructure, not retrofit of existing facilities. As set out in our original letter of 11 September, we do not believe that this investment would be the best use of public finance, and we call for a thorough review of all the evidence before a final investment decision.

There are also specific points we feel need addressing in Professor Stuart Haszeldine's letter, as below.

Liquefied Natural Gas (LNG) imports

We are glad to see that Professor Haszeldine and his co-signatories share our grave concerns about the very high life-cycle emissions associated with imported LNG. These are explained in more detail in our original letter, and are further highlighted by a study just published.[2] This estimates that when US-UK LNG imports are burned, that upstream emissions (from extraction, processing and transport rather than combustion) account for almost half (48%) of the total LNG greenhouse gas footprint when CO2 and methane are compared over 100 years. This figure rises to 63% if a 20yr comparison period is used to assess the impact of methane.[3] The exact figures will clearly vary for different scenarios, but it's crucial to note that these emissions cannot be mitigated by capturing carbon at end use.

In their letter Haszeldine et al suggest that emissions from LNG imports will not be a significant concern, since "as gas demand declines, an ever-larger fraction of UK supply will

[1] Vaughan, A (2024) 'Bitter row over the future of carbon capture in the UK', The Times 27/09/24
[2] Howarth RW. The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States. Energy Sci Eng. 2024; 1-17. doi:10.1002/ese3.1934
[3] Calculated using figures taken from Supplemental Table B

come from increased pipeline imports from Norway". However, the 2023 DESNZ report, *The role of gas storage and other forms of flexibility in security of supply*,[4] reports that "LNG and interconnector gas supply is projected to rise from a predicted 13% in 2023 to around 32% by 2030" and peak at 58% in 2045, and that "it is likely that LNG will make up a significant proportion of these future gas imports." Based on DESNZ statistics from March 2024, Carbon Tracker estimate that in 2023 LNG accounted already for 24% of the UK's total gas supply.[5]

It should be noted that the supply of gas from Norway is predicted to fall in the coming years. The Norwegian Offshore Directorate projects in its "base case" that its oil and gas output will drop by about two-thirds from 2025 to 2050.[6]

Therefore, although we strongly agree with Haszeldine et al. that reducing UK demand for gas heating through energy efficiency measures must be a key goal for government - and we would indeed argue for more funding to be directed towards this proven means of reducing emissions - this does not mean LNG imports will not rise as a consequence of gas-based CCUS projects.

In the report *Kind of Blue*, Carbon Tracker estimates that "if all the gas-based CCUS projects proposed by the UK's Net Zero strategy are built, by 2035 new gas demand could be two times greater than the projected domestic production requiring an inevitable reliance on LNG imports".[7] Given the projected decline in North Sea supply, any extra demand for gas created by new CCS-enabled facilities will most likely be met by LNG imports. It would therefore make sense to assess these projects using carbon intensity data for imported LNG, rather than the current average carbon intensity for the UK gas grid.

As well as the climate impacts of LNG imports, it is clear that relying on LNG for hydrogen production also carries energy security and cost risks from continued reliance on the global gas market.

Carbon capture and storage prospects

The letter contains the accusation that we advocate for "continuing to release millions of tonnes of fossil CO_2 each year into the atmosphere." We do not, of course, but simply challenge the assumption that blue hydrogen or gas power projects with CCUS are a reliable means of preventing these emissions. This is firstly because of the significant upstream emissions, as noted above. And secondly because the past history of CCUS does not inspire confidence. A 2021 study estimated that almost 80% of the large-scale CCUS projects had either been cancelled or put on hold. Where CCUS is operational this tends to be extraction of CO_2 as part of the processing of natural gas to produce a marketable

[4] DESNZ (2023) The role of gas storage and other forms of flexibility in security of supply: Energy security plan update
[5] Sani (2024) Kind of Blue Carbon Tracker
[6] Norwegian Offshore Directorate Resource Report 2024 'Three potential scenarios'
[7] Sani (2024) Kind of Blue Carbon Tracker

product. A review of 12 major projects, while not comprehensive, gives a clear picture of cost overruns and missed targets.[8]

It is also clear that multiple billions in public funding spent on carbon capture are billions which are therefore not available for spending on other means of cutting emissions, including those with important social, economic and ecological benefits, such as insulating homes, improving public transport and active travel, or ecosystem restoration. An economic review of CCS points out that the cost of CCS implementation has not declined at all in 40 years, in contrast to renewable technologies like solar, wind, and batteries, which have fallen in cost dramatically. The authors conclude that using carbon capture and storage for any more than the most essential uses in hard to abate sectors would be prohibitively expensive.[9]

Haszledine et al. may see our approach as being unduly pessimistic or sceptical about CCUS. We believe that they are too pessimistic about the potential of the alternatives. We would call attention to the review of independent studies on 100% renewable energy by the IEEE for an alternative perspective.[10] This comprehensive paper states that "the main conclusion of the vast majority of 100% renewable energy systems studies is that such systems can power all energy in all regions of the world at low cost" and that, "as such, we do not need to rely on fossil fuels in the future".

