LEX-24983 Document 1

DEPARTMENT OF AGRICULTURE, WATER AND THE ENVIRONMENT

MS21-006008

To: Minister for the Environment (for decision)

Approval Decision Brief (assessment report) – Vickery Extension Project, Gunnedah, NSW (EPBC 2016/7649)

Timing: 15 September 2021 - Statutory timeframe for final decision

Recommendations:

1. That you consider the information provided in this brief and attachments, including:

   a. the proposed decision briefing package at **Attachment A**, the updated legal considerations report at **Attachment B** and the NSW DPIE assessment report at Attachment G of **Attachment A** to that proposed decision brief, and

   b. information concerning the impacts of the proposed action on human safety and your duty to take reasonable care, in the exercise of your powers under ss 130 and 133 of the EPBC Act, to avoid causing personal injury or death to persons under 18 years of age and ordinarily resident in Australia, arising from emissions of carbon dioxide into the Earth's atmosphere at **Attachment B**.

   Considered / Please discuss

2. That you consider the responses to the invitation for comment on the proposed decision at **Attachment C** and **Attachment H**.

   Considered / Please discuss

3. That you consider the impacts of the proposed action on human safety and have given this consideration elevated weight in making the decision.

   Considered / Please discuss

4. That you agree that you have enough information to make the decision set out in the notice at **Attachment E**.

   Agreed / Not agreed

5. That you agree to approve, for the purposes of each controlling provision, the action as summarised in the table below.

   Agreed / Not agreed

6. That you agree to attach the conditions of approval as set out in **Attachment E**.

   Agreed / Not agreed

7. If you agree with recommendations 4, 5 and 6, that you accept the reasoning in the departmental briefing package (including the updated legal considerations report) as the reasons for your decision.

Accepted / Not Accepted

8. If you agree with recommendations 4, 5 and 6, that you sign the notice of your decision at **Attachment E**.

Signed / Not signed

9. If you agree with recommendations 4, 5 and 6, that you sign the letters at **Attachment K** advising the person proposing to take the action, relevant Commonwealth Ministers, and the NSW Government of your decision.

Signed / Not signed

Summary of recommendations on each controlling provision:

Controlling Provisions for the action	**Recommendation**	
	Approve	**Refuse to Approve**
Listed threatened species and communities (ss 18, 18A)	Approve	
A water resource, in relation to coal seam gas development and large coal mining development (ss 24D, 24E)	Approve	

The Hon Sussan Ley MP, Minister for the Environment Date: 15/9/21

Comments:

Clearing Officer: Sent 14 / 09 / 2021	Melissa Brown	First Assistant Secretary, Environmental Approvals Division	s. 22(1)(a)(ii)
Contact Officer:	s. 22(1)(a)(ii)	Director, Northern NSW Assessments Section	s. 22(1)(a)(ii)

Key Points:

1. The purpose of this brief is to seek your consideration of a final approval decision for the Vickery Extension Project (the 'proposed action') under Part 9 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

2. Vickery Coal Pty Ltd (the person proposing to take action and the proponent) proposes to extend an existing approved open cut mine (the Vickery Coal Project EPBC 2012/6263) and related surface infrastructure and activities, and to process up to 10 million tonnes of coal per annum (Mtpa) for 25 years.

3. The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (**IESC**) has provided advice on the proposed action under the NSW assessment process (14 November 2018) (Attachment J of **Attachment A** to this brief).

4. In addition to this advice, independent technical reviews of the proposed action have been conducted under the NSW assessment process.

5. On 12 August 2020, the NSW Independent Planning Commission approved the proposed action subject to conditions, in accordance with Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (Attachment G3 of **Attachment A**). The NSW development consent conditions (Attachment G2 of **Attachment A**) require the approval holder to submit management plans that include mitigation measures, monitoring, thresholds, and a trigger action response plan should the project trigger a threshold.

6. The technical reviews were provided as part of the documentation considered by the IESC in November 2018. The department has taken the IESC advice (Attachment J of **Attachment A**) into consideration in preparing the decision notice and attached conditions of approval (**Attachment E**).

7. On 12 April 2021, as recommended in the proposed approval decision brief (**Attachment A**) you proposed to approve the proposed action and you wrote to Vickery Coal Pty Ltd and relevant Commonwealth Ministers seeking comments on your proposed decision, as required under sections 131AA(1) and 131(1) of the EPBC Act. You also wrote to the NSW Minister for Planning and Public Spaces informing him of your proposed decision.

8. The responses to your invitation to comment are provided at **Attachment C** and **Attachment H** summarised below.

9. Under section 130 of the EPBC Act you are now required to decide whether or not to approve the proposed action, and if you decide to approve under section 133, what conditions you will attach to the approval under section 134 of the EPBC Act.

10. The mandatory considerations that you must have regard to when deciding whether or not to approve the proposed action, and the department's analysis of them, are in this brief, and the updated legal considerations report at **Attachment B** to this brief.

Background

11. On 12 April 2021, you proposed to approve the taking of the proposed action under the EPBC Act, subject to the proposed conditions of approval set out in the proposed approval decision notice (Attachment B of **Attachment A**).

12. The legal considerations report, IESC advice and the NSW Assessment Report indicate that the two most significant impacts of the proposed action are impacts on listed threatened species and groundwater drawdown:

    - the proposed action could result in impacts on Swift Parrot (*Lathamus discolor*) foraging habitat, Regent Honeyeater *(Anthochaera phrygia)* habitat and potential Koala (*Phascolarctos cinereus*, combined populations of Queensland, New South Wales and the Australian Capital Territory) habitat.

    - groundwater drawdown from mining operations could affect groundwater availability and aquifer interactions, and groundwater drawdown associated with the proposed water supply borefield could affect groundwater availability and the dynamics of surface water-groundwater interactions.

13. Impacts of the proposed action, and avoidance and mitigation measures, are discussed in more detail in the NSW Assessment Report at Attachment G5 of **Attachment A** to this brief.

14. The department recommended and you agreed that the potential impacts of the proposed action on water resources and listed threatened species could be addressed through the recommended conditions of approval, and that the impacts would not be unacceptable, provided that the action is undertaken in accordance with the recommended conditions (**Attachment E**).

Consultation

15. As recommended in the proposed approval decision brief, you wrote to the proponent and relevant Commonwealth Ministers inviting comments on the proposed decision, as required under sections 131AA(1) and 131(1) of the EPBC Act.

16. You also notified the NSW Minister for Planning and Public Spaces, the Hon Rob Stokes MP, of the proposed approval decision.

Comments from Whitehaven Coal Ltd

17. On 22 April 2021, the department received comments from the proponent about the proposed conditions (**Attachment H**). These comments were largely focused on: removing conditions that duplicated NSW conditions; aligning Commonwealth conditions that built upon NSW conditions more closely with the monitoring and reporting requirements of NSW conditions; and clarifying the intent of some conditions.

18. The proponent stated that they do not consider that any of their suggested edits change the intent of the conditions. Their view is that the suggestions may help to clarify the interpretation of some of the conditions, which they consider would be of benefit to the department, stakeholders and the proponent.

19. The proponent's suggested amendments have been incorporated into the final decision notice (**Attachment E)**. The department considered that these changes were appropriate. The following changes have been made:

    a. Clarification of the definitions of performance criteria and limits specific to both the alluvial aquifer and riparian ecosystem. Performance criteria and limits will be derived from the results of monitoring data.

    b. Clarifying project areas and updating appendices to make it clear where the proposed action and monitoring activities are to be undertaken.

    c. Linking the requirement to install and monitor groundwater bores to the commencement of 'mining operations' rather than the commencement of the action, to align with when potential impacts may occur.

    d. Replacing 'reversal of an impact' from the cease groundwater extraction provisions with the requirement to have agreement from the Minister to recommence groundwater extraction after the impact to groundwater has been addressed. This was also a recommendation from Geoscience Australia.

    e. Groundwater-surface water interactions and connectivity have been linked to the submission of the performance criteria and limits, considering groundwater-surface water connectivity.

    f. Clarifying offset statement publication, offsetting retirement requirements and third-party verification.

    g. Aligning the preparation of Annual Reviews under the NSW Development Consent, so that EPBC compliance report timing aligns with the timing of the NSW Annual Review.

20. A revised copy of the proposed final conditions was provided to Vickery Coal Pty Ltd on 25 May 2021. On 1 June 2021, the proponent confirmed that they agreed to the conditions as amended (**Attachment H**).

Comments from the Minister for Resources, Water and Northern Australia

21. On 4 May 2021, s. 22(1)(a)(ii) Director, National Water Policy and Reform Section, the Department of Agriculture, Water and the Environment, responded on behalf of Minister Pitt (**Attachment C2**). s. 22(1)(a)(ii) stated that the National Water Policy and Reform Section had no comments to make, from a water division perspective, on the proposed conditions.

22. s. 22(1)(a)(ii) noted that the IESC has indicated that there is little impact to water from the proposed action and that this arrangement is managed wholly within current extraction permits and NSW policy.

23. s. 22(1)(a)(ii) further stated that it is the division's understanding that the intention of the proposed conditions is to mitigate, manage and offset any potential impacts to water resources through ensuring firm adherence to the monitoring and reporting of performance measures for the controlled action.

24. On 23 April 2021, the Department of Industry, Science, Energy and Resources provided comments from Geosciences Australia (**GA**) in response to the invitation to Minister Pitt (**Attachment C2**).

