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Examination Principle Issues	**Climate Change**

POST EXAMINATION CONSULTATION – 8th SEPT 2023

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1 INTRODUCTION

1 I am responding to your letter of 30 August seeking comments from the Applicant and all Interested Parties.

2 I support the letter submitted by Emma Nicholson in response to your letter of 11 August.

3 I usually restrict my submissions to technocratic matters relating to policy and law. However, due to the very disturbing events this year relating to planetary level climate disruption, I feel that I have a responsibility as someone with an active interest in these events and the scientific response to it, to provide a short Prelude section next, and put these matters on record before the SoS.

4 I also provide an update on the legal and policy context since the examination closed.

1.1 Important note of relevance to decision making

5 Considerable information on the legal and policy context published since the examination is provided. It would be an error to characterise this information as being general and not relevant to the SoS decision making process. The information is provided to directly address and inform the SoS decision making process. The purpose of providing the information on the CBDP and other documents was that it is vital information relating to whether there can be confidence that the A66 project is consistent with the CBDP, and therefore, the UK climate targets and budgets, and international obligations.

6 At the time of his/her decision, the SoS should consider the latest evidence on the revised NZS (known as the Carbon Budget Delivery Plan – CBDP), the status of any on-going legal challenge to it, and my submissions here (by which I respectfully mean that this submission should be made available to the SoS to consider personally).

7 The wider context here is that reasoned consideration of the GHGs from the A66 project and how they comply with the risk-assessed delivery of the CBDP (and the NDC and sixth carbon budget) is very much a live issue for the SoS in her/his decision-making, under section 104 of the 2008 Planning Act. The SoS must reach conclusions as to whether approving the scheme would lead to the UK being in breach of its international obligations (s104(4)); in breach of any statutory duty (s104(5)); or be unlawful (s104(6)). The latest evidence is required to be able to make a reasoned conclusion on these matters, and the material which I am submitting is provided with the express intention to assist the SoS in reaching those conclusions.

1.2 Availability of material to Secretary of State

8 As this submission contains statements relating to how the SoS may reach a reasoned conclusion on the environmental impacts of the A66 project. **I respectfully request that this**

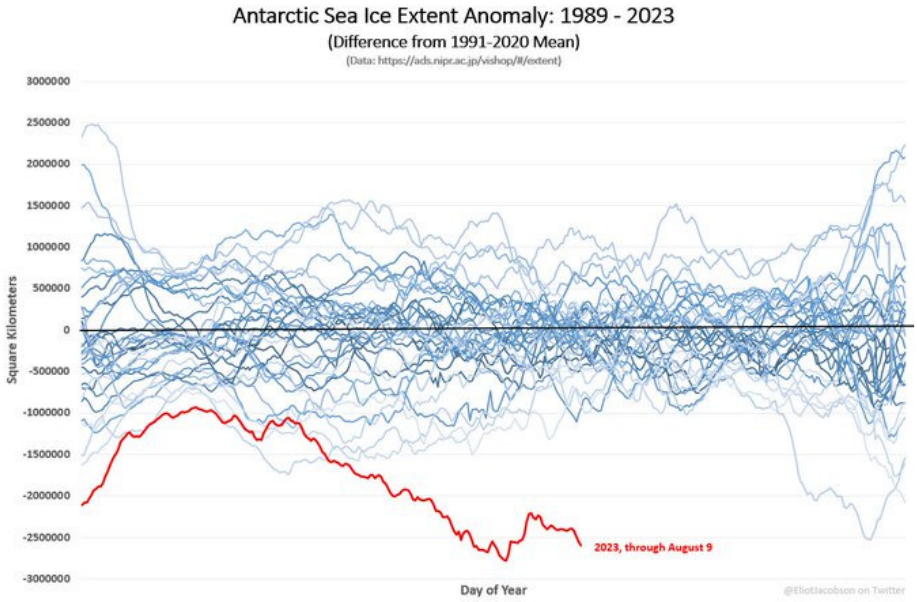
submission is placed in full before the Secretary of State, and/or a delegated decision minister, her/himself to consider.

2 PRELUDE

9 This year has seen the Climate Emergency unfold before the world's eyes in real time. This has been shocking to many scientists involved in the field with a common response being this is happening "much faster than we expected". There is currently a wide discussion on whether the planet is currently undergoing some tipping point (or combination of tipping points).

10 The effects of climate change are usually seen by the public in terms of increasing extreme weather events. Examples abound such as the record-breaking temperatures in the UK last year, and temperature records being widely broken around the globe this year. We have seen widespread flooding events, and of course, we have all witnessed the distressing and devastating wildfires in Hawaii, Rhodes, and Canada. All attributable to man-made climate change. However, shocking as these events are, they are superficial in comparison with some of the more unprecedented deeper geophysical signals being seen. I just highlight a couple of these very briefly below.

11 This year has seen, from the satellite record, a massive loss of sea ice reforming in this year's Antarctic winter. The signal (or "canary in the mine") of this is shown on the graph below[1]:

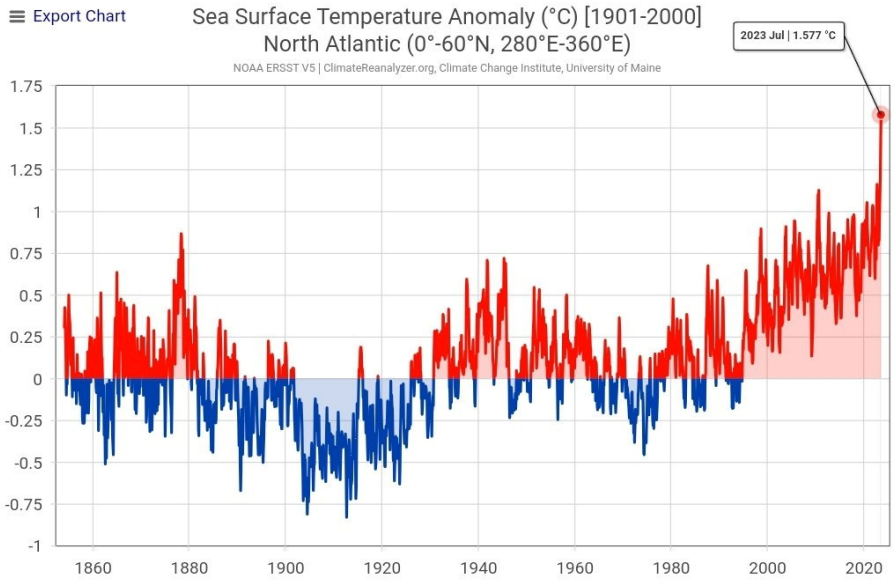


[1] Source: https://twitter.com/EliotJacobson/status/1689651022862643200?s=20

Figure 1: Antarctic Sea Ice Extent Anomaly

12 The graph shows the anomaly – the extent of sea ice loss compared to the recent average (1991-2020). In real terms, this is sea ice which would be expected to reform in a typical Antarctic winter is simply not reforming this year over a massive scale of area. Scientists are currently grappling to understand the causes for this large deviation this year which is statistically extremely unlikely (please see the British Antarctic Survey commentary at Appendix B). The loss amounts to an area around 10 times the size of Britain, and the impact could be to weaken land ice and glaciers on the Antarctica continental shelf itself. If this is the signal of a tipping point starting in which the sea ice around Antarctica ice is permanently lost at this scale, then this in turn would lead to land-based ice moving into and melting in the sea giving rise to very large sea level rises, and impacts to low lying cities around the world. Whilst this has always been a possible impact of climate change over centuries, the key takeaway concerning this year's data above is that scientists are shocked to see this happening now and it had not been predicted by modelling to occur at this stage of global heating.

13 This year has also seen sea temperatures rise unusually high, globally, and also in the North Atlantic, as shown on the next graph[2]. This has contributed to some of the marine heatwaves (for example off Ireland and the UK earlier in the year) which have caused serious impacts to marine life. Again, the sharp increase for the 2023 data point is what is shocking and concerning.



[2] Source: https://twitter.com/LeonSimons8/status/1688188964027486208?s=20

Figure 2: North Atlantic Sea Surface Temperature Anomaly

14 There are many other examples, and there is a very energised debate on-going in climate science circles about these geophysical scale climate events. Please see the Nature science journal commentary at Appendix A.

15 In terms of the examination, all parties should be in no doubt that that the Climate Emergency is here, and **it is crucial that the UK does not make decisions which make the build-up of atmospheric carbon dioxide worse**.

16 As the judgement in the first Net Zero Strategy legal challenge[3] says:

> *"Given the nature of the problems posed by climate change, the need for substantial changes across the country and the challenges involved, telling Parliament how the Secretary of State proposes to meet the carbon budgets does indeed require him to explain the thinking behind his proposals and how they will enable the carbon budgets to be met."*

17 The same principle of explaining the thinking behind his/her decision of the A66 and how it will enable the carbon budgets to be met applies to this DCO decision.

3 RECENT UPDATES: POLICY AND LEGAL FRAMEWORK

18 This section is provided as vital information which the SoS should consider when making a reasoned conclusion relating to s104(4), s104(5) and s104(6) of the 2008 Planning Act. It is not provided as a generalised commentary, or as a challenge to Government policy. It addresses the risk to delivery of climate policy under the CBDP which is vital contextual information for the SoS reaching a reasoned conclusion.

3.1 The Scale and Logistical Impact of Net-Zero

19 Before discussing the Carbon Budget Delivery Plan (CBDP) in detail, I wish to submit as a prologue, evidence on the scale of the logistical impact of the legislative and policy changes between the pre-net-zero world and the net-zero world, following the Climate Change Act 2008 (2050 Target Amendment) Order 2019[4]. This is to provide high-level context which the SoS should consider when making a reasoned conclusion relating to s104(4), s104(5) and s104(6) of the 2008 Planning Act.

[3] Para 233, R (Friends of the Earth) v Secretary of State for Business Energy and Industrial Strategy [2022] EWHC 1841 (Admin)

[4] The Climate Change Act 2008 (2050 Target Amendment) Order 2019, Statutory instrument at https://www.legislation.gov.uk/ukdsi/2019/9780111187654

20 The "Net Zero" statutory instrument has one simple statement of substance at clause 2:

> *2.—(1) Section 1 of the Climate Change Act 2008 is amended as follows.*
>
> *(2) In subsection (1), for "80%" substitute "100%".*

21 The ramifications of the last four words 'for "80%" substitute "100%"' words have not yet been fully grasped and understood by many, including ministers making decisions on infrastructure.

22 As background, the original end target for 2008 Act was for an 80% reduction of greenhouse gas ("**GHG**") emissions[5] by 2050 from 1990 baseline and was based on outdated science. The new end target is for 100% reduction by 2050: this makes a small step toward congruence with the science[6].

23 I use "Emissions space" ("**EmSp**") to mean that the available carbon emissions which may be legitimately emitted each year under the Climate Change Act 2008 (the "2008 Act") and the 100% target.

24 I provide the chart below for illustration and to explain three key effects of the legislative change in terms of how the numbers add up, or critically how they may not add up. The chart does **not** purport to be precisely accurate in terms of trajectories[7], but is provided to illustrate the principles discussed.

[5] The 2008 Act and 2019 "2050 Target Amendment" cover a number of GHGs. However, for this examination, carbon dioxide (CO_2e), or "carbon" is the only gas of interest.

[6] Please see my later point, which I place on record, that the legislative targets, based on CCC, are not science-based. Science-based budgets are more rigorous and demanding, and are needed to comply with Paris Agreement

[7] The graph is based on approximate numbers from Figure 1 of the CCC 6th Carbon Budget Report "The Sixth Carbon Budget, The UK's path to Net Zero", December 2020, [redacted] This includes emissions from international aviation and shipping (IAS) and shows 2020 levels at approximately 500MtCO2e (and approx. 56% of 1990 levels).

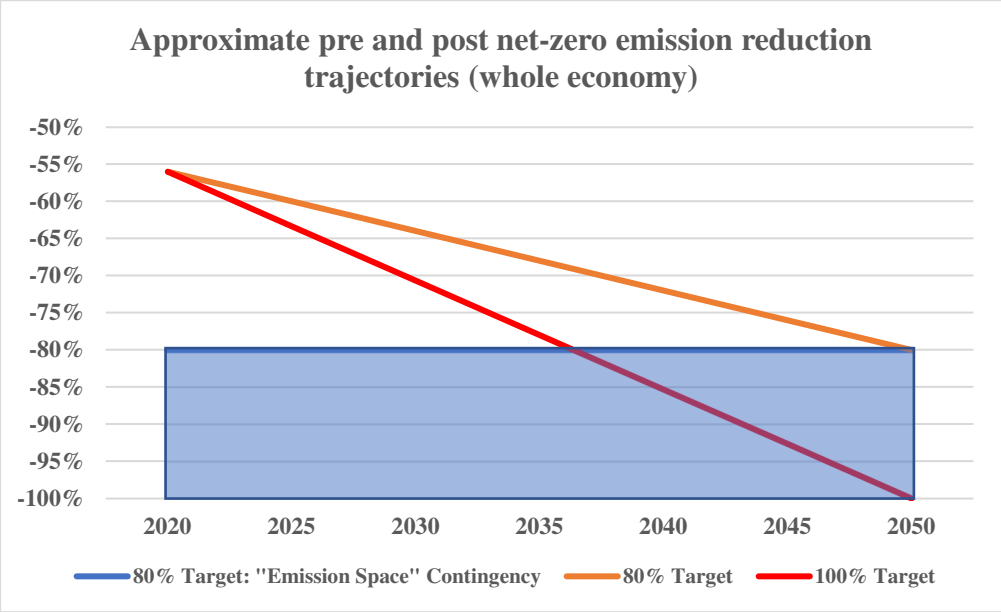


Figure 3: Approximate pre and post net-zero emission reduction trajectories (whole economy)

25 The keys effects of the legislative change can be seen in the graph as follows:

(A) *The UK economy EmSp rapidly contracts each year until 2050* at an average year-on-year rate of c.16.6 million tonnes of CO2e[8] from 2020 under the 100% target. Based on 2020 level, the rate of decarbonisation is approximately 3-4% a year. All existing economic activity must be contained within this rapid contraction of the EmSp. Each sector of the economy must contract emissions, via sectoral decarbonisation. New activity, eg additional emissions from new power infrastructure, competes for emissions sustaining existing activity either within its own sector(s), or from other sectors.

(B) *The legislated emissions contraction rate via 5-year carbon budgets is extraordinary.* The contraction rate (3-4% a year from 2020) for the 100% target (red line) is an approximate doubling of the contraction rate for the 80% target (orange line). The Government's objective is to decarbonise the electricity supply sector by 2035: in 2022, the sector generated 48 MtCO2e, 11% of UK emissions (CCC analysis[9])

[8] Approximately equivalent carbon footprint to 16,000,000 return flights from London to New York

[9] Page 199/200, "Progress in reducing Emissions - 2023 Report to Parliament", Climate Change Committee (CCC), June 2023, https://www.theccc.org.uk/wp-content/uploads/2023/06/Progress-in-reducing-UK-emissions-2023-Report-to-Parliament.pdf

(C) *The removal of any on-going background EmSp from 2020*. This is most critical effect and the one not usually discussed. It is very relevant to the question of whether there is enough EmSp for the A66 to be developed.

A 20% background level of emissions were legally permitted under 2008 Act until 2050 equating to around c.180 million tonnes of CO2e a year, as indicated by the blue block on the figure. This allowed considerable policy and delivery flexibility **that is simply and starkly no longer available**: for example, additional emissions from new fossil fuel based electricity generation could possibly have been contained within the 80% at 2050 target if other sectors had rapidly decarbonised, but this is no longer clearly possible.

26 In short, the approximate doubling of the rate of emissions contraction from 2020, ***and*** removing the legally permitted contingency of c.180 million tonnes CO2e a year in the economy, introduces immense delivery risks to:

- (A) the NDC international obligation for 2030, and
- (B) carbon budgets going forward, especially the 6CB and following budgets after 2033, and
- (C) the net-zero 2050 target (itself dependent on robust delivery of (A) and (B) first).

27 This logistical impact of the recent legislation requires a paradigm shift in policy and planning for the whole economy, which we simply are not seeing yet. Where plans exist like the CBDP, they are under (permissioned) legal challenge for the proposals and policies within them, and critically for not being adequately risk assessed.

28 Please note that speculative technology like negative emissions has been built into Government policy to attempt to deal with the loss of the background contingency EmSp. However, negative emissions technologies (NETs) are widely criticised, and are not expected to deliver[10]. The delivery risks involved exert further pressure on the very limited EmSp.

29 Further, I place on record that the legislative targets[11], based on CCC, are not science-based. Science-based budgets are more rigorous and demanding and are needed to comply with Paris

[10] This is again a complex subject which may be expanded, if required. For the moment, and in short, greenhouse gas removals (GGR) and negative emissions technologies may provide extremely costly, speculative, and unproven at scale methods which proxy for an "overdraft facility" on carbon emissions. Even if these work, they would be like paying back a loan at a huge interest rate. See Kevin Anderson , John F. Broderick & Isak Stoddard (2020): A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris-compliant pathways, Climate Policy, DOI: 10.1080/14693062.2020.1728209, Appendix D "*However, there is wide recognition that the efficacy and global rollout of such technologies are highly speculative, with a non-trivial risk of failing to deliver at, or even approaching, the scales typically assumed in the models. … Whilst the authors of this paper are supportive of funding further research, development and, potentially, deployment of NETs, the assumption that they will significantly extend the carbon budgets is a serious moral hazard (Anderson & Peters, 2016).*"

[11] under the Climate Change Act 2008

Agreement[12]. The point is that even meeting the CCC targets is actually not enough to have any chance of keeping global average temperature to well under 2ºC (the 1.5ºC Paris Agreement target is now almost certainly breached[13], and see Appendix E).

3.2 The Revised Net Zero Strategy

30 The Government laid the original Net Zero Strategy (NZS) before Parliament on 19 October 2021 as a report under section 14 of the Climate Change Act (CCA) 2008. The strategy was intended to fulfil the duty, at section 13 of CCA 2008, to "prepare such proposals and policies" that will enable the carbon budgets under the CCA 2008 to be met, now extended by the 2019 amendment to the 2008 Act. That is proposals and policies that would secure delivery of the UK climate targets including the legislated carbon budgets.

31 The NZS was subsequently found to be unlawful in July 2022 ("**first NZS legal case**"), and the Government were ordered to lay before Parliament a fresh report under section 14 before the end of March 2023.

32 On March 31st 2023, the Government subsequently published a revised Net Zero Strategy (NZS) with the overarching title "Powering Up Britain" (PUB), and the Carbon Budget Delivery Plan (CBDP) within it, as well as many other related documents comprising nearly 3000 pages in total.

33 On July 7th 2023, Friends of the Earth, ClientEarth and Good Law Project, the same claimants as in the first NZS legal case, announced that they are taking the Government to court for the second time in under two years ("**the second NZS legal case**") because of "*the Government's failure to include a proper assessment of the delivery risks associated with the policies and proposals in the Carbon Budget Delivery Plan*"[14].

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[12] A key issue is the "area under the curve" in the emissions trajectories. The near flat line trajectories in Figure 1 of the CCC 6th Carbon Budget Report "The Sixth Carbon Budget, The UK's path to Net Zero", December 2020, [redacted] are inadequate and are based on policy targets like "Net Zero 2050". Science-based carbon budgets such as those from the Tyndall Centre (research that the UK Department of Business, Energy and Industrial Strategy supported) demonstrate that the area under their curve of their emissions trajectories is consistent with the global carbon budgets from the Intergovernmental Panel on Climate Change (IPCC) where the CCC do not. The Tyndall budgets are consistent with IPCC global carbon budgets of 1.7ºC degrees of global heating. This is not 1.5oC because, essentially, there are not enough degrees of freedom in the system to produce budgets consistent with 1.5ºC, the lowest end of the Paris target. See more in Tyndall's "Factor of Two" research paper, Kevin Anderson, John F. Broderick & Isak Stoddard (2020) A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris-compliant pathways, Climate Policy, 20:10, 1290-1304, DOI: 10.1080/14693062.2020.1728209.

[13] "*Many climate experts believe that outcome is inevitable. Global temperatures will climb higher than 1.5 degrees compared with 150 years ago, they say, though often only in private.*", from article Scientific American, Chelsea Harvey, "The World Will Likely Miss 1.5 Degrees C—Why Isn't Anyone Saying So?", [redacted]

[14] Good Law Project press release, July 2023, "The Government is still failing on net zero, so we are taking them back to court", [redacted]

34 On September 1st 2023, these claimants announced that they have been given permission to go to a full Judicial Review hearing in the High Court[15].

3.3 Delivery risk and policy gap in securing delivery of net zero, and the undisclosed Risk Tables

35 In relation to securing the NZS, I highlight here what the Court said in the first NZS legal case judgment[16] on delivery risk and policy gap. Holgate J. recorded the NZS's acknowledgement that the delivery pathways to achieve the 6th Carbon Budget are highly ambitious and face considerable delivery challenges and recorded that achievement was subject to a wide uncertainty range. The judge noted at paragraphs 204 and 211 that in approving the Net Zero Strategy, "*one obviously material consideration which the Secretary of State must take into account is risk to the delivery of individual proposals and policies and to the achievement of the carbon budgets and the 2050 net zero target.*" In finding the NZS unlawful, the judge described risk to delivery as the critical issue when concluding that the information provided to the Minister when reporting on the NZS was insufficient to enable him to discharge his reporting obligations under section 14 of the Climate Change Act 2008.

36 Critically at paragraph 249 the judge says:

> *"… the ability to meet the statutory targets depends upon the contributions made by a multiplicity of proposals and policies adopted by the Secretary of State. This is obviously material to the risk of delivery. It is critical to any assessment by Parliament, and by the public, of how the statutory targets are likely to be met, by what means and with what implications."*

37 With the new PUB and CBDP, a number of issues arise which are likely[17] to be taken before the Court, these include:

(A) Delivery risks have not been assessed in the CBDP for each policy and proposal as they should have been;

(B) The CBDP (at paragraph 26) is based on the assumption that all quantified policies and proposals will be delivered in full;

(C) The Statements of Facts and Grounds (SFG)[18] from one of the claimants in the second NZS case describes that '*in pre-action correspondence, the Secretary of State for Energy*

[15] 'Not fit for purpose': Green groups secure High Court hearing over government's net zero plans, Business Green, Sept 1st 2023, [redacted]

[16] R (Friends of the Earth) v Secretary of State for Business Energy and Industrial Strategy [2022] EWHC 1841 (Admin)

[17] Based on Good Law Project press release, July 2023, "The Government is still failing on net zero, so we are taking them back to court", and the Pre-Action Protocol (PAP) letter embedded within it at [redacted]

[18] See [redacted] and link within to SFG at [redacted]

*Security and Net Zero ("SSESNZ") has revealed that he was, in fact, provided with analysis that set out in tables information about the delivery risk associated with each policy or proposal contained in the CBDP ("**the Risk Tables**")*'. These have not been published by SSESNZ to date.

38 The points are important in consideration of the A66 project and any subsequent decision on it. The recent practice of ministers has been to approve projects (for example, recent roads DCO projects) based on the assumption that all quantified policies and proposals under the NZS will be delivered in full. That is, there has been an assumption in recent DCO decisions that the delivery of NZS is fully secured when quite plainly it is not. As far as the SoS decision making process for the A66 project, she/he must reach a reasoned conclusion based on the known risks to delivery of the NZS and CBDP, based on the Risk Tables held by the Government.

39 It is acknowledged that the (Climate Change Act 2008) section 14 CBDP Risk Tables have not been disclosed by the Government (itself considered unlawful by a claimant in the second NZS legal case, now going to full High Court hearing) so may not be available to the applicant. The issue remains that the SoS must consider risk to policy delivery, with the assistance of her/his own Risk Tables for Industry and surface Transport, in order to reach a reasoned conclusion about the GHG emissions from the A66 project.

3.4 Climate Change Committee (CCC) 2023 Progress Report

40 On 28th June 2023, the Climate Change Committee (CCC) submitted its "Progress in reducing Emissions - 2023 Report to Parliament" [19] (referred to as CCC_2023_PROG) under Section 36 (1) of the Climate Change Act 2008. The report contained a clear analysis of the surface transport sector, and many recommendations for it. Some key points are now summarised.

41 The risk assessment from the CCC in its 2023 Progress Report (see later) was available to the Applicant well before recent SoS consultations but the Applicant has not updated its application and GHG assessment in response to the CCC report. This is despite the advice of the CCC being considered as having material weight by the judge in the first NZS legal judgement. (And I submit in this document the CCC advice has material weight for the SoS in reaching her/his reasoned conclusion).

[19] "Progress in reducing Emissions - 2023 Report to Parliament", Climate Change Committee (CCC), June 2023;

3.5 Recommendation for a systematic review of current and future road-building projects

42 CCC_2023_PROG includes a recommendation that the Government should review its road-building proposals. Recommendation R2023-148 asked Government to:

> *Conduct a systematic review of current and future road-building projects to assess their consistency with the Government's environmental goals. This should ensure that decisions do not lock in unsustainable levels of traffic growth and develop conditions (which can be included in the Roads Investment Strategy 3 process and beyond) that permit schemes to be taken forward only if they meaningfully support cost-effective delivery of Net Zero and climate adaptation.*

43 The CCC's recommendation includes "*current*" road-building projects, which includes the A66.

44 It also recommends that "*decisions do not lock in unsustainable levels of traffic growth*". The A66 application quite clearly does this as its forecasts both trip growth and longer trips.

