Written evidence submitted by Climate Emergency Policy and Planning (CEPP) (CCUS0018)

1 INTRODUCTION

1 Climate Emergency Planning and Policy (CEPP) 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.

2 I, Dr Andrew Boswell, established 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.

3 As 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.

4 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. 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 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, though a limited underestimate as explained later in this document, has been made. Other similar projects have either gained planning approval <u>without</u> 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), or are still in the planning process but with no assessment of upstream emissions yet made (eg: the Peterhead gas-CCS scheme in the Scottish planning system).

5 I am the claimant in a legal case which challenges the previous DESNZ Secretary of State's decision to later approve the Net Zero Teesside (NZT) project for development consent which is due to be heard by the Court of Appeal on March 4th and 5th 2025.

6 In so far as the facts in this statement are within my knowledge, they are true. In so far as the facts in this statement are not within my direct knowledge, they are true to the best of my knowledge and belief.

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2 SUMMARY

7 The full life-cycle greenhouse gas emissions of projects in the CCUS programme have been systemically underestimated. This particularly relates to upstream natural gas supply emissions for gas-CCS and blue hydrogen.

8 The cluster model in the CCUS architecture amplifies this effect by front-loading gas-CCS and blue hydrogen projects before any third-party industrial decarbonisation can take place.

9 This places the delivery of near-term UK carbon budgets and meeting international obligations such as the 2030 NDC at further risk (delivery is already highly risked as evidenced by the annual Climate Change Committee (CCC) progress reports and the UK climate plan twice being found to be unlawful).

10 Value for money of the CCUS programme is poor because of the risks to delivery of climate targets as above, the delay before any genuine industrial decarbonisation is possible, and the risks of the programme failing.

11 Further, the opportunity cost of funding for CCUS diverting funds from the roll-out of renewables pathways has not been assessed. Recently National Energy System Operator (NESO) advised that a pathway to 2030 without CCUS was entirely possible. Policy making from DESNZ and CCC has not fully assessed such an alternative, and whether it may be continued after 2030 too, and should do.

12 CEPP provides detailed submissions on the above points, and provides illustrative calculations of the climate impacts (both UK and internationally) of the near time climate impact of gas-CCS systems in the UK energy mix.

13 CEPP recommend:

(a) that no CCUS project should receive Government funding, nor a Final Investment Decision (FID) until a full scientific review of the CCUS programme has been made; each project is assessed under Principle H the Energy and Environment principles of the Subsidy Control Act[1].

(b) that the PAC make a strong recommendation to the Climate Change Committee that its upcoming Seventh Carbon Budget report must fully consider the upstream emissions in its consideration of the CCUS programme: with assessment of the full impact to UK consumption emissions; a review the proposed cluster model and its front loading of very high emissions; and advice on how some industrial decarbonisation, if needed, might be achieved without start-up projects involving gas-CCS or blue hydrogen.

(c) that DESNZ undertake a review of the potential to remove CCS (either as gas-CCS or blue hydrogen) from its energy policy with a value for money and investment costs analysis for delivering UK climate targets and budgets via alternatives to the CCUS programme.

(d) that NESO to give evidence to the committee, particularly on the details of its recent “Clean Power 2030” report.

[1] https://www.legislation.gov.uk/ukpga/2022/23/schedule/2

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3 MAIN ISSUES

3.1 Background

14 In this section, I highlight some high-level points from the 2024 National Audit Office ("NAO") report[2]. The concerns which I want to place before the Public Accounts Committee members relate to two key issues (1) the fundamental architecture of the current CCUS programme and (2) the systemic underestimation of upstream emissions, and I give some pointers here to themes for later discussion.

15 NAO identifies Carbon Capture, Usage and Storage (CCUS) as potentially involving these technologies[3]: hydrogen production, energy generation, industrial and waste processes, and Greenhouse Gas Removals.

16 CCS enabled gas-fired electricity generation ("gas-CCS") and CCS enabled hydrogen production from natural gas ("blue hydrogen"): each have an extremely high carbon footprint. This is primarily due to upstream emissions in the fuel supply chain of natural gas which has not been properly considered in the development of CCUS policy. This will be demonstrated later in this document by developing an illustrative calculation of the full life-cycle emissions and climate impacts for gas-CCS systems.

17 The centrality and dominance of gas-CCS and blue hydrogen plants in each of the Track-1 and Track-2 CCUS clusters is both a climate change issue and a value for money issue. This is both in the short-term and the long-term.

18 In the short term, both technologies would be required to run at full capacity. Blue hydrogen produces hydrogen so would run at full capacity for clear commercial reasons. In theoretical policy, gas-CCS is mooted as a dispatchable technology which may be switched in and out of the energy system, but the promoter for NZT has revealed that in practice it would need to be run at full capacity for the first four years of operation to provide constant flows of injection of CO_2 into undersea storage (see later).

19 Both technologies can then be expected to be run at full capacity, each generating very large emissions, up to 2030 adding significant risk to the delivery of the fifth carbon budget (2028-2032) and the UK international climate change obligations (the Nationally Determined Contribution, NDC).

20 NAO highlighted in July's report[4] that any delay in follow-on third party emitter projects making use of common transport and storage infrastructure risked the programme's value for money. A recent press report[5] indicates that across both Track-1 clusters, there is only one follow up emitter project that is funding ready:

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[2] National Audit Office, 2024, "Carbon Capture, Usage and Storage programme" (the "NAO" report)

3 NAO, "Summary", bullet 1

[4] NAO, Part 2, 2.16

[5] "UK government gives funding to just three of first CCUS cluster projects", 9 October 2024, S&P Global, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/100924-uk-government-gives-funding-to-just-three-of-first-ccus-cluster-projects

meaning that little, if any, industrial decarbonisation can possibly be achieved by 2030.

21 In the long-term, the very high emissions from the gas-CCS and blue hydrogen plants central to each cluster will continue to undermine carbon budgets and UK international climate obligations within its own territories, and also climate impacts outside UK territory as much of the emissions which would be generated from UK CCUS demand are emitted into international greenhouse gas inventories, as will be explained later. This does provide value for money in decarbonising the UK economy.

3.2 Is CCUS required for the energy system until 2030?

22 NAO note[6] that the Government sees CCUS "*as central to achieving net zero by 2050*", and say[7] that "*the government does not have and is currently not developing a credible alternative pathway without the use of CCUS*". However, recent advice from the National Energy System Operator's (NESO) to Government on how to achieve clean power by 2030 (NESO report "Clean Power 2030") identifies two primary clean power pathways[8]. **One pathway does not involve the use of CCUS**[9]. Whilst, NESO considers some new dispatchable power is needed after 2030 (and I do not agree and will address this later), this advice to Government makes it clear that implementation of gas-CCS and blue hydrogen is not actually needed before 2030, contrary to the much earlier projections of the CCC in the 6th carbon budget report (2020) and DESNZ in the Carbon Budget Delivery Plan (2023).

23 The Climate Change Committee highlighted in its 2024 Progress Report[10] that the UK only had credible plans for only around a third of the emissions reductions needed to meet the UK's 2030 Nationally Determined Contribution (2030 being the halfway year of the 5th carbon budget, 2028-2032) and a quarter of those needed to meet the 6th Carbon Budget (2033-2037).

24 In May 2024, the High Court found that the Government's climate plan (the Carbon Budget Delivery Plan) to be unlawful for the second time[11]. In Court, it was revealed that the Government's own assessments revealed huge doubt that its climate policies could actually be delivered and generate their intended carbon savings. The Court also found that they had not been properly risk assessed with information on risks to individual policies absent from the plan.

25 Should gas-CCS and blue hydrogen be built out to 2030, significant new emissions will be generated with very little, if any, industrial decarbonisation to compensate. Achieving the fifth carbon budget and the UK's 2030 international obligation (NDC) are already highly risked. There are simply not spare emission reductions else

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6 NAO, "Summary", bullet 1

7 NAO, "Summary", bullet 24

8 NESO report, page 8

9 One pathway successfully builds 50 GW of offshore wind by 2030, but with no new dispatchable power from hydrogen or gas with CCS (called "Further Flex and Renewables"). The other pathway delivers 43 GW offshore wind and new dispatchable plants, totalling 2.7 GW (called "New Dispatch").

10 CCC, July 2024, "Progress in reducing emissions 2024 Report to Parliament", Page 14 (description to Figure 2), https://www.theccc.org.uk/publication/progress-in-reducing-emissions-2024-report-to-parliament/

11 Friends of the Earth, May 2024, "High Court judgment on government's climate plan", https://friendsoftheearth.uk/climate/high-court-judgment-governments-climate-plan

where in the economy to make up for increased emissions being added to the Power and Fuel Supply sectors. These are the two sectors where gas-CCS and blue hydrogen generate most of their UK territorial emissions.