The role of hydrogen and gas power with CCUS

We recognise the debates around the use of hydrogen in 'hard-to-abate' sectors, with cost currently an issue for green hydrogen. But with encouraging progress on electrification reducing projected demand in some areas, it is likely estimates for requirements are overstated. We would also welcome further clarity about plans to substitute for current 'grey' hydrogen, which is often omitted from these discussions.

The plans announced for the UK's new CCUS clusters, currently under consideration for Government funding, involve building new (additional) fossil fuel infrastructure (mostly gas power stations and blue hydrogen facilities), with a service life of decades. Oil and gas companies argue that they can be part of the solution to climate change, and if they were willing to themselves invest in retrofitting existing power stations with carbon capture, there would be a stronger argument for this being a bridging technology. However, it's vital to note that the power sector is not in itself a 'hard-to-abate' sector and that there are clear alternatives for decarbonisation which do not risk locking the UK into fossil gas.

Carbon storage

A clarification may be needed here. The letter from Haszeldine and colleagues states that we have claimed that CO_2 has leaked from the Sleipner storage site. What we in fact wrote

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[8] B Fossil Fuel Companies Made Bold Promises to Capture Carbon. Here's What Actually Happened. DeSmog website 25/09/23
[9] Bacilieri et al. (2023) Assessing the relative costs of high-CCS and low-CCS pathways to 1.5 degrees Oxford Smith School of Enterprise and the Environment | Working Paper No. 23-08
[10] Breyer et al. (2022) On the History and Future of 100% Renewable Energy Systems Research IEEE Access 10, 78176–78218

was that it had leaked from the stratum in which it was expected to be sealed, although ultimately contained by a caprock structure above. Our point was that both the Sleipner and the Snohvit experience demonstrate that injected CO_2 may behave in unexpected ways, and that predictions based on geological surveys and modelling may well prove inaccurate even when the best of expertise is applied to them. On this point we would have to agree with the author of the IEEFA report that there are considerable risks and uncertainties, especially with regard to the very much larger and more complex cluster projects planned for the UK which have no precedent anywhere.

The need for a review

While decarbonisation is clearly of the utmost urgency, we call on DESNZ to - at minimum - carry out the following before making any funding decisions:

- Publish up to date predictions for LNG imports if all currently planned CCUS projects are funded, and the basis on which these are calculated.
- Publish an up to date sector wide cumulative greenhouse gas assessment, including realistic projections for upstream methane leakage, for the projects identified in the CCUS programme up to 2035 against the Carbon Budget Delivery Plan.
- Review the adequacy of the Low Carbon Hydrogen Standard in the light of independent assessments of upstream emissions, both for imported LNG and for North Sea extraction, and including consideration of whether the GWP_{100} for methane is adequate as we approach climate tipping points.
- Consider alternative, more effective ways in which this investment could be used to cut emissions.
- Rule out the use of hydrogen for home heating.

As a more general point, it is essential that government energy policy decisions are taken taking into account all available evidence. This must include serious consideration of evidence from independent sources, and not just the well-funded lobbying operations of industry bodies.

Many thanks for your consideration.

Yours sincerely

Professor Kevin Anderson, Tyndall Centre, University of Manchester
Dr Keith Baker, Research Fellow, Department of Civil Engineering and Environmental Management, Glasgow Caledonian University
Professor Tom Baxter, Visiting Professor, University of Strathclyde and Chemical Engineering Consultant
Professor Mike Berners-Lee, Lancaster Environment Centre, Lancaster University
Dr Andrew Boswell, Climate Emergency Planning and Policy
Professor David Cebon, Professor of Mechanical Engineering, Cambridge University
Mike Childs, Head of Science, Policy & Research, Friends of the Earth England, Wales and Northern Ireland
Dr James Dyke, Associate Professor in Earth System Science, University of Exeter
Ruby Earle, Just Transition Campaigner, Platform
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Professor Robert Howarth, Professor of Ecology and Environmental Biology, Cornell University
Tahir Latif, Secretary, Greener Jobs Alliance
Professor Mark Maslin, Professor of Earth System Science, University College London
Dr Amy McDonnell, Zero Hour
Dr Stuart Parkinson, Scientists for Global Responsibility
Emeritus Professor Rupert Read, University of East Anglia
Ellen Robottom, Secretary, Campaign against Climate Change
Pascoe Sabido, Researcher and Campaigner, Corporate Europe Observatory
June Sekera, Senior Research Fellow, Global Development Policy Center, Boston University
Professor Peter Strachan, independent researcher, Energy Transition & Public Policy

Additionally, in support:
Professor Paul Behrens, Oxford Martin School
Dr Alison Green, Executive Director, Scientists Warning Foundation
Professor Bill McGuire, Emeritus Professor of Geophysical and Climate Hazards at UCL
Emeritus Professor Barry McMullin, School of Electronic Engineering, Dublin City University
Dr Philip Webber, Visiting Professor, School of Earth & Environment, Leeds

13 Appendix F: Climate Change Committee : FOI : Upstream Emissions

Climate Change Committee
10 South Colonnade,
Canary Wharf, London
E14 4PU
w theccc.org.uk

Environmental Information Regulations (EIR) request

Received: 4 November 2024
Date: 27 November 2024
Ref: Sent by email from enquiries@theccc.org.uk
Published: www.theccc.org.uk/about/transparency

Your request:

Freedom of Information request

Dear CCC,

Enquiry on Upstream Emissions of Natural Gas

Please reply to the following queries.