3.6 Shortfalls on delivery of carbon budgets and targets (overview)

45 CCC_2023_PROG notes that, in the CBDP, there is a shortfall on the emissions reductions[20] required to meet the UK 6th carbon budget (6CB) and UK's Nationally Determined Contribution (NDC) for 2030, our international obligations under the Paris agreement.

46 CCC_2023_PROG, then reports on page 93 that, out of all the sectors in the whole economy, the surface transport sector is primarily responsible for the shortfall:

> *"The smaller emissions reduction embodied in the quantified policies and plans compared to the NZS[21] comes predominantly from surface transport (Figure 3.13)."*

47 Figure 3.13, reproduced over the page, compares the residual emissions (the emissions which are calculated to be left remaining after decarbonisation policies and proposals) for each sector for an average year in the 6CB (ie: the mid-year 2035). The red arrow shows that the residual emissions for surface transport were 29.4 MtCO2e in the NZS (published 2021) has now been recomputed as 44.2 MtCO2e in the CBDP (ie 50% higher).

48 Only the surface transport sector in the CBDP has a serious shortfall compared to the NZS. The shortfall is 14.8 MtCO2e/yr in the 6CB as highlighted on the figure below, and clearly shows surface transport as being by far the largest adjustment.

[20] CCC _2023_PROG/page 93

[21] NZS here is the original NZS. The comparison is the CDBP with the NZS.

49 In terms of the simple diagram presented at Figure 3 above, and the extremely tight and inflexible emissions space, what is happening is that the surface transport sector already, at its existing levels, cannot fit into the EmSp for Net Zero. The result is that the country is projected not to meet its legislated near-term (2030 and 2035) carbon targets on the basis of the CBDP analysis. Whilst, the Government do say in the CBDP that they intend to make up the shortfall[22], it is not clear whether the gap will be, or can be, fully closed, nor how the proposals for closing the gap will be risk assessed (as they don't exist yet).

[22] For example, on the 2030 NDC, CBDP para 29 says:

> *"We have quantified emissions savings to deliver 88 Mt or 92% of the NDC. We are confident the delivery of emissions savings by unquantified policies detailed in this package will largely close this gap and the government will bring forward further measures to ensure that the UK will meet its international commitments if required."*

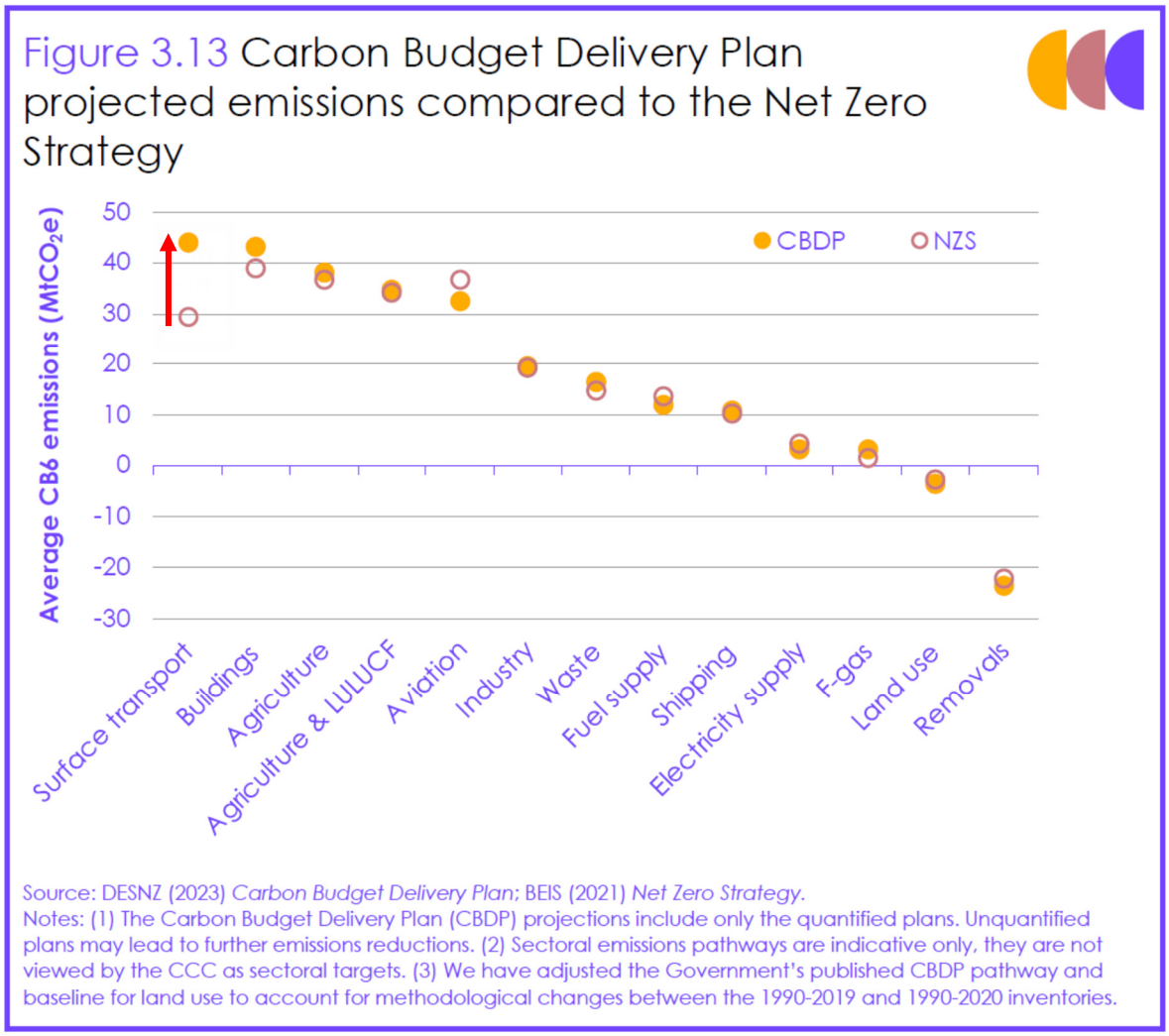


Figure 4: CCC Progress Report 2023, Fig 3.13 reproduced

50 CCC_2023_PROG then explains the causes for the shortfall in emissions reduction in surface transport on page 108 as being from two primary causes:

> *"The CBDP acknowledged new evidence showing that the carbon savings from plug-in hybrid (PHEV) cars are around three to five times lower in the real world than previously assumed. This means that the carbon savings accrued from the adoption of PHEVs are substantially smaller – by around 9 MtCO2e/year – than in the Net Zero Strategy analysis."*
>
> *"Most policies that aim to support and incentivise the public to choose lower-carbon modes of transport have been removed from the quantified pathway – over 5*

MtCO2e/year of abatement that had been attributed to modal shift from cars to more sustainable modes of transport is no longer quantified. While these policies are still referenced in the Government's plan, making a choice not to quantify them signals a lack of commitment to modal shift. A pathway that is almost exclusively technology-dependent is likely to be less cost-effective, entails higher delivery risk (see Chapter 3)and risks missing out on opportunities to realise co-benefits to society."

51 It is important to note, the context of delivery risk being key, that the CCC highlight that by choosing a technology-dependent pathway in the CBDP that the Government have opted for a plan with higher delivery risk.

52 Further, it should be noted that the CBDP (and PUB TA) itself describes that the baseline for surface transport has been altered due to underestimates of projected traffic growth in the National Transport model[23]. This baseline shift appears not to be covered in the CCC analysis, but indicates further erosion of the emissions space due to surface transport, and also another area which requires risk assessment for the future (as described later).

53 I now look at the impact of near-term climate targets (ie 2030 NDC; and 6th carbon budget (average year 2035)), highlighting the surface transport and industry sectors being relevant to the A66 scheme.

3.7 Operations/Surface Transport - Impact on UK international obligation(s) (2030 NDC)

54 Figure 4b on page 24 of CCC_2023_PROG, reproduced below, shows that the surface transport and industry sectors have the largest emission reductions[24] for the 2030 NDC.

55 Surface Transport is required to reduce from a baseline of 116.7 MtCO2e/yr to 75.3 MtCO2e/yr (the "CBDP pathway") in 2030. The CCC assess credible plans only existing for 40% of this (16.6 MtCO2e/yr – green on the Figure).

3.8 Construction/Industry - Impact on UK international obligation(s) (2030 NDC)

56 Industry is required to reduce from a baseline of 59.3 MtCO2e/yr to 35.4 MtCO2e/yr (the "CBDP pathway") in 2030. The CCC assess credible plans only existing for 4.6% of this (1.1 MtCO2e/yr – green on the Figure). The Industry sector is important in assessing the significance of the construction emissions from the A66 which fall in the Industry sector. As far as s104(4) is concerned, the scheme adds over 500,000 tonnes CO2 from construction before 2029, and this creates a strong risk that the UK will fail to deliver its 2030 NDC, when (1) the NDC already has an 8% shortfall, and (2) 60% of the required emission reductions in industry by 2030 are not secured according to the CCC.

[23] PUBTA, PDF page12, para 22

[24] The figures quoted are derived from the supplementary "Progress in reducing emissions - 2023 Report to Parliament - Charts and data" at

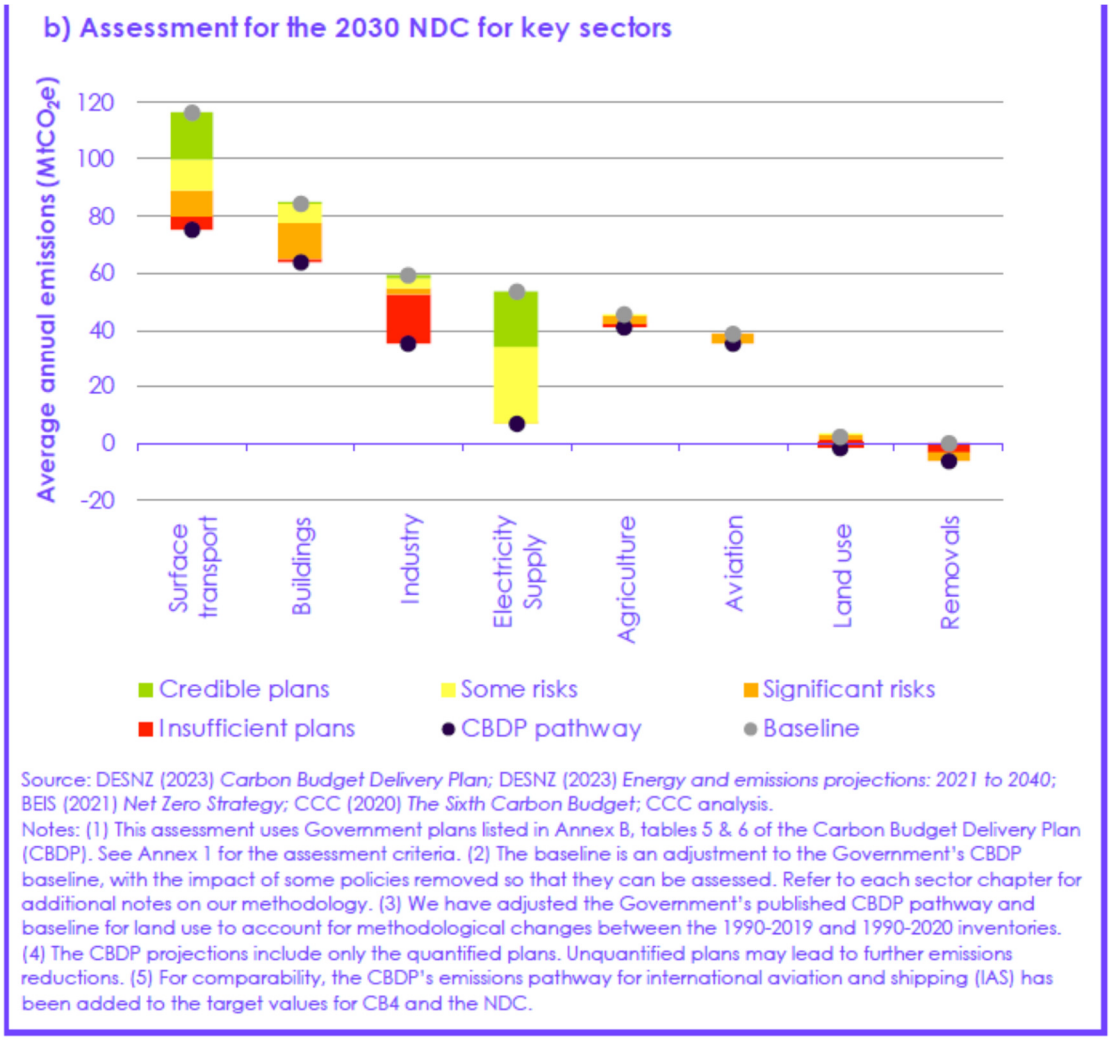


Figure 5:CCC Progress Report 2023, Fig 4b reproduced

3.9 Operations/Surface Transport - Impact on 6th carbon budget

57 Figure 4.10 on page 122 of CCC_2023_PROG, reproduced below, shows the assessment of policies and plans for surface transport across the 4th, 5th and 6th carbon budgets.

58 For the 6CB, surface transport is required to reduce[25] from a baseline of 118.8 MtCO2e to 44.2 MtCO2e. The CCC assess credible plans only existing for 38.8% of this (28.7

[25] The figures quoted are derived from the supplementary "Progress in reducing emissions - 2023 Report to Parliament - Charts and data" at

MtCO2e/yr – green on the Figure). A remaining 45.73 MtCO2e of surface transport emissions reductions require to be fully secured in the 6CB.

59 For the 5CB, surface transport is required to reduce[26] from a baseline of 116.8 MtCO2e to 75.3 MtCO2e. The CCC assess credible plans only existing for 39.9% of this (16.6 MtCO2e/yr – green on the Figure). A remaining 24.52 MtCO2e of surface transport emissions reductions require to be fully secured in the 5CB.

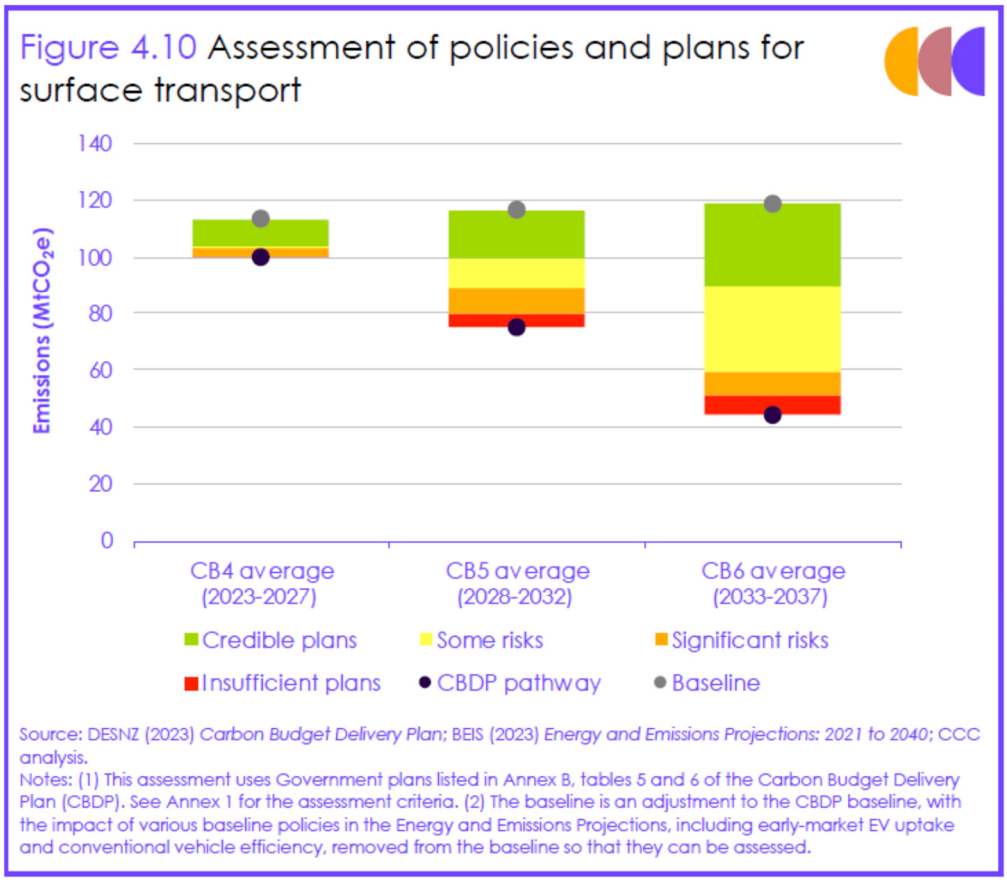


Figure 6: CCC Progress Report 2023, Fig 4.10 reproduced

60 The report finds that overall "credible plans" exist for less than 39% of the required emissions reduction in surface transport to meet the Sixth Carbon Budget. This means that **61% of the required emissions reductions in surface transport for the 6th carbon budget are not**

[26] The figures quoted are derived from the supplementary "Progress in reducing emissions - 2023 Report to Parliament - Charts and data" at

fully <u>secured</u> "on paper" yet. This reveals the true extent of the "delivery gap" in transport decarbonisation policy from the Government's own advisors on climate change delivery.

61 As far as s104(5) and s104(5) are concerned, the scheme adds over substantive new releases of CO2 to the atmosphere from operation after opening, and <u>this creates a strong risk that the UK will fail to deliver the sixth carbon budget</u>, when (1) the sixth carbon budget already has a 3% shortfall[27], and (2) 61% of the required emission reductions in transport for the 6CB are not secured according to the CCC.

3.10 Construction/Industry - Impact on 4th, 5th and 6th carbon budget

62 The construction of the A66 scheme comes under the Industry sector.

63 Figure 6.5, reproduced below, on page 189 of CCC_2023_PROG, reproduced below, shows the assessment of policies and plans for Industry across the 4th, 5th and 6th carbon budgets.

64 The serious risks to delivering the 5CB Industry sector must be considered. The scheme adds over 500,000 tonnes CO2 from construction before 2029, and this creates <u>a strong risk that the UK will fail to deliver its 5th carbon budget</u>, when 22,973,854 tCO2 (see Table 1 below) of the required <u>annual</u> emission reductions in industry for the 5th carbon budget are not secured (the red, orange and yellow bands in Figure 7 below) according to the CCC.

[27] CBDP, PDF Page 15, paras 30-35: "*97% of the savings required to meet Carbon Budget 6"* have been identified (ie 3% short)

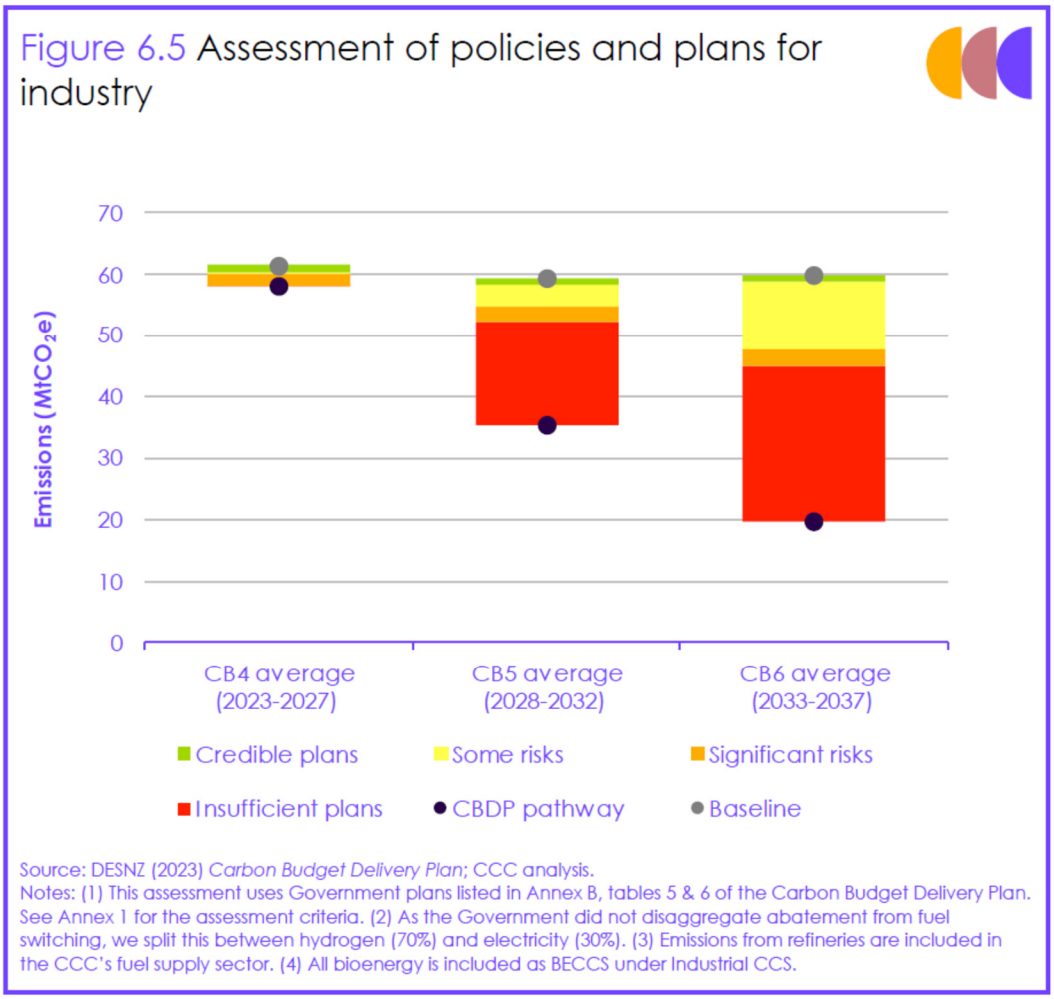


Figure 7: CCC Progress Report 2023, Fig 6.5 reproduced

3.11 Relevant benchmarks summary

65 As a result of the discussion above, Table 1 below provides a summary of benchmarks derived for the 4CB, 5CB and 6CB, these are:

- The 5-year national carbon budgets (code B_1);
- The 5-year Domestic Transport Residual Emissions (code B_2)
- Annual and 5-year valued for Credible Plans and To Be Secured (sum of all non-credible plans) for Surface Transport[28] according to the CCC analysis (codes B_3 – B_6)
- The 5-year Industry Residual Emissions (code B_7)
- Annual and 5-year valued for Credible Plans and To Be Secured (sum of all non-credible plans) for Industry[29] according to the CCC analysis (codes B_8 – B_11)

66 The narrative above shows how the data relates to the figures in the CCC Report for Surface Transport. I have not repeated the narrative for Industry, although the same principles apply, and I just show the figures below.

Code	tCO2e	Fourth (2023 to 2027)	Fifth (2028 to 2032)	Sixth (2033 to 2037)
B_1	National Budget - 5 years	1,950,000,000	1,725,000,000	965,000,000
B_2	Domestic Transport Residual Emissions (DTRE, CBDP, Table 2) - 5 years	546,000,000	422,000,000	254,000,000
B_3	Surface Transport (Credible plans - CCC) - Annual average	9,164,654	16,600,000	28,700,000
B_4	Surface Transport (To Be Secured - CCC) - Annual average	3,955,384	24,520,000	45,730,000
B_5	Surface Transport (Credible plans - CCC) - 5 years	45,823,269	83,000,000	143,500,000
B_6	Surface Transport (To Be Secured - CCC) - 5 years	19,776,919	122,600,000	228,650,000
B_7	Industry Residual Emissions (IRE, CBDP, Table 2) - 5 years	340,000,000	207,000,000	111,000,000
B_8	Industry (Credible plans - CCC) - Annual average	1,243,741	1,100,000	1,100,000
B_9	Industry (To Be Secured - CCC) - Annual average	2,301,741	22,973,854	39,148,353
B_10	Industry (Credible plans - CCC) - 5 years	6,218,707	5,500,000	5,500,000
B_11	Industry (To Be Secured - CCC) - 5 years	11,508,707	114,869,270	195,741,764

Table 1: Summary of relevant benchmarks

67 These benchmark figures can be used as part of a contextualisation process fir the A66 GHG emissions against the residual emissions in the CBDP surface transport and industry sectors. This would provide a way to follow the IEMA guidance to contextualise the GHG emissions of a project against sectoral reduction strategies as discussed in the IEMA section. Further, each of the residual emission figures for sectors above is based on assumed 100% delivery of

[28] From data for Figure 4.10 "Progress in reducing emissions - 2023 Report to Parliament - Charts and data" at [redacted]

[29] From data for Figure 6.5 "Progress in reducing emissions - 2023 Report to Parliament - Charts and data" at [redacted]

all proposals and policies within the CBDP for that sector. Figures above are given for the CCC risk assessment. The SoS must consider both the CCC risk assessment and the Government's own CBDP Risk Tables in reaching a reasoned conclusion concerning the impacts of the GHGs released to the atmosphere from the A66 scheme. The applicant has not provided such a contextualised assessment. The SoS must consider both the CBDP shortfall, and the risk to the CBDP itself in reaching a reasoned conclusion on the A66 GHG emissions.