26 This does not make sense either as climate policy or as value for money from the CCUS programme.

27 There is a further issue that the international climate impacts of these technologies in the natural gas supply chain have not been fully considered, again discussed later.

28 The CCUS programme also risks going against the growing scientific consensus[12],[13] that 100% of our energy needs can be met by renewables without CCS—with Oxford University reporting[14] that scaling-up key green technologies like energy storage, solar and wind for decarbonisation will save the world $12 trillion, and that the more rapidly these technologies are deployed, the more money will be saved.

29 **There is a huge opportunity cost with the CCUS programme in its diversion of funding away from technology which genuinely reduces carbon emissions, saves money and keeps the UK closer to being on track with its national and international climate obligations**.

30 The NESO report shows that CCUS is not required for the UK energy system before 2030.

31 There may be CCS applications which are valuable to develop as part of UK climate plans, for example in industrial and waste processes, and CEPP considers that any development of these should be considered in a different way to the current CCUS programme architecture based around clusters.

3.3 The cluster model: emissions bake in, and very high risks and low value for money for climate policy

32 The NAO report outlines the history of the cluster model: that DESNZ sought to ~~learn lessons~~ from the two previous attempts[15] since 2007 to support CCUS in the

[12] Oxford Brookes University, 2022, "Researchers agree: The world can reach a 100% renewable energy system by or before 2050", https://www.brookes.ac.uk/about-brookes/news/2022/08/researchers-agree-the-world-can-reach-a-100-renewa

[13] Breyer et al, 2022, "On the History and Future of 100% Renewable Energy Systems Research", https://ieeexplore.ieee.org/document/9837910

[14] "Decarbonising the energy system by 2050 could save trillions - Oxford study", https://www.ox.ac.uk/news/2022-09-14-decarbonising-energy-system-2050-could-save-trillions-oxford-study

15 See NAO, Figure 2 which shows the first CCUS programme (Nov 2007-Nov 2011), the second CCUS programme (April 2012-Nov 2015) and the current third programme (Nov 2018 – present)

16 NAO, Part 1, 1.12

[17] Currently four industrial clusters have been announced across the UK: HyNet and the East Coast Cluster in Track-1, Acorn and Viking in Track-2. The East Coast Cluster covers Teesside and Humberside, but the Track 1 projects are exclusively in the Teesside area under the Net Zero Teesside cluster.

[18] Track 2: Viking: Details of this cluster appear not to be in the public domain

[19] Track-1: Net Zero Teesside: Start-up project is Net Zero Teesside Power, carbon capture enabled gas fired electricity station

Track 2: Acorn: Peterhead, carbon capture enabled gas fired electricity station

[20] Track-1: HyNet: HyNet Hydrogen Production Plant, Phase 1

design[16] of the current CCUS programme which includes using a model of industrial clusters[17], splitting the chain, creating a pipeline of projects and working with HM Treasury on funding availability. In this submission, I examine the impact of this cluster based architecture on full life-cycle greenhouse gas emissions (GHGs).

33 Each proposed cluster in this model has a CO2 capture enabled "start-up" project with CO2 capture which is designed to be delivered alongside the 'split-off' project to develop the CO2 transport and storage infrastructure. Where known[18], the start-up project at the core of each cluster is either a gas-CCS[19] or a blue hydrogen plant[20]. This is CEPP's point above about the centrality and dominance of gas-CCS and blue hydrogen: in each known case such a plant is used to 'bootstrap' the cluster. However, both technologies have a very high greenhouse gas emission footprint, as will be described later. The impact of this highly negative footprint comes before any follow up third-party emitters[21] can be added to the cluster. This may be years later, and in the meantime, very large emissions will be generated, contrary to the direction of travel towards Net Zero and not aligning to meeting near term carbon budgets. This is very high risk and low value for money for UK climate policy.

34 Overall, by front loading very high emitting technology at the outset, the cluster model is, at best, an extremely inefficient way to deliver some possible industrial decarbonisation later. This inefficiency essentially means it is a very low value for money route to decarbonisation. It is also a route that they may fail completely because the later decarbonisation benefits will always be outweighed by the cost of the baked in emissions from the gas-CCS and blue hydrogen sitting centrally in each cluster.

35 The point above on the very large emissions from these start-up project technologies is made in DESNZ's "Overarching National Policy Statement for Energy (EN-1)"[22] where it states at 5.3.11:

> *"Operational GHG emissions are a significant adverse impact from some types of energy infrastructure which cannot be totally avoided (even with full deployment of CCS technology)."*

36 Picking up on the point above that industrial and waste decarbonisation projects may trail years behind high emitter start-up projects, NAO note that in March 2023, DESNZ announced that it had short-listed eight emitter projects in Track-1[23]. According to a recent press report from S&P Global, the number of projects being brought forward for funding under Track-1 since the October 4th 2024 Government announcement on CCUS has now been reduced to five[24].

37 If this report is correct, then for the East Coast Cluster, **only** the start-up Net Zero Teesside gas-CCS plant and the 'split-off' Northern Endurance Partnership CO2 transport and storage system would get first tranche funding. In other words, no

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[21] Those subsequent emitter projects which use the transport and storage infrastructure, once the start-up project is complete and the CO2 transport and storage infrastructure is operational.

22 "Overarching National Policy Statement for energy (EN-1)", DESNZ, 17 January 2024. This is Planning guidance for developers of nationally significant energy infrastructure projects, issued under the Planning Act 2008. https://www.gov.uk/government/publications/overarching-national-policy-statement-for-energy-en-1

[23] NAO, Part 1, bullet 4

[24] "UK government gives funding to just three of first CCUS cluster projects", 9 October 2024, S&P Global, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/100924-uk-government-gives-funding-to-just-three-of-first-ccus-cluster-projects

follow up emitters are to receive funding in this round. The next project in the East Coast Cluster, the H2 Teesside blue hydrogen plant, is still in planning with planning approval in late August 2025 at the earliest.

38 For the HyNet North West cluster, S&P Global report a similar situation with the first phase of EET blue hydrogen plant (350-MW HPP1) and Eni's Liverpool Bay CO2 transport and storage system due for funding, and just one follow up emitter project, Protos' CCS-enabled energy from waste facility.

39 Based on eight projects, NAO notes[25] that DESNZ plans to identify additional emitters that could join these clusters later, known as Track-1 expansion. However, it appears currently there is Track-1 contraction. The effect discussed above of front-loading high emitter projects will have very real impacts to carbon budgets and for value for money for any possible industrial decarbonisation delivered later.

40 Further uncertainty and risks come from the emitter projects for the Track-2 Acorn and Viking clusters currently being unknown[26].

41 All of this suggests that gas-CCS and blue hydrogen projects, with their very high carbon footprints, would be central and dominant in Track-1 and Track-2 CCUS clusters for the foreseeable future, at least to the end of the fifth carbon budget in 2032.

42 I should emphasise that CEPP does **not** see this as merely a sequencing issue, and that if somehow bringing on third party emitters could be accelerated, then the risks to climate policy, and the poor value for money for possible later industrial decarbonisation, would recede.

43 CEPP sees the centrality and dominance of high emitting gas-CCS and blue hydrogen as a fundamental flaw in the architecture of the proposed CCUS programme for the longer term too. Having such high emitting plants as baked-in elements in the energy system until the 2060s and beyond is not consistent with Net Zero and other climate targets. It does not provide good value for money against the alternative of the UK developing along a renewables pathway without CCUS clusters as NESO shows (see later) is possible until 2030, and the research highlighted above shows saves money in the longer term.

44 If there are merits in some decarbonisation by CCS in the industry and waste sectors, then it must be developed outside of the current CCUS programme architecture with its flawed lock-in of front-loaded highly emitting projects. However, the committee should note electrification alternatives are being developed for industrial processes like concrete[27] and steel production[28], and the CCUS programme, conceived before these developments, risks suppressing innovation in finding more efficient and value for money methods. If CCS is needed for some industrial decarbonisation projects, then this may be done by developing the necessary transport and storage network without gas-CCS and blue hydrogen as bootstrapping start-up projects.

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[25] NAO, Part 1, bullet 4

[26] NAO, Part 3, 3.15

[27] https://earthfriendlyconcrete.com/

[28] "Electric arc furnaces: the technology poised to make British steelmaking more sustainable", https://theconversation.com/electric-arc-furnaces-the-technology-poised-to-make-british-steelmaking-more-sustainable-214756

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3.4 Why are the CCUS programme's climate credentials now being challenged?