25. GA stated that the proposed approval conditions are generally outcomes-focussed, well-conceived and clearly written. GA identified four main issues with the proposed conditions and made recommendations to address those issues. These issues, and the department's response, are as follows:

   a. GA recommended that the Commonwealth should approve the Water Management Plan. The department considers that approval by the NSW Planning Secretary is sufficiently rigorous, and it is not necessary for the proponent to seek additional endorsement from the department. Condition B53 of the NSW development consent requires the proponent to prepare a Water Management Plan to the satisfaction of the Planning Secretary. NSW DPIE have also attached a number of conditions to the plan including that the plan must address the recommendations for surface water and ground water monitoring by the IESC. The recommended EPBC Act condition 9 also requires that the proponent submits performance criteria and limits, relevant to groundwater extraction impacts for the alluvial aquifer, for the Minister's approval.

   b. GA considered the timeframes for the approval holder to undertake certain actions may not be sufficient and may need to be revised. The timeframes for the actions required under the conditions have been reviewed and agreed to by the proponent. The department is confident that the final conditions enable robust monitoring and compliance, and set appropriate timeframes for the approval holder to undertake management actions.

   c. GA raised concerns about the efficacy of enforcing the cessation of pumping from the water supply bore field for any limit exceedance relevant to alluvial aquifers or aquatic and riparian ecosystems. GA noted that an exceedance may not be due to water supply pumping e.g. the water exceedance may be due to mine dewatering so ceasing water supply pumping would have no effect. Conditions concerning mine water are dealt with in the NSW Conditions of Consent (B53). The department considers that Condition 8 (**Attachment E**), which bolsters condition B53 of the NSW development consent in relation to mine water, sufficiently addresses issues that may arise from water coming from the water supply field.

   d. GA noted that, the approval holder must not recommence groundwater extraction until 'the impact has been reversed'. GA stated in their advice that in some instances the impact to a water resource may never be reversed or take many years. GA suggest other options, such as offsets for the impact caused or remediation activities could be considered. As noted above, the requirement for the approval holder to not recommence groundwater extraction until 'the impact has been reversed' has been replaced with mitigation and managements measures which must be approved by the Minister before recommencing groundwater extraction.

Comments from the Minister for Indigenous Australians

26. Minister Wyatt responded on 28 April 2021, (**Attachment C3**). Minister Wyatt supported the measures proposed as part of the Commonwealth's approval to minimise potential impacts to the Murray Cod and impose limitations on the removal of habitat for koalas, swift parrots and regent honeyeaters, and noted the conditions imposed by NSW to protect the squirrel glider. Minister Wyatt stated that these native species have cultural significance to Indigenous Australians as part of their obligations to care for country.

27. Minister Wyatt suggested that it may be appropriate that *Dhawura Ngilan: A Vision for Aboriginal and Torres Strait islander Heritage in Australia and the Best Practice Standards in Indigenous Cultural Heritage Management and Legislation* apply to this and other development projects. He strongly encouraged you to work with NSW to ensure the preservation of Aboriginal cultural heritage materials by applying these best practice standards to the oversight of the project.
28. While Minister Wyatt supports the proposed approval of the project, he stated that there are tensions between Indigenous stakeholders in relation to development proposals and projects. He stated that this project is no exception and that governments must ensure adequate and comprehensive representation is achieved when consulting with Indigenous stakeholders. This includes accounting for the differing perspectives of groups from the same country or Nation.
29. Minister Wyatt noted that neither the Commonwealth nor the NSW Government attach any requirement for Indigenous enterprise or employment outcomes to the approval of privately funded projects. He said that he is advised that local traditional owners are seeking such outcomes. He also noted that Vickery Coal Pty Ltd's parent company Whitehaven has demonstrated a real commitment to both Indigenous employment and business opportunities, achieving double its 10 percent target on one project and nine percent Indigenous employment across its business.
30. The letter to the proponent includes this advice and encourages ongoing Indigenous stakeholder consultation.

Comments from the Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development

31. On 21 April 2021, the Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development noted that the Vickery Extension Project will have a significant social, economic and environmental impact on the local community of Gunnedah and the surrounding regions (**Attachment C1**).

Comments from the Minister for Energy and Emissions Reduction

32. A nil response was received from the Minister for Energy and Emissions Reduction on the invitation to comment.

Comments from the Minister for Agriculture, Drought and Emergency Management

33. A nil response was received from the Minister for Agriculture, Drought, Emergency Management on the invitation to comment.

Comments from the Minister for Industry, Science and Technology

34. A nil response was received from the Minister for Industry, Science and Technology on the invitation to comment.

Matters for consideration

35. You are now required under sections 130 and 133 of the EPBC Act to decide whether to approve the action and, if you decide to approve, what conditions you will attach to the approval under section 134 of the EPBC Act. The department considers that you have

enough information to make an informed decision on whether or not to approve the action.

36. Except for the matters discussed in this brief, the matters for consideration and factors to be taken into account in making your decision are as set out in the proposed approval decision brief and its attachments (**Attachment A**), and the updated Legal Considerations Report (**Attachment B**).

37. The department confirms that all relevant conservation advices, recovery plans and threat abatement plans are still current and have not changed from the date of the proposed approval decision (**Attachment A**).

Changes to conditions

38. In preparing this final decision brief, the department has had regard to comments from all parties consulted, both internal and external.

39. As a result, the recommended conditions of approval have changed from the proposed decision (at Attachment B of **Attachment A**). The rationale for these changes are set out in the discussion at paragraph 19 and 25 above. The rationale for the conditions are otherwise set out in the proposed approval decision brief and its attachments (**Attachment A**). The department has also recently made some minor changes to the conditions and consulted with the proponent in relation to these changes.

40. While the objectives of the conditions remain the same, some conditions have been amended to provide further clarity around their intent and to improve the enforceability of the conditions.

41. Accordingly, the department considers that the recommended conditions of approval are necessary or convenient to protect, or repair or mitigate damage to, the matters protected by a provision of Part 3 of the EPBC Act which would be apply to this approval.

42. Consistent with the requirements in subsection 134(4), in recommending the conditions of approval at **Attachment E**, the department has considered: relevant conditions that have been imposed under the NSW approval; the information provided by Vickery Coal Pty Ltd; and the desirability of ensuring that the conditions are a cost effective means for the Commonwealth and Vickery Coal Pty Ltd to achieve the object of the conditions.

Human safety and your duty of care

43. After the proposed decision was made, the Federal Court of Australia declared that you have a duty to take reasonable care, in the exercise of your powers under ss 130 and 133 of the EPBC Act in respect of the proposed action, to avoid causing personal injury or death to persons under 18 years of age and ordinarily resident in Australia, arising from emissions of carbon dioxide into the Earth's atmosphere: *Sharma v Minister for Environment (No 2)* [2021] FCA 774). On 27 May 2021, the Court published its reasons for making that declaration: *Sharma v Minister for Environment* [2021] FCA 560. These decisions are collectively referred to as ***Sharma***.

44. Notwithstanding that you are appealing the Federal Court's judgment in *Sharma*, the Department has nonetheless applied the *Sharma* reasoning to this proposed action. In accordance with *Sharma,* in deciding whether or not to approve the taking of the

proposed action, you must take into account human safety and you must take reasonable care to avoid causing death or personal injury to Australian children. Human safety should be given elevated weight in balancing the matters you must consider in exercising your discretion to approve or not approve the proposed action under ss 130 and 133 of the EPBC Act.

45. The department has considered matters pertaining to the risks to human safety posed by the proposed action and your duty to take reasonable care to avoid causing death or injury to Australian children in making your decision at **Attachment B** to this brief.

46. The department considers, based on advice from the Department of Industry, Science, Energy and Resources (DISER), that approval of the proposed action is not likely to cause harm to human safety because it is likely that, if the proposed action is not approved, a comparable amount of coal will be consumed, in substitution for the proposed action's coal, thus involving materially the same amount of GHG emissions whether or not the proposed action is approved.

47. Out of an abundance of caution, the department has also considered the risk posed by the proposed action to human safety that could arise if this conclusion is incorrect. If the GHG emissions of the proposed action are 'additional', the proposed action may result in a very small increase in global GHG emissions and therefore cause a very small increase to global average surface temperatures. However, even if this is the case, the department recommends the approval of the proposed action because of the low risk of harm to human safety resulting from this level of emissions, together with the benefits of the approval, including those human safety benefits associated with steel production, as well as the social and economic considerations as set out in **Attachment B**.

48. For the reasons outlined in the updated Legal Considerations Report at **Attachment B**, the department recommends that you approve the proposed action, after giving elevated weight to human safety and your duty of care, while also having regard to all other mandatory considerations, including economic and social considerations.

Line area consultation

49. The following line areas were consulted in the preparation of the final decision briefing package and conditions:

    a. Water Resources Regulatory Support;

    b. Legal Division (and Australian Government Solicitor)

    c. Office of Water Science;

    d. Post Approvals;

    e. Environmental Audit; and

    f. Climate Adaptation and Resilience Division.

Notification of decision

50. Under section 133(3) of the EPBC Act, you must give a copy of the approval to the person named in the approval. A letter to Vickery Coal Pty Ltd is at **Attachment K** for your signature.

51. The department also recommends that you write to relevant Commonwealth Ministers, and the NSW Minister for Planning and Public Spaces, notifying them of your decision. The letters are at **Attachment K** for your signature.

ATTACHMENTS* (see Appendix for complete list)

A: Proposed decision briefing package (MS21-000508 & hard copies)

B: Updated legal considerations report

C: Ministerial responses to invitation for comment on proposed decision

D: Sharma Ors V Minister for the Environment Judgement

E: Final Approval decision notice (which includes the conditions) (**for signature)**

F: Whitehaven Coal Sustainability report, 2021

G: Expert Report, NSW Independent Planning Commission, Public Hearing – Vickery Extension Project, 30 June 2020, Professor Will Steffen

H: Proponent's response to invitation to comment and agreement to Final Conditions

I: Ashurst Letter to DAWE, 29 July 2021

J: DISER Analysis and DISER supplementary information

K: Letters notifying Vickery Coal Pty Ltd, relevant Commonwealth Ministers and the NSW Government of the final approval decision (**for signature)**

L: DAWE Provisional list of animals requiring urgent management intervention (2020)

M: DAWE Rapid analysis of impacts of the 2019-20 fires on animal species, and prioritization of species for management response

N: Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (2012)

O: National Recovery Plan for the Winged Peppercress (*Lepidium monoplocoides*)

P: The Greenhouse Gas Protocol 2004 (World Business Council for Sustainable Development and World Resources Institute)