3.12 Transport Select Committee "Strategic Road Investment" report

68 The Transport Select Committee published a report on "Strategic Road Investment" on 27 July 2023, and referred to here as TSC_SRI. I provide the report as Appendix C.

69 Under the TSC report section "Managing traffic demand on the Strategic Road Network", bullet 19 says:

> ***"Transport remains the biggest greenhouse gas contributor in the UK and the Government's strategy for decarbonising transport by 2050 is reliant on a rapid switch to zero emissions vehicles. However, in all future scenarios modelled by the Department for Transport, traffic on the Strategic Road Network is forecast to increase, and there is a great risk that uptake of cleaner vehicles will not be fast enough to mitigate that increase. The Government's determination to accommodate demand for new roads through investment without also considering steps to manage that demand is a risky strategy."*** {bold emphasis in original}

70 To expand, this relates to, and supports, my WR where I submit that there is <u>no evidence</u> that delivery of the CBDP – a critical and statutory climate policy required by the Climate Change Act 2008 - <u>is secured</u> [REP1-323]. This also supports the Climate Change Committee 2023 Progress Report finding that "a pathway that is almost exclusively technology-dependent is likely to be less cost-effective, <u>entails higher delivery risk</u>" [see quote under REP1-323/ bullet 39]. "Technology-dependent" refers primarily to the electrification of vehicles.

71 It is significant that this high-level body of MPs highlighted that accommodating demand for new roads in the context of increasing forecasts of traffic on the SRN as <u>a risky strategy</u>. The A66 is one of the projects generating the demand. This is an issue which the SoS must consider in the decision making in addition to those submitted at REP1-323 / section 11.1 where I conclude, on my WR evidence, that there is <u>not</u> sufficient emissions space in the 4CB and 5CB (Industry) residual emissions allocation for the project to be constructed, and there is not sufficient emissions space in the 5CB and 6CB (Surface Transport) residual emissions allocations for the project to be operated.

72 The MPs then go further at bullet 21 from the TSC SRI:

> ***"The Government should model and report on scenarios where traffic levels on the SRN are a) reduced and b) maintained at current levels, alongside the***

> ***transition to a cleaner vehicle fleet, in order to assess the potential contribution of demand management to reaching net zero."*** {bold, italic emphasis in original}

73 This links to REP1-323 / section 6.5 and supports the very point which I am making there that the CBDP identifies the risk that traffic demand may go beyond the Government's high-end projections, and critically that there has been no risk assessment of this. The A66 application quite clearly forecasts significant growth rates of traffic from the scheme [APP-518, Table 6.3] and longer trips which would contribute to an increase in the (sector emissions trajectory) baseline. At REP1-323 / section 6.5, I ask "*how does that fit in the overall risk assessment of not delivering on the new baseline and policies in the revised NZS?*".

74 Following the TSC report, I go further and submit that given the risks identified to net zero delivery, and the MP's call for modelling of scenarios with no or reduced traffic growth *"to assess the potential contribution of demand management to reaching net zero",* that there can be no justification to approve a scheme which forecasts significant traffic growth before such modelling has been undertaken and reported. The issue of increased traffic from the scheme, and its impact on delivery of net-zero must be given strong weight in the planning balance. Further the SoS must have all the relevant data, and that includes the additional traffic forecasts and understanding of demand management for reaching net zero.

75 At minimum, the decision on the A66 scheme should wait until the additional modelling recommended by the MPs has been carried out, and the effects of demand management on the delivery of the UK's carbon budgets and net-zero is better understood.

4 IEMA

76 The applicant purports to follow the IEMA guidance ("**IEMA**"). The SoS has also purported to use and follow the IEMA guidance, and make IEMA significance assessments, in other recent DCO decisions.

4.1 IEMA Contextualisation: sectoral reduction strategies

77 IEMA places weight on "Contextualising a project's carbon footprint" – a substantive sub-section (section 6.4) is given in the IEMA chapter on Significance on this.

78 On IEMA page 26, it is stated:

> *"The starting point for context is therefore the percentage contribution to the national or devolved administration carbon budget as advised by the CCC. However, the contribution of most individual projects to national-level budgets will be small and so this context will have limited value."*

79 IEMA goes on at Table 1 on page 28 to provide "*Sources of contextual information against which projects can be evaluated*".

80 One context in the table is "Sectoral budgets or reduction strategies". I acknowledge CBDP 19 referring to projected residual emissions, "*These are only projections and should not be interpreted as hard sectoral policy targets.*".

81 However, IEMA is advising strongly that contextualisation should be done with sectoral reduction strategies, and this is exactly what the residual emissions (and the proposals and policies to meet them) are in the CBDP. They are not hard targets, but they do provide a sectoral reduction strategy which provides a fertile and valuable source of contextualisation. The applicant has not done this.

82 The SoS must reach a reasoned conclusion on the GHG emissions from the A66, and the additional emissions which they add to the atmosphere, and to the Industry and Surface Transport sectors of the CBDP. To do this, it is necessary to consider the construction and operation emissions, respectively, in the context of the sectoral reduction strategies (ie IEMA contextualisation) in the Industry and Surface Transport sectors of the CBDP. The outcomes of these sectors are given by the sectoral residual emissions data and provides quantitative data for the first part of the contextualisation. However, a second vital part of the contextualisation must involve explicitly evaluating the A66 schemes with the risks to those sectors as assessed by the CCC in its progress report and by the CBDP Risk Tables held by the Government.

4.2 IEMA Contextualisation: Existing and emerging national and local policy or regulation

83 IEMA goes on at Table 1 on page 28 to provide another context "*Existing and emerging national and local policy or regulation*" and states an advantage of such contextualisation is that "*Policy should be compatible with the UK's national GHG commitments and actions to achieve those*".

84 The CBDP provides policy which the SoS has presented to parliament as "compatible with the UK's national GHG commitments and actions to achieve those", notwithstanding the identified shortfalls for the NDC and sixth carbon budget also presented to parliament in the CBDP, and the current legal case against the CBDP. And, the CCC Progress report provides the latest detailed analysis of progress, or lack of it, towards those sectoral reduction strategies. The judge in the first NZS legal case fully endorses, and legally approves, the critical expert role of the CCC by stating that their advice must be given "considerable weight".

85 Further, the risk to delivery of the CBDP was so great that in July 2023 campaigners took the strategy to Court for a second time (the second NZS legal case), particular on the issue the risk to policy delivery not being satisfactorily assessed in the CBDP, and this case now has

permission for a full High Court hearing. It has emerged in the pre-action protocol correspondence that the Government have produced Risk Tables for the proposals and policies in the CBDP but failed to publish them under section 14 of the Climate Change Act[30].

86 The point again, is that this is not general background material, but is vital information which the SoS must consider in reaching a reasoned conclusion on the A66 project. In this case, it is not just a matter of considering if there is sufficient emissions space to meet the residual emissions for the Industry and domestic Transport sectors as they are published in the CBDP. The SoS must first take into account the risk to delivering the residual emissions, which may be determined from her/his own CBDP Risk Tables, and the even more restricted emissions space that it imposes for any project coming forward. Second, the SoS must consider if the risk-assessed residual emissions provide, or do not provide, emissions space to construct and operate the A66.

4.3 IEMA summary

87 The applicant has adopted the IEMA guidance for significance assessment. Currently, it is not possible to reach a reasoned conclusion on the significance assessment because the applicant has not provided the contextualisation of genuinely considering if the large, additional GHG emissions can fit within the CBDP sectoral residual emissions, when it is properly risk assessed. Whilst the sectoral residual emissions are not considered a hard target, if the GHG emissions do not fit, then other sectors must make up the shortfall and there must also be a reasoned conclusion of why this could possibly be acceptable in the wider context of delivering the whole CBDP.

88 In short, where large additional emissions are proposed for a project, the Secretary of State must address both the current failures to deliver on sectoral reduction strategies as identified in the CCC Progress report, the shortfalls in delivering existing national policy identified in the CBDP (ie the shortfalls for the NDC and the 6CB), and the risk to proposals and policies in the CBDP (her/his own Risk Tables), in making her/his significance assessment. These each form vital contextualisation for the large carbon footprint from the A66 project each year.

5 COMMENTS ON CLIMATE CHANGE DECISION MAKING FOR THE A66

5.1 Considerations that must be before the Secretary of State

[30] See https://glplive.org/NZ2-SFG

89 I summarised issues for the SoS decision making at section 4.2 of my final submission [REP9-056], and respectfully requested that the SoS must considers them in his/her decision making.

90 I request that the SoS also considers these additional factors in reaching a reasoned conclusion on the A66 project:

A. The risks identified in the CCC Progress report to delivery of the CBDP. Noting, that whilst this is a planning decision, significant material weight should be given to the CCC and their 2023 Progress Report by the SoS in reaching a reasoned conclusion with respect to section 104 of the 2008 Planning Act. It would be wrong, and challengeable, for the SoS to dismiss the CCC's advice in its report as less than significant material weight.

B. Using the Government's CBDP Risk Tables, and showing the reasoning, of whether the A66 scheme can be compatible with the UK 2030 NDC and the sixth carbon budget.

C. Fully following the IEMA guidance, including contextualisation of the A66 GHGs with sectoral reduction strategies, and existing and emerging national and local policy or regulation.

6 PARTICULATE MATTER

91 Recent legislation has introduced new targets for PM2.5 particulate matter for 2040 with interim targets for 2028.

92 According to 2021 analysis from the European Environment Agency (EEA)[31], in 2019 fine particulate matter (PM2.5) was responsible for more than 33,000 deaths annually in the UK, and nitrogen dioxide (NO2) for 5,750. Half of the UK's deaths from PM2.5 could have been avoided if the UK had followed the latest recommendations by the World Health Organization (WHO). A 2021 scientific study in Nature[32] confirmed fossil fuel combustion as a major source of PM2.5 health related issues. The study found that globally, 1.05 million deaths would have been avoidable in 2017 by eliminating fossil-fuel combustion.

[31] "*Thousands of needless air pollution deaths as UK government ignores health experts – ClientEarth reaction*", ClientEarth media release 15th November 2021, [redacted]

[32] "*Source sector and fuel contributions to ambient PM2.5 and attributable mortality across multiple spatial scales*", McDuffie et al, Nature, June 2021 [redacted]

93 The impact of PM2.5s from the construction and operation of the A66 must not be ignored: the PM2.5 effects must be estimated, and the impacts assessed against current UK legislation.

94 The SoS must grapple with the implications of the new legislation for the A66 project. However, the application and environmental statement have not been suitably updated against the new legislation and targets.

6.1 Recent legislative changes

95 Sections 1 and 2 of the Environment Act 2021 ("**the 2021 Act**") require the Secretary of State for Environment, Food and Rural Affairs to set environmental targets for air quality, while section 8 requires an Environmental Improvement Plan ("**EIP**") to be prepared.

96 In January 2023, 2040 targets were set via the Environmental Targets (Fine Particulate Matter) (England) Regulations 2023 ("**the 2023 Regulations**") and, separately, interim targets for 2028 via the EIP ("**the 2028 interim targets**"), which replaced the 25-year environment plan [of 2018].

97 The 2023 Regulations were made on 30 January 2023 and came into effect on 31 January 2023, and introduced an annual mean concentration target for PM2.5 of 10µg/m³ and a Population Exposure Reduction Target ("**PERT**") to reduce population exposure to PM2.5 by 35% by the end of 2040 compared to 2018 levels.

98 The 2028 interim targets introduced:

A. an Annual Mean Concentration Target ("**AMCT**") which is that the highest annual mean concentration in the most recent full calendar year must not exceed 12 µg/m3 of PM2.5; and

B. an interim legal PERT target to reduce population exposure to PM2.5 by 22% by the end of January 2028

6.2 Issues with the application and environmental statement

99 APP-048 provides Chapter 5 of the Environmental Statement "Air Quality".

100 APP-048 Table 5-4 gives Air Quality Objectives "relevant to the assessment of local air quality impacts". Old information is given and has not been updated for the new legislation.

101 Under APP-048 section 5.10 "Assessment of likely significant effects", no estimation or assessment is given for the PM2.5 effects from construction or operation of the A66 project.

102 The human health impacts of PM2.5 are very serious as evidenced by the EEA (quote above) and many other studies.

103 Under APP-090 5.10.71/72 "Human health effects" are assessed for the operational phase on the basis of the out-of-date targets and objectives for PM2.5. The conclusion at APP-090 5.10.78 that "*The assessment of effects from the construction phase are assessed as being temporary and not significant*" is therefore unevidenced.

104 Under APP-090 5.10.80 "Human health effects" are assessed for the operational phase on the basis of the out-of-date targets and objectives for PM2.5. The conclusion at APP-090 5.10.81 of "*no likely significant adverse effects are anticipated in relation to human health*" is therefore unevidenced.

6.3 Issues for the Secretary of State

105 The new legislation and targets were enacted during the DCO examination period and the SoS cannot brush aside the new targets. Under section104 of the 2008 Planning Act, she/he must decide the application in accordance with any relevant national policy statement, except to the extent that she/he is satisfied that deciding the application in accordance with any national policy statement would lead to her/him to being in breach of any duty imposed by or under an enactment (section 104(5)). That includes the new legally binding targets, and interim targets, for PM2.5.

106 As outlined above, the Applicant's Air Quality assessment does not address the new targets, nor consider the relevant potential health impacts from the construction or operation of the A66.

107 The Secretary of State must now require that the applicant updates the Environmental Statement against the new legislation, via further consultation processes.

7 SIGNED

Dr Andrew Boswell,
Climate Emergency Policy and Planning, September 8th, 2023

8 APPENDIX A: "Earth's hottest month: these charts show what happened in July and what comes next", Nature commentary, 18th August 2023

<supplied in a separate file>

9 APPENDIX B: British Antarctica Survey, August 3rd 2023, "The mystery of the missing Antarctic Sea ice"

<supplied in a separate file>

10 APPENDIX C: TSC REPORT: Strategic Road Investment" (Published 27 July 2023)

HC 904, Published on 27 July 2023 by authority of the House of Commons

<supplied in a separate file>

11 APPENDIX D: Factor of Two paper (2023)

Kevin Anderson, John F. Broderick & Isak Stoddard (2020)
"A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris-compliant pathways" , Climate Policy

<supplied in a separate file>

12 APPENDIX E: "World will miss 1.5C warming limit - top UK expert", BBC, July 2023

<supplied in a separate file>

News in focus

MARIO TAMA/GETTY

Intense heatwaves in the desert in the southwestern United States have been killing off the iconic saguaro cactus.

EARTH'S HOTTEST MONTH: THESE CHARTS SHOW WHAT HAPPENED IN JULY AND WHAT COMES NEXT

The planet has warmed by 1.2 °C on average, but that's enough to produce big extremes.

By Jeff Tollefson

From wilting saguaro cacti in Arizona and hot-tub-like temperatures off the coast of Florida to increased heat-related hospitalizations in Europe and agricultural losses in China, last month felt unusually hot. It was: several teams have now confirmed that July 2023 was the hottest month in recorded history. And there's more to come.

July is typically the hottest month of the year, and this July shattered records going back as far as 1850 by around 0.25 °C. Overall, the average global temperature was 1.54 °C above the preindustrial average for July, according to Berkeley Earth, a non-profit group in California that is one of several organizations tracking global warming. This increase seems small — but what many people actually experienced was a bout of long, often brutal heatwaves.

"We're in a particularly extreme period on top of a long-term warming trend, and the view from the top is a little scary," says Zeke Hausfather, a climate scientist at Berkeley Earth.

Loading the dice

Multiple factors might have played a small part in the record-breaking temperatures, including a budding El Niño warming event in the equatorial Pacific Ocean and a volcanic eruption last year on the island of Tonga that injected water vapour, itself a powerful greenhouse gas, into the stratosphere. New regulations have also curbed the release of sulfur dioxide pollution from ships, which tends to have a cooling effect. But the biggest driver by far, scientists say, is increasing greenhouse-gas concentrations in the atmosphere, which have been steadily raising average global temperatures and have loaded the dice in favour of extreme weather and climate events (see 'Going up').

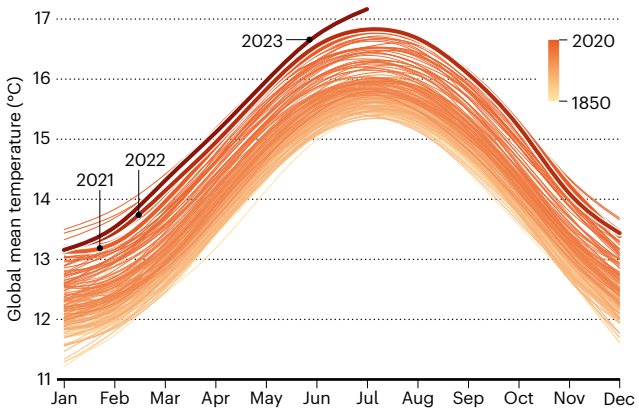
An analysis by scientists at the World Weather Attribution initiative found that, in a world without human influence, the heatwave in China last month would have been expected only once every 250 years. Temperatures in southern Europe and North America, meanwhile, would have been "virtually impossible" in the preindustrial era. But such extremes are becoming the norm: last month's events can now be expected every 5–15 years, and could happen as often as every 2–5 years if global temperatures increase to 2 °C above those of the preindustrial period, which is the upper limit imposed by the 2015 Paris climate agreement.

"It only takes a small change in average temperature for the frequency of extremes to completely blow out, which is what we've seen in the Northern Hemisphere recently," says Sarah Perkins-Kirkpatrick, a climate scientist at the University of New South Wales in Sydney, Australia.

Global average temperature, often measured on a rolling ten-year basis, is a metric that scientists use to track broad trends in a noisy, complex system. Thus far, the world has warmed by 1.14 °C using that metric. But no one actually lives in an average world. And although 90% of the excess heat due to the presence of greenhouse gases has gone into the oceans, the fact is that temperatures over land are both warmer and rising faster than are those of the ocean surface. Many parts of Earth's land surface have already warmed by more than 1.5 °C in at least one season, and temperatures in numerous places last month were as much as 8 °C above the average for July (see 'Hot spots').

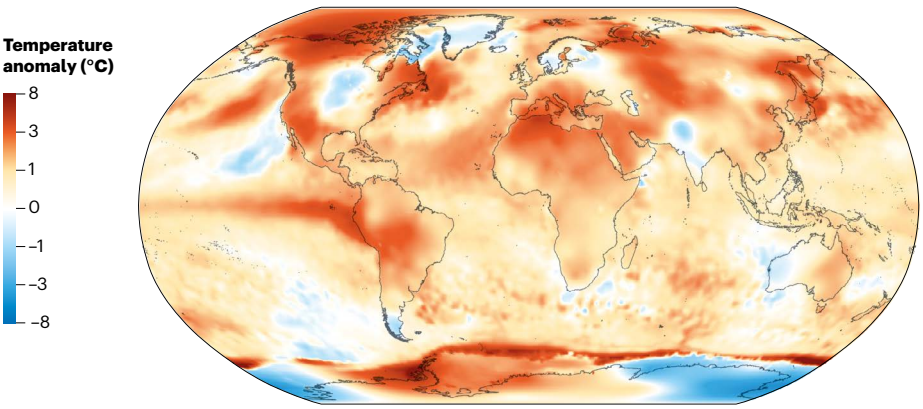
GOING UP

Earth's mean temperature has been rising steadily for more than a century, and this year is already setting records. July 2023 has now been declared the hottest month ever. Berkeley Earth, a non-profit environmental-data organization in California, estimates that last month was more than 1.5 °C warmer than the pre-industrial average of 1850–1900.



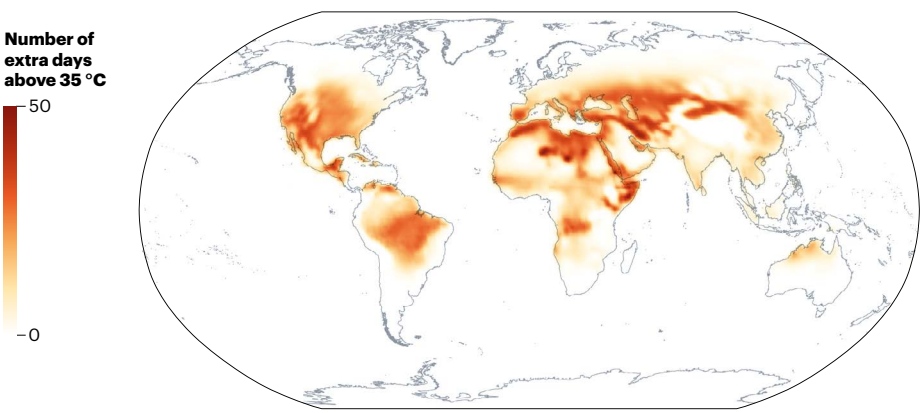
HOT SPOTS

So far, the average global temperature has climbed by about 1.1 °C, but the changes that people actually feel around the globe can be much larger. Some of the biggest increases have been over land in the Northern Hemisphere, and in many places it has been up to 8 °C above the historical average of 1951–1980 during July 2023.



HEATWAVE PROJECTIONS

If global temperatures were to rise by 3 °C, as some models predict could happen by the end of this century, some places on Earth could experience nearly 50 extra days each year above 35 °C, affecting public health and ecosystems globally.



Heatwaves rising

To some extent, this should come as no surprise. The Paris agreement limits of 1.5–2 °C were intended to establish a relatively safe zone that, if maintained, would prevent many of the most severe impacts of a warming world. But a key message from the 2021–22 assessment produced by the Intergovernmental Panel on Climate Change is that every tenth of a degree of warming at the global level comes with additional – and often extreme – impacts at the local and regional level.

A few decades ago, many of the impacts were theoretical, but a growing body of research suggests that the planet is beginning to breach important ecological thresholds, says Jofre Carnicer, an ecologist at the University of Barcelona in Spain. Carnicer says that temperature and precipitation trends are already pushing many parts of Europe into entirely new fire regimes, as evidenced by extreme wildfires in Greece and elsewhere this year (J. Carnicer *et al. Sci. Rep.* **12**, 10365; 2022).

Global temperature trends have tracked fairly well with projections from climate models going back more than two decades, but research into what that means at the local level is just beginning, Carnicer says (see 'Heatwave projections'). "This is really new science," he says, and it suggests that even the low threshold of a 1.5 °C average – which could be breached for the first time in the next several years – might be a significant challenge for the world.

The science makes one thing clear: the warming shows no sign of stopping. This year's El Niño event is just getting started, and many scientists suspect that 2023 could be the hottest year on record. Next year is likely to be even warmer.

"July 2023 is just the latest in a long run of extremely warm months and years," says Sarah Kapnick, chief scientist for the US National Oceanic and Atmospheric Administration. "The long-term increase in global temperature marches on and on and on."

SOURCE: GOING UP/HOT SPOTS: BERKELEY EARTH; HEATWAVE PROJECTIONS: IPCC

The mystery of the missing Antarctic sea ice

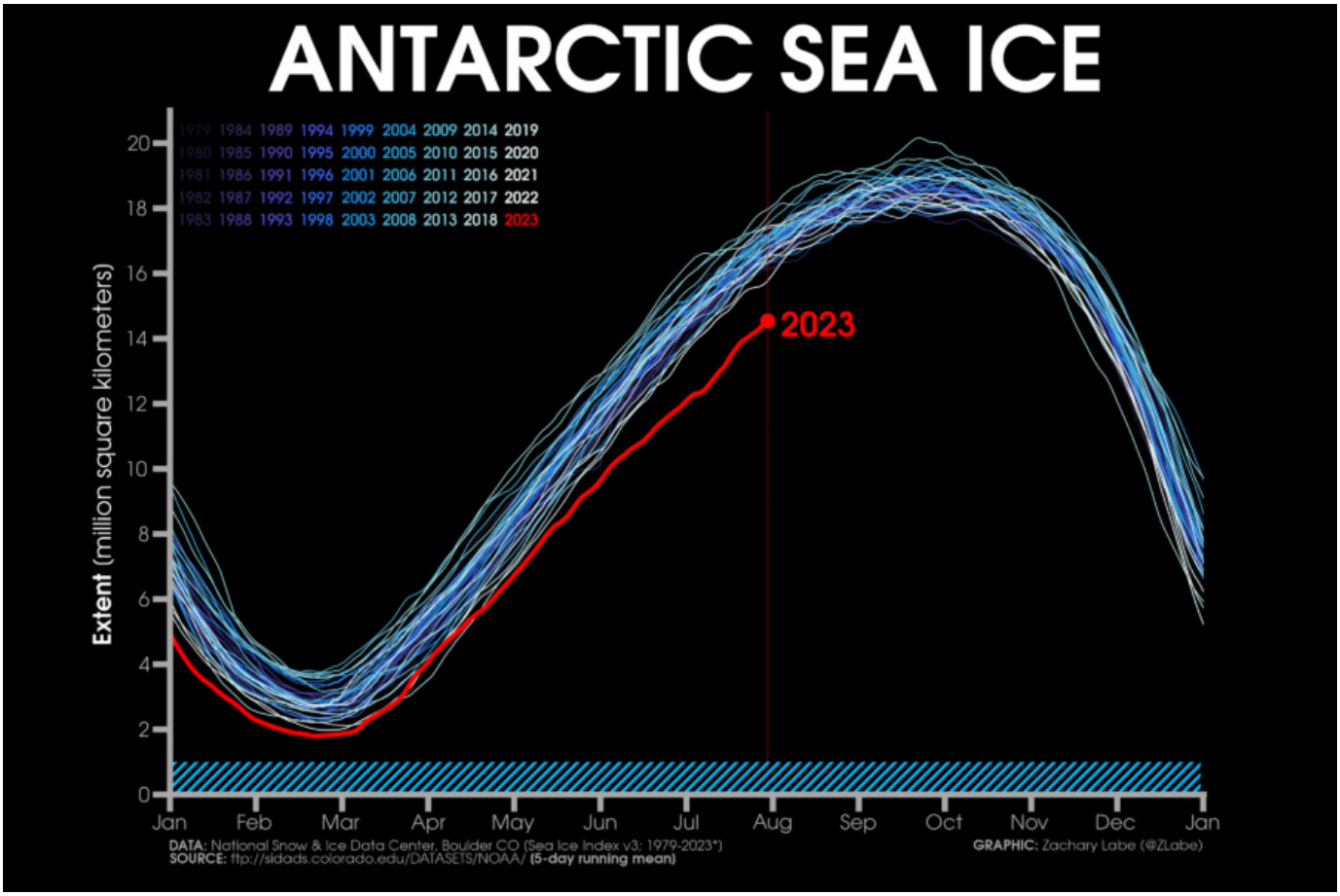
3 August, 2023 In the news

Winter sea ice in the Antarctic is at a historic low, and scientists are working to understand why an area of ice the size of Greenland is missing. Scientists from British Antarctic Survey have been active in the media offering commentary on this extreme event.