45 Two letters from scientists and campaigners have been written recently to the DESNZ Secretary of State about the UK CCUS programme: one before the Oct 4th announcement (see first letter in Appendix D, September 11th 2024), and one after (see second letter, October 18th letter, in Appendix E). These letters highlighted **how the full lifecycle GHG emissions have been systemically underestimated** amongst other issues including hydrogen leakage, storage and transport issues, health and safety, monitoring and enforcement, and better alternatives for investment.

46 Although many have been warning about the issues for considerable time, the key reason that the issue has now come to a head with an extremely contentious debate around the CCUS programme on-going is that full lifecycle GHG emissions have been systemically underestimated in the policy decision making which has led to the current CCUS programme.

47 DESNZ and the CCC have both baked-in the CCUS programme in plans since 2018 and have ignored the warnings from outside their own policy making bubble. As the science has become clearer and clearer as to the very high climate impacts of both gas-CCS and blue hydrogen, they have locked-in harder to existing policy which increasingly does not make sense either for climate goals or for value for money.

48 When gas is imported, upstream emissions from the natural gas supply chain are generated both within UK territory and outside of it. The evidence given later shows that the vast majority of these emissions may be in ex-territorial international shipping and in the gas source countries. With North Sea gas declining, implementation of gas-CCS and blue hydrogen will create a demand from the UK for increased imports. The further issue is that UK policy making has predominantly been concerned only those emissions which come under the UK territorially based Climate Change Act 2008. A recent FoI (see Appendix F) shows for example that calculations for the CCC Sixth Carbon budget report were made in line with "territorial emissions accounting". In other words, the UK has developed its own climate policy incorporating CCUS without concern for the impact from the natural gas demand on international climate impacts. In global terms, this is policy development in a vacuum. I later make an illustrative calculation which shows that each TWh of demand for gas-CCS electricity under the CCUS programme creates more climate pollution in outside the UK, than the UK would collect to store under the North Sea.

49 Following the October 4th announcement of £22bn for CCUS, the issues described above need to be addressed now. CEPP welcome the Public Accounts Committee inquiry, and hope that the issues raised here will be investigated fully. Value for money for the CCUS programme is deeply intertwined with how climate policy is developed, so the potential failings of UK climate policy must be addressed to by the committee as they have also been by the Courts[29] in recent years.

[29] With the Net Zero Strategy and Carbo Budget Delivery Plan being found twice to be unlawful at the High Court

50 Scientists and campaigners have asked for a pause and review before any money is committed to funding the CCUS programme, as described above. Moving to any Final Investment Decisions (FIDs) on the CCUS programme would be disastrous as the risks to climate policy and value for money in delivering it, as well the opportunity costs in developing better policies, become clearer by the day.

3.5 Funding without full climate impact and value for money assessment

51 A further risk that has emerged from a report this summer from the Subsidy Advice Unit (SAU) into funding hydrogen plants[30], including high carbon emitting blue hydrogen. As background, the Energy and Environment principles of the Subsidy Control Act are given in Schedule B[31] where Principle H states that subsidies must achieve an overall reduction in GHGs. The relevant guidance[32] is clear that Principle H requires subsidies must achieve an overall reduction in GHG (Guidance 4.61), and that all GHGs must be considered including methane which is a known upstream effect of gas-CCS and blue hydrogen developments, and nitrous oxide which would be formed as result of likely hydrogen leakage (Guidance 4.62), and that there should be consideration of "... sectors that are not in receipt of the subsidy" e.g. genuine renewables and demand reduction such as retrofit. (Guidance 4.67).

52 However, SAU found at 3.79 of their report that DESNZ did not consider in its assessment that it needed to follow Principle H:

> *"The Assessment does not assess Principle H as it concludes that it is not applicable to the Scheme. The reasoning advanced is that the Scheme will subsidise the construction of CCUS-enabled low carbon hydrogen production plants and not their operation. However, we note that the assessment of Principle B considers the operation of the plants, and the Assessment of the subsidy control principles takes account of benefits arising from operation of the plants."*

53 **It appears that DESNZ consider that its CCUS plans are exempted from a requirement that decarbonisation projects should actually reduce greenhouse gas emissions.** This is of great concern given that the evidence CEPP is providing here that first the CCUS programme with its central dominance of gas-CCS and blue hydrogen will increase emissions significantly (both in the short-term and into the longer term), and that this is a key risk to value for money.

54 CEPP hope that committee share this concern, and will investigate the currently unsatisfactory situation that CCUS related funding decisions for subsidies can be made without having made an assessment of whether a project actually reduces emissions, and with assessment of the risks to value for money if it does not.

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[30] Final report of the Subsidy Advice Unit into Strand 4 of the Net Zero Hydrogen fund, Sept 11th 2024, https://www.gov.uk/government/publications/report-on-the-proposed-net-zero-hydrogen-fund-nzhf-carbon-capture-use-and-storage-ccus-scheme-by-the-department-for-energy-security-and-net-zero

[31] https://www.legislation.gov.uk/ukpga/2022/23/schedule/2

[32] https://assets.publishing.service.gov.uk/media/658025b295bf65000d719140/uk_subsidy_control_regime_statutory_guidance.pdf

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4 OVERALL PROBLEMS WITH CLUSTER BASED CCUS IN CLIMATE MITIGATION POLICY

4.1 Full lifecycle GHG emissions have been systemically underestimated

55 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.

56 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).

57 **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.

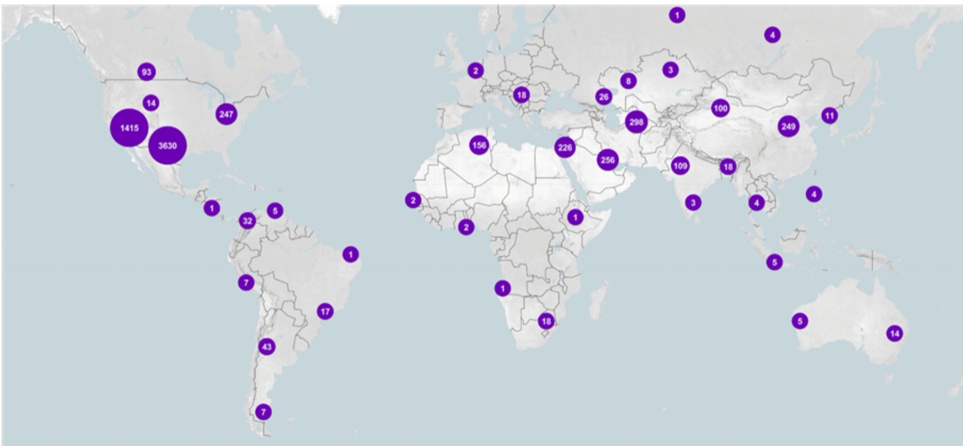

Figure 1: Recent map of methane leaks from new Tanager-1 satellite

58 The map from Carbon Mapper shows the first methane and carbon dioxide (CO_2) detections by the Tanager-1 satellite[33] 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).

59 CEPP now go into depth on this and other factors which lead to underestimation of climate impacts of gas-CCS and blue hydrogen projects.

60 This section addresses the climate impacts which come from the centrality and dominance of gas-CCS and blue hydrogen in the overall CCUS programme discussed above. If these highly polluting technologies are locked-in as start-up projects in CCUS clusters, but continue to operate past Net Zero in 2050, and past

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[33] 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

2060 for those introduced in the 2030s, the overall CCUS programme will fail to meet its objectives in respect of delivering net-zero.

61 Later failure to meet Net Zero and other climate targets will be due to the very large carbon footprint being largely ignored during the evolution of the current CCUS programme since 2018.

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

4.2 Overestimation of carbon capture rate

63 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.