Q: Protected Matters Search Report

R: Request for updated environmental history information and response

S: Expert reports considered in Sharma

Appendix - final decision attachment list

Document	Document Description
Attachment A	Proposed decision briefing package
Attachment B	Updated legal considerations report
Attachment C1	Response to invitation to comment – Deputy Prime Minister and Minister for Infrastructure, Transport and Regional Development for Resources
Attachment C2a	Response to invitation to comment - Minister for Resources, Water and Northern Australia - Department of Agriculture, Water and the Environment
Attachment C2b	Response to invitation to comment - Minister for Resources, Water and Northern Australia - Department of Industry, Science, Energy and Resources
Attachment C2c	Response to invitation to comment - Minister for Resources, Water and Northern Australia - Geoscience Australia
Attachment C3	Response to invitation to comment - Minister for Indigenous Australians
Attachment D1	Sharma v Minister for Environment [2021] FCA 560 (Sharma No 1)
Attachment D2	Sharma v Minister for Environment (No 2) [2021] FCA 774 (Sharma No 2)
Attachment E	Final decision notice - **FOR SIGNATURE**
Attachment F	Whitehaven Coal Sustainability Report
Attachment G	Expert Report, NSW Independent Planning Commission, Public Hearing – Vickery Extension Project, 30 June 2020, Professor Will Steffen
Attachment H	Proponent's agreement to conditions
Attachment I	Ashurst letter to DAWE
Attachment J1	DISER Analysis
Attachment J2	Supplementary DISER analysis
Attachment K1	Letter to Proponent - **FOR SIGNATURE**
Attachment K2	Letter to Minister for Agriculture and Northern Australia - **FOR SIGNATURE**
Attachment K3	Letter to Minister for Energy and Emissions Reduction- **FOR SIGNATURE**
Attachment K4	Letter to Minister for Indigenous Australians - **FOR SIGNATURE**
Attachment K5	Letter to Minister for Industry, Science and Technology - **FOR SIGNATURE**
Attachment K6	Letter to Minister for Infrastructure and Transport and Regional Development - **FOR SIGNATURE**
Attachment K7	Letter to Minister for Resources and Water - **FOR SIGNATURE**
Attachment K8	Letter to NSW Government - **FOR SIGNATURE**
Attachment L	DAWE Provisional list of animals requiring urgent management intervention (2020)
Attachment M	DAWE Rapid analysis of impacts of the 2019-20 fires on animal species, and prioritization of species for management response
Attachment N	Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (2012)
Attachment O	National Recovery Plan for the Winged Peppercress (*Lepidium monoplocoides*)
Attachment P	The Greenhouse Gas Protocol 2004 (World Business Council for Sustainable Development and World Resources Institute)
Attachment Q	Protected Matters Search

Attachment R1	Letter from Whitehaven on Environmental History Information dated 2 September 2021 in response to Department's further information request dated 25 August 2021
Attachment R2	Appendix A to Environmental History Information (Attachment R1)
Attachment R3	Appendix B to Environmental History Information (Attachment R1)
Attachment S1	Expert Report of Ramona Meyricke (stamped) 20206340
Attachment S2	Professor Anthony Capon Expert Report
Attachment S3	Professor Will Steffen Expert Report
Attachment S4	Expert Report of Dr Mallon
Attachment S5	Supplementary Report of Professor Steffen

LEX-24983 Document 2

DEPARTMENT OF AGRICULTURE, WATER AND THE ENVIRONMENT

MS21-006368

To: Minister for the Environment (For Decision)

STATEMENT OF REASONS FOR DECISION TO APPROVE THE VICKERY EXTENSION PROJECT, GUNNEDAH, NSW (EPBC 2016/7649)

Timing: 16 September 2021

Recommendations:

1. That you consider the draft statement of reasons (**Attachment A**) and make any modifications you consider necessary to ensure the statement reflects your reasons for your decision dated 15 September 2021 to approve the Vickery Extension Project with conditions (**Attachment B**).

   Considered/ Please discuss

2. That you agree that the draft statement of reasons at **Attachment A** accurately reflects your reasoning for your decision at **Attachment B**.

   Agreed / Not agreed

3. If you agree with recommendation 2, that you sign the draft statement of reasons at **Attachment A**.

   Signed / Not signed

4. That you agree to the department's recommendation that the statement of reasons be published on the department's website.

   Agreed / Not agreed

Minister: Susan Ley Date: 16/9/21

Comments:

Clearing Officer: Sent: 16 / 9 /2021	Melissa Brown	First Assistant Secretary, Environmental Approvals Division	s. 22(1)(a)(ii)
Contact Officer:	s. 22(1)(a)(ii)	Director, Northern NSW Assessments	s. 22(1)(a)(ii)

Key Points:

1. On 15 September 2021, you approved the Vickery Extension Project (**EPBC 2016/7649**) (**Approval**) under sections 130(1) and 133(1) of the *Environment Protection and Biodiversity Conservation Act 1999* subject to conditions (**Attachment B**).

2. The statement of reasons was prepared against the briefing package on which your decision was made.

    a. For your information, the final decision and proposed decision packages (**Attachment B**) are available electronically in PDMS (see **MS21-006008**) and hard copies of both packages have been delivered to your Office.

3. The department notes you may make any modifications you consider necessary to ensure the statement reflects your reasoning.

4. Although it is not mandatory, we recommend you publish the statement of reasons on the department's website.

    a. There is high level of public interest in this decision following the Federal Court's judgment in *Sharma v Minister for the Environment*.

    b. Publishing the statement of reasons is consistent with the government's policies on transparency in decision-making and the department's EPBC Act policy statement for statement of reasons.

Consultation:

5. Legal Division and Australian Government Solicitor.

Attachments:

A: The statement of reasons—FOR SIGNATURE

B: Final decision brief dated 15 September 2021 (including the proposed decision briefing package) (MS21-006008)

MS21-000508

To: Minister for the Environment (For Decision)

Proposed Approval Decision Brief (assessment report) – Vickery Extension Project, Gunnedah, NSW (EPBC 2016/7649)

Timing: 13 April 2021 - to allow for the required 10 business day consultation period under sections 131 and 131AA ahead of the statutory deadline for the final decision of 30 April 2021.

Recommendations:

That you consider the information provided in this brief, the NSW assessment report (**Attachment G5**) and conditions at **Attachment G2**, and the Department's legal considerations report and summary of impacts to Commonwealth matters at **Attachment A1**.

Considered / please discuss

That you have regard to the approved conservation advices relevant to the proposed action at **Attachments H1-H3** and confirm that you have done so.

Confirmed / Please discuss

That you agree to propose to make the decision set out at **Attachment B** and summarised in the table below.

Agreed / Not agreed

That you agree to propose to attach the conditions of approval as set out in **Attachment B** to the decision at recommendation 3.

Agreed / Not agreed

If you agree with recommendations 3 and 4, that you sign the letters at **Attachment C** to inform the proponent, relevant Commonwealth Ministers, and the NSW Government of your proposed decision and invite their comments.

Signed / Not signed

That you agree to **not publish** the proposed decision (**Attachment B**) for public comment under section 131A of the EPBC Act.

Agreed / Not agreed

Summary of recommendations on each controlling provision:

Controlling Provisions for the action	Recommendation	
	Approve	Refuse to Approve
Listed threatened species and communities (ss 18, 18A)	Approve with conditions	

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Water resource/trigger (s24D, s24E)	Approve with conditions	
The Hon Sussan Ley MP, Minister for the Environment	Date: 12th April 2021	
Comments:		

Clearing Officer: Sent 9 / 4 / 2021	Louise Vickery	Assistant Secretary, Environment Assessments (NSW, ACT) Branch	s. 22(1)(a)(ii)
Contact Officer:	s. 22(1)(a)(ii)	Director, Northern NSW Assessments Section	s. 22(1)(a)(ii)

Key Points:

1. The purpose of this brief is for you to indicate whether you propose to approve the Vickery Extension Project (the 'proposed action', described at paragraph 9 below) under Part 9 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

2. Before you make a final decision to approve the proposed action, further comments must be invited from other Ministers and from the proponent. Once you have indicated whether you propose to approve the proposed action, the Department will facilitate this process and then brief you to make a final decision.

3. The Department's assessment of the considerations relating to decision-making under Part 9 of the EPBC Act is set out in the legal considerations report at **Attachment A1**. The Department recommends that you propose to approve the proposed action subject to the proposed conditions specified in **Attachment B**.

4. Vickery Coal Pty Ltd – the person proposing to take action and the proponent – proposes to expand the mining footprint of the existing approved open cut mine (the Vickery Coal Project EPBC 2012/6263) and related surface infrastructure and activities, and to enable the increase of 'peak' extraction from 4.5 to up to 10 million tonnes of coal per annum (Mtpa) (for both the existing project and proposed extension), over 25 years.

5. The existing approved open cut mine, Vickery Coal Project (EPBC 2012/6263), was referred in January 2012 and was determined by the Minister's delegate to be, not a controlled action if undertaken in a particular manner, on 17 May 2012. The existing Vickery Coal Project referral decision is at **Attachment D4**.

6. The extension to the existing open cut mine, Vickery Extension Project (EPBC 2016/7649), the proposed action, has been assessed by the NSW Department of Planning, Industry and Environment (DPIE) on behalf of the Commonwealth for the purposes of the EPBC Act under the Bilateral Agreement, for the following controlling provisions:

   a. sections 18 and 18A (listed threatened species and communities)

   b. sections 24D and 24E (a water resource, in relation to coal seam gas development and large coal mining development).

7. On 12 August 2020, following its assessment and public hearings, the Independent Planning Commission of NSW (IPC) granted project consent under the *Environmental Planning and Assessment Act 1979* (NSW), subject to a suite of conditions (**Attachment G2**). The IPC concluded that the proposed action is in the public interest and any negative impacts can be effectively mitigated with strict conditions.

8. Since the NSW approval, the Department received correspondence from Greenpeace and Lock the Gate Alliance concerning the environmental history of the proponent and one of its parent bodies, Whitehaven Coal Limited. The Department has sought further information from the proponent and NSW Government on the proponent's environmental history and has undertaken a detailed analysis which is outlined in the legal considerations report at **Attachment A1**.