Sea ice is frozen ocean water that forms and melts entirely in the ocean, and it has a natural pattern of growth and reduction that has been monitored by satellites for 44 years. This data gives scientists a detailed picture of the area that sea ice covers surrounding the continent of Antarctica, known as the sea ice 'extent'.

Antarctic sea ice has been quite stable in its average extent over that period – until 2016, when it began to decline. Since 2016, there have been seen several record summer lows, with Antarctic summers 2021/22 and 2022/23 setting new sea ice minimas.

At the start of August 2023, the depths of Antarctic winter, deviation from all previous records has intensified. As of August 2023, the sea ice extent is almost 2.4 million km^2 lower than the 1979-2022 average – a missing area around ten times the size of the UK.



Antarctic sea ice extent for each year from 1979 to 2023 (satellite-era; NSIDC, DMSP SSM/I-SSMIS), updated 31/7/2023. Visualisation by Zachary Labe.

> Dr Caroline Holmes, polar climate scientist at BAS and part of the DEFIANT project, which is investigating sea ice around the Weddell Sea in Antarctica, says:
>
> "Right now, in August 2023, the sea ice extent in Antarctica is still far below all previous records for this time of year. In this period where oceans are freezing up, we're seeing areas that are still, remarkably, largely ice-free – such as the northern bounds of the sea ice away from the coast, the coast of the eastern Bellingshausen Sea and west of the peninsula."

What's causing the 2023 sea ice anomaly?

Climate models have always led us believe that Antarctic sea ice would reduce as a result of human-induced warming. However, the current change to sea-ice extent is dramatic, and has led scientists to question what mechanisms can explain it. However, Antarctic sea ice is very complicated to model accurately because it is affected by so many of Earth's natural processes.

> Dr Caroline Holmes continues:
>
> "Wind patterns, storms, ocean currents and air and ocean temperatures all affect how much of the sea around Antarctica is covered by ice, and they often push and pull in different directions. This means it can be hard to link the behaviour of Antarctic sea ice in any particular year, or over several years, to just one factor.
>
> "Before 2015, contrasting trends in sea ice growth in different regions of the vast continent mostly counterbalanced each other. What's remarkable about 2023 is that these regional differences are largely absent."

Natural atmospheric patterns that affect sea ice include the El Niño-Southern Oscillation, the strength of the southern hemisphere jet stream, and regional low-pressure systems. For instance, sea ice in Antarctica reached record lows in the Antarctic summer 2022/23, driven by very anomalous atmospheric circulation, which scientists say could be natural and associated with the triple La Niña of the last few years. Meanwhile, climate change can

drive the extremes of natural events to greater levels with each cycle, making it even harder for scientists to judge how much current extremes are due to human-induced global warming.

BAS polar oceanographer, Andrew Meijers, who is the UK lead on an EU project called OCEAN:ICE, explains:

"Many climate scientists will be viewing the period since 2016 as the real world catching up to the models – that climate change has finally 'burned through' the natural barriers around the sea ice formed by the unique wind and atmospheric circulation, which insulates the continent to a significant extent.

"We don't have a lot of concreted evidence to actually support this view, because the actual mechanism of change is very unclear: some are arguing for atmospheric drivers, some for the ocean. I suspect some sort of coupled response between both, with extra complications added by increased glacial melt into the upper ocean from the Antarctic ice sheet."

Why does sea ice matter?

Icebergs in the Amundsen Sea. Photo: Pierre Dutrieux, British Antarctic Survey

Regardless of the degree to which the current anomaly in Antarctic sea ice is due to human-induced warming, this extreme event demands urgent scientific attention.

Dr Ella Gilbert, climate scientist at British Antarctic Survey, says:

"Antarctic sea ice varies a lot year-to-year, but even by Antarctic standards this is well outside the bounds of normality.

"Given how complex a system it is, we can't say conclusively whether the past 40 years (the period for which we have satellite observations) are an accurate reflection of the "natural" behaviour of Antarctic sea ice. While seven days may be a long time in politics, seven years is a short time when it comes to the climate. It is too early to say conclusively whether the recent dramatic fall in Antarctic sea ice extent is simply a blip in the record or, as now seems more likely, the first sign of a longer-lasting reduction induced by climate change.

"Regardless of the vagaries of Antarctic sea ice behaviour, the polar regions play a vital role in the climate system. And they are changing before our very eyes."

Sea ice plays an important stabilising role in the Antarctic. It covers a vast area of the dark sea with a bright white surface that reflects the sun's energy back into space – known as the Albedo effect – helping reduce temperatures at the poles. Research also suggests that Antarctic sea ice protects glacial ice shelves from ocean swells.

Andrew Meijers, continues:

"As the ocean circulation around Antarctica has a hugely disproportionate impact on global heat and carbon distribution between the ocean and atmosphere, as well as driving sea level rise via ice sheet melt and supplying nutrients to much of the worlds oceans, we should be very concerned and attentive to such massive changes as we are seeing now.

"There is a desperate need for more observations in the region, particularly in winter and under the sea ice and ice shelves, to really understand how the system works and how it is changing."

This article is based on comment from British Antarctic Survey scientists in the media, including:

- **Antarctica is missing a chunk of sea ice bigger than Greenland – what's going on? (theconversation.com)**
- **Is the climate crisis finally catching up with Antarctica? Finding the answer has never been more pressing | Andrew Meijers | The Guardian**
- **The rapid loss of Antarctic sea ice brings grim scenarios into view (economist.com)**
- **World at One – 03/08/2023 – BBC Sounds (from 31.17)**
- **'Something weird is going on': search for answers as Antarctic sea ice stays at historic lows | Antarctica | The Guardian**
- **Antarctica sees one in 7.5 million year event as ice levels plummet (yahoo.com)**
- **Missing ice and bleached coral: the sudden warming of the oceans | Financial Times**

House of Commons

Transport Committee

Strategic road investment

Sixth Report of Session 2022–23

Report, together with formal minutes relating to the report

Ordered by the House of Commons
to be printed 18 July 2023

HC 904
Published on 27 July 2023
by authority of the House of Commons

Transport Committee

The Transport Committee is appointed by the House of Commons to examine the expenditure of the Department for Transport and its associated public bodies.

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The committee is one of the departmental select committees, the powers of which are set out in House of Commons Standing Orders, principally in SO No 152. These are available on the internet via www.parliament.uk.

Publication

Committee reports are published on the Committee's website at www.parliament.uk/transcom and in print by Order of the House.

Committee staff

The current staff of the Committee are Jonathan Arkless (Committee Specialist), Millie Bacon (Inquiry Manager), Judith Boyce (Clerk), Daniel Gillett (Committee Specialist), Alexandra Hunter-Wainwright (Committee Operations Manager), Olivia Rose (Media Officer), Abi Samuels (Second Clerk), Owen Sheppard (Senior Media Officer), and Mandy Sullivan (Committee Operations Officer).

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Summary

In 2015 the Infrastructure Act created a new investment regime for the Strategic Road Network (SRN) to provide the people and businesses that rely on it with assurances about upkeep and efficiency. But since then, road building projects have been beset by delay and overspend, amidst legal challenges on environmental grounds. In the face of increasing costs, looming net zero commitments and an ageing network in need of maintenance, the Department needs to ensure that future Road Investment Strategy portfolios are deliverable. It is time for the Government to reconsider its portfolio of expensive, complex SRN enhancement projects.

Alignment with government policy goals

The Government has identified the SRN as a key driver of growth and productivity. However, the extent to which further investment in the Network would help to boost growth, in comparison to investment in other modes of transport and connectivity, is contested.

In June 2019, the UK Government committed to decarbonising all sectors of the UK economy by 2050, and its strategy for decarbonising transport is reliant on a rapid switch to zero emissions vehicles. But traffic on the Strategic Road Network is forecast to increase and there is a risk that uptake of cleaner vehicles will not be fast enough to mitigate it. The Government should model and report on future scenarios where demand for the SRN is managed and must also provide a credible strategy for meeting the power needs of the future vehicle fleet.

Meeting user priorities

The SRN is ageing and requires significant renewal work, with many of its users demanding improvements in its day-to-day maintenance and upkeep. Future investment should be focused on renewing older parts of the SRN and ensuring that resources are available to run the existing network efficiently. The Government must make sufficient provision for both revenue and capital maintenance funds, and could make more money available by cancelling complex, costly enhancement projects.

Portfolio planning and delivery

Throughout Road Investment Strategies 1 and 2, National Highways has overspent and underdelivered. The Department for Transport needs to ensure that future Road Investment Strategies are deliverable and reconsider the viability of its expensive enhancement projects. The Department should introduce more robust measures to assess deliverability when setting a Road Investment Strategy and must also produce a plan for how it will better anticipate and deal with risks to timely delivery, and to ensure projects remain on budget and good value for money.

Engagement with sub-national transport bodies

Sub-national transport bodies, were established following the publication of National Highways' licence and have no codified role in the Road Investment Strategy setting process. National Highways' licence should be updated to include a formalised engagement process with STBs. This would enable STBs to convey regional priorities more effectively, and help National Highways gain a better understanding of potential risks and mitigations for schemes proposed for the regions.

Reporting and transparency

Understanding and scrutinising the delivery progress of a Road Investment Strategy portfolio or project involves cross-referencing multiple reporting documents from National Highways and the Office of Rail and Road. This is not a convenient or accurate way of assessing progress, especially given the frequent changes that can be made to Road Investment Strategies. Reporting on the delivery of Road Investment Strategy portfolios must be simplified, and National Highways should introduce a "live" project dashboard which provides up-to-date information on each SRN project.

1 Introduction

The Strategic Road Network

1. The Strategic Road Network (SRN) is 4,300 miles of motorways and major 'trunk' A-roads in England which is managed by National Highways, a Government-owned company (formerly known as Highways England).[1] Prior to 2015, the Highways Agency managed the SRN as an executive agency of the Department for Transport until the Infrastructure Act 2015 introduced strategic highways companies.[2] At the time, the Department for Transport described the creation of strategic highways companies as a way to:

> fundamentally transform the way our strategic roads are run. This change means better long-term planning, more efficient delivery, greater transparency, clearer accountability and ultimately a better service for the people and businesses that use and rely on the network on a daily basis.[3]

2. The Infrastructure Act also gives the Secretary of State power to set Road Investment Strategies (RIS) for National Highways to deliver. A RIS determines National Highways' programme of improvements and works to the SRN, and the budget available to deliver it. In practice, each RIS covers a five-year span known as a "road period". There have been two road periods so far:

- RIS 1 ran from April 2015 to March 2020. Its overall budget was £15.2 billion, which included £9.4 billion for major improvements. Major schemes in the portfolio included the A303 Stonehenge Tunnel, and dualling the A1 from Morpeth to Ellingham in Northumberland.
- RIS 2 began on 1 April 2020 and will run until 31 March 2025. Its initial budget was £27.4 billion, with £14.1 billion allocated to a portfolio of 69 road enhancement projects. From late 2021, significant changes were made to the RIS 2 Delivery Plan as it became clear that it could not be implemented as planned.[4] In March 2023, Secretary of State Rt Hon Mark Harper MP announced further delays to RIS 2 schemes which would be deferred to RIS 3 and said that other schemes earmarked for RIS 3 would continue to be developed for consideration in RIS 4—in other words, beyond 2030.[5]

Road Investment Strategy 3

3. The Department and National Highways are in the early phases of planning for RIS 3, which will cover the period April 2025 to March 2030. In May 2023 the Department announced a consultation on shaping the future of England's strategic roads, which outlined National Highways' proposed priorities for RIS 3.[6]

1 Department for Transport, Highways England: Framework Document, April 2015
2 Infrastructure Act 2015, February 2015
3 Department for Transport, Highways England: Licence, April 2015
4 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022, page 18, Figure 5
5 HC Deb, 9 March 2023, HCW265
6 Department for Transport, Shaping the future of England's strategic roads, May 2023

Our inquiry

4. In 2022 the National Audit Office (NAO) assessed National Highways' progress in delivering RIS 2 and reported that, by 2025, National Highways will have completed less work on the RIS 2 programme, and at a higher cost than originally planned.[7]

5. With one full RIS completed, a second at the mid-point and a third in the initial planning stages, we launched an inquiry into strategic road investment on 20 December 2022. We intended to take stock of the Government's approach to road investment, explore how this aligned with other policy aims, and examine National Highways' management of RIS portfolios in the light of the NAO's findings.

6. We received more than 50 submissions of written evidence and held three oral evidence sessions, at which we took evidence from witnesses including the haulage and logistics industry, motoring consumer organisations and transport campaigners. We also heard from the Accounting Officers of both the Department for Transport and National Highways. We are grateful to all those who contributed to our inquiry, and for the assistance of the National Audit Office.

7 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022

2 Alignment with government policy goals

7. RIS 2 states that "the principal purpose of the Strategic Road Network is to enable safe, reliable, predictable, efficient, often long distance, journeys of both people […] and goods in England".[8] In terms of its contribution to growth and productivity, the Department has identified the Strategic Road Network as "a significant economic asset for the UK on which we all rely. Most obviously it is essential for businesses and logistics firms moving goods around the country".[9] However, there is a potential for tension between investment in roads as a way of achieving the Government's aims for growth and connectivity on one hand, and its net zero carbon ambitions on the other.

Economic growth

8. The Department for Transport bases the economic case for spending on strategic roads on journey time and cost savings, productivity increases, and investment and employment effects.[10] As such, the Department's stated strategic aims for road investment align with a range of Government objectives including productivity, growth and levelling up.[11] For both RIS 1 and RIS 2, the Department for Transport and National Highways published documents setting out the forecast economic benefits of the programmes; RIS 1 had a "strong economic case"[12] and RIS 2 was expected to deliver "high value for money."[13]

9. The Department for Transport argued that investment in the SRN "supports job creation and inward investment across the country" and that it "tackles congestion."[14] Logistics UK and the Road Haulage Association agreed that support for RIS 2 is beneficial for connectivity and productivity. Logistics UK told us:

> Spending for road infrastructure needs to continue to be well planned and stable over the long term. […] Many of the enhancements planned in RIS 2 have also been identified as being of critical importance far beyond their local area by Logistics UK's members, including the A303, A66 Northern Trans-Pennine, M42 and the Lower Thames Crossing. Each of these routes, and many more besides, are either unreliable or frequently congested. This leads to unacceptable costs for hauliers, their customers and the broader economy.[15]

The Road Haulage Association told us that:

> The UK road network, in particular the Strategic Road Network (SRN), is our members' workplace. Commercial vehicle operators need roads that are fit for purpose and allow for consistent, reliable and predictable

8 Department for Transport, Road Investment Strategy 2, 2020
9 Department for Transport, Planning ahead for the Strategic Road Network Developing the third Road Investment Strategy, December 2021
10 Department for Transport, Exploring the Economic Benefits of Strategic Roads, 2017
11 Department for Transport (SRI0039)
12 Department for Transport, Road Investment Strategy: Economic Analysis of the Investment Plan, 2015
13 National Highways, Economic Analysis of the Second Road Period, 2020
14 Department for Transport (SRI0039)
15 Logistics UK (SRI0022)

> journey times. Any cutting of budgeted projects risks under developing the infrastructure that our industry needs, which is vital to future economic growth.[16]

10. Evidence on the economic impact of strategic road building is mixed, however. The Local Government Technical Advisers Group (LGTAG) told us:

> In general, any contribution [by national programmes of public investment including road building] to the sustainable rate of economic growth of a mature economy, with well-developed transport systems, is likely to be modest.[17]

The Chartered Institute of Highways and Transportation said:

> Road enhancement and new road schemes will not automatically deliver economic growth for disadvantaged areas […] achieving growth in the economy is dependent on many factors outside the transport sphere.[18]

Transport for Quality of Life said that analysis of National Highway's Post Opening Project Evaluations shows that the evidence that past road schemes have supported economic growth is "limited and weak", and that there is "little empirical evidence that road investment increases productivity."[19]

11. **The Strategic Road Network plays an important role in economic growth and productivity. However, the extent to which further investment in the Network would help to boost growth, in comparison to investment in other modes of transport and connectivity, is contested. We intend to look in more detail at how the outcomes of transport investment are prioritised and appraised in our forthcoming inquiry on the Government's strategic transport objectives.**

Net zero transport

12. We heard throughout this inquiry that investment in strategic roads could also have an impact on the Government's ambitions for achieving net zero carbon emissions. In June 2019, the UK Government put a net zero emissions target by 2050 into legislation. It also published a Net Zero Strategy for decarbonising all sectors of the UK economy by 2050. The Net Zero Strategy identified transport as the largest polluting sector of the UK economy in terms of greenhouse gas emissions. The majority (55 per cent) of these emissions are from passenger cars, followed by heavy goods vehicles and light goods vehicles. The remaining greenhouse gas emissions from transport are made up of domestic shipping, rail, and domestic aviation.[20] Official statistics are not available for the summed totals of all air pollutants, that is, not just greenhouse gas emissions.[21] In response, in 2021 the Department for Transport published its Decarbonising Transport strategy,[22] and National Highways its Net Zero Highways plan.[23]

16 RHA (SRI0043)
17 Local Government Technical Advisers Group (LGTAG) (SRI0018)
18 CIHT (SRI0020)
19 Transport for Quality of Life (SRI0012)
20 HM Government, Net Zero Strategy: Build Back Greener, 2021
21 Department for Transport, Transport and Environment Statistics 2021 Annual Report, May 2021
22 Department for Transport, Decarbonising Transport, 2021
23 National Highways, Net Zero Highways, 2021

Growth in traffic demand

13. A policy central to decarbonising the Strategic Road Network (SRN) is that the sale of new petrol and diesel cars and vans will be phased out by 2030 and the sale of non-zero emissions heavy goods vehicles will be phased out by 2035. The Department has forecast that, in all future scenarios, travel on the SRN will grow, as set out in the 2022 National Road Traffic Projections (NRTP)[24] and the phase out of these vehicles is designed to help counteract that. The Climate Change Committee's (CCC) Sixth Carbon Budget, however, suggests that reduced demand for car use throughout the UK will be required to reach net zero, unless battery technology and charging infrastructure rapidly develop and lead to a faster uptake of electric vehicles than anticipated.[25]

14. We have heard evidence which suggests that accommodating traffic growth on the SRN and attempting to offset emissions by reducing tailpipe emissions poses a "risk" to achieving decarbonisation of transport by 2050.[26] Professor Greg Marsden, Professor of Transport Governance at Leeds University, analysed the path to net zero as set out in the DfT's Decarbonising Transport document alongside the NRTP traffic forecast projections and told us that:

> Whilst it is possible to draw technology adoption pathways [electrification of the vehicle fleet] which reduce emissions towards the Sixth Carbon Budget, these have no credibility. Norway, which has been transitioning rapidly to electric vehicles, in 2021 still only had 21 per cent of its cars as electric vehicles. The UK believes it will have matched this by 2025—but with nothing like the incentives in place in Norway.[27]

15. Transport for Quality of Life (TfQL) argued that the planned RIS 2 portfolio is not consistent with UK carbon targets, and that "none of the scenarios in DfT's 2022 National Road Traffic Projections (NRTP) are consistent with […] the DfT's own Transport Decarbonisation Strategy."[28] TfQL's analysis of the NRTP traffic forecast projections, compared to the figures set out in the Sixth Carbon Budget, suggested that while the Climate Change Committee's Sixth Carbon Budget would require a reduction of 47 per cent in carbon emissions from surface transport between 2018 and 2030, the maximum reduction predicted under any of the eight NRTP scenarios is 35 per cent.[29]

16. Professor Glenn Lyons, Professor of Future Mobility at the University of West of England, characterised the Government's reliance on a cleaner vehicle fleet to decarbonise transport as a "gamble".[30] Referring to recent analysis undertaken by the RAC Foundation[31] he said:

24 Department for Transport, National Road Traffic Projections 2022, 2022
25 Climate Change Committee, Policies for the Sixth Carbon Budget, 2020
26 Oral evidence taken on 29 March 2023, HC 904, Q177
27 Professor Greg Marsden (SRI0010)
28 Transport for Quality of Life (SRI0012)
29 Transport for Quality of Life (SRI0012)
30 Oral evidence taken on 1 March 2023, HC 904, Q177
31 RAC Foundation, Is It Necessary to Reduce Car Milage to Meet Our Carbon Emission Goals?, 2023

> You can bet on some possible combinations of factors that would allow us to continue to rely on using the road network much as we have, but there are many, many combinations of uncertain factors where we would be gambling and losing.[32]

Managing traffic demand on the Strategic Road Network

17. The Scottish and Welsh Governments have introduced traffic reduction targets to achieve their own net zero aims. The Scottish Government's Climate Change Plan update in 2020 included a commitment to reduce car kilometres by 20 per cent by 2030 against a 2019 baseline.[33] Similarly, the Welsh Government has committed to reducing the number of car miles travelled per person by 10 per cent by 2030 (from 2019 levels).[34] Ralph Smyth of Transport Action Network was in favour of such demand management policies:

> No matter how many road schemes we build, and there is less money and they are becoming more expensive, […] we are not even going to make a dent in that increase in congestion. Maybe it is time to try some different solutions. Simply, it is because if you can only have a few road schemes here and there, they will move the congestion along rather than tackling it, but a system of demand management will actually address that congestion network-wide.[35]

18. The UK Government, however, has no plans to adopt traffic demand management policies for the SRN. The Department for Transport stated that "roads will continue to be the predominant form of transport in a net zero world, reflecting their flexibility and convenience to users and businesses."[36] Dame Bernadette Kelly, Permanent Secretary at the Department, told us that:

> The focus of UK Government policy is on driving the transition to zero emission vehicles so that people can drive without contributing to carbon emissions. That is the focus, rather than targets for reduced road usage.[37]

Richard Holden MP, Parliamentary Under Secretary of State for Roads at the Department for Transport, confirmed this policy:

> When you talk about demand management, I think there are multiple different aspects to that. I don't think it is sensible for either the economy or the environment to throttle the major road network.[38]

19. **Transport remains the biggest greenhouse gas contributor in the UK and the Government's strategy for decarbonising transport by 2050 is reliant on a rapid switch to zero emissions vehicles. However, in all future scenarios modelled by the Department for Transport, traffic on the Strategic Road Network is forecast to increase, and there is a great risk that uptake of cleaner vehicles will not be fast enough to mitigate that**

32 Oral evidence taken on 29 March 2023, HC 904, Q177
33 Transport Scotland, A route map to achieve a 20 per cent reduction in car kilometres by 2030, January 2022
34 Welsh Government, Net Zero Wales Carbon Budget 2 (2021–2025), October 2021
35 Oral evidence taken on 1 March 2023, Q168
36 Department for Transport (SRI0039)
37 Oral evidence taken on 1 February 2023, HC 904, Q96
38 Oral evidence taken on 29 March 2023, HC 904, Q272

increase. The Government's determination to accommodate demand for new roads through investment without also considering steps to manage that demand is a risky strategy.