64 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[34], as below:

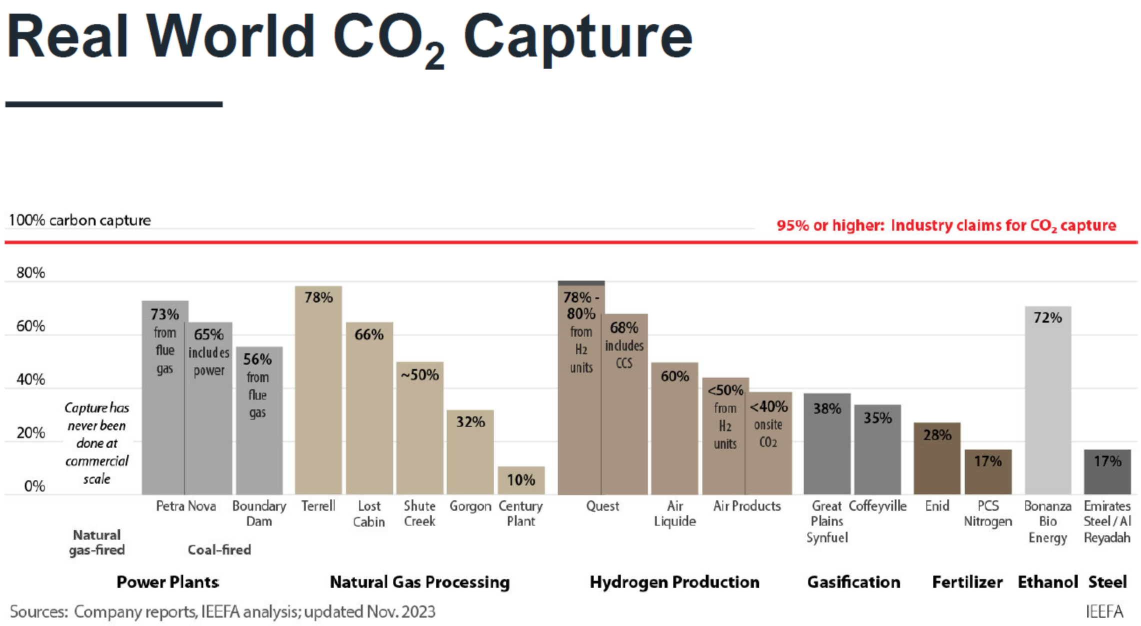

Figure 2: IEEFA: Real World CO2 Capture (2024)

65 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).

[34] 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

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

67 The committee 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[35]. This strongly suggest that scheme promoters are not confident of reaching the much high capture rates which they promise.

68 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.

69 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.

4.3 Venting of CO2 is not included

70 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%[36]. NZT calculated that this amounted to 3,592,523 tonnes of CO2 over 25 years[37]. This figure equates to an additional carbon intensity component of 25.0 gCO2/KWh in the power station footprint (see calculations later).

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

71 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.

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35 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

36 Net Zero Teesside Planning Examination, Document 9.29 - "Cumulative GHG Onshore and Offshore Assessment August 2022", section 3.3.4, 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

37 Net Zero Teesside Planning Examination, Document 9.29, Table 3-3.

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72 **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, the October 2024 paper by Professor Robert Howarth[38] 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[39] in January 2024—a pause which remains in force today**.

73 A recent report from Carbon Tracker "Kind of Blue"[40] sets out in detail the key issues which act together to compound the climate impact of gas-CCS or blue hydrogen production, including:

(a) <u>The emission factors used for upstream emissions in the natural gas supply chain are underestimated</u>. 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 <u>emissions factors</u> 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[41] 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

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[38] 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

[39] 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/

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

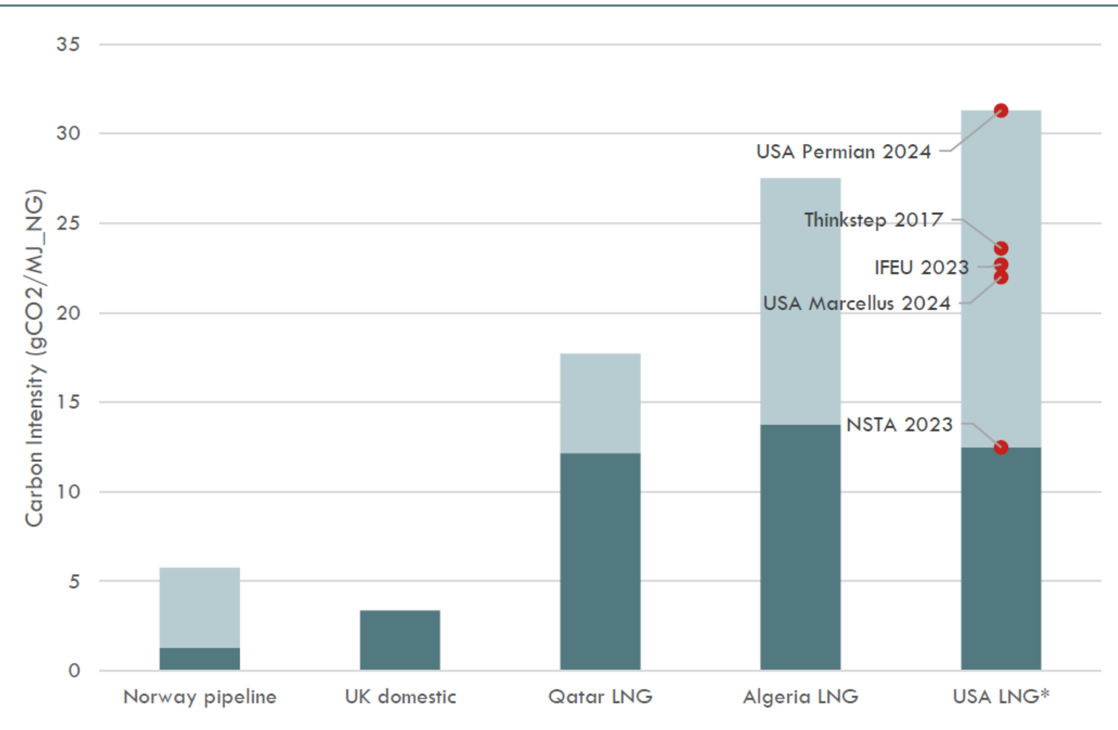
[41] Stuart N. Riddick, Denise L. Mauzerall. Likely substantial underestimation of reported methane emissions from United Kingdom upstream oil and gas activities. Energy & Environmental Science, 2023; 16 (1): 295 DOI: 10.1039/d2ee03072a, https://pubs.rsc.org/en/content/articlehtml/2023/ee/d2ee03072a

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)*."

This is one example of how in recent years, satellite and remote sensing has achieved much a more accurate picture of upstream methane emissions, <u>and that this is revealing this systemic underestimation</u>[42].

(c) The source of the natural gas is important given the very different scale of emissions possible[43]. LNG imports have a much greater upstream emission footprint than UK domestic or Norwegian pipeline sources, see below.

FIG 7: NATURAL GAS UPSTREAM EMISSIONS VARY WIDELY DEPENDING ON THE ORIGIN COUNTRY AND TRANSPORT ROUTE



Source: Carbon Tracker (2024); based on multiple sources available in Appendix Table 5.

Figure 3: Carbon intensity for different Natural Gas supplies[44]
(*the lighter shading shows the range of carbon intensities*)

(d) UK sources of natural gas are declining, and imports are growing[45].

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[42] 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.*"

[43] 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.*"

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

[45] 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.*

(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"[46], 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[47]

Critically, the DESNZ December 2023 report also identified that further research and analysis was required[48] 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[49] 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.*"

74 **The overall scale of CCUS planned in the UK will also become a driver for increased LNG imports.** Carbon Tracker find that 4 GW of blue hydrogen and 9 GW of gas-CCS plants are planned by 2035[50], 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%[51].

Domestic production is expected to drop further in the coming decades while pipeline imports from Norway are also expected to decrease, though more slowly."

[46] 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

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

[48] 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

[49] UK Continental Shelf

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

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

75 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.** This also applies for understanding the impact of the CCUS programme on carbon budgets as explored later in this document, and the impact of that on the value for money of the CCUS programme.

76 The DESNZ emission factors are mostly based on a 2015 report from Exergia[52]. The nine-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.

77 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.**

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

78 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[53] 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).

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

[53] 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

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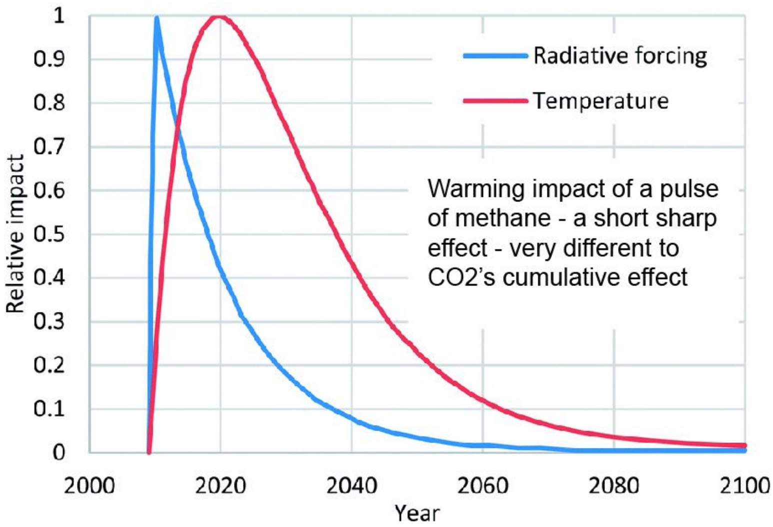

From Study: "Methane emissions: choosing the right climate metric and time horizon"

Figure 4: The short sharp effect of methane emissions

79 It is urgent to reduce methane emissions. This was recognised by global policy initiatives like the Global Methane Pledge[54] signed by over 150 countries[55] 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[56]. Yet in September, Carbon Brief reported that levels of methane in the atmosphere have soared by record-breaking amounts since 2020[57].