Proposed action

9. The proposed action is located 25 km north of Gunnedah, NSW, within the Gunnedah and Narrabri local government areas. The proposed action involves:

   - Physical extensions to the approved mine footprint, including open cut and waste rock emplacement areas. Increasing the project disturbance area by approximately 984.4 hectares (ha), from Vickery Coal Project (EPBC 2012/6263) referral, to a total disturbance area of 2,993 ha (combining the approved and extension projects).
     - The extension disturbance area of 984.4 hectares (ha), contains 728.4 ha of native vegetation, which is comprised of 108.4 ha of woodland and 620 ha of grassland.
   - Extraction of approximately 28 million tonnes of additional Run of Mine (ROM) coal. (ROM coal is coal of all sizes which comes out of the mine without any crushing or screening). The Vickery Coal Project (EPBC 2012/6263) was expected to produce approximately 140 million tonnes of ROM coal. The Vickery Extension Project will produce an extra 28 million tonnes of ROM coal, increasing total production to 168 million tonnes.
   - Enabling the increase of the 'peak' extraction rate of ROM coal from 4.5 to 10 million tonnes per annum (Mtpa).

- Constructing and operating a Coal Handling and Processing Plant, train load out facility, rail loop and rail spur line at the project site.
- Constructing and operating a water supply borefield and pipeline.
- Changing the final landform by removing the eastern overburden emplacement area (which is now proposed to be used as a secondary infrastructure area), increasing the size of the approved western overburden emplacement area and retaining one pit lake void (rather than two).

10. The life of the project is 26 years, which includes one year of construction and 25 years of mining operations.

11. The proposed action has a direct capital investment of $607 million and up to 500 construction jobs and 450 full time jobs during operations at the mine.

Regional context

12. The proposed action is located in the Gunnedah Coal Basin, which has a long history of coal exploration and mining, including open cut and underground mining activities since the mid-1980s. There are several coal mines located across the Gunnedah Coal Basin, most of which are operated by Whitehaven Coal Limited (see Figure 2 at **Attachment G5**).

13. The proposed action area adjoins the Vickery State Forest, to the immediate east, which covers an area of about 1,942 ha. The proposal would not directly disturb the forest.

14. Land use in the area is largely pastoral agricultural enterprise, predominantly used for grazing purposes. The mining area of the proposed action has been mostly used for grazing for the past 50 years, with small-scale cropping in areas of higher soil fertility. The rail spur area of the proposed action has been located adjacent to property boundaries in this area to reduce the impacts on cropping areas (see Figure 6 at **Attachment G5**).

15. The proposed mining area is located within the Namoi catchment and drains to the Namoi River via its tributaries including Driggle Draggle Creek and Stratford Creek, both of which are ephemeral watercourses. See Figure 8 at **Attachment G5** for regional catchment and drainage context.

16. The proposed rail spur is located in the Namoi River catchment area, which contains an extensive floodplain. Flow paths crossed by the proposed rail spur include Stratford Creek, Deadmans Gully and Namoi River (see Figure 8 at **Attachment G5**).

Submissions on assessment documents

17. The NSW Assessment process has allowed for three opportunities for public comment on the proposed action. DPIE exhibited the project Environmental Impact Statement from 13 September to 25 October 2018 and received 560 public submissions, with 344 submissions supporting and 201 submissions objecting to the Project and 12 submissions provided comments on the Project.

18. Issues raised in the submissions made to DPIE include:

a. social impacts – impacts on the local farming community and cumulative impacts and benefits of mining on the broader community in the region

b. the rail spur – its impacts on the Namoi River floodplain with regard to flooding and other water related impacts and agricultural impacts

c. water resources – further clarification/ details of the flood modelling, groundwater sensitivity assessment and exchange between the Namoi River/ groundwater, and the impacts and management of discharges from sediment dams

d. biodiversity impacts – further clarification on biodiversity offset liability, credit calculations for rehabilitation and preparation of a Koala Plan of Management

e. final landform and land use – final void configuration and the trade-off between biodiversity conservation and agricultural land use in the rehabilitated landscape

f. additional issues – Aboriginal and Historic Heritage associated with the site, greenhouse gas emissions, traffic and transport along with support for the project identifying positive social, employment and economic benefits of mining to the broader regional economy.

19. The IPC held an initial public hearing on 4-5 February 2019 and its second public hearing on 2-3 July 2020. The IPC received a total of 2863 written public submissions, 774 submissions supported the proposed action, 2043 submissions objected to the proposed action (of which 935 used template wording), 46 submissions commented on the proposed action.

    a. Submissions to the IPC in support of the proposed action identified the local and regional socio-economic benefits of the proposed action, including employment opportunities which would be created and diversification from a predominantly agricultural economy.

    b. Submissions opposed to the proposed action raised issues including impacts to groundwater, biodiversity, agricultural land, greenhouse gas emissions, and unwanted social impacts such as elevated house prices.

Impacts and the Department's recommended proposed conditions

20. The Department's assessment of the likely impacts of the proposed action on matters of national environmental significance, as well as proposed mitigation measures and offsets, is provided in the legal considerations report at **Attachment A1**. In keeping with the streamlined assessment approach of the bilateral agreement, the Department's assessment is primarily based on information provided in the NSW assessment documents (**Attachments G1-G7**).

21. The Department has reviewed the relevant information, including advice from line areas (**Attachments E1-E3**), and considers that it is necessary to impose conditions on the approval to protect, repair and mitigate damage to matters of national environmental significance. Some of the recommended conditions reflect conditions attached to the NSW consent, others are additional. The Department's reasoning in relation to the proposed conditions is also provided at **Attachment A1**.

Threatened species and ecological communities (s 18 & 18A)

22. The proposed action will result in the disturbance of approximately 728.4 ha of native vegetation.

23. The impacts of the proposed action on EPBC Act listed threatened species includes the clearance of:

- 104.7 ha of potential Swift Parrot (*Lathamus discolor*) foraging habitat
- 75.2 ha of potential Regent Honeyeater *(Anthochaera phrygius)* habitat
- 80.9 ha of potential Koala (*Phascolarctos cinereus*, combined populations of Queensland, New South Wales and the Australian Capital Territory) habitat.

24. The IPC concluded that impacts to threatened species and communities would not be unacceptable if undertaken in accordance with the NSW conditions of consent (**Attachment G2**).

25. The IPC has imposed a range of conditions to manage the biodiversity impacts of the proposed action, including requiring the proponent to:

- implement its existing biodiversity strategy for the proposed action, including required conservation bonds and security mechanisms
- retire ecosystem and species credits for the additional clearing required for the proposed action within 2 years of the date of commencement of development and provide a 6-monthly report to DPIE on progress towards retiring credits
- prepare and implement a Biodiversity Management Plan for the proposed action
- prepare and implement a Koala Plan of Management for the proposed action.

26. The Department has taken the NSW conditions of consent into account. To minimise impacts to relevant threatened species, the Department has recommended conditions that:

- require the approval holder to comply with the relevant NSW conditions as they relate to biodiversity management and ecological rehabilitation
- limit the clearing of the threatened species habitat within the proposed action area.
- require biodiversity offsets in accordance with NSW offsetting policies endorsed by the Commonwealth
- require an offset statement to be prepared and published by the proponent to demonstrate that offsets with the identified land-based offsets for the proponent have been secured.

27. The Department also consulted the *EPBC Species and Ecological Communities Weekly Report* – 1 April 2021 (**Attachment A4**) to check for recent or upcoming decisions relating to the listing of species and communities, approved conservation advices, recovery plans or threat abatement plans that may be of relevance to this proposal.

28. The conservation advices, recovery plans and threat abatement plans you must consider are at **Attachment H** and are discussed in the legal considerations report at **Attachment A1**.

29. The Department recommends that for the purposes of sections 18 and 18A you propose to approve the proposed action subject to conditions 14-21 of **Attachment B** which the Department considers are necessary and convenient to avoid, minimise, manage and offset adverse impacts to threatened species and communities.

Water resources (s 24D & 24E)

30. On 14 November 2018, the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) provided advice on the proposed action (**Attachment J**).

31. Key impacts identified in the IESC advice (**Attachment J**) were groundwater drawdown from mining operations affecting groundwater availability and aquifer interactions, and groundwater drawdown associated with the proposed water supply borefield affecting groundwater availability and the dynamics of surface water-groundwater interactions.

32. The IESC advice also identified areas where further information is required to determine the full range of potential impacts to Groundwater Dependent Ecosystems (GDE's), groundwater and surface water. In response to the IESC's advice the proponent undertook further groundwater and flood modelling. The NSW Assessment report (**Attachment G5,** page vii) states that the independent groundwater and flooding experts engaged by NSW DPIE consider that the additional analysis and modelling is fit for purpose and ensures the full range of potential impacts of the proposed action can be assessed.

33. The IPC determined that potential surface and groundwater impacts could be effectively managed under the NSW conditions of consent at **Attachment G2**.

34. The Department accepts the IPC's conclusions and considers that the following NSW conditions of consent are appropriate and necessary to protect water resources:

    a. conditions B39-B40 – require the proponent to ensure it has sufficient water for all stages of the development, to report the annual extraction of water and to adjust the scale of the operations to match the available water supply

    b. conditions B41-B54 – general water management measures, including modelling and the requirement for specific management plans; water licences; water supply compensation for impacted landowners; and water discharge limits

35. To protect water resources and for regulatory streamlining purposes, the Department has recommended that the approval holder be required to comply with these NSW conditions in the EPBC Act approval. The approval holder will be required to report annually to the Department on compliance with the NSW conditions, which allows the Department to retain its own ongoing audit and compliance role in the protection of water resources.

36. The Department is satisfied that the NSW conditions relating to the management of surface water and groundwater are generally sufficient to protect water resources and for the most part address the IESC's concerns.

37. To address the outstanding issues raised by the IESC, the Department has recommended additional conditions that are considered necessary and convenient to

protect water resources by minimising groundwater drawdown impacts associated with mining operations and the borefield. These additional conditions are summarised below.