20. **In our recent report on Implementation of the National Bus Strategy we recommended that a debate needs to be had about whether the Department for Transport should introduce a target to reduce car usage in England by the end of the decade, such as those seen in Scotland and Wales. Understanding the impact of reducing or maintaining traffic on the SRN would inform this debate.**

21. ***The Government should model and report on scenarios where traffic levels on the SRN are a) reduced and b) maintained at current levels, alongside the transition to a cleaner vehicle fleet, in order to assess the potential contribution of demand management to reaching net zero.***

The transition to zero emission vehicles

22. A vital step in enabling the transition to a zero emissions vehicle fleet is to ensure that the right charging infrastructure is in place. We asked[39] the Department for Transport about the provision of electric vehicle charging infrastructure on the SRN and were pointed towards the Government's rapid charging fund, known as Project Rapid.[40] This is a £950 million fund which aims to provide 6,000 high-powered charge points across the SRN by 2035,[41] including six at every motorway service station in England by the end of 2023.[42] Where grid supply is not sufficient for rapid charging infrastructure, National Highways intends to invest in Energy Storage Systems through an £8 million fund.[43]

23. As of June 2023, there were approximately 400 rapid and ultra-rapid chargers at motorway service areas.[44] Edmund King of the AA was sceptical about whether Project Rapid was adequate and whether the 2035 target would be achieved. He told us:

> I would not be so optimistic. […] at the moment, just two per cent of cars are electric. Often, when I am at a motorway service area fighting for a charger, I look around and say to myself, "Gosh, when 15 per cent of these cars are electric, I am going to need more than 12 chargers. I am going to need more than 20." […] We have to start planning now. National Grid tries to reassure us that it can put it in with advance planning. The deadline of 2030 is only seven years away, so we need to ramp this up.[45]

24. We asked Sharon Kindleysides of the Chartered Institute of Logistics and Transport whether the Government was doing enough to support the transition to zero emissions heavy goods vehicles in the logistics sector. She said, "we will probably need more charging […] I am not sure how many petrol pumps there are on a single stretch of motorway, but I am inclined to think it might be more than 6,000."[46]

39 Oral evidence taken on 1 February, HC904, Q93
40 Office for Zero Emissions Vehicles, Rapid Charging Fund, 2021
41 HM Government, Electric Vehicle Infrastructure Strategy
42 Department for Transport, Government vision for the rapid chargepoint network in England, 2020
43 National Highways, Energy Storage Systems to support EV drivers rapidly charging on England's motorways, 2021
44 House of Commons Library, Going the distance: Are motorways ready for more electric vehicles?, June 2023
45 Oral evidence taken on 1 March 2023, HC 904, Q154
46 Oral evidence taken on 1 March 2023, HC 904, Q156

25. **We welcome Project Rapid's dedicated fund for enhancing electric vehicle charging provision on the Strategic Road Network, but a quicker and greater rollout of rapid charging points and supporting infrastructure will be required to support a future electric vehicle fleet, especially considering the target for all new freight vehicles to be zero emissions by 2040. This should include potential provision for other alternative fuelling technologies such as hydrogen.**

26. ***The Government must provide a credible strategy which sets out how the SRN will meet the fuel needs of the future vehicle fleet, including for freight, and provide milestone targets for delivering infrastructure to do so.***

3 Meeting user priorities

27. In RIS 2, the Government has embarked on an ambitious programme of enhancement projects for the Strategic Road Network. Although the Department has not defined 'enhancement' schemes, they are generally understood as projects within the RIS portfolio which go beyond maintenance and involve construction to create, for example, new roads, junction upgrades or additional lanes. We have heard that this approach will not necessarily meet the needs of road users or target investment where it is most needed.

What do users of the SRN want?

28. According to Transport Focus, the independent watchdog for transport users sponsored by the Department for Transport, 69 per cent of car and van drivers were "satisfied" with their overall use of the SRN in 2020–21.[47] 31 per cent were unsatisfied with road surfacing and over half were unsatisfied with the management of roadworks. Car and van drivers' top three priorities for the SRN were improved quality of road surfaces, safer design and upkeep of roads, and better management of breakdowns. Conversely, spending on major enhancement projects was not identified as a priority. Guy Dangerfield, Head of Strategy at Transport Focus, told us:

> What we have found in the research that we have undertaken is that two thirds of strategic road users place greater importance on the maintenance and renewal of what we already have than on expanding the strategic road network.[48]

Edmund King, President of the AA, added that AA members' "number one [priority] is the actual state of the roads. That is their number one: get rid of the potholes."[49] Mr King added that:

> Looking back on this, 20 to 25 years ago there were lots of gaps in the network. I think that fundamentally we now have quite a good road network […] I think the priority within that should be: where are the congestion hotspots and crash hotspots, and can't we just concentrate on that rather than major schemes that sometimes are the whim of Government.[50]

29. Transport Focus' research also showed that in 2021 just 55 per cent of lorry and coach managers were satisfied that the Strategic Road Network was meeting their business needs.[51] Transport Focus found that the top five priorities of haulage, freight and coach drivers tallied with those of car and van drivers: improved quality of road surfaces, safer design and upkeep of roads, and better management of unplanned delays such as accidents or breakdowns.

30. Enhancement of the SRN and increasing capacity are bigger priorities for the haulage and logistics industry than for car and van drivers, however. The Road Haulage Association said that "any cutting of budgeted projects risks under developing the infrastructure

47 Transport Focus, [redacted], 2022
48 Oral evidence taken on 1 March 2023, HC 904, Q115
49 Oral evidence taken on 1 March 2023, HC 904, Q119
50 Oral evidence taken on 1 March 2023, HC 904, Q126
51 Transport Focus, [redacted], 2021

that our industry needs, which is vital to future economic growth."[52] Jonathan Walker, Head of Cities and Infrastructure Policy at Logistics UK, emphasised that the haulage industry's support for the portfolio of RIS 2 enhancements projects was rooted in a need for consistent journeys across the SRN:

> What the logistics industry wants more than anything is consistency and reliability on the road network, and predictability, so that your operations can be planned in advance and you get reliability of journey times, congestion and so on.[53]

Sharon Kindleysides, Chief Executive of the Chartered Institute for Logistics and Transport, said that it was important to maintain the road network that already exists, and identify gaps that relate to the logistics network.[54] Guy Dangerfield argued that the greatest needs of the haulage and coach industries could be better met by ensuring that there are better roadside facilities for drivers[55]—a topic on which we made recommendations in our 2022 report on the road freight supply chain.[56]

Balancing maintenance and enhancements

31. The RIS 2 budget included a £12.8 billion fund dedicated to the maintenance and renewal of roads and the operations of National Highways, with this investment afforded a 'Very High' value for money rating.[57] This was compared to £14.1 billion that was allocated to enhancement projects, which was assessed as 'High' value for money. As outlined above, we have heard that the priorities of SRN users could be more effectively met by focusing on maintaining and renewing the existing SRN and improving the operations of National Highways; spending more on maintenance and renewal would improve surface quality and safety, while investing more in operations could help to improve the management of breakdowns and roadworks.

32. Nick Harris, Chief Executive of National Highways, explained that over 70 per cent of National Highways' assets will be over 45 years old at the start of RIS 3, and in increasing need of renewal.[58] Emma Ward, Director General for Roads, Places and Environment at the Department for Transport, referred to the SRN as "ageing".[59] Guy Dangerfield outlined his view of what RIS 3 funding should target to address this:

> It is really important that RIS 3 contains the proper sum of capital renewal to keep pace with the inevitable deterioration that goes on from weather and wear and tear. The really important thing is that the renewals capital [for RIS 3] does not get squeezed to top up the enhancement portfolio and that the underlying quality of the existing network is not allowed to deteriorate because of delays in road period 2 [RIS 2].[60]

52 RHA (SRI0043)
53 Oral evidence taken on 1 March 2023, HC 904, Q119
54 Oral evidence taken on 1 March 2023, HC 904, Q128
55 Oral evidence taken on 1 March 2023, HC 904, Q134
56 Transport Committee, First Report of Session 2022–23, Road freight supply chain, HC 162
57 National Highways, Economic analysis of the second road period, 2020
58 Oral evidence taken on 1 February 2023, HC 904, Q73
59 Oral evidence taken on 29 March 2023, HC 904, Q237
60 Oral evidence taken on 1 March 2023, HC 904, Q115

Potential RIS 3 portfolio

33. The Department and National Highways are in the early phases of planning for RIS 3, which will cover the period April 2025 to March 2030. In November 2022, the National Audit Office reported that in September 2020, National Highways said it expected to spend £5.5 billion in the third road strategy, but since then, this has increased to £11.5 billion, largely because of project delays occurring during the second road strategy period.[61] The Minister told us that, given the "significant pressures" on the RIS 3 portfolio, the Department for Transport was currently "kicking the tyres" of enhancement projects slated for that road period.[62] Emma Ward added that RIS 3 "may well see a shift towards more renewals and maintenance".[63]

34. On 18 May 2023, National Highways published an initial consultation on RIS 3 outlining its proposed priorities and requesting views on the future needs of and priorities for the SRN.[64] The consultation suggests that renewal of existing assets "is likely to be a growing element of the roads programme" and recognises that users want "existing roads in good condition before building new ones". The consultation material also explains that RIS 3 will likely prioritise the completion of RIS 2 complex enhancement schemes which will still be in construction in the RIS 3 period, or which have been delayed until RIS 3. It is likely for RIS 3 that any "new" enhancement projects, that is, those not outstanding from the RIS 2 portfolio, will not be complex projects.

35. ***The existing Strategic Road Network is ageing and requires significant renewal work in places, while many users want to see better day-to-day maintenance and upkeep of the network. Future investment should be focused on renewing older parts of the SRN and ensuring that resources are available to run the network in a way which better meets the needs of the drivers and industries that rely on it. The portfolios for RIS 3, RIS 4 and beyond should prioritise investment in the maintenance, renewal and resilience of existing assets over brand new projects.***

36. ***Providing the level of day-to-day running and upkeep that meets the needs of SRN users will require revenue funding alongside capital investment in more costly renewal and repair projects. The Government must, therefore, make sufficient provision for both revenue and capital maintenance funds. This funding could be gained by cancelling complex, costly enhancement projects. Increased user satisfaction should be reflected through Transport Focus' annual SRN user reports.***

61 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022
62 Oral evidence taken on 29 March 2023, HC 904, Q236
63 Oral evidence taken on 29 March 2023, HC 904, Q238
64 Department for Transport, Shaping the future of England's strategic roads, May 2023

4 Portfolio planning and delivery

37. The introduction of national highways companies (currently National Highways) and road periods was intended to introduce better long-term planning, clarity, and more efficient delivery to the Strategic Road Network. We have looked at the extent to which that has proved to be the case in practice.

Management of RIS 1 (2015–2020)

38. In 2017, the National Audit Office commented that RIS 1 represented "a significant improvement in the efficient management of the strategic road network". It also concluded, however, that the speed with which the Department for Transport designed RIS 1 "created risks to value for money and deliverability."[65]

39. In 2019 the Office of Road and Rail (ORR) reported that "fewer schemes are being delivered than originally expected and outturn costs for schemes have increased."[66] The ORR said in July 2020 that the scope of the RIS 1 project portfolio was "overly optimistic", as it had to be revised and downsized during the delivery period from 112 schemes due to have started construction to 73.[67] By the end of the period, 37 of the original 112 projects had been rolled over to RIS 2 and, in total, 44 schemes were subject to pause, cancellation or change.

Management of RIS 2 (2020–2025)

40. RIS 2 began on 1 April 2020 and will run until 31 March 2025. Of its initial £27.4 billion budget, £12.8 billion was allocated to operations, maintenance and renewal of roads, and £0.5 billion to preparing RIS 3. The remaining £14.1 billion was allocated to a portfolio of 69 road enhancement projects. Of these 69 projects, 33 were deemed 'Nationally Significant Infrastructure Projects' requiring approval by the Secretary of State through a Development Consent Order. Nine of these projects were what the NAO described as 'Tier 1' projects that "either cost more than £500 million and/or are novel, contentious, involve complex engineering work or detailed consultation with stakeholders."[68] The Department for Transport told us that this included "two of the most complex road projects in recent decades", the A303 Amesbury to Berwick Down (Stonehenge Tunnel) and the Lower Thames Crossing.[69]

41. In 2019, the ORR published a RIS 2 Efficiency Review which flagged that the RIS 2 portfolio was "more complex" than that for RIS 1, that there was a greater number of larger, more complex schemes specified for RIS 2, and that spending on RIS 2 enhancements was planned to be over 40 per cent higher in real terms than on RIS 1.[70]

42. In practice, the portfolio has turned out to be difficult to deliver. The Department for Transport and National Highways' joint evidence to us acknowledged that:

65 National Audit Office, Progress with the Road Investment Strategy, March 2017
66 Office of Rail and Road, Annual assessment of Highways England's performance - 2018–19, July 2019
67 Office of Road and Rail, Annual Assessment of Highways England End of Road Period 1, July 2020
68 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022
69 Department for Transport (SRI0039)
70 Office of Rail and Road, RIS 2 Efficiency Review, June 2019

> There have […] been challenges with the delivery of RIS 2, notably in three areas; securing planning consents, smart motorways and now inflationary impacts. These have had a significant impact on the overall delivery of RIS 2, both in terms of cost and schedule. This, with other specific project challenges, has resulted in the need to replan delivery of 22 projects.[71]

As a result of this re-planning, the total RIS 2 budget was reduced by £3.4 billion to £24 billion in the 2021 Spending Review, with the enhancements budget reduced to £10.5 billion.[72]

43. In November 2022 the National Audit Office (NAO) published a report on progress in delivering RIS 2.[73] The NAO found that:

- £1.19 billion of a contingency budget for enhancement projects had already been spent by July 2022—more than the initial £1.16 billion contingency budget set aside until 2025.
- Inflation would result in an estimated additional £740 million additional cost pressure for road enhancements schemes to March 2025.
- There had been an additional £6 billion increase since 2020 in the forecast cost of projects approved in 2020 and planned for delivery between April 2025 and March 2030. The forecast cost was now £11.5 billion, up from an initial estimate of £5.5 billion.[74]

The NAO's analysis concluded that, by the end of RIS 2, National Highways would have completed less work on road enhancements and at a higher cost than originally planned.

44. The Department for Transport and National Highways identified three causes for the delays to RIS 2: setbacks in securing planning consents, changes to smart motorways plans, and the impact of inflation.[75] Nick Harris, Chief Executive of National Highways, made it clear to us in February 2023 that he did not believe that the COVID-19 pandemic had created any significant delays for National Highways in delivering the RIS 2 portfolio.[76]

Delays in planning processes

45. At the start of the RIS 2 programme, National Highways set out to obtain development consent for the 33 Nationally Significant Infrastructure Projects in the portfolio. The NAO charted the subsequent delays in obtaining consent and said that:

> During [RIS 1] it [National Highways] received consent for seven projects, none of which were subject to legal challenge. By May 2022 National Highways had experienced delays in receiving or applying for development consent on 12 projects.[77]

71 Department for Transport (SRI0039)
72 HM Treasury, Autumn Budget and Spending Review 2021, October 2021
73 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022
74 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022, page 4
75 Department for Transport (SRI0039)
76 Oral evidence taken on 1 February 2023, HC 904, Q4
77 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022

The legal challenges faced by these projects were made primarily on climate grounds after the UK Government put into legislation in 2019 a net zero emissions target by 2050.[78]

46. Dame Bernadette Kelly, the Department's Permanent Secretary, said that these delays were unexpected:

> It is fair to say that we had not anticipated, in the planning for RIS 2, that we would see the challenges and the delays that we did […] we saw a number of significant cases, legal challenges and other difficult planning decisions which had an impact on a significant number of those projects.[79]

47. In response to the delays, the Department has undertaken a review of the National Networks National Policy Statement (NNNPS), the Government's statement of strategic planning policy for major schemes.[80] At the time of writing, we are scrutinising the draft revised NNNPS. Officials from the Department also told us that, alongside National Highways, it had implemented a development consent action plan. They said this was "having an effect", with nine Development Consent Orders being approved since April 2022.[81] The Department has also increased staffing capacity and capability, from 28 staff in the last year of RIS 1 to 55 in February 2023 and has identified 24 lessons learnt from RIS 1 for developing the nine "tier 1" projects.[82]

Changes to the smart motorways programme

48. Changes of plan relating to smart motorway projects have also affected the RIS 2 portfolio. We first expressed concern about the rollout of all-lane running motorways in 2016 due to safety risks.[83] In November 2021 we reiterated our concerns about safety risks, saying that these should have been addressed before all-lane running motorways were rolled out, and recommended that their rollout should be paused.[84] In January 2022 the Government agreed, in response to our Report, to pause the rollout of all new all-lane running motorways and the planned conversions of Dynamic Hard Shoulder schemes to all-lane running.[85] In total, four all-lane running schemes and seven conversions of Dynamic Hard Shoulder to all-lane running were paused. In April 2023 the Department announced that these 11 schemes—all in the RIS 2 portfolio—would be cancelled, along with three new smart motorway schemes that had been proposed for RIS 3.[86]

78 Department for Business, Energy and Industrial Strategy, UK becomes first major economy to pass net zero emissions law, June 2019
79 Oral evidence taken on 29 March 2023, HC 904, Q37
80 Department for Transport, Draft national networks national policy statement consultation document, March 2023
81 Oral evidence taken on 1 February 2023, HC 904, Q40
82 Correspondence from the Permanent Secretary, Department for Transport, relating to strategic road investment, dated 21 February 2023
83 Transport Committee, Second Report of Session 2016–17, All lane running, HC 63
84 Transport Committee, Third Report of Session 2021–22, Rollout and safety of smart motorways, HC 26
85 Transport Committee, Sixth Special Report of Session 2021–22, Rollout and safety of smart motorways: Government Response to the Committee's Third Report, HC 1020
86 Written Statements, Volume 731, Smart Motorway Schemes: Cancellation, 17 April 2023

Confidence in delivery

49. In February 2023 Dame Bernadette Kelly told us that, although the RIS 2 portfolio "was always a very challenging, complex portfolio, with much more in the way of large projects than RIS 1",[87] nonetheless "we judged that the programme was deliverable".[88] She continued:

> That was also the conclusion that the Office of Rail and Road drew, as did the Infrastructure and Projects Authority. […] from an accounting officer perspective, I had assurance and was satisfied at that point that the programme that was being planned was a deliverable portfolio.[89]

50. In terms of horizon-scanning for future risk, the Government's plans for decarbonisation and the highlighted safety risks of smart motorways had been well documented and should have factored more into risk planning. That these considerations were present but the final RIS 2 portfolio was so ambitious suggests an optimism bias, or overconfidence, regarding the capacity and capability of the Department and National Highways to deliver it.

RIS 3 and beyond (2025 onwards)

51. In March 2023, the Secretary of State for Transport announced further delays to RIS 2 schemes which would be deferred to RIS 3 and said that other schemes earmarked for RIS 3 would continue to be developed for consideration in RIS 4—in other words, beyond 2030.[90] This included pushing back the start of construction on the Lower Thames Crossing[91] by two years until 2026, into RIS 3, so that it will require funding from the RIS 3 budget. The National Audit Office has reported that the expected cost of the Lower Thames Crossing project has increased by £1.5 billion, to a total of between £5.3 billion and £9 billion, with £800 million having already been spent on planning.[92] In May 2023 the DfT announced a consultation on shaping the future of England's strategic roads, which outlined National Highways proposed priorities for RIS 3.[93] In its Initial Report for RIS 3, National Highways confirmed that projects from RIS 2, including expensive, complex projects such as the Lower Thames Crossing would be included in the portfolio:

> There is still a significant number of schemes, committed in RIS 1 and RIS 2 that we agreed with government, which we will continue to consider in our decision making for RIS 3. We know that bottlenecks and varying standards of roads currently affect journeys, with inconsistent investment prior to RIS 1 leading to piecemeal development of our network and with traffic volumes set to grow, we need to tackle these problem areas.[94]

87 Oral evidence taken on 1 February 2023, HC 904, Q2
88 Oral evidence taken on 1 February 2023, HC 904, Q10
89 Oral evidence taken on 1 February 2023, HC 904, Q2
90 HC Deb, 9 March 2023, HCW265
91 National Highways, Lower Thames Crossing, June 2023
92 National Audit Office, Road enhancements: progress with the second road investment strategy, November 2022
93 Department for Transport, Shaping the future of England's strategic roads, May 2023
94 National Highways, Strategic Road Network Initial Report 2025–2030, May 2023

52. **Throughout RIS 1 and 2, there has been a consistent theme of overly ambitious portfolio planning, and National Highways has overspent and underdelivered. Despite delays in RIS 1, an even more ambitious portfolio was chosen for RIS 2. Schemes have been consistently pushed back into the following RIS portfolio, and some projects initially planned for RIS 3 (2025–30) have already been pushed back to RIS 4. Rather than the efficiency and certainty which road periods were meant to introduce, this has led to confusion and uncertainty. While current inflationary costs were unexpected, changes to the smart motorways programme and legal challenges to projects on environmental grounds could have been better anticipated given longstanding criticisms.**

53. ***Given the history of consistent delays to complex projects, it seems that portfolios to date have been too ambitious and have suffered from 'optimism bias'. The Department needs to ensure that future RIS portfolios which include such projects are deliverable; it is time for the Government to reconsider its portfolio of expensive, complex SRN enhancement projects. There is a compelling case for each RIS portfolio to be smaller in scope to avoid continual deferral of projects from one road period to the next, or for the Government to dedicate more resource to ensuring that projects can be completed within a reasonable window.***

54. ***The Government should implement more robust and transparent measures to assess deliverability when setting a RIS so that a wider range of stakeholders can flag risks to completing projects on time. We are scrutinising the draft revised National Networks National Policy Statement in a separate inquiry, but regardless of what framework is in place, the Department clearly needs to ensure its proposals are robust enough to stand up to scrutiny and challenge against that framework. The Department must also produce a plan for how it will better anticipate, assess and deal with risks to timely delivery, and ensure projects remain on budget and good value for money.***

5 Engagement with sub-national transport bodies

55. There is a seven-step process for setting a Road Investment Strategy, as set out in the terms of National Highways' licence.[95] This comprises an initial network assessment by National Highways, a consultation conducted by the Secretary of State on a draft RIS, and efficiency and deliverability reviews by the Highways Monitor. A Strategic Business Plan and a Delivery Plan are also agreed on over several iterations. Throughout this process National Highways and the Department for Transport undertake engagement with numerous external bodies to establish whether the potential RIS portfolio is deliverable.

56. English sub-national transport bodies (STBs) do not have a formal role in the development and publication of a RIS. STBs provide strategic transport governance at a much larger scale than existing local transport authorities by grouping authorities together. In practice, the membership of STBs is formed from a mix of local highways authorities, Local Enterprise Partnerships (LEPs), local airports, National Highways, Network Rail and the Department for Transport. There are currently seven STBs across England, six of which operate on a pre-statutory basis, meaning that they have no statutory duties but still act as a voice for their region's transport needs. The seventh, Transport for the North, has a statutory role.

57. Transport for the South East told us that it had provided advice on "the south east's priorities for investment in the SRN" and welcomed the "increased engagement and input" it had had with the Department and National Highways in planning for the next RIS.[96] However, Transport for the South East also said that "this engagement has not been consistent and has not always been as open or collaborative as that for the strategic level of RIS 3 development."[97]

58. Midlands Connect also said that they had a positive relationship with National Highways but that there is room for improvement.[98] This was a view supported by Darren Oldham, Rail and Roads Director at Transport for the North, who said that its relationship with National Highways "[feels like] a situation where we are effectively told what the decisions and outcomes are". His opinion was that an obligation for National Highways to formally include STBs in RIS engagement would lead to much more of a "two-way process".[99]

59. Because the licence for National Highways (the appointed strategic highways company) was published prior to the formation of STBs, in 2015, they have no formal role in the development and publication of a RIS. STBs suggested to us that National Highways' licence should be updated to reflect the establishment of STBs. Maria Machancoses, Chief Executive of Midlands Connect, told us that it would be helpful for the licence to acknowledge the importance of engaging with STBs and establish protocols for doing so.[100]

95 Department for Transport, Highways England: Licence, 2015
96 Transport for the South East (SRI0037)
97 Transport for the South East (SRI0037)
98 Midlands Connect (SRI0040)
99 Oral evidence taken on 29 March 2023, HC 904, Q199
100 Oral evidence taken on 29 March 2023, HC 904 Q198

Naomi Green, Managing Director of England's Economic Heartland, said that a formal role for STBs would mean that proposed schemes could be designed and finessed to better meet regional needs and account for local knowledge, which could improve proposals.[101]

60. Better engagement could have benefits beyond decision-making: implementation, refinement of schemes and risk mitigation could also be improved. Transport for the North argued that:

> earlier and more thorough engagement with key partners and stakeholders would have supported a more comprehensive approach to mitigating risks [in RIS 1 and RIS 2], particularly with respect to statutory planning processes where most delays and uncertainty with delivery occur.[102]

61. We asked the Minister what power STBs have over the prioritisation of schemes within their region; he responded that STBs receive funding from the Department.[103] Emma Ward, Director General for Roads, added that National Highways already has a framework agreement in place with the sub-national transport bodies and that there is a joint engagement and action plan. Asked whether their role could be recognised in National Highways' licence, she said, "I am not sure there is anything that National Highways are not doing that they would do, or do differently, even if the licence was changed",[104] and noted that "both sets of organisations are maturing".[105]

62. ***Sub-national transport bodies were established following the publication of National Highways' licence, and therefore have no codified role in the RIS setting process. There are good examples of collaborative planning and working between STBs and National Highways, but this is inconsistent. An acknowledgement of STBs in National Highways' licence would enable STBs to convey regional priorities more effectively, and help National Highways gain a better understanding of potential risks and mitigations for schemes proposed for the regions. National Highways' licence should be updated to include a formalised engagement process with STBs, regardless of their statutory status.***

101 Oral evidence taken on 29 March 2023, HC 904 Q199
102 Transport for the North (SRI0028)
103 Oral evidence taken on 29 March 2023, HC 904 Q234
104 Oral evidence taken on 29 March 2023, HC 904, Q234
105 Oral evidence taken on 29 March 2023, HC 904, Q235

6 Reporting and transparency

63. Throughout our inquiry we have relied on a collection of documents from Government, Government-owned companies, regulatory bodies and auditors to understand the progress and status of RIS portfolios and projects. This is indicative of how challenging it can be to track the progress of strategic road projects, which can be exacerbated by a regularly changing portfolio.