80 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[58].

81 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

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

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

[56] 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

[57] 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/

[58] 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

over the 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.

82 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.

83 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[59] 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.

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

84 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, <u>all the extra demand will have to be satisfied by LNG imports</u>. 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.

85 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.

86 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 emission for natural gas supply fall under the Fuel Supply sector in the carbon budgets under the Climate Change 2008.

87 I have expressed severe concern above that UK policy making has predominantly been concerned <u>only</u> 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". In other words, the UK has developed its

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[59] "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.*"

own climate policy incorporating CCUS without concern for the impact from the natural gas demand on international climate impacts.

88 I now develop illustrative calculations to demonstrate these climate impact issues for developing gas-CCS in the UK.

89 GHG reporting for blue hydrogen production also shares the same issues of overstated carbon capture rates, CO2 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. However, detailed calculations for blue hydrogen are not covered in detail in this submission[60].

[60] Essentially due to lack of time

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5 CLIMATE IMPACTS OF CCS ENABLED GAS FIRED ELECTRICITY GENERATION (GAS-CCS)

5.1 Background and policymaking history

90 Gas-CCS has been proposed as a technology to provide dispatchable electricity when weather conditions reduce the generation capacity of renewable energy. Despite gas-CCS and blue hydrogen not being low carbon for reasons given above, they are often grouped as new dispatchable 'low carbon' technologies. It is extremely concerning that building new infrastructure now, and into the 2030s and 2040s, would see gas-CCS persist as part of the energy mix until 2060 and beyond.

91 Whilst before 2030, gas-CCS is proposed for the start-up projects for two of the clusters: Net Zero Teesside in Track-1 and Acorn in Track-2, policy documents show projections for gas-CCS capacities to 2030 and beyond to 2050.

92 In Powering Up Britain Technical Annex (PUBTA) which is a technical paper published alongside the 2023 Carbon Budget Delivery Plan (CBDP), DESNZ foresee capacities of gas-CCS growing from 3GW in 2030, to 9GW in 2035 and to 18GW in 2050[61]. Whilst intended for dispatchable electricity generation, and not baseload, these capacities would provide a full generation capacity of 26.2 TWh (2030), 78.8 TWh (2035) and 157.6 TWh (2050).

93 The Climate Change Committee (CCC) 6th Carbon Budget report (CCC-6CB) plans for 30Twh gas-CCS generation in 2035[62]. CCC-6CB is not clear on its advice for gas-CCS in 2030, but its 'Balanced Pathway' provides for 46TWh of dispatchable energy which includes hydrogen alongside gas-CCS. See more details in Appendix A.

94 Against this, recent advice from the National Energy System Operator's (NESO) to Government on how to achieve clean power by 2030 (NESO report "Clean Power 2030") identifies two primary clean power pathways[63]. One pathway successfully builds 50 GW of offshore wind by 2030, but with no new dispatchable power from hydrogen or gas with CCS (called "Further Flex and Renewables"). The other pathway delivers 43 GW offshore wind and new dispatchable plants, totalling 2.7 GW (called "New Dispatch").

95 This is very significant as it shows that NESO's modelling shows that it is possible to reach 2030 without any CCS. Whilst, NESO considers some new dispatchable power is needed after 2030 (and I do not agree[64]), it suggests that implementation of gas-CCS and blue hydrogen is not actually needed before 2030, contrary to the much earlier projections of the CCC in the 6th carbon budget report (2020) and DESNZ in the CBDP (2023). Even in their "New Dispatch" scenario, NESO only model 11.24TWh of new dispatch in 2030[65], much lower than the CCC projection of 46TWh.

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[61] Powering Up Britain Technical Annex (PUBTA), 30 March 2023, page 24, Table 2

[62] CCC-6CB-report, page 135

[63] NESO report, page 8

[64] For the reasons given in the wider submission that gas-CCS will continue to generate very high emissions which are not consistent with the UK climate targets and international obligations.

[65] NESO Clean Power 2030 Data Workbook (which accompanies NESO report), https://www.neso.energy/document/346781/download,

96 Although I may not agree with their conclusions or pathways, in my view, the NESO report and the previous annual "Future Energy Scenario" reports by NESO's predecessor are excellently presented and researched. I say this because I now raise two issues with the NESO report: I raise these as constructive criticism which should be noted now as they relate to further discussion later in this document.

97 I also suggest to the Public Accounts Committee that it would be helpful to call NESO to give evidence on some of the wider issues discussed here.

5.2 Issues with the NESO report

98 [First issue]. NESO show that in their "New Dispatch" scenario that gas-CCS will operate at 31% of annual operating hours in 2030[66]. This is inconsistent with how the promoters of the Net Zero Teesside gas-CCS plant understand it would operate. They say in their planning application[67] that they anticipate, that on commissioning, the plant "*will operate in baseload mode with continuous operation with carbon capture for several years*". This is because "*continuous and stable CO2 production and export is preferable during this period to minimise changes to injection rates to the offshore underground storage reservoir*".

In fact, NZT never show, for planning purposes, the plant operating at less than 58% of annual operating hours during its entire 25-year lifetime[68]. And to enable stable CO2 injection, the plant is expected to run at 8,424 hours (96% of annual operating hours) with no start-up or shut-downs for the first four years, which includes 2030, the NESO model year.

There are three implications of this:

- Theoretical policy projections by the CCC and others do not appear to have taken into account this physical real-world requirement for stability in injecting CO2 into offshore underground storage reservoirs. This suggests that gas-CCS cannot be used in dispatchable mode for several years after the implementation of new underground storage reservoirs linked to it as the 'start-up' emitter. This makes for a large difference in the operation of the plants between policy theory and practice, and has large impacts on the greenhouse gas calculations and climate impacts as discussed below. Essentially, with the Track-1 and Track-2 gas-CCS plants, the operators consider that they need to run the plants at much greater generation output, and therefore climate impact, than the policymakers have considered for 2030.

- The operators of gas-CCS appear to have different projections of operational hours from policymakers for later years too (ie: 58% or more for NZT) which

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Tab CP.06

[66] NESO report, page 79

[67] Net Zero Teesside, Planning Application, "Chapter 4: The Proposed Development (ES Volume I - Document Ref. 6.2).]", section 4.4.4 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010103/EN010103-000896-NZT%20DCO%206.2.4%20ES%20Vol%20I%20Chapter%204%20Proposed%20Development.pdf

[68] Net Zero Teesside, Planning Application, ES Volume I Chapter 21 Climate Change, Table 20-10, https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010103/EN010103-000905-NZT%20DCO%206.2.21%20ES%20Vol%20I%20Chapter%2021%20Climate%20Change.pdf – the minimum annual operating hours are shown as 5,112 hours (58% of 8760 hours in a year) with 80 Start-up/Shut-downs

might lead to a more systemic issue of the plants operating at greater climate impact than considered by the policymakers.

- Therefore, NESO's model (with gas-CCS operating at no more than 31% of annual operating hours in 2030) underestimates the amount of gas-CCS in the system at 2030 which has knock-on impacts to their carbon calculations, and narratives on protection from gas volatility[69], and wider economic modelling on their pathways.

99 [Second issue]. "Annex 4: Costs and benefit analysis" of the NESO report attributes 5.4 MtCO2e at Figure 2[70] from unabated gas and residual emissions from CCS in its "New Dispatch" pathway. Examination of the data[71] under Figure 3[72] shows that this is made up of 5.25MtCO2e from unabated gas and <u>0.072MtCO2e from residual emissions from CCS (both gas-CSS and blue hydrogen, with the split between the two not being made clear by NESO)</u>. With the NESO "New Dispatch" model showing 11.24TWh of "low carbon dispatchable power" in 2030[73] (as above), this "New Dispatch" power is then purported to be running at a carbon intensity of 6.44 gCO2/KWh.

This carbon intensity is extremely low and quite clearly wrong. Even without considering upstream supply chain emissions and downstream CO2 venting emissions, the NZT proposers first calculated a carbon intensity of 41.2 gCO2/KWh at 90% carbon capture in their planning Environmental Statement. The NZT proposer then, following submissions from CEPP, corrected this to include upstream and downstream emissions. Whilst this final environmental statement made the correction to include upstream emissions at all, it based its calculations on the DESNZ emission factor which underestimate the impacts (as described above). Even at this level of underestimation, this second calculation, made by NZT, corresponded to a carbon intensity of 141.6 gCO2/KWh for the operational emissions of the NZT plant[74].