- The proponent must include the following information in the Water Management Plan required by NSW condition B53:
  - Management and mitigation strategies to minimise potential impacts to the EPBC Act listed Murray Cod (*Maccullochella peelii*).
  - Details of any chemical dust suppressants used. These details must include the chemicals proposed for use, typical application rates, and an assessment of the likelihood that the chemicals will enter the environment (e.g. soil, groundwater or surface water) and the potential persistence and toxicity to protected matters of these chemicals or their breakdown products.
  - Performance criteria and limits specific to aquatic and riparian ecosystems that account for changes to groundwater-surface water interactions derived from results of the monitoring.
- In addition to the Groundwater Management Plan monitoring requirements specified in NSW condition B53, the proponent must:
  - Establish and maintain a network of groundwater monitoring bores across the Development Application Area designed to detect changes in groundwater levels and groundwater-surface water interactions. These monitoring bores must be installed prior to the commencement of the action. Monitor groundwater levels at least once every 3 months.
  - Publish on the website all groundwater monitoring data from the bore network, updated at least once every 3 months. If the proponent detects an exceedance of any performance criteria specified in the approved Groundwater Management Plan or Surface Water Management Plan they must notify the Department of the exceedance within two business days of detecting the exceedance.
  - The proponent must submit written approval limits for alluvial aquifers and riparian ecosystems. The proponent must not commence groundwater extraction until the limits have been approved by you in writing.
  - If the proponent exceeds a limit relating to the performance measures for alluvial aquifers they must notify you in writing and cease groundwater extraction from the water supply borefield within two business days. Note ceasing groundwater extraction from the alluvial aquifer does not prevent mining activities. This allows the proponent to continue mining if water can be obtained from another source. It is expected that this would only occur during drought, when farmers are likely to be drawing from the same aquifer. This ensures farmers are able to continue to access water in drought periods.
  - The proponent may not recommence groundwater extraction until you have agreed, in writing, that the impact has been mitigated.

38. The Department recommends that you propose, for the purposes of sections 24D and 24E to approve the proposed action, subject to conditions 1-13 of **<u>Attachment B</u>** which

the Department considers are necessary to avoid, minimise and manage adverse impacts to water resources.

Consultation on proposed decision

39. Before you make a decision on whether or not to approve the proposed action, you are required under sections 131(1) and 131AA(1) of the EPBC Act to:

    a. inform the proponent and any other Commonwealth Minister(s) whom you believe have administrative responsibilities relating to the proposed action, of the decision that you propose to make; and

    b. invite the proponent and the Commonwealth Minister(s) to comment on your proposed decision within 10 business days.

40. If you propose to approve the proposed action, the Department will provide the invitations to comment at **Attachment C** to the following stakeholders:

    a. Vickery Coal Pty Ltd, the proponent

    b. The Hon Keith Pitt MP, Minister for Resources, Water and Northern Australia

    c. The Hon David Littleproud MP, Minister for Agriculture, Drought and Emergency Management

    d. The Hon Ken Wyatt AM MP, Minister for Indigenous Australians

    e. The Hon Angus Taylor MP, Minister for Energy and Emissions Reduction

    f. The Hon Michael McCormack MP, Minister for Infrastructure, Transport and Regional Development

    g. The Hon Christian Porter MP, Minister for Industry, Science and Technology.

41. A letter notifying the NSW Minister for Planning and Public Spaces, the Hon Rob Stokes MP, of your proposed decision has also been prepared (see **Attachment C8**).

42. Under section 131A of the EPBC Act, you may invite public comments on your proposed decision and any conditions that you are proposing to attach to the approval. The Department considers that sufficient opportunity to comment on the proposed action has already been provided to the public, noting the NSW assessment process included a 90-day public exhibition period and the IPC process included a public hearings. The Department considers that publishing your proposed decision for a further round of public comment is unlikely to elicit views or information that have not already been thoroughly considered.

Consultation on this brief

43. The following line areas were consulted in the preparation of this proposed decision briefing package and conditions:

    a. Office of Water Science

    b. Legal Division

    c. Post Approvals

d. Environmental Audit.

Other issues

44. The Legal Considerations Report (**Attachment A1**) covers the following matters raised in public submissions:

a. Greenhouse Gas Emissions

b. Aboriginal Cultural Heritage

c. Historic Heritage

d. Social and Economic Impacts

Sharma Ors v Minister

45. On 8 September 2020, proceedings were commenced in the Federal Court by eight people under the age of 18 (through their litigation guardian) on behalf of young people in Australia and elsewhere seeking to prevent you or your delegate from approving the proposed action.

46. The hearing concluded on 5 March 2021 and judgment is reserved.

47. You have given an undertaking not to make a final approval decision on the matter until 29 April 2021.

Period of approval

48. The Department recommends that the approval has effect until 31 December 2051.

49. This date aligns with the approval timeframe in the NSW conditions of consent and allows for construction, operation, decommissioning and rehabilitation actions to be undertaken in accordance with the described action.

Next steps

50. Once the time period for the submission of comments on your proposed decision has ended, the Department will brief you to make a final decision. The brief will include any comments received on your proposed decision and will take any comments received into consideration.

ATTACHMENTS* (see Appendix for complete list)

Attachment A: Departmental Documents

Attachment B: Proposed Approval Decision Notice

Attachment C: Letters (**for signature)**

Attachment D: Quality Assurance, ERT and Background Documentation

Attachment E: Line Area Advice

Attachment F: Requests and Responses for Further Information

Attachment G: NSW Assessment Documentation

Attachment H: Statutory Documentation

Attachment I: Proponent's Assessment Material

Attachment J: IESC Advice 2018

Attachment K: Namoi Bioregional Assessment

Appendix – proposed approval decision attachment list

Document	Document Description
Brief	Proposed decision brief - **FOR SIGNATURE**
Attachment A1	Legal considerations (Departmental advice for assessment)
Attachment A2	Departmental maps showing species distribution and the extent of the 2019-2020 bushfires at National and Bioregional scales.
Attachment A3	An analysis based on the recent available Independent Environmental Audits on the Whitehaven Coal website
Attachment A4	EPBC Act Species and Ecological Communities Weekly Report generated to list recent and imminent decisions (1 April 2021)
Attachment B	Proposed approval decision notice - **DO NOT SIGN**
Attachment C1	Letter to Proponent - **FOR SIGNATURE**
Attachment C2	Letter to Minister for Resources, Water and Northern Australia - **FOR SIGNATURE**
Attachment C3	Letter to Minister for Agriculture, Drought, Emergency Management and Communications - **FOR SIGNATURE**
Attachment C4	Letter to Minister for Indigenous Australians - **FOR SIGNATURE**
Attachment C5	Letter to Minister for Energy and Emissions Reduction - **FOR SIGNATURE**
Attachment C6	Letter to Minister for Infrastructure, Transport, Regional Development - **FOR SIGNATURE**
Attachment C7	Letter to Minister for Industry, Science and Technology - **FOR SIGNATURE**
Attachment C8	Letter to NSW Minister for Planning and Public Spaces - **FOR SIGNATURE**
Attachment D1	QA checklist
Attachment D2	ERT report with 10 km buffer generated on 24 March 2021
Attachment D3	Department's Review of the 24 March 2021 ERT report
Attachment D4	Existing approved open cut mine referral package for Vickery Coal Project (2012/6263)
Attachment D5	Approved variations to the proposed action and the designated proponent
Attachment D6	Notices for Extension of timeframe in which to make a decision whether to approve a controlled action (29 September 2020 and 9 December 2020)
Attachment D7	Vickery Extension Project referral package (2016/7649)
Attachment E1	Species Information and Policy Section listing advice
Attachment E2	OWS advice on state conditions related to surface and ground water
Attachment E3	Environmental history check (October 2020)
Attachment F1	Letter requesting further information about Environmental History from the proponent (10 December 2020) and the response from the proponent (29 January 2021)

Attachment F2	Letter requesting further information about the proponent's Environmental History from NSW Planning (9 December 2020) and the response from NSW Planning (2 February 2021)
Attachment F3	Letter requesting further information about Environmental History from the proponent (5 March 2021) and the response from the proponent (19 March 2021)
Attachment F4	2019-2020 bushfire information provided by the proponent about impacted areas adjacent to proposed action area and distribution of species.
Attachment F5	Presentation by Whitehaven Coal provided to the Department about the Vickery Extension Project
Attachment F6	An email from Whitehaven advising the Department of the Company Structure of Vickery/Whitehaven (3 December 2020)
Attachment G1	DPIE Notification letter to the Commonwealth Minister
Attachment G2	State Development Consent (12 August 2020)
Attachment G3	Independent Planning Commission (IPC) - Statement of reasons for NSW decision (12 August 2020)
Attachment G4	Independent Planning Commission (IPC) - Issues Report (30 April 2019)
Attachment G5	NSW Assessment Report (AR)
Attachment G6	NSW Biodiversity Conservation Division advice
Attachment G7	NSW Preliminary Issues Report (November 2018)
Attachment H1	Conservation Advice for Regent Honeyeater (*Anthochaera phrygia*)
Attachment H2	Conservation Advice for Swift Parrot (*Lathamus discolor*)
Attachment H3	Conservation Advice for Koala (*Phascolarctos cinereus*)
Attachment H4	Recovery Plan for Regent Honeyeater (*Anthochaera phrygia*)
Attachment H5	Recovery Plan for Swift Parrot (*Lathamus discolor*)
Attachment H6	Threat abatement plan for predation by feral cats
Attachment H7	Threat abatement plan for competition and land degradation by rabbits
Attachment I1	EIS and attachments
Attachment I2	Response to Submissions Report (RTS) (August 2019)
Attachment I3	Amended response to submissions report (September 2019)
Attachment J	IESC advice (14 November 2018)
Attachment K	Namoi subregion bioregional assessment

Attachment A1

VICKERY EXTENSION PROJECT (EPBC 2016/7649)

EPBC ACT ASSESSMENT LEGAL CONSIDERATIONS REPORT

8 APRIL 2021

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5 Greenhouse gas emissions

258. Greenhouse Gas (GHG) emissions are categorised into three different types:

- Scope 1: direct emissions from owned or controlled sources of an organisation/ development;
- Scope 2: indirect emissions from the, generation of purchased energy electricity, heat and steam used by an organisation/ development; and
- Scope 3: all other upstream and downstream emissions related to an organisation/ development.

259. Under GHG emissions reporting and accounting frameworks[13], the Scope 2 and 3 emissions estimated for the Project are the Scope 1 emissions of other organisations/ developments. For example, the Scope 3 emissions from combustion of coal in an overseas country would form part of the Scope 1 emissions of the organisation / development using the coal (e.g. for metallurgical use of steel manufacturing or for electricity generation) and would also be the Scope 1 emissions of the country where the coal is combusted under applicable national accounting frameworks (page 121, Attachment G5).