64. Kate Cohen, Director for Roads and Projects Infrastructure at the Department for Transport, explained the various reporting resources to us:

> Every year there are three annual publications of progress on the RIS. One is the delivery plan produced by National Highways. One is the ministerial statement that gets presented to Parliament each year. Then there is an annual assessment by the ORR [Office of Rail and Road]. In those three documents, which are published annually, together with the annual report and accounts for National Highways, there is a complete list of progress against all the KPIs and all the schemes, progress against their predicted start of works and opening dates for the key milestones.[106]

65. This explanation exemplifies the work required to track and understand the status of RIS spending and delivery; the documents do provide comprehensive reference points for the status of RIS projects, but need to be identified, located and cross-referenced. And as these documents are published annually, frequent changes to RIS portfolios, such as we have seen over RIS 2, can mean that these documents can become obsolete. This requires further work to track down statements and press releases outlining details of changes to the programme, many of which do not include details of scheme expenditure. Often, we found that information on the various legal challenges to RIS projects, their planning status, and their position in the Development Consent Order process was most easily found on the websites of the campaign groups who had mounted legal challenges.

66. On 29 March 2023 we asked Richard Holden MP, Parliamentary Under Secretary of State for Roads, for a definitive list of all projects in each of the RIS portfolios, along with their current status.[107] We were grateful to receive a response, but noted that the information given in it on RIS 2 progress and a potential list of RIS 3 schemes was extracted from the National Highways Delivery Plan Update,[108] published some eight months previously, in July 2022.[109] Previously, on 9 March, the Secretary of State for Transport had announced that the A27 and A5036 RIS 2 projects would be deferred to RIS 3, something that the Minister referred to during questioning.[110] Even the Minister's correspondence, dated 5 April, did not reflect these all of these updates.

67. **Understanding and scrutinising the delivery progress of a RIS portfolio, or given project is not simple. It involves cross-referencing several annual reporting documents from National Highways and the Office of Rail and Road which are not updated with changes made in the interim. This is not accessible or transparent, especially given the**

106 Oral evidence taken on 29 March 2023, HC 904, Q226
107 Oral evidence taken on 29 March 2023, HC 904, Q225
108 National Highways, Delivery Plan 2022–2023, July 2022
109 Correspondence from the Parliamentary Under-Secretary for Roads, Department for Transport, relating to strategic road investment, dated 5 April 2023
110 Oral evidence taken on 29 March 2023, HC 904, Q236

frequent and significant changes that can be made to the RIS programme. That the Minister responsible for strategic road investment was not able to provide us with an up-to-date progress report on the RIS 2 portfolio exemplifies how challenging it can be to track RIS progress. Reporting on the delivery of RIS portfolios must be simplified and made more accessible.

68. ***The Government should work with National Highways to introduce a "live" project dashboard which provides up-to-date information on each project in the RIS 1, RIS 2 and subsequent RIS portfolios. The dashboard should provide information on original and current: costs; Start of Work date; Open for Traffic date; and planning status (if applicable).***

Conclusions and recommendations

Alignment with government policy goals

1. The Strategic Road Network plays an important role in economic growth and productivity. However, the extent to which further investment in the Network would help to boost growth, in comparison to investment in other modes of transport and connectivity, is contested. We intend to look in more detail at how the outcomes of transport investment are prioritised and appraised in our forthcoming inquiry on the Government's strategic transport objectives. (Paragraph 11)

2. Transport remains the biggest greenhouse gas contributor in the UK and the Government's strategy for decarbonising transport by 2050 is reliant on a rapid switch to zero emissions vehicles. However, in all future scenarios modelled by the Department for Transport, traffic on the Strategic Road Network is forecast to increase, and there is a great risk that uptake of cleaner vehicles will not be fast enough to mitigate that increase. The Government's determination to accommodate demand for new roads through investment without also considering steps to manage that demand is a risky strategy. (Paragraph 19)

3. In our recent report on Implementation of the National Bus Strategy we recommended that a debate needs to be had about whether the Department for Transport should introduce a target to reduce car usage in England by the end of the decade, such as those seen in Scotland and Wales. Understanding the impact of reducing or maintaining traffic on the SRN would inform this debate. (Paragraph 20)

4. *The Government should model and report on scenarios where traffic levels on the SRN are a) reduced and b) maintained at current levels, alongside the transition to a cleaner vehicle fleet, in order to assess the potential contribution of demand management to reaching net zero.* (Paragraph 21)

5. We welcome Project Rapid's dedicated fund for enhancing electric vehicle charging provision on the Strategic Road Network, but a quicker and greater rollout of rapid charging points and supporting infrastructure will be required to support a future electric vehicle fleet, especially considering the target for all new freight vehicles to be zero emissions by 2040. This should include potential provision for other alternative fuelling technologies such as hydrogen. (Paragraph 25)

6. *The Government must provide a credible strategy which sets out how the SRN will meet the fuel needs of the future vehicle fleet, including for freight, and provide milestone targets for delivering infrastructure to do so.* (Paragraph 26)

Meeting user priorities

7. *The existing Strategic Road Network is ageing and requires significant renewal work in places, while many users want to see better day-to-day maintenance and upkeep of the network. Future investment should be focused on renewing older parts of the SRN and ensuring that resources are available to run the network in a way which*

better meets the needs of the drivers and industries that rely on it. The portfolios for RIS 3, RIS 4 and beyond should prioritise investment in the maintenance, renewal and resilience of existing assets over brand new projects. (Paragraph 35)

8. *Providing the level of day-to-day running and upkeep that meets the needs of SRN users will require revenue funding alongside capital investment in more costly renewal and repair projects. The Government must, therefore, make sufficient provision for both revenue and capital maintenance funds. This funding could be gained by cancelling complex, costly enhancement projects. Increased user satisfaction should be reflected through Transport Focus' annual SRN user reports.* (Paragraph 36)

Portfolio planning and delivery

9. Throughout RIS 1 and 2, there has been a consistent theme of overly ambitious portfolio planning, and National Highways has overspent and underdelivered. Despite delays in RIS 1, an even more ambitious portfolio was chosen for RIS 2. Schemes have been consistently pushed back into the following RIS portfolio, and some projects initially planned for RIS 3 (2025–30) have already been pushed back to RIS 4. Rather than the efficiency and certainty which road periods were meant to introduce, this has led to confusion and uncertainty. While current inflationary costs were unexpected, changes to the smart motorways programme and legal challenges to projects on environmental grounds could have been better anticipated given longstanding criticisms. (Paragraph 52)

10. *Given the history of consistent delays to complex projects, it seems that portfolios to date have been too ambitious and have suffered from 'optimism bias'. The Department needs to ensure that future RIS portfolios which include such projects are deliverable; it is time for the Government to reconsider its portfolio of expensive, complex SRN enhancement projects. There is a compelling case for each RIS portfolio to be smaller in scope to avoid continual deferral of projects from one road period to the next, or for the Government to dedicate more resource to ensuring that projects can be completed within a reasonable window.* (Paragraph 53)

11. *The Government should implement more robust and transparent measures to assess deliverability when setting a RIS so that a wider range of stakeholders can flag risks to completing projects on time. We are scrutinising the draft revised National Networks National Policy Statement in a separate inquiry, but regardless of what framework is in place, the Department clearly needs to ensure its proposals are robust enough to stand up to scrutiny and challenge against that framework. The Department must also produce a plan for how it will better anticipate, assess and deal with risks to timely delivery, and ensure projects remain on budget and good value for money.* (Paragraph 54)

Engagement with sub-national transport bodies

12. *Sub-national transport bodies were established following the publication of National Highways' licence, and therefore have no codified role in the RIS setting process. There are good examples of collaborative planning and working between STBs and National Highways, but this is inconsistent. An acknowledgement of STBs in National*

Highways' licence would enable STBs to convey regional priorities more effectively, and help National Highways gain a better understanding of potential risks and mitigations for schemes proposed for the regions. National Highways' licence should be updated to include a formalised engagement process with STBs, regardless of their statutory status. (Paragraph 62)

Reporting and transparency

13. Understanding and scrutinising the delivery progress of a RIS portfolio, or given project is not simple. It involves cross-referencing several annual reporting documents from National Highways and the Office of Rail and Road which are not updated with changes made in the interim. This is not accessible or transparent, especially given the frequent and significant changes that can be made to the RIS programme. That the Minister responsible for strategic road investment was not able to provide us with an up-to-date progress report on the RIS 2 portfolio exemplifies how challenging it can be to track RIS progress. Reporting on the delivery of RIS portfolios must be simplified and made more accessible. (Paragraph 67)

14. *The Government should work with National Highways to introduce a "live" project dashboard which provides up-to-date information on each project in the RIS 1, RIS 2 and subsequent RIS portfolios. The dashboard should provide information on original and current: costs; Start of Work date; Open for Traffic date; and planning status (if applicable).* (Paragraph 68)

Formal minutes

Tuesday 18 July 2023

Members present:

Iain Stewart, in the Chair

Mike Amesbury

Jack Brereton

Sara Britcliffe

Ruth Cadbury

Karl McCartney

Gavin Newlands

Draft Report (*Strategic road investment*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 68 read and agreed to.

Summary agreed to.

Resolved, That the Report be the Sixth Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

Adjourment

[Adjourned till tomorrow at 9.30 am

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Wednesday 1 February 2023

Dame Bernadette Kelly DCB, Permanent Secretary, Department for Transport; **Emma Ward CBE**, Director General for Roads, Places and Environment Group, Department for Transport; **Nick Harris**, Chief Executive, National Highways Q1–105

Wednesday 1 March 2023

Edmund King, President, The AA; **Sharon Kindleysides**, Chief Executive Officer, Chartered Institute of Logistics and Transport; **Jonathan Walker**, Head of Cities and Infrastructure Policy, Logistics UK; **Guy Dangerfield**, Head of Transport User Strategy, Transport Focus Q106–161

Lisa Hopkinson, Associate, Transport for Quality of Life; **Ralph Smyth**, Advisor, Transport Action Network; **Professor Glenn Lyons**, Professor of Future Mobility, University of the West of England Q162–189

Wednesday 29 March 2023

Naomi Green, Managing Director, England's Economic Heartland; **Maria Machancoses**, Chief Executive Officer, Midlands Connect; **Darren Oldham**, Director for Rail and Road, Transport for the North Q190–220

Richard Holden MP, Parliamentary Under-Secretary of State for Roads and Local Transport, Department for Transport; **Emma Ward CBE**, Director General for Roads, Places and Environment, Department for Transport; **Kate Cohen**, Director for Roads and Projects Infrastructure, Department for Transport Q221–272

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

SRI numbers are generated by the evidence processing system and so may not be complete.

1 Action for Yorkshire Transport (SRI0004)

2 ADEPT – Association of Directors of Environment, Economy, Planning & Transport (SRI0015)

3 Anable, Professor Jillian (Professor of Transport and Energy, University of Leeds); and Professor Goodwin, Phil (Emeritus Professor of Transport Policy, University College London and the University of the West of England) (SRI0036)

4 Arundel Bypass Neighbourhood Committee (SRI0001)

5 CIHT (SRI0020)

6 CPRE Peak District and SOuth Yorkshire (SRI0035)

7 CPRE, the countryside charity (SRI0027)

8 Cambridgeshire and Peterborough Combined Authority (SRI0055)

9 Campaign for Better Transport (SRI0042)

10 CoMoUK (SRI0048)

11 Cuss, Edmund Camerer (SRI0003)

12 Cycling UK (SRI0051)

13 Department for Transport (SRI0039)

14 England's Economic Heartland (SRI0046)

15 Eyre, Mr Sam (Undergraduate Student, University of Sheffield) (SRI0008)

16 Gadsby, Mr Philip (SRI0006)

17 Gillham, Dr Christopher (SRI0047)

18 Gravesham Borough Council (SRI0034)

19 Green Alliance (SRI0021)

20 Hammond, Mr Peter (SRI0002)

21 ITS United Kingdom (SRI0058)

22 Institution of Civil Engineers (SRI0029)

23 Keene, Dr Suzanne (SRI0024)

24 Living Streets (SRI0038)

25 Local Government Technical Advisers Group (LGTAG) (SRI0018)

26 Logistics UK (SRI0022)

27 Lyons, Professor Glenn (Mott MacDonald Professor of Future Mobility, University of the West of England, Bristol) (SRI0014)

28 MTRU (SRI0054)

29 Marsden, Professor Greg (Professor of Transport Governance, Institute for Transport Studies, University of Leeds) (SRI0010)

30 Metz, Dr David (honorary professor, Centre for Transport Studies, University College London) (SRI0005)

31 Midlands Connect (SRI0040)

32 Mineral Products Association (SRI0041)

33 Office of Rail and Road (SRI0030)

34 Oxfordshire County Council (SRI0044)

35 RHA (SRI0043)

36 Ringway Infrastructure Services Limited (SRI0007)

37 Rogers, Bill (Chair, South Coast Alliance for Transport and the Environment, East Sussex) (SRI0023)

38 Sustrans (SRI0019)

39 Thames Crossing Action Group (SRI0049)

40 The Stonehenge Alliance (SRI0017)

41 Transport Action Network (SRI0059)

42 Transport Focus (SRI0011)

43 Transport Futures East Sussex (SRI0053)

44 Transport North East (SRI0031)

45 Transport Planning Society (SRI0013)

46 Transport for Quality of Life (SRI0012)

47 Transport for West Midlands (SRI0033)

48 Transport for the North (SRI0028)

49 Transport for the South East (SRI0037)

50 Wagland, Kay (SRI0057)

51 Walberton Parish Council (SRI0045)

52 Wellby, Ian (SRI0052)

53 Wiltshire Climate Alliance, Transport Topic Group (SRI0026)

54 Woodland Trust (SRI0016)

55 techUK (SRI0056)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the publications page of the Committee's website.

Session 2022–23

Number	Title	Reference
1st	Road freight supply chain	HC 162
2nd	The Integrated Rail Plan for the North and Midlands	HC 292
3rd	Fuelling the future: motive power and connectivity	HC 159
4th	Implementation of the National Bus Strategy	HC 161
5th	Maritime 2050	HC 160
1st Special	UK aviation: reform for take-off: Government response to the Committee's Fifth Report of Session 2021–22	HC 542
2nd Special	Road freight supply chain: Government response to the Committee's First Report	HC 701
3rd Special	Road Pricing: Government Response to the Committee's Fourth Report of Session 2021–22	HC 1178
4th Special	Fuelling the future: motive power and connectivity: Government response to the Committee's Third Report	HC 1382
5th Special	Maritime 2050: Government Response to the Committee's Fifth Report	HC 1420
6th Special	Implementation of the National Bus Strategy: Government response to the Committee's Fourth Report	HC 1431
7th Special	The Integrated Rail Plan for the North and Midlands: Government response to the Committee's Second Report	HC 1729

Session 2021–22

Number	Title	Reference
1st	Zero emission vehicles	HC 27
2nd	Major transport infrastructure projects	HC 24
3rd	Rollout and safety of smart motorways	HC 26
4th	Road pricing	HC 789
5th	UK aviation: reform for take-off	HC 683
1st Special	The impact of the coronavirus pandemic on the aviation sector: Interim report: Government Response to the Committee's Fifth Report of Session 2019–21	HC 28
2nd Special	Road safety: young and novice drivers: Government Response to Committee's Fourth Report of Session 2019–21	HC 29

Number	Title	Reference
3rd Special	Trains Fit for the Future? Government Response to the Committee's Sixth Report of Session 2019–21	HC 249
4th Special	Safe return of international travel? Government Response to the Committee's Seventh Report of Session 2019–21	HC 489
5th Special	Zero emission vehicles: Government Response to the Committee's First Report	HC 759
6th Special	Rollout and safety of smart motorways: Government Response to the Committee's Third Report	HC 1020
7th Special	Major transport infrastructure projects: Government Response to the Committee's Second Report	HC 938

Session 2019–21

Number	Title	Reference
1st	Appointment of the Chair of the Civil Aviation Authority	HC 354
2nd	The impact of the coronavirus pandemic on the aviation sector	HC 268
3rd	E-scooters: pavement nuisance or transport innovation?	HC 255
4th	Road safety: young and novice drivers	HC 169
5th	The impact of the coronavirus pandemic on the aviation sector: Interim report	HC 1257
6th	Trains fit for the future?	HC 876
7th	Safe return of international travel?	HC 1341

Climate Policy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tcpo20

A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris-compliant pathways

Kevin Anderson , John F. Broderick & Isak Stoddard

To cite this article: Kevin Anderson , John F. Broderick & Isak Stoddard (2020): A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris-compliant pathways, Climate Policy, DOI: 10.1080/14693062.2020.1728209

To link to this article: [redacted]

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A factor of two: how the mitigation plans of 'climate progressive' nations fall far short of Paris-compliant pathways

Kevin Anderson [a,b,c], John F. Broderick [a] and Isak Stoddard [b,c]

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ABSTRACT

The Paris Agreement establishes an international covenant to reduce emissions in line with holding the increase in temperature to 'well below 2°C … and to pursue … 1.5°C.' Global modelling studies have repeatedly concluded that such commitments can be delivered through technocratic adjustments to contemporary society, principally price mechanisms driving technical change. However, as emissions have continued to rise, so these models have come to increasingly rely on the extensive deployment of highly speculative negative emissions technologies (NETs). Moreover, in determining the mitigation challenges for industrialized nations, scant regard is paid to the language and spirit of equity enshrined in the Paris Agreement. If, instead, the mitigation agenda of 'developed country Parties' is determined without reliance on planetary scale NETs and with genuine regard for equity and 'common but differentiated responsibilities and respective capabilities', the necessary rates of mitigation increase markedly. This is evident even when considering the UK and Sweden, two nations at the forefront of developing 'progressive' climate change legislation and with clear emissions pathways and/or quantitative carbon budgets. In both cases, the carbon budgets underpinning mitigation policy are halved, the immediate mitigation rate is increased to over 10% per annum, and the time to deliver a fully decarbonized energy system is brought forward to 2035-40. Such a challenging mitigation agenda implies profound changes to many facets of industrialized economies. This conclusion is not drawn from political ideology, but rather is a direct consequence of the international community's obligations under the Paris Agreement and the small and rapidly dwindling global carbon budget.

Key Policy Insights

- Without a belief in the successful deployment of planetary scale negative emissions technologies, double-digit annual mitigation rates are required of developed countries, from 2020, if they are to align their policies with the Paris Agreement's temperature commitments and principles of equity.
- Paris-compliant carbon budgets for developed countries imply full decarbonization of energy by 2035-40, necessitating a scale of change in physical infrastructure reminiscent of the post-Second World War Marshall Plan. This brings issues of values, measures of prosperity and socio-economic inequality to the fore.

ARTICLE HISTORY
Received 19 July 2019
Accepted 5 February 2020

KEYWORDS
Carbon budgets; Developed country mitigation; Paris Agreement; CBDR&RC; Negative Emissions Technologies (NETs); Energy sector emissions

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Supplemental data for this article can be accessed [redacted]

This article has been republished with minor changes. These changes do not impact the academic content of the article.

- The stringency of Paris-compliant pathways severely limits the opportunity for inter-sectoral emissions trading. Consequently aviation, as with all sectors, will need to identify policies to reduce emissions to zero, directly or through the use of zero carbon fuels.
- The UK and Swedish governments' emissions pathways imply a carbon budget of at least a factor of two greater than their fair contribution to delivering on the Paris Agreement's 1.5-2°C commitment.

1. Introduction

The 2015 Paris Agreement established an unprecedented international covenant to hold 'the increase in the global average temperature to well below 2°C… and to pursue efforts to limit the temperature increase to 1.5°C.' (UN, 2015). Whilst the precise legal reading of the Agreement remains open to interpretation, this paper takes world leaders' commitments, and their accompanying speeches (G7, 2016; Lövin, 2018; May, 2017), at face value, comparing the national (territorial) mitigation strategies of two 'climate progressive' nations (UK and Sweden) against the demands enshrined in the Paris Agreement.[1]

The language of 'well below 2°C' is interpreted here as implying an absolute duty, whilst to 'pursue … 1.5°C' is regarded as aspirational intent. Key to delivering on the Paris Agreement is the recognition that peaking emissions 'will take longer for developing country Parties' (Paris Agreement Article 4.1). This draws an important distinction, through the principle of 'common but differentiated responsibilities and respective capabilities' (CBDR&RC), between the expected mitigation efforts of different nations (e.g. Article 4.1 and 4.4).

Against this backdrop, and with a focus on energy-related CO_2 emissions, this paper uses carbon budgets as a guide to define the 1.5–2°C mitigation challenge, and to quantify budget allocations between 'developed' and 'developing' country Parties. To facilitate comparison between Parties, the carbon budget assumptions are presented clearly and directly.

Significantly, the analysis excludes planetary-scale negative emissions technologies (NETs). Certainly, there are strong arguments for the research, development and potential deployment of NETs[2], but their ubiquitous inclusion at the scale assumed in IPCC mitigation scenarios (Fuss et al., 2014), including within the UK and Sweden's climate strategies, is premature (Larkin, Kuriakose, Sharmina, & Anderson, 2018). The profound implications of assuming NETs at scale and of failing to differentiate mitigation efforts between the developed and developing country Parties are key issues explored within this paper (Appendix A details the reasoning for excluding NETs).

2. Carbon budgets as a guide to Paris-compliant mitigation

The concept of carbon budgets has, for over a decade, underpinned mitigation studies (Allen et al., 2009; Anderson & Bows, 2011; Bows, Mander, Starkey, Bleda, & Anderson, 2006; Knutti & Rogelj, 2015; Raupach et al., 2014; Rockström et al., 2017) and offered a robust scientific foundation for informing mitigation policies (Matthews, Zickfeld, Knutti, & Allen, 2018).

Following the Paris Agreement's inclusion of 'pursuing efforts to … 1.5°C', the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) requested the Intergovernmental Panel on Climate Change (IPCC) to consider the impacts of 1.5°C of warming and the related emissions pathways. The subsequent 2018 Special Report, Global Warming of 1.5°C (IPCC 2018, SR1.5), presents a simplified table of carbon budgets against temperature (Table 2.2, Chapter 2), similar to that contained in the IPCC's earlier Fifth Assessment (AR5) Synthesis Report (Table 2.2; IPCC, 2014). When comparing the IPCC reports, the tabulated budget values are substantially larger in SR1.5, by around 60% and 250%, respectively, for the 67% chance of staying below 2°C and 1.5°C.

Differences in carbon budgets for a given probability of a given temperature threshold arise for several reasons. SR1.5 budgets are summed to the point of net-zero global CO_2 emissions, whilst AR5 budgets were summed to the point of reaching a given temperature change. Further, SR1.5 budgets are based on the *transient climate response to cumulative carbon emissions* (TCRE), a measure of warming for a given quantity of CO_2 which can be informed by observations. The impact of non-CO_2 greenhouse gases (GHGs) and aerosols assumed for

the twenty-first century is estimated separately to CO_2, along with the choice of model for assessing their warming effect. The Earth System Models (ESMs) used by AR5 include a range of climate feedbacks. Such feedbacks are estimated separately in SR1.5, suggesting a reduction in carbon budgets by 100 $GtCO_2$ to 2100, with a potentially greater response following this date.

When considering mitigation strategies, it is important to be aware that carbon budgets, although offering a scientifically robust framework, are necessarily the product of a range of evolving assumptions (Rogelj, Forster, Kriegler, Smith, & Séférian, 2019). Provisional results suggest that the range of climate sensitivity in the forthcoming IPCC Sixth Assessment Report (AR6) may increase as improved characterization of feedbacks are included in ESMs (Belcher, Boucher, & Sutton, 2019). Moreover, if the observed rise in the concentration of atmospheric methane is, in significant part, a consequence of increasing methane release from warming tropical regions (Mikaloff & Schaefer, 2019; Nisbet et al., 2016), then the more optimistic non-CO_2 assumptions within SR1.5 may need revisiting. In light of this, and being cognisant of the UNFCCC's precautionary principle (Article 3.3, 1992), the budgets outlined in the following section should be regarded as the minimum necessary to achieve the Paris Agreement's goals.

3. Translating the Paris agreement objectives into carbon budgets

As with the 2009 Copenhagen Accord and various intergovernmental political declarations, such as those of the G-7, the Paris Agreement adopted qualitative language to define quantitative temperature limits. Whilst the exact wording within such documents has varied, it would be disingenuous to suggest anything other than an international consensus aligned with, at the very least, a 'likely' chance of remaining below 2°C. The Paris Agreement's inclusion of 1.5°C significantly ramped up this commitment, tightening still further the acceptable likelihood of remaining well below 2°C, if not 1.5°C.