CEPP provides an illustrative calculation in Appendix B that shows gas-CCS operating at a carbon intensity of 488.66 gCO2/KWh when calculated with realistic modelling of upstream emissions and conservative operating assumptions (fully described in Appendix B).

100 This means that NESO have severely underestimated the emissions in the "New Dispatch" scenario. **In terms of meeting carbon budgets and path to Net Zero, this actually means that when corrected, there is a stronger case for the UK to evolve its energy system along a path like NESO's "Further Flex and Renewables" which does not implement gas-CCS, nor blue hydrogen, both up to 2030 and beyond 2030.**

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[69] NESO report, page 79

[70] NESO report, "Annex 4, Costs and benefit analysis", Page 15, https://www.neso.energy/document/346806/download

[71] NESO Clean Power 2030 Data Workbook, Tab CP.24

[72] NESO, Annex 4, Page 16

[73] NESO Clean Power 2030 Data Workbook, Tab CP.06

[74] This was after a detailed exchange of letters and submissions between 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 CEPP 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

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101 In terms of the CCUS programme, the much greater emissions with gas-CCS and blue hydrogen than NESO calculate means that using these technologies on future energy scenarios must be urgently reviewed. Including CCUS technologies in the energy system severely risks delivery of climate targets (and in the case of 2030, the fifth carbon budget and international NDC obligation), and is a very significant value for money risk with proceeding with the CCUS programme, in its current form designed around cluster with gas-CCS and blue hydrogen as start-up projects.

5.3 Climate impacts of gas-CCS under the CCUS programme

102 Appendix B provides an illustrative calculation of the carbon intensities of the different emissions fractions for a gas-CCS plant (modelled on the Track-1 Net Zero Teesside project). Here I provide a summary.

103 Whilst this data is illustrative, I have laid out all my assumptions and consider them to be reasonable, and also conservative. For example, I have modelled upstream emissions from LNG at a moderate level, should the CCUS programme create demand that is predominantly met from most emission intense UK exports, then y calculations are an underestimate of the impacts.

104 This is the final data table generated in Appendix B, and presents the emissions as emissions intensities per 1 TWh of energy produced by a gas-CCS plant. The TOTAL figure of 0.483 MtCO2e/TWh means that 0.482 MtCO2e is generated of each TWh across UK and international territories. This also equates to a carbon intensity of 483gCO2/KWh expressed in the more usual units for carbon intensities.

	Power sector	Fuel Supply sector	International	TOTAL	CO2 Captured	CO2 Stored
Emissions MtCO2e/TWh	0.107	0.038	0.338	0.483	0.330	0.305

Figure 5: Emissions generated per TWh of gas-CCS

105 CEPP's calculations also show how the emissions and spread over two carbon budget sectors under the Climate Change Act 2008, and those emissions which are ex-UK and would be accounted for under international shipping and source country emission inventories. I have also calculated the amount of CO2 that would be stored after CO2 venting.

106 There are a number of points to note.

107 These figures show the additional emissions which are generated for each TWh of electricity which is generated by the CCUS programme as opposed to generation by energy storage, flexible grid and renewable technology. They illustrate the opportunity cost for emissions reductions lost when CCUS is favoured over rapidly emerging (with rapidly reducing costs too) alternatives to CCUS.

108 In the context of the NESO report and modelling pathways to Clean Energy in 2030, the above figures show the additional emissions generated from each TWh of gas-CCS which is deployed (in the NESO "New Dispatch" pathway) instead of renewables in the NESO "Further Flex and Renewables" pathway ie an additional 0.48 MtCO2e is generated per TWh.

109 The impact to the UK emissions accounting under the Climate Change Act is 0.145MtCO2e (0.107+0.038). However, the additional UK consumption emissions are over twice that at 0.338MtCO2e being generated on international inventories.

110 This illustrates an important point when considering carbon budget focussed policy decision making on the CCUS programme – when upstream emissions are properly accounted the far greater impact is to ex-UK inventories. UK policy making has been largely focussed around carbon budgets. The FoI attached at Appendix F shows that, for example the CCC policy development, **this is a blind spot in policy making that must now be corrected**. The PAC committee should note that UK consumption emissions from the CCUS programme are not fully assessed, and this error then infects policymaking decisions including value for money considerations.

111 A further interesting fact from these figures is that 0.305MtCO2e are calculated as being stored for this 1 TWh of gas-CCS electricity. This is smaller than the emissions which are generated in international inventories. **This means that each TWh of demand for gas-CCS electricity under the CCUS programme creates more climate pollution in outside the UK, than the UK would collect to store under the North Sea**. DESNZ and CCC must now fully account for this impact of UK consumption emissions generation by the CCUS programme on international efforts to tackle climate change.

5.4 UK Carbon Budgets and international impacts

112 The table below shows the impacts on the carbon budget sectoral residual emissions of gas-CCS being used in some scenarios for 2030 and 2035. These are:

(a) First, the 11.24TWh of 'low carbon' dispatchable power (if it were all implemented as gas-CCS) in NESO 2030 "New Dispatch" pathway. This is a straight displacement of renewable energy if this pathway were to be pursued rather than NESO's "Further Flex and Renewables" pathway. The climate cost of this scenario (the total of the three columns for 5CB Power, 5CB Fuel Supply and international) is 5.43MtCO2e to the Power and Fuel Supply sectors (to store 3.42MtCO2e) per year.

Note that in this case, and each case, that the cost of the scenario is greater than the carbon stored. Whilst third party emitter project may later make additional savings, the front-loading effect of the cluster model in this scenario means that the cost of gas-CCS has a negative impact on the fifth carbon budget before other emitters may come on line. The Power sector has 13MtCO2e of residual emissions allocated by policy in the Carbon Budget Delivery Plan for 2030 and 9.3% of it would be used for this NESO pathway.

(b) Second, NESO's 2.7 GW of 'low carbon' dispatchable power (if it were all implemented as gas-CCS) under the 2030 "New Dispatch pathway is modelled at 96% annual operation hours which the NZT promoters have said that say that it will have to operate at to provide a continuous and stable CO2 production and export at the storage site. The climate cost of this pathway is 11.00 MtCO2e to the Power and Fuel Supply sectors (to store 6.93MtCO2e) per year.
The Power sector has 13MtCO2e of residual emissions allocated by policy in the Carbon Budget Delivery Plan for 2030 and 18.83% of it would be used for this

NESO pathway at this real-world modelling of how NZT consider gas-CCS would operate for the first four years.

			5CB Power	5CB Fuel Supply	Intl	CO2 stored	6CB Power	6CB Fuel Supply	Intl	CO2 stored
Sectoral residual emissions ANNUAL MtCO2e			**13**	**14**	**14**		**8**	**10**	**10**	
11.24TWh	NESO	**2030**	1.21	0.42	3.80	3.42				
11.24TWh	NESO	**2030**	***9.3%***	***3.0%***	***27.2%***					
22.74TWh**	NESO NZT	**2030**	2.44	0.86	7.70	6.93				
22.74TWh**	NESO NZT	**2030**	***18.8%***	***6.1%***	***55.0%***					
30TWh	CCC	**2035**					3.22	1.13	10.15	9.14
30TWh	CCC	**2035**					***40.3%***	***11.3%***	***101.5%***	

** 2.7GW NESO at 96% operation

Figure 6: Emissions generated for gas-CCS in UK and international carbon accounts

(c) Third, CCC's 30TWh of gas-CCS Generation under its CCC 6th Carbon budget report "Balanced Pathway". The climate cost of this pathway is 14.50 MtCO2e to the Power and Fuel Supply sectors (to store 9.14MtCO2e) per year.

The Power sector has 8MtCO2e of residual emissions allocated by policy in the Carbon Budget Delivery Plan for 2035 and 40.3% of it would be used for this CCC pathway.

It should also be noted that whilst 11.3% of the UK Fuel Supply residual emissions are used by this pathway, the impact on ex-UK emissions is much greater with emissions equivalent to over 100% of the UK Fuel Supply allocation being emitted as UK consumption emissions (accounted on international inventories).

The emissions added to UK consumption emissions (10.15 MtCO2e) is greater than the carbon stored (9.14 MtCO2e).