What figures does the CCC use in its models of fuel supply emissions for the per unit (eg in CO_2e/KWh) "upstream" emissions of natural gas supplying :-

1) gas power stations

2) hydrogen plants (ie gas reformers) ?

Have these figures been updated since the publication of the Sixth Carbon Budget Report and is there any intention to update them further before carrying out any further analysis?

Some explanation of how your figures are arrived at would also be helpful.

Background Information and comments related to the above questions

The Sixth Carbon Budget Report (Fuel Supply Report, page 24) states that the emissions saving for blue hydrogen compared to grey hydrogen plants:-

".....depends on both achieving a 95% CO_2 capture rate at the gas reformation stage, but also on upstream emissions from fossil gas production being at the bottom end of our estimated range of

15-70 gCO_2e/kWh. …"

Climate Change Committee

It is not entirely clear whether the figure used then was 15gCO2e/kWh or some slightly higher figure within that 15-70 range.

That range applied specifically to UK gas supplies. Recent independent studies report that these have been under-reported by the industry.

UK gas supplies will run down over time. Will UK gas emissions figures nevertheless continue to be used as a proxy for all the gas supplied?

Alternatively, if estimates will factor in an increasing proportion of imports in the UK gas supply and especially if your methodology is to use figures entirely based on LNG, which seems certain to fulfil additional UK gas demand, will only those emissions occurring within the UK be accounted for? If so, how will they be defined? For example, for LNG, will extraction and compression (into a tanker) emissions be excluded, due to the country of origin including them in their own carbon accounting ? Also, will shipping emissions be excluded until the end of 2032 and thereafter included from the start of the Sixth Carbon Budget period in 2033 (ie once international Aviation and Shipping emissions attributable to the UK start being included in Carbon Budgets)? If that last assumption is correct, will half of the import shipping emissions be included, with half allocated to the exporting country or will some other method be used to measure the "UK share"?

Please explain what UK wide energy system modelling is done to generate emissions levels, and if you use the Dynamic Despatch Model. In the case that the DDM is not used by CCC, please explain how your modelling differs from the DDM.

Your Sixth CB Methodology Report, (page 161) stated that in your modelling, gas-CCS is used as a proxy for BECCS, and unabated CCGT for hydrogen plants. Is this still the case? If not, how has it changed?

Direct replies to these questions and any further explanatory comments you believe would be helpful would be very welcome.

Best Regards,

[name redacted]

Our response:

Thank you for your request. We have handled your request under the Environmental Information Regulations 2004.

1. We do not use a single figure for upstream emissions of natural gas in our analysis. Under the Climate Change Act (2008), we are required to follow international carbon reporting practice for determining emissions, as per the UK's national emissions inventory. The guidelines for this are set through the international process by the UNFCCC/IPCC and are based on territorial emissions. We model emissions associated with domestic fuel production on a bottom-up basis in our 'fuel supply sector. Combustion emissions associated with use of natural gas are allocated to the sector where the use of fuel occurs. Emissions associated

Climate Change Committee

with production of imported fuels are captured in the emission inventory of the exporting country.

2. Our analysis in the Sixth Carbon Budget advice report will be updated with the publication of our Seventh Carbon Budget advice report, on 26 February 2025.

3. The calculation in the Sixth Carbon Budget advice report for emissions savings from blue hydrogen is illustrative and provided as context. Gas emissions are based on the carbon content of the fuel, in line with territorial emissions accounting.

4. Our latest modelling of the energy system, using AFRY's BID3 model, was published in 2023 and can be found in our Delivering a reliable decarbonised power system report.

Information disclosed in response to this EIR request is releasable to the public. In keeping with the spirit and effect of the EIR and the government's Transparency Agenda, this letter and the information disclosed to you may be placed on the CCC website, together with any related information that will provide a key to its wider context. No information identifying you will be placed on the CCC website.

If you are dissatisfied with the handling of your request, you have the right to ask for an internal review. If you are not content with the outcome of the review, you may apply directly to the Information Commissioner for a decision. In keeping with our transparency policy, the information released to you will be published on www.theccc.org.uk. Please note that this publication will not include your personal data.

Kind regards,

Climate Change Committee

Climate Change Committee

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