In its guidance to authors, the IPCC (2010) provides a taxonomy of likelihoods that can be used to translate qualitative language into quantitative probabilities. Progressing a sequential logic from the language of the Paris Agreement through the IPCC's scale of likelihoods conservatively transposes the Agreement into somewhere between a 'likely' (66–100% probability) chance of reaching 2°C and 'about as likely as not' (33–66%) for 1.5°C. Working from this, a carbon budget of 900 $GtCO_2$ (from January 2018) is adopted here to reflect the Paris Agreement's temperature objectives. SR1.5 relates 900 $GtCO_2$ with a likely peak warming of 1.7°C above a 1850–1900 baseline (Table 2.2, IPCC 2018), with an equal expectation of temperature change being higher and lower, reflecting the intention to 'hold the increase in the global average temperature to well below 2°C'. The likelihood of remaining below 1.5°C is less than 33%, with smaller budgets facing proportionally larger uncertainties, aside from the observed TCRE uncertainty. By considering a larger budget the proportionate impact of these uncertainties is reduced, though remains substantial.[3]

Subsequently, a deduction is made of 100 $GtCO_2$ from Earth system feedbacks (based on SR1.5) along with two years (2018/19) of fossil fuel and cement process emissions (assuming a growth rate of, respectively, 2.0% and 1.6% (Korsbakken, Andrew, & Peters, 2019)) and static CO_2 emissions from land use, land-use change and forestry (LULUCF) using a 2017 baseline (Global Carbon Project, 2018). These sum to 84 $GtCO_2$, giving a global 'Paris-compliant' carbon budget, for all CO_2 sources, and from the start of 2020, of 716 $GtCO_2$.

3.1. Global overheads for cement and land use change and forestry

This paper specifically focuses on carbon emissions arising from energy, ultimately disaggregating a Paris-compliant global carbon budget to nations, with the UK and Sweden as two case studies. Consequently, it is necessary to remove the prospective cumulative emissions associated with non-energy sources of CO_2. These are dominated by two sources: emissions released from chemical reactions during cement production (i.e. process emissions) and those arising from ongoing deforestation. Typically, emissions from these sources are, implicitly at least, held to be the sole responsibility of the country of origin. Here, however, informed by the principle of CBDR&RC, such emissions are considered as a 'global overhead'. The specific ethical reasons for this choice are detailed in the following subsections 3.1.1 and 3.1.2. The implication of this approach is that the responsibility for these non-energy emissions is distributed amongst all nations, and not solely those developing country parties from where the majority of such emissions arise. This approach extends the incentive to address

cement process and deforestation emissions to all nations, as failure to mitigate them reduces each nation's energy-only carbon budget; that is, the higher the global non-energy emissions of CO_2, the smaller the energy-only global carbon budget, and hence its apportionment between nations.

3.1.1. Future emissions from cement production

The majority of developed country Parties already have extensive cement-rich infrastructures. By contrast, many developing country Parties are either undertaking, or just beginning, major infrastructure programmes. The cement intensity of new infrastructure can be reduced through material substitution, alternative clinkers and more resource-efficient designs (IEA, 2018). Even with such changes, the portfolio of scenarios assessing the prospects of cement envisage ongoing global growth in the sector, driven in large part by infrastructure programmes within emerging and developing countries (IEA, 2018; van Ruijven et al., 2016).

As it stands today, the difference in the cement intensity (i.e. kg-cement/person-year) between developed countries with mature infrastructure and those developing nations rapidly constructing such infrastructure, ranges between a factor of two and five (see Appendix B for more detail). Put simply, whilst there are, at scale, substitutes for fossil fuel energy, as yet there are no such substitutes, at scale, for cement. Consequently, and given the key role of cement in facilitating development, penalizing poorer and industrializing nations for rapid infrastructure expansion runs counter to the concept of CBDR&RC.

Nevertheless, whilst ethical considerations are important, the global cement industry cannot be exempt from deep and rapid decarbonization. The inclusion here of the cement sector as a 'global overhead' does not exempt nations with high cement use from seeking to reduce process emissions, rather it puts pressure on the global industry to rapidly curtail its emissions. Failure to do so only puts further downwards pressure on global, and hence national, energy-only carbon budgets that are already at the threshold of what is achievable.

The IEA's Cement Technology Roadmap (2018) provides a core scenario for global cement growth. This scenario not only breaks from the historical precedent of cement as a key manufactured material, but also assumes the rapid uptake of low-carbon technologies, including carbon capture and storage (CCS), across the sector. Despite reservations as to the appropriateness of the IEA scenario, it is their 2DS low-carbon road map, subsequently extrapolated to complete decarbonization by 2075, that informs the analysis here. This extended road map equates to a total carbon budget, from 2020 onwards and for cement-based process emissions only, of a highly optimistic 60 $GtCO_2$ (Appendix B details this estimate and the reservations with the IEA analysis).

The scale of ambition implied by the extrapolated IEA roadmaps requires an immediate and concerted global effort by the cement industry, with much lower rates of growth and elimination of all process emissions by 2075. If, instead, the sector grows in line with its post-2000 or post-2010 average annual rates of 5.1% and 3.4% (and assuming the IEA's carbon-intensity improvement) then, respectively, the sector's 2020–2075 process emissions would be 140 and 100 $GtCO_2$. This would have major implications for energy decarbonization rates, potentially making Paris-compliant carbon budgets unachievable.

3.1.2. Future emissions from deforestation

Prior studies have excluded LULUCF, noting that this sector makes up a small and declining fraction of emissions with high measurement uncertainty (Raupach et al., 2014; Robiou du Pont, Jeffery, Gütschow, Christoff, & Meinshausen, 2016). However, the equity-based arguments made for allocating cement process emissions as a global overhead (i.e. no alternative at scale) rather than the sole responsibility of individual nations, similarly hold for emissions arising from deforestation. In the process of industrialization, many developed country Parties underwent significant levels of deforestation accessing land for agriculture and development (Ramankutty & Foley, 1999). Placing all responsibility for current deforestation emissions on those developing country Parties following similar patterns of industrialization is inconsistent with the equity steer of the climate change regime, and more specifically the core principle of CBDR&RC. Further reinforcing this global overhead argument is the fact that two of the key drivers for deforestation are globalized agricultural and, to a lesser extent, timber markets,[4] alongside more multifaceted and regional factors.

Considering deforestation emissions as a global overhead does not absolve deforesting nations from responsibility. It does, however, reduce the burden on them, providing an incentive for all nations to encourage a

global reduction in deforestation, not least because the lower the total emissions from deforestation, the greater the available global carbon budget for the energy sector.

Given that this paper is premised on a global decarbonization agenda consistent with the Paris Agreement, it is assumed here that there is an increased emphasis on rapidly reducing and ultimately eliminating LULUCF emissions. Beyond this, it is anticipated that a programme of ambitious net carbon sequestration is pursued across global forests, such that between 2020 and 2100, emissions from deforestation and degradation are balanced by the carbon uptake in managed LULUCF sequestration. As such, within this analysis the post-2020 global carbon budgets are unaffected by the dynamics of forestry carbon emissions and sequestration.[5] Consequently, and with the explicit and highly optimistic assumptions on cement, the Paris-compliant global carbon budget for energy-only emissions reduces to 656 $GtCO_2$ from 2020 onwards.

4. Apportioning the global carbon budget

This paper develops a pragmatic apportionment regime, building on Anderson and Bows (2011). Ambitious peak dates and mitigation rates for developing country parties are considered first, before proposing pathways within the total global carbon budget constraint. This resource sharing approach recognizes principles of equity in that it allows for a delayed emissions peak and lower initial mitigation rates for the developing country Parties, but only to the degree that these are still physically possible to deliver within a Paris-compliant global carbon budget. A more precise reading of the principle of CBDR&RC, would suggest such an approach falls far short of an equitable sharing of the climate burden, but it does provide a useful complementary analysis to other 'effort sharing' regimes, such as The Climate Equity Reference Framework (Holz, Kartha, & Athanasiou, 2017).

4.1. Classification of developed & developing country parties

The Paris Agreement recognizes 'that peaking will take longer for developing country Parties', and, throughout the text, draws specific attention to the 'least developed countries and small island developing States'. The precise nomenclature separating developed from developing nation groups has evolved since the UNFCCC's differentiation of Parties between Annex I and non-Annex I, which was also carried over to the 1997 Kyoto Protocol. However, the international climate negotiations continue to embed differential mitigation efforts between developed and developing country Parties. Although UNFCCC preambular language referring to historical responsibility was not included in the Paris Agreement, the principle of CBDR&RC did remain (recitations, Article 2 para 2, Article 4 paras 3 and 19), albeit with the qualifier 'in light of national circumstances', as do references to equity and developed country leadership.

Within the Paris Agreement and the texts of subsequent COP decisions, the nations comprising developing and developed country Parties are not specified. Elsewhere, and in relation to climate change, the UN system tends to equate developing country parties with the 'G77 and China' grouping (a total now of 134 nations).[6] It is this distinction between developed and developing nations, that informs the approach adopted here. However, the boundary of this distinction requires clarification as there are a small numer of G77 countries with inconsistent development rankings, alongside a similarly small set of nations excluded from any classification.

To reveal the implications of such anomalies on the apportionment of the global budget to developing and developed country Parties, two pairs of adjusted classifications are here proposed. The first allocates nations excluded from any UN classification to either the developed or developing country Parties; this gives two new groups, Develop*ed* 1 (DD1) and Develop*ing* 1 (DG1). The second re-allocates those few oil-rich wealthy nations still classified as developing, but with GDP per capita and human development index (HDI) values well above the mean of developed nations. This gives rise to two more groups DD2 and DG2, full details of which are in Appendix C.

Within both the DG1 and DG2 groupings, the carbon budget of China dominates, masking how many poorer nations will inevitably peak their emissions later than China. This differentiation within the developing country Parties does not, however, detract from the reasoning for drawing a distinction between developed and developing. Considering China in isolation, its relative economic output demonstrates just how far removed it still is

from the developed group (DD2), with a GDP per capita of just 23% of that for DD2 (39% using PPP) or just 14% when compared with the USA (28% PPP basis).

4.2. CO_2 pathways for developing nations and budget implications for developed nations

Heuristic CO_2 pathways are first generated for developing country Parties (DG1 and DG2), informed by the Paris Agreement's framing of equity and, through a process of iteration, within a set of associated constraints.[7] Pathways progress from current rates of growth, through a 2025 peak in emissions, increasing to a maximum 10% mitigation rate, a timeframe and rate far more ambitious than in other similar global and national analyses (cf Arup, 2016; Holz et al., 2017; Wang & Watson, 2010). The pathway is for territorial fossil fuel CO_2 emissions only, including bunker fuel emissions arising from international aviation and shipping. Global bunker estimates are taken as the difference between the Global Carbon Project's (GCP, 2018) world emissions and the sum of all the national emissions within the GCP database. Bunker fuel emissions are subsequently apportioned to developing and developed country Parties on the basis of their respective proportion of global emissions excluding bunkers.[8] This approach finds 2017 emissions to be as follows: DG1: 20.5 $GtCO_2$; DD1 14.3 $GtCO_2$; DG2 19.0 $GtCO_2$; and DD2 15.8 $GtCO_2$.

For 2018, the BP Statistical Review (2019) reports global emissions to have increased by 2.0%, with a 2.9% rise in non-OECD countries (used here as an approximation for developing nations). From 2019, the pathway adopts emissions growth in line with the developing country Party five year average annual growth rate (1.8% per annum, p.a.), declining as it approaches the 2025 peak year. Beyond 2025 the pathway commences an escalating rate of mitigation, rising from at 0.1% in the first post-peak year to a 1% total reduction by year four, before increasing at 0.5% each year to a maximum of 10% p.a. 22 years after the peak, as illustrated in Figure 1.

Whilst the DG1 and DG2 pathways (Figure 1) are highly ambitious, they nevertheless equate to cumulative emissions from 2020 of, respectively, 561 and 520 $GtCO_2$. Consequently, even with an unprecedented departure from historical and recent emission trends, cumulative CO_2 emissions solely from the developing country Parties represent 79–86% of the post 2020 Paris-compliant global carbon budget. The remaining budget range for the developed nations (DD1 and DD2) is 95 and 136 $GtCO_2$. Transposing these budgets into annual mitigation rates suggests immediate and prolonged cuts of, respectively, 14% and 11% p.a. (Figure 1b). If developing country emissions do not decline immediately after peaking, and instead plateau for 5 years, they occupy all or nearly all of the global carbon budget (673 and 624 $GtCO_2$ for DG1 and DG2 respectively).

4.3. Apportioning the developed country Parties' carbon budget to nations

There are various options for apportioning a finite carbon budget between countries, including population-based approaches, grandfathering and allocations founded on, for example, economic resouces and historical responsibility (Rose, Stevens, Edmonds, and Wise, 1998; Kanitkar, Jayaraman, D'Souza, and Purkayastha, 2013; Raupach et al., 2014; Robiou du Pont et al., 2016; Holz et al., 2017). Apportionment on the basis of population has immediate egalitarian appeal over grandfathering, especially where the levels of emissions vary significantly. However, population-based regimes overlook a range of critical parameters. They do not take account of historical emissions, capacity to finance decarbonization, renewable energy resources, the inertia of existing high-carbon and fossil-fuel infrastructure, nor the carbon-intensity of the existing economy. A more functional, comprehensive and arguably fairer amalgamation of factors can be found in grandfathering, the approach adopted here. A potential weakness of grandfathering is that it risks penalizing those nations already on a Paris-compliant pathway. In practice, however, no industrialized nation is even approaching such rates of mitigation, and even where moderate progress has been made, as in the UK, it typically excludes emissions from international aviation and shipping.

5. How near to Paris? A case study of 'climate progressive' developed country Parties

The Paris framework of Nationally Determined Contributions (NDCs) marks a substantial change from the earlier Kyoto Protocol, with all nations (developed and developing) submitting voluntary emission pledges. It is clear, however, that the present aggregated sum of NDCs falls far short of the Paris Agreement's 1.5–2°C goals, (UNEP,

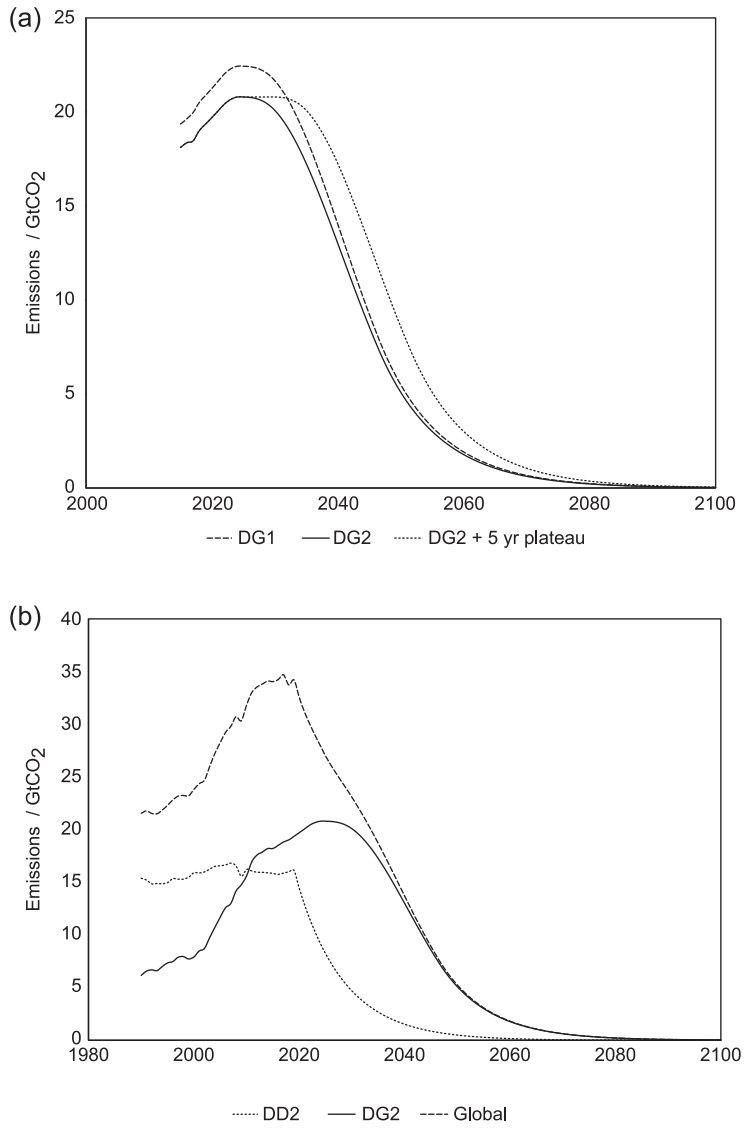

Figure 1. Fossil fuel only CO_2 pathways for (a) developing country Parties, with DG1 plus 5 year plateau omitted for clarity, and (b) developing and developed country parties for groupings DG2 and DD2. DG1 and DD1 pathways are not substantially different in profile.

2018), with nations expected to propose revised NDCs in 2020, in preparation for the 'Global stocktake' of progress beginning in 2023.

As 2020 approaches, it is worthwhile assessing the progress and plans of industrialized nations heralded as 'leading' on mitigation. The UK and Sweden are at the vanguard of detailing primary legislation designed to frame total national emissions through direct carbon budgets (UK) and net-zero goals (UK and Sweden). Downscaling the developed country Parties' budget from Section 4 into simple mitigation pathways, and hence decarbonization rates, provides a quantitative framework against which the UK and Sweden's mitigation plans can be judged.

Grandfathering the energy-only CO_2 budget of the developed country Parties (from a 2012–2017 baseline) allocates 3.0% (DD1) and 2.7% (DD2) to the UK and 0.30% (DD1) and 0.28% (DD2) to Sweden. To provide a simplified mitigation pathway from the start of 2020 onwards, carbon budgets are transposed into annual mitigation rates (Table 1). These pathways assume a constant rate of reduction, beginning January 2020 and maintaining

Table 1. UK and Sweden's Paris-compliant post-2019 energy-only CO2 budget and associated minimum mitigation rates. DD is abbreviation for Developed country Parties.

	Share of DD1 carbon budget (94 $GtCO_2$)	Minimum mitigation rate DD1	Share of DD2 carbon budget of (135 $GtCO_2$)	Minimum mitigation rate DD2
UK	2800 $MtCO_2$	13% *p.a.*	3700 $MtCO_2$	10% *p.*a.
Sweden	280 $MtCO_2$	15% *p.a*	370 $MtCO_2$	12% *p.*a

Note: DD1 follows the current UN classification (see Appendix C), DD2 updates this list, with several nations with very high PPP/capita and a high human development index (HDI) moved from the developing to the developed country Parties. The average mitigation rates for developed country Parties ranges from 11% (DD2) to 14% (DD1).

total emissions within the given budgets. However, political inertia, increasing returns to scale and so-called hard-to-abate sectors suggest that it will take several years to transition from current gradual mitigation efforts to rates consistent with delivering Paris-compliant carbon budgets. Consequently, these rates of mitigation we estimate here will likely underplay the actual rates that would be required by the early to mid 2020s.

5.1. CO_2 emissions implicit in UK current policy pathway

The Climate Change Act (2008) established a number of government powers and responsibilities, chief among them a series of five year carbon budgets and a longer term reduction commitment for 2050. The Committee on Climate Change (CCC) was established as a statutory body to advise government on the appropriate levels of carbon budgets and to feedback progress against these and the 2050 commitment. To date, the UK has set carbon budgets to 2032 and a long term target of net-zero emissions by 2050. Emissions are currently within the limits prescribed by the first two complete carbon budgets and are expected to be below the third budget ending in 2022.

All of the Kyoto Protocol basket of six GHGs are included in the UK's legislated carbon budgets, as are removals by land use change and the purchase of internationally traded carbon units (both reductions credits and cap-and-trade allowances). Therefore, direct comparison with the budgets and mitigation rates derived in the preceding section requires a series of adjustments. Data from the UK Department of Business, Energy and Industrial Strategy report CO_2 separately; however, for the period to 2032, non-CO_2 GHGs are deducted from headline carbon budgets made using the CCC Fourth Carbon Budget medium abatement scenario (CCC, 2010). A linear path to the 2050 CO_2 values described in the Further Ambition scenario is then followed (CCC, 2019). International aviation and shipping emissions are not counted as a UK source within the Climate Change Act. They are added here using the Department for Transport central forecast to 2050[9], assuming the construction of a new runway at Heathrow (as approved by government in 2018), and supposing a linear pathway for shipping based on the Internatinal Maritime Organisation's (IMO) strategy to reduce emissions to 50% of 2008 levels by 2050. The CCC's (2010) central scenario for cement sector emissions is deducted to align with our global overhead for cement. All CO_2 emissions remaining in 2050 are then assumed to taper to zero by 2075 (see Figure 2). This remainder sums to 670 $MtCO_2$ or ~7% of the 2020–2100 total.

Under these assumptions, from 2020 to 2100, UK emissions total 9,000 $MtCO_2$, more than double that of the DD2 pathway (three times the sum of the DD1 pathway). Similarly, the equivalent annual CO_2 reduction rate is approximately 5% versus 10%. The Climate Change Act initially legislated for an 80% reduction from a 1990 baseline, with the 2019 alteration to a net-zero target in 2050 reducing the total implicit cumulative emissions by 13% (1300 $MtCO_2$). As such, and despite the adoption of a net-zero target, the key conclusion of this analysis remains unchanged. The UK emissions pathway implies a carbon budget at least a factor of two greater than the UK's Paris-compliant budget estimated here (DD2).

5.2. CO_2 emissions implicit in Swedish current policy pathway

A new 'climate policy framework' was adopted by the Swedish parliament in 2017. The framework builds on the recommendations of the Swedish Cross-Party Committee on Environmental Objectives and includes long term

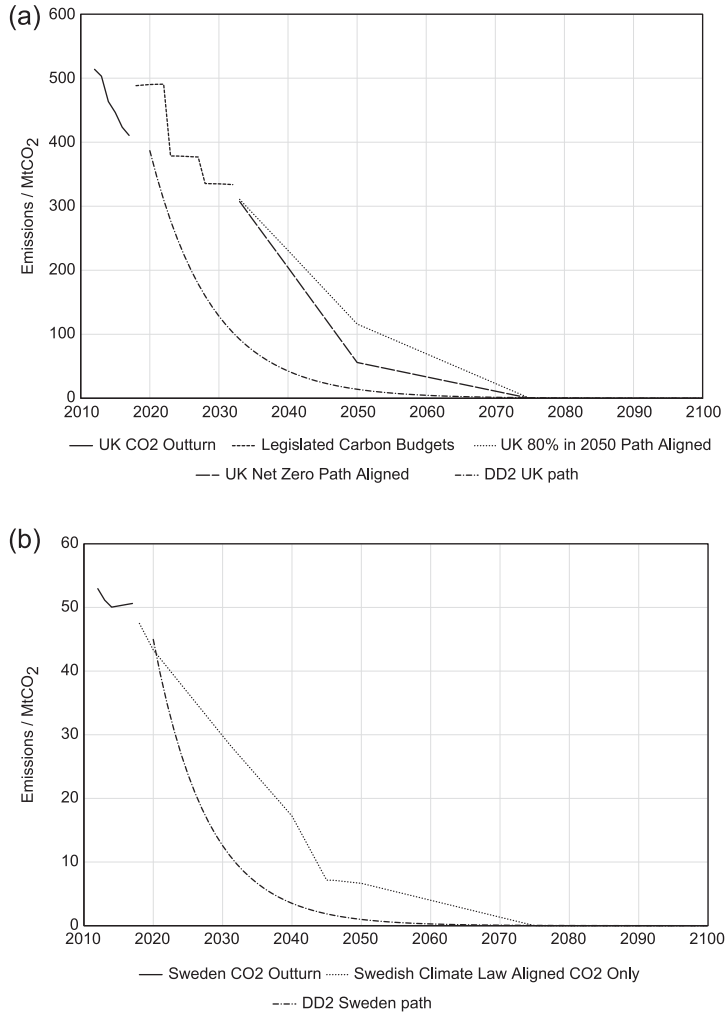

Figure 2. National climate policy frameworks aligned to the scope of developed country pathway DD2 for (a) UK Climate Change Act for both 80% & net-zero by 2050 targets, and (b) Swedish Climate Law.

targets for emission reductions, a Climate Law (which came into force in January 2018) and the setting up of a Climate Policy Council (CPC). The long term targets comprise an overarching goal of net-zero emissions by 2045, alongside a number of subgoals addressing emissions covered by the EU's Effort Sharing Regulation (ESR), including a sector-specific goal for national transport emissions. The Climate Law places statutory requirements on the Swedish government to align its climate policies and action plans with the framework's long term targets and to provide annual reports on progress in conjunction with submitting a draft budget bill. Similar to the UK's CCC, the CPC is an interdisciplinary agency tasked with evaluating how closely government policies align with the climate targets enshrined in the climate policy framework.