Written evidence submitted by Climate Emergency Policy and Planning (CEPP) (CCUS0018)

6 RECOMMENDATIONS

113 Make a strong recommendation that no CCUS project should receive Government funding, nor a Final Investment Decision (FID), until:

(a) A full scientific review of the CCUS programme has been made as requested recently by scientists twice (see Appendices D and E);

(b) Each project is reviewed that it makes an overall reduction of greenhouse gas emissions under Principle H the Energy and Environment principles of the Subsidy Control Act[75];

(c) On (a) and (b) above, fully consideration of the effects of the project on both UK territorial GHG emissions under the Climate Change Act carbon budgets, and ex-territorial GHG emissions in international shipping and other country GHG inventories should be considered.

114 Make a strong recommendation to the Climate Change Committee that its upcoming Seventh Carbon Budget report must fully consider the upstream emissions in its consideration of the CCUS programme. The full impact to UK consumption emissions from the CCUS programme on international climate action must be fully accounted for in its advice to Government. Further it should review the proposed cluster model and its front loading of very high emissions, for alignment with the 5th carbon budget in the period 2028-2032 and with meeting the UK 2030 NDC. CCC should also give advice on how some industrial decarbonisation might be achieved without start-up projects involving gas-CCS or blue hydrogen (ie outside of the cluster model architecture).

115 Require that DESNZ undertake a review of the potential to remove CCS (either as gas-CCS or blue hydrogen) from its energy policy. This should look at first how much of UK energy needs can be provided by deployment of energy storage, solar and wind technology with a full scientific analysis of UK weather patterns, and second what the relative value for money and investment costs are for delivering UK climate targets and budgets via alternatives to the CCUS programme. A genuine evidence-based response, based on latest science of non-CCS pathways (ie 100% renewable energy pathways), is needed to the question "if the UK can get to 2030 with CCS (as per NESO report), then can it get to 2035 and 2040 also without CCS?"

116 Request NESO to give evidence to the committee, particularly on the details of its recent "Clean Power 2030" report as they relate to its two pathways to 2030 and the CCUS programme, and its consideration of CCUS for after 2030. NESO should be asked for its view of the two issues I have raised (ie the non real-world modelling of 'New Despatch' energy and the absurdly low emission intensity for 'New Dispatch" in its recent report), and how these effect its advice on its pathways to 2030.

Dr Andrew Boswell,
Climate Emergency Policy and Planning, November 28th, 2024

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[75] https://www.legislation.gov.uk/ukpga/2022/23/schedule/2

Written evidence submitted by Climate Emergency Policy and Planning (CEPP) (CCUS0018)

Appendix A: Sources for Capacity and Generation of gas-CCS: 2030, 2035, 2050

	2030 gas-CCS Capacity (GW)	2030 DLCG Generation (TWh)	2030 gas-CCS Generation (TWh)	2030 Total Demand (TWh)	2035 gas-CCS Capacity (GW)	2035 DLCG Generation (TWh)	2035 gas-CCS Generation (TWh)	2035 Total Demand (TWh)	2050 gas-CCS Capacity (GW)	2050 DLCG Generation (TWh)	2050 gas-CCS Generation (TWh)	2050 Total Load (TWh)
CCC 6th Carbon budget report (Balanced Pathway)				360[76]				460[77]				610[78]
CCC 6th Carbon budget report (Balanced Pathway)		46[79]	??			65[80]	30[81]			70[82]		
CCC 6th Carbon budget report (Lowest of all Pathways)						42[83]				63[84]		
CCC 6th Carbon budget report (Highest of all Pathways)						65[85]				100[86]		
CCC 6th Carbon budget report (Max)/year for Balanced Pathway										79[87] / 2045		
NESO Clean Power 2030 report (New Dispatch pathway)		11.24[88]										
CBDP/PUBTA 2023	3[89]				9				18			
NIC (2020)									18[90]		23[91]	

DLCG = Dispatchable 'Low Carbon' Generation

[76] Climate Change Committee, The Sixth Carbon budget ("CCC-6CB-report"), 2020, page 134
[77] CCC-6CB-report, page 134
[78] CCC-6CB-report, page 134
[79] CCC-6CB-report, page 138, Figure 3.4.c (and by reference to CCC supplied spreadsheet)
[80] CCC-6CB-report, page 141, Figure 3.4.e (and by reference to CCC supplied spreadsheet)
[81] CCC-6CB-report, page 135
[82] CCC-6CB-report, page 141, Figure 3.4.e (and by reference to CCC supplied spreadsheet)
[83] CCC-6CB-report, page 141, Figure 3.4.e (and by reference to CCC supplied spreadsheet)
[84] CCC-6CB-report, page 141, Figure 3.4.e (and by reference to CCC supplied spreadsheet)
[85] CCC-6CB-report, page 141, Figure 3.4.e (and by reference to CCC supplied spreadsheet)
[86] CCC-6CB-report, page 141, Figure 3.4.e (and by reference to CCC supplied spreadsheet)
[87] CCC-6CB-report, page 138, Figure 3.4.c (and by reference to CCC supplied spreadsheet)
[88] NESO report, page 24, Figure 6 (and Tab CP.06 of NESO supplied spreadsheet)
[89] Powering Up Britain Technical Annex (PUBTA), 30 March 2023, page 24, Table 2
[90] National Infrastructure Commission, 2020, "Net Zero Opportunities for the Power Sector", page 18
[91] National Infrastructure Commission, 2020, "Net Zero Opportunities for the Power Sector", page 18

Appendix B: Calculations of emissions from gas-CCS plants

117 I base these calculations on the Track-1 Net Zero Teesside gas-CCS plant. This is because the overall background starting place for calculations are available from the planning examination, subsequent documents and the planning Decision Letter in which the DESNZ SoS has already agreed with CEPP's starting calculations[92].

118 tCO2e is tonnes of Carbon Dioxide equivalents.

119 CEPP use the following starting numbers and assumptions:

(a) Annual Operating Hours at baseload: 8,424 (96% of possible total 8,760)

(b) Plant will operate at 8,434 hours/yrs for years 1-4 including 2030 (for stability injection of CO2 storage[93], as already described)

(c) At 90% capture rate and baseload at 96%, 25-year full lifecycle emissions are:

(i) 5,929,380 tCO2e – 10% uncaptured CO2[94]

(ii) 53,364,420 tCO2e – 90% captured CO2[95]

(iii) 3,592,523 tCO2e – CO2 venting[96]

(iv) 10,101,668 tCO2e – upstream emissions[97]

(v) 751,136 tCO2e of miscellaneous operation emissions (Electricity usage, Waste disposal, Workers commuting, Materials and Materials transport)[98]

120 CEPP takes all these figures forward except the 90% capture rate. The risk that these projects are unable to deliver on claimed capture rates must be considered high, and greenhouse gas assessment should be made of more precautionary capture rates in line with performance of existing commercial sites. Therefore, CEPP uses an 80% capture rate below (which is still at the maximum capture rate achieved globally) ie:

(i) 11,858,760 tCO2e – 20% uncaptured CO2
(ii) 47,435,040 tCO2e – 80% captured CO2

[92] 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

[93] Net Zero Teesside, Planning Application, "Chapter 4: The Proposed Development (ES Volume I - Document Ref. 6.2).]", section 4.4.4 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010103/EN010103-000896-NZT%20DCO%206.2.4%20ES%20Vol%20I%20Chapter%204%20Proposed%20Development.pdf

[94] Net Zero Teesside Planning Examination, Document 9.29, Table 3-1

[95] Net Zero Teesside Planning Examination, Document 9.29, Table 3-3.

[96] Net Zero Teesside Planning Examination, Document 9.29, Table 3-3.

[97] Net Zero Teesside Planning Examination, Document 9.29, Table 3-1

[98] Net Zero Teesside Planning Examination, Document 9.29, Table 3-1

121 Following these assumptions, the first step is to transform these emissions to carbon emissions intensities for each produced (per KWh):

	Combustion	Misc	CO2 venting	Upstream	TOTAL	CO2 Captured	CO2 Stored
Emissions tCO2	11,858,760	751,136	3,592,523	10,101,668	26,304,087	47,435,040	43,842,517
Emission intensity gCO2/KWh	82.40	5.22	24.96	**70.19**	182.77	329.60	304.64

I have also included emissions intensities for "CO2 captured", and the "CO2 stored" (which is "CO2 captured" minus "CO2 venting") which provides a convenient way to calculate CO2 Stored per TWh later.

122 However, the above is based on the DESNZ emission factor which I have explained is a severe underestimate for the upstream emissions. Therefore, I now do "real world" adjustment to the emission intensity for the upstream emission based on these assumptions:

(a) CEPP has already made the point that all the extra demand for new gas-CCS projects will have to be satisfied by LNG imports. Therefore, CEPP applies an uplift for 100% LNG[99].