Proponent Assessment

260. The proponent's EIS included an Air Quality and Greenhouse Gas Assessment (AQA), undertaken by Ramboll Australia Pty Ltd, dated 16 February 2018. The Proponent's EIS states that the AQA was peer reviewed (AQA Peer Review) by Todoroski Air Services Pty Ltd, specifically for the GHG calculations in relation to Scope 3 emissions for the proposed action.

261. The EIS proposes a range of management and mitigation measures to minimise Scope 1 and Scope 2 GHG emissions as far as possible. Diesel consumption is by far the largest Scope 1 contributor (at around 90 per cent) and therefore reduction in diesel use is a high priority for the proposed action. It is also in the proponent's financial interest to minimise the use of diesel. Minimisation strategies include:

   a. maximising efficiencies of the mining fleet – related to maintenance, higher efficiency engines, idle times;

   b. optimising mine scheduling to reduce haul lengths and grades;

   c. revegetation in addition to rehabilitation and offsetting requirements, for example the proposed local enhancement plantings on Whitehaven properties; and

   d. energy efficiency initiatives to reduce indirect electricity consumption Scope 2 emissions (page 122, Attachment G5).

262. In relation to the Project's coal quality and emissions, the proponent's further information to DPIE states:

‘The relevant benchmark for premium thermal coal is a calorific value (i.e. energy content) of 6,000kcal/kg net as received (NAR). The calorific value of Vickery Extension Project's thermal coal is above this benchmark and is higher than the average for Australia and other major coal exporters, including Indonesia, Russia,

[13] The *Greenhouse Gas Protocol* (GHG Protocol) (World Business Council for Sustainable Development [WBCSD] and World Resources Institute [WRI], 2004 was applied for the Project.

South Africa, Colombia and the United States. This means that the Project's coal performs at a higher level of boiler efficiency in power stations, compared to coal from other sources, and that a greater volume of inferior quality coal would need to be combusted to achieve the same energy output as the Project's coal' (page 43, Attachment G3).

Public Comments

263. Public submissions on the EIS raised questions about the predicted emissions from the proposed action being lower than those for the Approved Project (the Vickery Coal Project), despite factors such as an increased production rate, larger mining footprint and overburden stockpile that suggest the air quality impacts would be greater.

264. Public submissions during the IPC process raised concerns about the contribution of greenhouse gases from the proposed action to climate change and that the approval of the proposed action is inconsistent with the carbon budget approach to stabilization (page 43, Attachment G3).).

DPIE Assessment

Source of emissions and amount of emissions

265. The DPIE AR notes that the main sources of Scope 1, Scope 2 and Scope 3 Greenhouse Gas (GHG) emissions from the proposed action are from electricity consumption, fugitive emissions of carbon dioxide (CO2) and methane (CH4), diesel usage, and the transport and end use of product coal (page 121, Attachment G5).

266. The GHG emissions of the Project have been assessed on a cumulative basis incorporating the Approved Project and extension project, but consideration has been given to the additional impacts over and above those associated with the Approved Project for comparative purposes (page xiv, Attachment G5).

Amount of emissions from both the original and extension projects

267. The NSW assessment report states that the emissions from the cumulative projects would generate approximately 3.1 Mt carbon dioxide equivalent (CO2-e) of Scope 1 emissions, 0.8 Mt Scope 2 and 366 Mt CO2-e Scope 3 emissions (see Table 1 below).

268. Annually, the cumulative projects would contribute an average of approximately 0.12 Mt CO2-e of Scope 1 GHG emissions, and approximately 14.7 Mt CO2-e of Scope 2 and Scope 3 GHG emissions, over its life (page 122, Attachment G5).

Table 1: Direct and indirect GHG emissions of the proposed action (source NSW assessment report)

GHG emissions Scope and description of key sources	Million tonnes (Mt) CO2-e over project life
Scope 1 • Diesel consumption • Use of explosives • Fugitive emissions	3.1
Scope 2 • Emissions from the consumption of purchased electricity	0.8
Scope 3 • Upstream emissions from the diesel and electricity supply used for the Project • Downstream emissions from the transport of coal product from the Project • Downstream emissions from the combustion of coal product from the Project	365

Emissions from the Extension project component only

269. In comparison to the original Approved Project, the extension project would result in a reduction of about 1 Mt CO2-e of Scope 1 emissions, increase of about 0.15 Mt CO2-e Scope 2 emissions and an increase of about 100 Mt CO2-e of Scope 3 emissions over the life of the proposed action.

270. The reduction in Scope 1 GHG emissions can be partially attributed to the inclusion of the CHPP, rail loop and rail spur, due to reduction in the consumption of diesel fuel associated with ROM coal haulage by truck to the Gunnedah CHPP.

Scope 1 & 2 emissions

271. Based on the Commonwealth Government's Quarterly Update of Australia's National Greenhouse Gas Inventory: June 2019, Australia's annual emissions equate to about 532 Mt CO2-e. As such, the proposed action's Scope 1 emissions would contribute to about 0.028 per cent of Australia's annual GHG emissions (page 122, Attachment G5).

272. According to the DPIE AR, the proposed action's Scope 1 emissions would contribute to about 0.028 per cent of Australia's current annual GHG emissions and would remain a very small contribution when compared to Australia's commitments under the Paris Agreement, as identified in the Commonwealth government's nationally determined contribution (NDC).

273. The DPIE AR notes that the predicted GHG emissions intensity for the proposed action would be about 0.02 tonnes of CO2-e per tonne of ROM coal (including all Scope 1 and Scope 2 emissions) and is comparable or better to other similar coal mining projects in the region, which range from 0.02 to 0.07 tonnes of CO2-e per tonne of ROM coal.

274. DPIE recommended conditions to manage the GHG emissions of the proposed action, including requiring for the proponent to:

- take all reasonable steps to improve energy efficiency and reduce Scope 1 and Scope 2 GHG emissions for the proposed action; and
- prepare and implement an Air Quality and Greenhouse Gas Management Plan, including proposed measures to ensure best practice management is being employed to minimise the Scope 1 and 2 emissions of the proposed action.

275. NSW DPIE considers, in the DPIE AR, that the proposed action is not inconsistent with the NSW Government's NSW Climate Change Policy Framework and notes that the proponent has committed to minimising the Scope 1 emissions over which it has direct control.

Scope 3 emissions

276. NSW DPIE acknowledges, in the DPIE AR, that the Scope 3 emissions from the combustion of product coal is a significant contributor to anthropological climate change, and that the contribution of the proposed action to the potential impacts of climate change in NSW must be considered in assessing the overall merits of the development application.

277. DPIE notes that the proposed action's Scope 3 emissions would not contribute to Australia's NDC, as product coal would be exported for combustion overseas. These Scope 3 emissions become the consumer countries' Scope 1 and 2 emissions and would be accounted for in their respective national inventories.

278. The NSW and Commonwealth Government's current policy frameworks do not promote restricting private development as a means for Australia to meet its commitments under the Paris Agreement or the long-term aspirational objective of the NSW Government's Climate Change Policy Framework. Neither do they require any action to be taken by the private sector in Australia to minimise or offset the GHG emissions of any parties outside of Australia, including the emissions that may be generated in transporting or using goods that are produced in Australia.

279. The proposed action would produce metallurgical coal (around 70 per cent of the product coal) including semi-soft coking coal, pulverised coal injection coal and thermal coal (around 30 per cent of the product coal) to supply Whitehaven's main export market customers in Japan, the Republic of Korea (South Korea) and the Republic of China (Taiwan).

    a. Japan and South Korea are signatories to the Paris Agreement and have developed GHG emission reduction targets, which would be managed under the NDCs of these countries.

    b. Taiwan is not a signatory to the Paris Agreement but has developed its own GHG emission reduction targets (enforced under its Greenhouse Gas Reduction and Management Act) that are comparable to those of countries who are signatories.

280. Overall, the DPIE considers that the GHG emissions for the proposed action have been adequately considered and that, if the proposed action is undertaken in accordance with the NSW conditions, are acceptable when weighed against the

relevant climate change policy framework, objects of the EP&A Act (including the principles of Ecologically Sustainable Development) and the socio-economic benefits of the proposed action.

IPC decisions and conditions

281. The IPC agrees with DPIE and acknowledges that Scope 3 emissions from the combustion of product coal are a significant contributor to anthropological climate change and that the contribution of the proposed action to the potential impacts of climate change in NSW must be considered in assessing the overall merits of the development application (page 48, Attachment G3).

282. The IPC notes that, under the Paris Agreement, the Australian Government committed to a NDC to reduce national GHG emissions by between 26 and 28 per cent from 2005 levels by 2030. The IPC also notes that Australia does not require monitoring or reporting of Scope 3 emissions under the Commonwealth Government's National Greenhouse and Energy Report Scheme (NGERS) and they are not counted in Australia's national inventory of GHG emissions under the Paris Agreement. The IPC agrees with the DPIE that the proposed action's Scope 3 emissions would not contribute to Australia's NDC, as product coal would be exported overseas. The IPC notes that these Scope 3 emissions become the consumer countries' Scope 1 and 2 emissions and would be accounted for under the Paris Agreement in their respective national inventories (page 48, Attachment G3).

283. The IPC notes that between 60-70 per cent of the coal proposed to be extracted is likely to be metallurgical coal, with the remainder being thermal coal. The IPC notes that at this point in time, metallurgical coals are essential inputs for the production of approximately 70 per cent of all steel globally. The IPC is of the view that in the absence of a viable alternative to the use of metallurgical coal in steel making and on balance, the impacts associated with the emissions from the combustion of the proposed action's metallurgical coal are acceptable. The IPC also notes that the coal proposed for extraction is anticipated to be of relatively high quality. The IPC notes that the use of higher quality coal may result in lower pollutants (page 49, Attachment G3).

284. The IPC imposed NSW conditions B35-37 to ensure that the proposed action's emissions are minimised to the greatest extent possible by applying best practice in GHG emissions reductions for Scope 1 and 2 emissions (page 48, Attachment G3). These conditions require the proponent to:

- take all reasonable steps to improve energy efficiency and reduce Scope 1 and Scope 2 GHG emissions for the proposed action
- prepare and implement an Air Quality and Greenhouse Gas Management Plan, including proposed measures to ensure best practice management is being employed to minimise the Scope 1 and 2 emissions of the proposed action.