Despite being informed by the UK's Climate Change Act and advised by the UK's CCC, the Swedish climate policy framework excludes direct reference to carbon budgets and adopts a less robust mandate for the CPC. Nonetheless, a carbon budget can be derived from the emission targets included within the framework and emission pathways presented by the CPC. As the Swedish emission targets include all GHGs, non-CO_2 gases are deducted from the pathways, assuming a constant proportion between emitted CO_2 and other GHGs across the period of analysis. Emissions from international aviation and shipping are added. Aviation is based on the Swedish Transport Administration's headline growth scenario and the International Aviation Transport

Association's (IATA) 2050 objective to reduce net aviation CO_2 emissions by 50% by 2050, relative to 2005 levels, whilst shipping takes the IMO's 2050 objective. These calculations are based on bunker fuels which, for aviation, potentially underestimate total annual CO_2 emissions attributable to Swedish residents' international air travel by up to 50% (Larsson, Elofsson, Sterner, & Åkerman, 2019). To align with the global overhead framing, presented in Section 3, process emissions from Sweden's cement sector are deducted from the budget, assuming they remain constant to 2030 before following a linear mitigation trajectory to zero emissions by 2045. As for the UK, all remaining emissions in 2050 are extrapolated to zero by 2075 (see Figure 2). This remainder sums to 80 $MtCO_2$ or ~10% of the 2020–2100 total. Appendix D details the assumptions underpinning the proposed pathway.

Sweden's climate policy framework allows for so-called 'complimentary measures' to contribute to meeting the emission targets; these include international offsets, increased uptake from land and forest, and biomass energy with carbon capture and storage (BECCS). For the overarching goal of net-zero emission by 2045, emissions are to be 85% lower than 1990 levels, leaving a potential 15% (10.7 $MtCO_2e$) to be covered by 'complimentary measures' annually. For the subgoals associated with the EU's ESR, emissions are to be 63% lower in 2030, and 75% lower in 2040 compared to 1990 levels, with complimentary measures making up a maximum of 8% and 2% respectively. However, for consistency and comparison with the other pathways in this paper, it is assumed that no complimentary measures are used.

From 2020 to 2100, fossil fuel CO_2 emissions total 800 $MtCO_2$ under the current Swedish climate policy framework which is more than twice that of the Swedish DD2 carbon budget (and close to three times larger than the Swedish DD1 budget).[10] Similarly, the equivalent annual CO_2 reduction rate is approximately 5% versus 12%. If Sweden were to use all of its stated 'complimentary measures' to reach the targets, the implied budget would be more than 2.5 times that of the DD2 scenario. Figure 2 shows the significant gap between the carbon budget and trajectories implied by the Swedish climate policy framework and that of a Paris-compliant pathway.

6. Discussion

Academics, policy makers, journalists and some NGOs, regularly cite UK mitigation as broadly consistent with the demands of the Paris Agreement (Averchenkova & Matikainen, 2016; CCC, 2019; Harvey, 2016). Similarly, Sweden, building on its reputation as a sustainable and enlightened nation, has introduced a new 'world leading' Climate Law (Business Green, 2018; Swedish Press, 2018). Yet the analysis here suggests the mitigation agenda of both these 'climate progressive' nations hugely underplays what is necessary if they are to make their proportionate response to the Paris Agreement's 1.5 and 2°C goals. In simple terms, the major quantitative indicators (total national carbon budget, annual rate of mitigation and timeframe to deliver a zero-carbon energy system) exhibit more than a factor of two difference between what the UK and Swedish governments are proposing and what is Paris-compliant. However, in important respects, this significant quantitative disparity belies the fundamental scale of the qualitative and institutional change required of society.

Certainly the transformation detailed in, for example, the UK CCC's technical reports (CCC, 2019) is a key constituent of a Paris-compliant agenda. Though even here, the transformation needs to remove any privileged status afforded aviation as a major and persistent high-carbon sector. It also needs to be complete within two decades rather than the 2050 and beyond timeframe favoured by the CCC and prescribed in the Swedish climate policy framework. But beyond low-carbon technologies and price mechanisms, a 10% (minimum) annual mitigation rate and twenty year decarbonization timeframe demands profound changes to many of the core values, dynamics and structures of contemporary society Table 2.

Table 2. Comparison of CO_2 emissions pathways for UK and Sweden.

	UK	Sweden
Current policy carbon budget	9.0 $GtCO_2$	0.80 $GtCO_2$
Paris-compliant carbon budget	3.7 $GtCO_2$	0.37 $GtCO_2$
Current policy mitigation rate equivalent	5.1%	5.3%
Paris-compliant mitigation rate	>10%	>12%

Such double-digit rates of mitgation, if referenced at all, have remained at the periphery of academic and policy discussion. Published in 2006, the Stern Review developed its conclusions from an assumption that global CO_2 growth between 2000 and 2006 was 0.95% p.a. (Stern et al., 2006). This compares with the empirical data, freely available at the time, putting the increase at 2.4% p.a. The cumulative implications of this substantial difference between real-world post 2000 data and Stern's modelled extrapolation of growth rates from the 1990s, is difficult to exaggerate. In essence, the headline conclusions of the Stern report substantially underplayed the disruptive scale of the mitigation challenge. Other global scale scenarios of this era similarly either ignored real-world data or adopted assumptions with low rates of near term growth (CCSP, 2007; Hulme, Neufeldt, & Colyer, 2009).

Over a decade on, global emissions are still rising and the empirical data has become much more widely understood and accessible (e.g. through the Global Carbon Project and UNEP Gap Reports). Today, planetary scale NETs, largely BECCS, are ubiquitous across high-level mitigation models, preserving the prospect of the Paris Agreement's objectives being delivered through incremental adjustments and marginal economics. The latest net-zero report from the UK CCC (2019) demonstrates the growing reliance on NET assumptions. Whilst the committee's earlier advice (80% reduction by 2050; CCC, 2010) had BECCS reach 37 $MtCO_2$ by 2050, their new and ostensibly more challenging net-zero analysis sees reliance on 'engineered removals' increase by over 40% to 53 $MtCO_2$.

The very high mitigation rates derived in this paper cast significant doubt on the extent to which carbon price mechanisms and green growth strategies reliant on decoupling of emissions from economic growth (Hickel & Kallis, 2019) can deliver on the Paris Agreement. Marginal adjustments to a market-oriented economy may have succeeded had they been deployed at the time of the first IPCC report in 1990. But three decades later, annual emissions of CO_2 have risen by more than 60%, and continued to do so in 2017 and 2018. Set against the scientific logic of carbon budgets, the global community has spent virtually all of the Paris-compliant emission space and now faces a decarbonization agenda far removed from any economic equilibrium.

Turning to developing countries, the mitigation pathways derived in this paper are far more ambitious than the aggregate of their NDCs. For 2030, emissions implied by NDCs are over 30% higher than those within DG1 and DG2. Moreover, these pathways and associated budgets are notably more ambitious than those linked to equity-based allocation schemes, such as the Fair Shares analysis (see Holz et al., 2017). This raises critical questions as to the mechanisms and scale of international financing necessary to support the more onerous DG1/2 mitigation pathways.

Delivering on the Paris 1.5–2°C commitment will require major changes to the productive capacity of industrialized societies. But even this will be insufficient to deliver early double-digit rates of mitigation. Here the numerical scale of the asymmetry in responsibility for emissions (Chancel & Piketty, 2015) brings issues of values, measures of prosperity and the socio-economic inequality of contemporary society to the fore. Such re-visioning of society is not, however, driven by political ideology, but rather is a direct consequence of the international community's obligations under the Paris Agreement and the small and rapidly dwindling global carbon budget.

As in fluid dynamics, where theories of laminar flow are no guide to understanding turbulence, so the neoclassical ideology and accompanying 'computable general equilibrium' (CGE) models serve to distract from the multi-facetted disequilibrium posed by the Paris Agreement. The rate and depth of such a physical and social transformation will likely entail two to three decades of socio-economic activity reminiscent of 'the arsenal of democracy' invoked by Roosevelt's 1940 'fireside chat' (Roosevelt, 1992) or the 1948 European Recovery Programme (the Marshall plan). But even these analogies do not fully capture the scale of the challenge in delivering a timely zero carbon energy system; a system that has fuelled over one hundred and fifty years of industrialization.

7. Conclusion

The carbon budgets and pathways developed here provide a heuristic framework for guiding responses to the mitigation challenges posed by the Paris Agreement. Whilst they are not predictions or probabilistic forecasts, they nevertheless illustrate the scale and timeframe of mitigation necessary to deliver on the 'well below 2°C' and 'pursue … 1.5°C' commitments.

The sequential logic of translating the Paris Agreement into budgets and mitigation rates for the developed and developing country Parties, subsequently downscaled to the UK and Sweden, is premised on a series of transparent assumptions. The decision to exclude non-linearities in the climate system with the potential for large and irreversible changes, is one such assumption.[11] Informed by a similarly cautious approach to issues characterized by high levels of uncertainty, though of a different category, is the exclusion of planetary scale NETs. These are now ubiquitous in IPCC mitigation scenarios and are central to the UK and (indirectly) Swedish government's mitigation agendas. In this regard, the paper offers a complement to much of the 'net-zero' analysis developed in response to the Paris Agreement.

Synthesizing the Paris temperature commitments with its precautionary context and language around equity, points to a mitigation agenda far beyond anything yet countenanced by mainstream policy makers. This is particularly evident when considering the two 'climate progressive' case-study nations. The UK and Sweden both have prominent legislative frameworks for informing their mitigation agendas. Both also have established 'committees on climate change' to advise on the timeframe, scale, obstacles and opportunities for delivering on their respective government's commitments. Despite this, the mitigation ambitions of even these nations is less than half of what is the absolute minimum necessary to deliver on the Paris Agreement. The UK and Sweden propose annual mitigation rates of ~5% whereas this analysis suggests, respectively, a minimum of 10% and 12% per annum.[12]

These results are sensitive to a range of important factors, particularly, but not exclusively: the peaking date; potential plateau and subsequent mitigation pathway of developing country Parties; the choice of apportionment regime; the re-classification of oil rich nations with very high GDP/capita (and relatively high HDI) from the developing to the developed country Parties group; the extent of future process emissions from cement, international aviation and shipping sectors; and land use emissions reversing to become neutral across the century. However, given that the premise of this paper is on delivering mitigation aligned with the Paris Agreement, highly optimistic assumptions are already applied to each of these factors. Consequently, the scale of the void between 'official' carbon budgets (and implied mitigation rates) and the Paris-compliant conclusions presented here is very likely to increase, should the favourable expectations of any of the key factors not be forthcoming, or if mitigation is further delayed.

In summary, most high-level emission scenarios transfer a significant proportion of the mitigation burden on to future generations. Remove this temporal transfer, and Paris-compliant pathways demand an immediate ramping up of mitigation to rates very rarely discussed. Even within more 'climate progressive' nations, the Paris Agreement neccesitates an immediate increase in their proposed mitigation rates by a factor of two to over 10% p.a., with full decarbonization achieved across all sectors by 2035–40. Delivering such rapid and deep mitigation implies profound changes to many facets of contemporary industrial society. But failing to take appropriate action will increasingly lock-in devastating climate impacts, imposed initially on poor and climate vulnerable societies, but ultimately across all of the international community and natural ecosystems.

Notes

1. Whilst recognizing the merits of consumption-based emissions accounts, this paper focuses on territorial emissions for three reasons: (1) the climate change policy frameworks and legislation for Sweden and the UK are based on territorial emissions. (2) there are substantial discrepancies between consumption-based inventories; (3) nation states have direct leverage over territorial emissions whilst typically only indirect leverage on activities giving rise to consumption-based emissions. If a consumption-based approach were taken, the developed country reduction rates calculated in Section 4.2 would be greater.
2. Prior to any deployment, differentiation between the NET options would need to identify the range of social and environmental risks and impacts, and judge whether these are more or less acceptable than the implications of not deploying them.
3. For a budget taken with the centre of the TCRE uncertainty range set at 1.5°C, the other quantified uncertainties are regarded by the IPCC as at least +/- 50% therefore covering a threefold range 290–870 GtCO2 (SR1.5 p107).
4. The exact relationship of the latter to actual levels of deforestation is more difficult to distil from the data, not least because of the challenges in reliably estimating rates and levels of logging. See Kissinger, Herold, and De Sy (2012) and Busch and Ferretti-Gallon (2017).
5. This position is considerably more optimistic than that detailed in earlier work of Anderson and Bows (2008), where net emissions from forestry, across the full twentieth century, were assumed to be between 213 and 319 GtCO2; the figure of 266

GtCO2 was later used in Anderson and Bows (2011). For an overview of the considerable uncertainties associated with estimating their future potential as sinks and sources of emissions see Mitchard (2018).

6. UNFCCC Party Groupings https://unfccc.int/process-and-meetings/parties-non-party-stakeholders/parties/party-groupings
7. Constraints imposed are: (1) The SR1.5 carbon budgets associated with the temperature commitments enshrined in the Paris Agreement. (2) The Paris Agreement's inclusion of principles of equity (through CBDR&RC and a delayed peaking of developing country Parties emissions). (3) Initial reduction rates of developing country Parties should not exceed those typically demonstrated by developed country Parties. Post-Copenhagen developed countries, on aggregate, achieved 0.5-1.0% p.a. and post-Paris there has been barely any change. (4) The maximum emission reductions assumed for developing country Parties should not exceed the emission reductions of developed country parties at any point in time.
8. This equates to 0.11 kgCO2/capita for developing nations and 0.36 kgCO2/capita for developed nations.
9. DfT forecast total aviation sector emissions of 39.9 MtCO2 in 2050 versus the CCC Further Ambition scenario 31.5 MtCO2.
10. The only identifed scenario that quantifies a carbon budget for Sweden is included as a heuristic scenario in a recent background report from the Environmental Protection Agency (Naturvårdsverket, 2019, Fig 10). Aligning this scenario to the assumptions made in this paper results in a budget of close to 1,000 MtCO2 for the period 2020–2100 i.e. around 2.5 and 3.5 times the size of the Swedish DD2 and DD1 budget, respectively, and significantly larger than our more optimistic interpretation of the Swedish climate policy framework.
11. The carbon budgets presented in SR1.5 are not further reduced by identified but currently poorly characterised Earth-system feedbacks (see Cai, Lenton, and Lontzek 2016; Melillo et al., 2017; Steffen et al., 2018).
12. This ~10% p.a. is premised on reductions commencing at the start of 2020. Should it take until 2025 to ramp mitigation up to such high levels, the rate rises considerably towards 15% p.a. to maintain the same carbon budget.

Acknowledgements

We, the authors, thank Jaise Kuriakose and Carly McLachlan (of the Tyndall Centre, University of Manchester) for their frequent and valuable discussions in the development of the paper. We are grateful to Glen Peters (Research Director at °Cicero, Oslo) and Niclas Hällström (Director, What Next Forum, Sweden) for their ever-helpul insights and guidance. We thank the three anonymous reviewers for their various contributions to tightening and clarifying our text. Finally we are indebted to the journal editor, Joanna Depledge, for her professional support and incisive editing. The views expressed are those of the authors alone.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The UK Energy Research Centre (UKERC EP/L024756/1) provided funding to KA for the RACER project, and EPSRC for DecarboN8 project under which some of this paper's analysis was developed. The Swedish Energy Agency (Energimyndigheten) also provided funding through the research project 'Regional carbon budgets and the rapid transition to a fossil-free energy system' (46532-1).

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World will miss 1.5C warming limit - top UK expert

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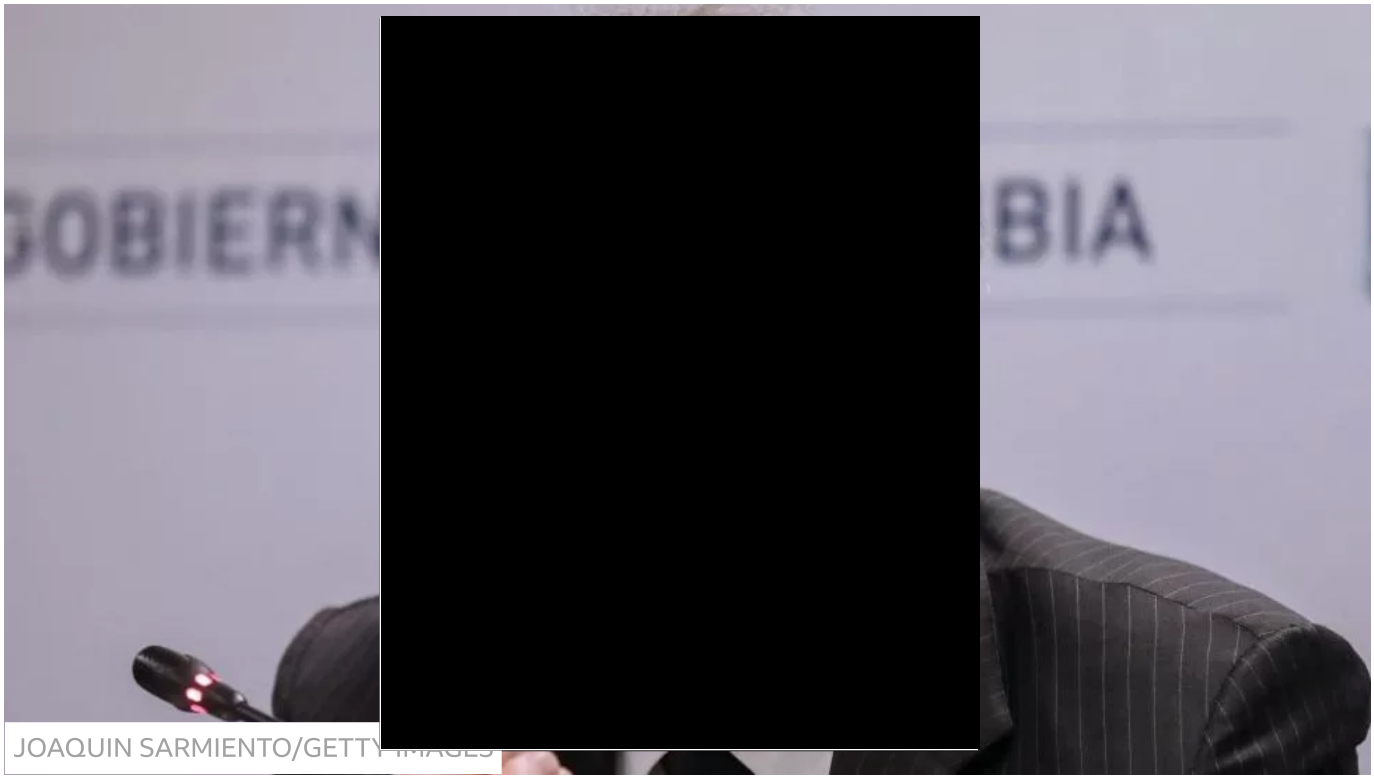


JOAQUIN SARMIENTO/GETTY IMAGES

Professor Sir Bob Watson formerly headed the UN climate body

Professor Sir Bob Watson, former head of the UN climate body, told the BBC's Today programme he was "pessimistic".

His warning comes amidst a summer of extreme heat for Europe, China and the US.

The UN says passing the limit will expose millions more people to potentially devastating climate events.

The world agreed to try to limit the temperature increase due to climate change to 1.5C above pre-industrial levels at a UN conference in Paris in 2015. That target has become the centrepiece of global efforts to tackle climate change.

Climate scientists have been warning governments for years that they are not cutting their countries' emissions quickly enough to keep within this target.

But it is surprising for someone as senior and well respected as the former head of the UN climate science body the IPCC to be so frank that he believes it will be missed.

Professor Sir Bob Watson is currently Emeritus Professor of the UK's Tyndall Centre for Climate Research - having previously worked at the UN, Nasa, UK's Department of Environment and the US White House - and is perhaps one of the foremost climate scientists in the world.

In the interview aired on Thursday he said: "I think most people fear that if we give up on the 1.5 [Celsius limit] which I do not believe we will achieve, in fact I'm very pessimistic about achieving even 2C, that if we allow the target to become looser and looser, higher and higher, governments will do even less in the future."

His comments although candid were supported by Lord Stern, Chairman of the Grantham Research Institute on Climate Change and the Environment, later on Thursday during an interview with BBC's WATO programme.

He said: "I think 1.5 is probably out of reach even if we accelerate quickly now, but we could bring it back if we start to bring down the cost of negative emissions and get better at negative emissions. Negative emissions means

to 2.7C.

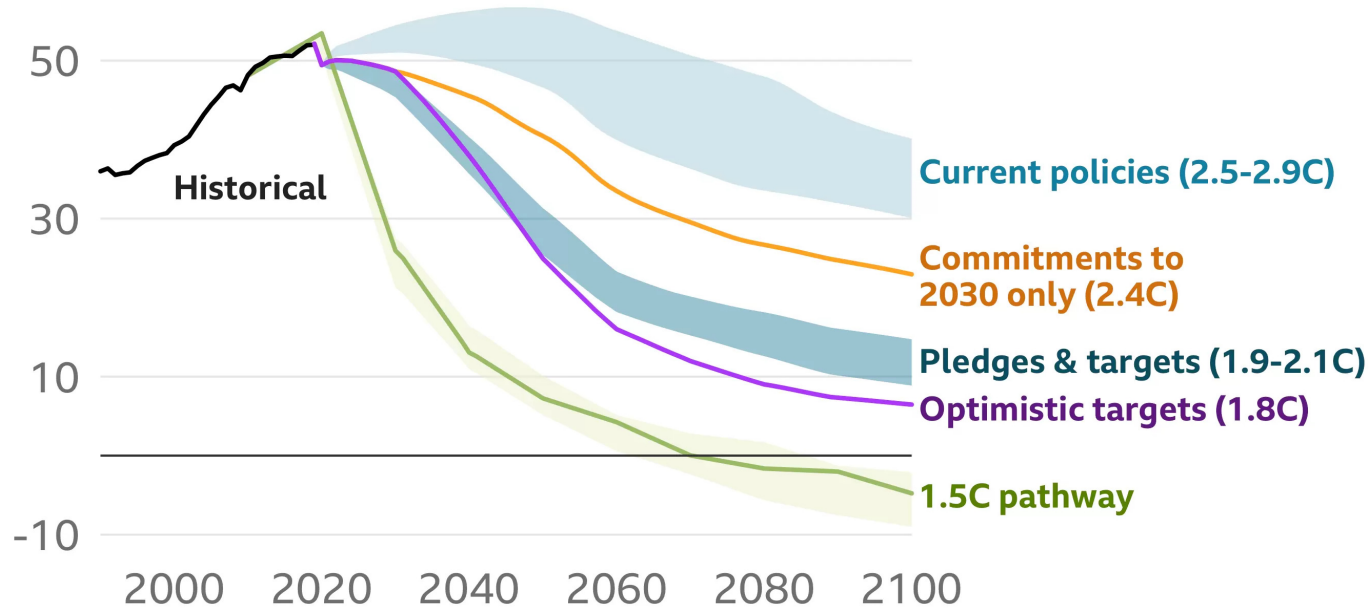
The figure is not a direct measure of the world's temperature but an indicator of how much or how little the Earth has warmed or cooled compared to the long-term global average - and even slight changes can have significant impacts.

The UN climate body, the IPCC, has said keeping temperature rises below 1.5C, rather than 2C, would mean:

- 10 million fewer people would lose their homes to rising sea levels
- a 50% reduction in the number of people experiencing water insecurity
- a reduction in coral reef loss from 99% to 70%

Projected trends in emissions and warming

Global greenhouse gas emissions in gigatonnes of carbon dioxide equivalent



Source: Climate Action Tracker

BBC

He told the Today programme that setting targets was not enough and countries needed to back these up with action: "We need to try and hold governments to start to act sensibly now and reduce emissions, but even governments with a really good target like the United Kingdom don't have the policies in place, don't have the financing in place to reach those goals."

In March the UK's watchdog on climate change, the UKCCC, said the UK had lost its leadership on climate issues. It said the government's backing of new oil and coal projects, airport expansion plans and slow progress on heat pumps showed a lack of urgency.

In response to comments from Lord Stern and Professor Sir Bob Watson, a government spokesperson said: "The UK is a world-leader on net zero, cutting emissions faster than any other G7 country and has attracted billions of investment into renewables, which now account for 40% of our electricity."

But Lord Deben, who until last month was chair of the UKCCC, said the government was "entirely wrong". Talking to BBC's WATO programme he said that other countries like the US and China were moving much faster, and that the UK was setting "the worst possible example to the rest of the world".

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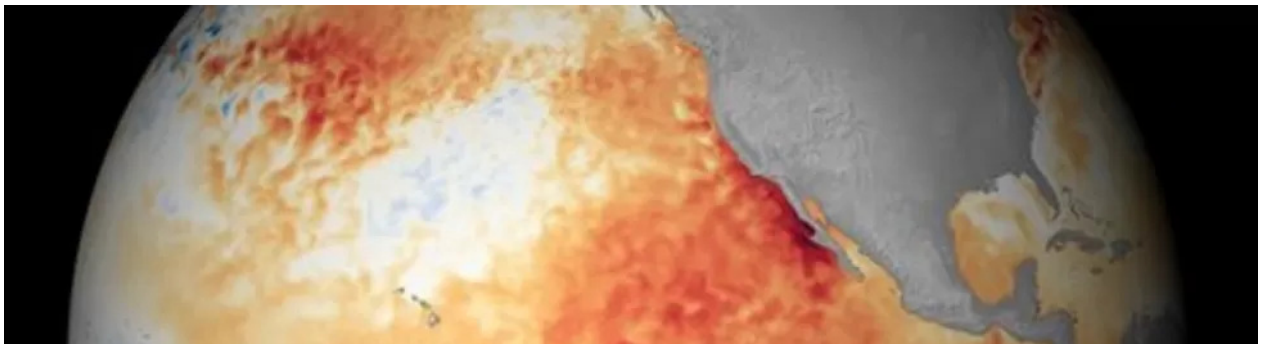

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