(b) The UK can be expected to import this LNG from a variety of source countries with different standards, and standards within the country. The Carbon Tracker report reaches these three scenarios based on considerable research into the upstream emissions of natural gas[100], based on recent data and scientific research shown below:

TABLE 1: NATURAL GAS UPSTREAM EMISSIONS BASED ON SUPPLY SCENARIO

Source	Upstream emissions (gCO2/MJ natural gas)	Notes
Pipeline Gas	2.3	Average of Norwegian and domestic gas
UK Average 2022	6.8	Average emission of UK's gas consumption in 2022
Average LNG (excl. USA)	17.5	Average of Qatar, Peru, Nigeria, Algeria
USA LNG Mid	22.4	Average of USA estimates
USA LNG High	31.3	LNG from the Permian Basin

Note: these values exclude grid transmission losses and venting which we estimate at 1.5 gCO2e/MJ, see Appendix for sources Table 5-7.

(a) I use the Carbon Tracker "USA LNG Mid" as the UK will import from countries such as Qatar as well USA LNG High location such as the US Permian Basin. I consider this to be a conservative assumption –

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[99] 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.** This also applies for understanding the impact of the CCUS programme on carbon budgets as explored later in this document.

[100] See Section 2 of the Carbon Tracker "Kind of Blue" report in Appendix B, "Upstream Emissions of Natural Gas". 2 pages (Pages 13-14, PDF Pages 16-17). This section provides vital information on the underestimation of emission factors for upstream emissions by UK bodies such as North Sea Transition Authority (NTSA) and provides references (footnotes 21-26) which formed the basis of a review of emissions factors by Carbon Tracker.

should the UK import proportionately more LNG from the high emitting LNG extraction fields such as the Permian Basin, then the climate impacts will be higher. I consider this to be a fair assumption for this illustrative modelling.

(b) Carbon Tracker highlight that, in addition to upstream supply emissions, there are 1.5 gCO2/MJ of upstream emissions for UK transmission losses and venting[101]. These emissions are included in the DESNZ emission factor of 8.4 gCO2/MJ (ie 0.423 kgCO2e/kg) as used by the applicant[102].

(c) This means that the data may be scaled to the "US LNG Mid" scenario, as follows:

Emission Factor			
	gCO2/MJ	+ 1.5 gCO2/MJ for UK Transmission/Venting	Relative to application FACTOR
Application	8.40	8.40 (included)	1.00
USA LNG Mid	22.40	23.90	**2.85**

(d) At 100% "US LNG Mid", the emission intensity of the Upstream emissions is then 70.19 * 2.85 = 200.04. However, this is based on the atmospheric impacts of methane being modelled over 100 years, not the 20 years in which they actually have a radiative forcing effect.

	Combustion	**Misc**	**CO2 venting**	**Upstream**	**TOTAL**	**CO2 Captured**	**CO2 Stored**
Emissions tCO2	11,858,760	751,136	3,592,523	28,741,651	44,944,070	47,435,040	43,842,517
Emission intensity gCO2/KWh	82.40	5.22	24.96	**200.04**	312.63	329.60	304.64

(e) The next step is to adjust for methane being correctly modelled for its concentrated radiative forcing effect over 20 years. The upstream emissions contain emissions from both CO2 and CH4, and the uplift for the CH4 emissions must only be applied to the CH4 fraction. So I also make an adjustment which takes into account CO2 in the upstream emissions (which is not subject to the GWP100 / GWP20 issue which pertains here to methane) – the method for this is described in a separate Appendix (Appendix C 'Calculation of the "uplift factor" for the sensitivity tests on GWP20 instead of GWP100') and is based upon the data in the recent paper by Professor Howarth. The uplift factor used here for these illustrative calculations is 1.86 and generates this result.

	Combustion	**Misc**	**CO2 venting**	**Upstream**	**TOTAL**	**CO2 Captured**	**CO2 Stored**
Emissions tCO2	11,858,760	751,136	3,592,523	53,459,470	69,661,889	47,435,040	43,842,517
Emission intensity gCO2/KWh	82.40	5.22	24.96	**376.08**	488.66	329.60	304.64

[101] See Carbon Tracker "Kind of Blue" (Appendix B), Table 7, Page 29 (PDF Page 32)

[102] See DESNZ, "2023 Government Greenhouse Gas Conversion Factors for Company Reporting, Methodology Paper for Conversion Factors Final Report", 2.17 d) "*For parts of the natural gas supply chain which occur in the UK (transmission and distribution and dispensing of CNG), data from DUKES (BEIS, 2022) is used to update the emissions for these activities estimated in Exergia.*"
https://assets.publishing.service.gov.uk/media/647f50dd103ca60013039a8a/2023-ghg-cf-methodology-paper.pdf

123 Now the emissions associated with each 1TWh of gas-CCS operation may be apportioned each carbon budget sector.

(a) Miscellaneous emissions go into several sectors[103], but are small enough that I do not calculate them further at this stage.

(b) "Combustion" and "CO2 venting" are accounted for under the Power sector at this intensity (82.40 + 24.96)/1000 = 0.107 MtCO2e/TWh

(c) I have already described how 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.

I now introduce another assumption for this illustrative calculation which is that 90% of natural gas supply emissions in my example of the "US LNG Mid" scenario are ex-UK territorial, and 10% are within the UK.

This then gives 0.038 MtCO2e/TWh of the upstream emissions falling in the carbon budget Fuel Supply sector (10%) and 0.338 MtCO2e/TWh of the upstream emissions falling into ex-UK international shipping and other country inventories.

(d) The CO2 stored in this scenario is 0.305 MtCO2e/TWh

	Power sector	Fuel Supply sector	International	TOTAL	CO2 Captured	CO2 Stored
Emissions MtCO2e/TWh	0.107	0.038	0.338	0.483	0.330	0.305

[103] The NZT promoter places these emissions in the Industry, Domestic Transport and Waste and F-gases sectors, See Table 1 of "Response to the Secretary of States Request for further information dated 16 May 2023 - 6.6 - Appendix 6 Contexualisation against CBDP and Draft Revised NPS response", https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010103/EN010103-002814-NZT%20DCO%206.6%20-%20Appendix%206%20Contexualisation%20against%20CBDP%20and%20Draft%20Revised%20NPS%20response.pdf

APPENDIX C: CALCULATION OF THE "UPLIFT FACTOR" FOR THE SENSITIVITY TESTS ON GWP20 INSTEAD OF GWP100

124 Table 3 of Professor Howarth's recent paper[104] gives a full lifecycle GHGs for LNG as *"4 different scenarios for shipping by tanker, using world-average voyage times (38 day round-trip). Methane emissions are shown both as mass of methane and mass of CO2 equivalents based on GW[P]20. Values are per final mass of LNG consumed."*

125 In the table below, and as a starting place, I have extracted the top-level numbers for each LNG tanker scenario.

Howarth Table 3	GWP20	g CO2e/kg			
	TOTAL CO2	Upstream CO2	CH4 (GWP20)	TOTAL (GWP20)	Upstream TOTAL (GWP20)
Steam-turbine tankers powered by LNG	4,202	1,452	3,566	7,768	5,018
4-stroke engine tankers powered by LNG	4,101	1,351	3,927	8,028	5,278
2-stroke engine tankers powered by LNG	4,046	1,296	3,661	7,707	4,957
Diesel-powered tankers	4,114	1,364	3,256	7,370	4,620

Table 1: Howarth paper: world average shipping times : GWP20

126 I then apply a GWP20 -> GWP100 conversion (= 0.36 = 29.8/82.5) to the methane emission column to generate the equivalent table as GWP100.

Howarth Table 3	GWP100	g CO2e/kg				
	TOTAL CO2	Upstream CO2	CH4 (GWP100)	TOTAL (GWP100)	Upstream TOTAL (GWP100)	GWP20/ GWP100
Steam-turbine tankers powered by LNG	4,202	1,452	1,288	5,490	2,740	1.83
4-stroke engine tankers powered by LNG	4,101	1,351	1,418	5,519	2,769	1.91
2-stroke engine tankers powered by LNG	4,046	1,296	1,322	5,368	2,618	1.89
Diesel-powered tankers	4,114	1,364	1,176	5,290	2,540	1.82
					AVERAGE	1.86

Table 2: Howarth paper: world average shipping times : GWP100 (converted to GWP100 and extraction of uplift factor)

127 The right-hand column above divides the GWP20 "Upstream TOTAL" data from the first table with the GWP100 "Upstream TOTAL" data from the second table. The uplift factor (1.86) is then taken as the average of the values derived for the four shipping methods.

[104] 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

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.

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
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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

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 CO2e/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% CO2 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 gCO2e/kWh. …"

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

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