285. The IPC concluded in the Statement of Reasons that GHG emissions for the proposed action have been adequately considered, and in the context of the climate change policy framework (including government policy, objects of the EP&A Act, ESD principles and socio-economic benefits), the impacts associated with the GHG

emissions of the proposed action are acceptable and consistent with the public interest (page 49, Attachment G3).

Department's consideration

286. The Department notes that under the EPBC Act the assessment is only for the Vickery Extension project and not the cumulative impacts of both projects, on the basis that the Vickery Coal Project was determined an NCA-PM under the EPBC Act.

287. The Department notes that the proposed action would result (over 25 years) in a:

   a. reduction of about 1 Mt CO2-e of Scope 1 emissions,

   b. increase of about 0.15 Mt CO2-e Scope 2 emissions,

   c. and an increase of about 100 Mt CO2-e of Scope 3 emissions over the life of the Project.

   d. The reduction in Scope 1 GHGE can be partially attributed to the inclusion of the Project CHPP, rail loop and rail spur, due to reduction in the consumption of diesel fuel associated with ROM coal haulage by truck to the Gunnedah CHPP.

288. The Department notes that NSW approval conditions B35-37 require that proposed action's emissions are minimised to the greatest extent possible by applying best practice in GHG emissions reductions for Scope 1 and 2 emissions (as described in para 283).

289. The Department notes that the IPC found Scope 3 emissions become the consumer countries' Scope 1 and 2 emissions and would be accounted for under the Paris Agreement in their respective national inventories (page 48, Attachment G3).

290. The Department does not consider that further conditions are necessary to protect water resources and listed threatened species and ecological communities.

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Attachment B

VICKERY EXTENSION PROJECT (EPBC 2016/7649)

EPBC ACT ASSESSMENT LEGAL CONSIDERATIONS REPORT

September 2021

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5 GREENHOUSE GAS EMISSIONS

268. Greenhouse Gas (GHG) emissions are categorised into three different types:

- Scope 1: direct emissions from owned or controlled sources of an organisation/ development;
- Scope 2: indirect emissions from the generation of purchased energy electricity, heat and steam used by an organisation/ development; and
- Scope 3: all other upstream and downstream emissions related to an organisation/ development.

- Under GHG emissions reporting and accounting frameworks[12], the Scope 2 and 3 emissions estimated for the proposed action are the Scope 1 emissions of other organisations/ developments. For example, the Scope 3 emissions from combustion of coal in an overseas country would form part of the Scope 1 emissions of the organisation / development using the coal (e.g. for metallurgical use of steel manufacturing or for electricity generation) and would also form part of the Scope 1 emissions of the country where the coal is combusted under applicable national accounting frameworks (page 121, Attachment G5).

5.1 PROPONENT'S ASSESSMENT

269. The proponent's EIS included an Air Quality and Greenhouse Gas Assessment (AQA), undertaken by Ramboll Australia Pty Ltd, dated 16 February 2018. The proponent's EIS states that the AQA was peer reviewed (AQA Peer Review) by Todoroski Air Services Pty Ltd, specifically for the GHG calculations in relation to Scope 3 emissions for the proposed action.

270. The EIS proposes a range of management and mitigation measures to minimise Scope 1 and Scope 2 GHG emissions as far as possible. Diesel consumption is by far the largest Scope 1 contributor (at around 90 per cent) and therefore reduction in diesel use is a high priority for the proposed action. It is also in the proponent's financial interest to minimise the use of diesel. Minimisation strategies include:

    a. maximising efficiencies of the mining fleet – related to maintenance, higher efficiency engines, idle times;

    b. optimising mine scheduling to reduce haul lengths and grades;

    c. revegetation in addition to rehabilitation and offsetting requirements, for example the proposed local enhancement plantings on Whitehaven properties; and

    d. energy efficiency initiatives to reduce indirect electricity consumption Scope 2 emissions (page 122, Attachment G5).

    e. In relation to the proposed action's coal quality and emissions, further information provided to DPIE by the proponent states:

    > 'The relevant benchmark for premium thermal coal is a calorific value (i.e. energy content) of 6,000kcal/kg net as received (NAR). The calorific value of Vickery Extension Project's thermal coal is above this benchmark and is higher than the average for Australia and other major coal exporters, including Indonesia, Russia, South Africa, Colombia and the United States. This means that the Project's coal performs at a higher level of boiler efficiency in power stations, compared to coal from other sources, and that a greater volume of inferior quality coal would need to be combusted to achieve the same energy output as the Project's coal' (page 43, Attachment G3).

5.2 PUBLIC COMMENTS

271. Public submissions on the EIS raised questions about the predicted emissions from the proposed action being lower than those for the Approved Project (the Vickery Coal

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[12] The *Greenhouse Gas Protocol* (GHG Protocol) (World Business Council for Sustainable Development [WBCSD] and World Resources Institute [WRI], 2004 was applied for the proposed action (Attachment G5 of Final Decision Brief)

Project), despite factors such as an increased production rate, larger mining footprint and overburden stockpile that suggest the air quality impacts would be greater.

272. Public submissions during the IPC process raised concerns about the contribution of greenhouse gases from the proposed action to climate change and stated that the approval of the proposed action would be inconsistent with the carbon budget approach to stabilization (page 43, Attachment G3).

5.3 DPIE ASSESSMENT

5.3.1 Source of emissions and amount of emissions

273. The DPIE AR notes that the main sources of Scope 1, Scope 2 and Scope 3 Greenhouse Gas (GHG) emissions from the proposed action are from electricity consumption, fugitive emissions of carbon dioxide (CO2) and methane (CH4), diesel usage, and the transport and end use of product coal (page 121, Attachment G5).

274. The GHG emissions of the proposed action have been assessed on a cumulative basis incorporating the Approved Project and extension project, but consideration has been given to the additional impacts over and above those associated with the Approved Project for comparative purposes (page xiv, Attachment G5).

5.3.2 Amount of emissions from both the original and extension projects

275. The DPIE AR states that the emissions from the cumulative projects would generate approximately 3.1 Mt carbon dioxide equivalent (CO2-e) of Scope 1 emissions, 0.8 Mt Scope 2 and 366 Mt CO2-e Scope 3 emissions (see Table 3 below).

276. Annually, the cumulative projects would contribute an average of approximately 0.12 Mt CO2-e of Scope 1 GHG emissions, and approximately 14.7 Mt CO2-e of Scope 2 and Scope 3 GHG emissions, over its life (page 122, Attachment G5).

Table 3 – Direct and indirect GHG emissions of the Project (source DPIE AR)

GHG emissions Scope and description of key sources	Million tonnes (Mt) CO2-e over project life
Scope 1 • Diesel consumption • Use of explosives • Fugitive emissions	3.1
Scope 2 • Emissions from the consumption of purchased electricity	0.8
Scope 3 • Upstream emissions from the diesel and electricity supply used for the Project • Downstream emissions from the transport of coal product from the Project • Downstream emissions from the combustion of coal product from the Project	365

5.3.3 Emissions from the Extension project component *only*

277. In comparison to the original Approved Project, the extension project would result in a reduction of about 1 Mt CO2-e of Scope 1 emissions, increase of about 0.15 Mt CO2-e Scope 2 emissions and an increase of about 100 Mt CO2-e of Scope 3 emissions over the life of the proposed action.

278. The reduction in Scope 1 GHG emissions can be partially attributed to the inclusion of the CHPP, rail loop and rail spur, due to reduction in the consumption of diesel fuel associated with ROM coal haulage by truck to the Gunnedah CHPP.

5.3.4 Scope 1 & 2 emissions

279. According to the DPIE AR, the proposed action's Scope 1 emissions would contribute to about 0.028 per cent of Australia's current annual GHG emissions and would remain a very small contribution when compared to Australia's commitments under the Paris Agreement, as identified in the Commonwealth government's nationally determined contribution (NDC).

280. The DPIE AR notes that the predicted GHG emissions intensity for the proposed action would be about 0.02 tonnes of CO2-e per tonne of ROM coal (including all Scope 1 and Scope 2 emissions) and is comparable or better to other similar coal mining projects in the region, which range from 0.02 to 0.07 tonnes of CO2-e per tonne of ROM coal.

281. DPIE recommended conditions to manage the GHG emissions of the proposed action, including requiring for the proponent to:

- take all reasonable steps to improve energy efficiency and reduce Scope 1 and Scope 2 GHG emissions for the proposed action; and
- prepare and implement an Air Quality and Greenhouse Gas Management Plan, including proposed measures to ensure best practice management is being employed to minimise the Scope 1 and 2 emissions of the proposed action.

282. NSW DPIE considers, in the DPIE AR, that the proposed action is not inconsistent with the NSW Government's NSW Climate Change Policy Framework and notes that the proponent has committed to minimising the Scope 1 emissions over which it has direct control.

5.3.5 Scope 3 emissions

283. NSW DPIE acknowledges, in the DPIE AR, that the Scope 3 emissions from the combustion of product coal is a significant contributor to anthropogenic climate change, and that the contribution of the proposed action to the potential impacts of climate change in NSW must be considered in assessing the overall merits of the development application.

284. DPIE notes that the proposed action's Scope 3 emissions would not contribute to Australia's NDC, as product coal would be exported for combustion overseas. These Scope 3 emissions become the consumer countries' Scope 1 and 2 emissions and would be accounted for in their respective national inventories.

285. DPIE notes that the NSW and Commonwealth Government's current policy frameworks do not promote restricting private development as a means for Australia to meet its commitments under the Paris Agreement or the long-term aspirational objective of the NSW Government's Climate Change Policy Framework. Neither do they require any action

to be taken by the private sector in Australia to minimise or offset the GHG emissions of any parties outside of Australia, including the emissions that may be generated in transporting or using goods that are produced in Australia.

286. The proposed action would produce metallurgical coal (around 60 per cent of the product coal) including semi-soft coking coal, pulverised coal injection coal and thermal coal (around 40 per cent of the product coal) to supply Whitehaven's main export market customers in Japan, the Republic of Korea (South Korea) and the Republic of China (Taiwan).

   a. Japan and South Korea are signatories to the Paris Agreement and have developed GHG emission reduction targets, which would be managed under the NDCs of these countries.

   b. Taiwan is not a signatory to the Paris Agreement but has developed its own GHG emission reduction targets (enforced under its Greenhouse Gas Reduction and Management Act) that are comparable to those of countries who are signatories.

287. Overall, the DPIE considers that the GHG emissions for the proposed action have been adequately considered and that, if the proposed action is undertaken in accordance with the NSW conditions, are acceptable when weighed against the relevant climate change policy framework, objects of the EP&A Act (including the principles of Ecologically Sustainable Development) and the socio-economic benefits of the proposed action.

5.4 IPC DECISIONS AND CONDITIONS

288. The IPC agrees with DPIE and acknowledges that Scope 3 emissions from the combustion of product coal are a significant contributor to anthropogenic climate change and that the contribution of the proposed action to the potential impacts of climate change in NSW must be considered in assessing the overall merits of the development application (page 48, Attachment G3).

289. The IPC notes that, under the Paris Agreement, the Australian Government committed to a NDC to reduce national GHG emissions by between 26 and 28 per cent from 2005 levels by 2030. The IPC also notes that Australia does not require monitoring or reporting of Scope 3 emissions under the Commonwealth Government's National Greenhouse and Energy Report Scheme (NGERS) and they are not counted in Australia's national inventory of GHG emissions under the Paris Agreement. The IPC agrees with DPIE that the proposed action's Scope 3 emissions would not contribute to Australia's NDC, as product coal would be exported overseas. The IPC notes that these Scope 3 emissions become the consumer countries' Scope 1 and 2 emissions and would be accounted for under the Paris Agreement in their respective national inventories (page 48, Attachment G3).

290. The IPC notes that between 60-70 per cent of the coal proposed to be extracted is likely to be metallurgical coal, with the remainder being thermal coal. The IPC notes that at this point in time, metallurgical coals are essential inputs for the production of approximately 70 per cent of all steel globally. The IPC is of the view that in the absence of a viable alternative to the use of metallurgical coal in steel making and on balance, the impacts associated with the emissions from the combustion of the proposed action's metallurgical coal are acceptable. The IPC also notes that the coal proposed for extraction is anticipated

to be of relatively high quality. The IPC notes that the use of higher quality coal may result in lower pollutants (page 49, Attachment G3).

291. The IPC imposed NSW conditions B35-37 to ensure that the proposed action's emissions are minimised to the greatest extent possible by applying best practice in GHG emissions reductions for Scope 1 and 2 emissions (page 48, Attachment G3). These conditions require the proponent to:

- take all reasonable steps to improve energy efficiency and reduce Scope 1 and Scope 2 GHG emissions for the proposed action
- prepare and implement an Air Quality and Greenhouse Gas Management Plan, including proposed measures to ensure best practice management is being employed to minimise the Scope 1 and 2 emissions of the proposed action.

292. The IPC concluded in the Statement of Reasons that GHG emissions for the proposed action have been adequately considered, and in the context of the climate change policy framework (including government policy, objects of the EP&A Act, ESD principles and socio-economic benefits), the impacts associated with the GHG emissions of the proposed action are acceptable and consistent with the public interest (page 49, Attachment G3).

5.5 DEPARTMENT'S CONSIDERATION

293. The department notes that, under the EPBC Act, this assessment is for the Vickery Extension project and not the cumulative impacts of both projects, on the basis that the Vickery Coal Project was earlier determined to be an NCA-PM under the EPBC Act.

294. On 13 September 2021, the proponent advised that the scope 1 emissions for the proposed action only are approximately 20% of the scope 1 emissions for the Project (3.1 Mt CO2-e). The department notes that the proposed action would result (over 25 years) in about:

- 0.62 Mt CO2-e of Scope 1 emissions,
- 0.15 Mt CO2-e Scope 2 emissions, and
- 100 Mt CO2-e of Scope 3 emissions over the life of the Project.

295. The department notes that in comparison to the original Approved Project, the Extension Project would result in a reduction of about 1 MT CO2-e of Scope 1 emissions. The reduction in Scope 1 GHGE can be partially attributed to the inclusion of the Project CHPP, rail loop and rail spur, due to reduction in the consumption of diesel fuel associated with ROM coal haulage by truck to the Gunnedah CHPP.

296. The department notes that NSW approval conditions B35-37 require that proposed action's emissions are minimised to the greatest extent possible by applying best practice in GHG emissions reductions for Scope 1 and 2 emissions (as described in para 283).

297. The department notes that the IPC found Scope 3 emissions become the consumer countries' Scope 1 and 2 emissions and would be accounted for under the Paris Agreement in their respective national inventories (page 48, Attachment G3). The management of GHG emissions under international and national frameworks is discussed further below in section 7.

298. The department does not consider that further conditions are necessary to protect water resources and listed threatened species and ecological communities.

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7 DUTY OF CARE AND HUMAN SAFETY

338. On 8 July 2021, the Federal Court of Australia declared that you have a duty to take reasonable care, in the exercise of your powers under ss 130 and 133 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) in respect of the proposed action, to avoid causing personal injury or death to persons under 18 years of age and ordinarily resident in Australia, arising from emissions of carbon dioxide into the Earth's atmosphere: *Sharma v Minister for Environment (No 2)* [2021] FCA 774 (***Sharma No 2***). On 27 May 2021, the Court published its reasons for making that declaration: *Sharma v Minister for Environment* [2021] FCA 560 (***Sharma No 1***). These decisions are collectively referred to as ***Sharma***.

339. The Court also found that human safety is a mandatory relevant consideration in relation to a controlled action that may endanger human safety, including through the emission of greenhouse gases (**GHG**). The Court said at [404] of *Sharma No 1*:

> 'In relation to a controlled action of that kind, the lives and safety of the Children are not optional considerations but have to be taken into account by the Minister when determining whether to approve or not approve the controlled action. That implication is found in the 'subject-matter, scope and purpose' of EPBC Act…'

340. The Court found that you owed the applicants and other Australian children a duty to take reasonable care to avoid causing them personal injury when deciding whether to approve the Extension Project. The relevant risk of personal injury was the real risk of harm to Australian children arising from heatwaves and bushfires, brought about by increases to global average surface temperatures: see *Sharma No 1* at [247]. The Court found that the Extension Project would lead to the emission of 100MT of CO2, which the Court found would cause a small but measurable increase to global average temperatures and that the proposed action's emissions would increase the risk of harm to Australian children arising from climate change. While the Court accepted that the contribution of the Extension Project to the increase in global average surface temperature might be characterised as "tiny", there was a "real risk that even an infinitesimal increase in global average surface temperature may trigger a 4°C Future World" and, in that context, "the Minister's prospective contribution is not so insignificant as to deny a real risk of harm to the Children": *Sharma No 1* at [253].

341. The department notes that you are appealing the whole of the Federal Court's judgment in *Sharma*, except for that part concerning the dismissal of the application for an injunction. The grounds for the appeal are set out in the notice of appeal that has been filed with the Federal Court. The basis of the appeal is generally that the primary judge made errors of law.

342. Notwithstanding that you are currently appealing the Federal Court's judgment in *Sharma*, the department has applied the *Sharma* reasoning to this decision.

7.1 APPLICATION OF SHARMA REASONING TO THIS DECISION

343. In deciding whether or not to approve the taking of the proposed action, you must take into account human safety and you must take reasonable care to avoid causing death or personal injury to Australian children. Human safety should be given 'elevated weight' in balancing the matters you must consider in exercising your discretion to approve or not approve the proposed action under ss 130 and 133 of the EPBC Act. The Court in *Sharma* stated at [407]:

> 'Faced with a controlled action which poses a real risk to the safety of members of the Australian community, the Minister may be expected to give at least elevated weight to the need to take reasonable care to avoid that risk of harm. To do so would be consonant with the policy of the EPBC Act. In such circumstances, the imposition of a duty of care which may, as a practical matter, impose a requirement upon the Minister to consider and give elevated weight to the need for reasonable care to be taken to avoid death or personal injury will not distort the Minister's discretion or skew the intended statutory balance.'

344. This part of the Report addresses the risks to human safety posed by the proposed action, your duty to take reasonable care to avoid causing death or injury to Australian children in making your decision and the department's recommendation, taking into account these

matters and weighing them against other considerations including economic and social considerations. This section is structured as follows:

7.2 Global coal markets and the likelihood of the proposed action's emissions increasing global GHG emissions;

7.3 How GHG emissions are managed under international and national frameworks;

7.4 Summary of GHG emissions for the proposed action, measures being undertaken by the company to manage the proposed action and Independent Planning Commission (**IPC**) Assessment;

7.5 Risks of a warming climate;

7.6 Social and economic considerations;

7.7 Conclusion.

7.2 GLOBAL COAL MARKETS AND THE LIKELIHOOD OF THE PROPOSED ACTION'S EMISSIONS INCREASING GLOBAL GHG EMISSIONS

345. To assist you in making your decision, the department has reviewed publications of the International Energy Agency that analyse trends in global markets including the 'World Energy Outlook 2020' (**WEO 2020**), 'Iron and Steel Roadmap 2020' (**Iron and Steel Roadmap**) and 'Net Zero by 2050'. The department has taken into account the letter from the proponent dated 29 July 2021, addressing the GHG emissions of the proposed action (Attachment I of the Final Decision Brief) which annexed a submission to the IPC dated 16 June 2020 (**Proponent's Letter**). The proponent's Letter also addresses WEO 2020, 2020 IEA Iron and Steel Roadmap, Net Zero by 2050 and the 'World Energy Outlook 2019' (**WEO 2019**).

346. The department has also taken into account the report of Professor Will Steffen submitted to the NSW IPC and dated 30 June 2020, annexing an earlier report dated 9 February 2019 (Attachment G of the Final Decision Brief). This report was submitted to the department in a letter dated 26 August 2021 from 8 young persons opposing the approval of the proposed action and was in evidence before the Court in the *Sharma* proceedings. The department has also considered the other expert reports of Professor Steffen filed in the *Sharma* proceedings, dated 7 December 2020 and 17 January 2021. These reports are referred to as the '**Steffen Reports**' and are included in this brief with the other reports filed in the proceeding from Dr Ramona Meyricke, Professor Anthony Capon and Dr Karl Mallon (Attachment S).

347. The department has also sought the advice of the Department of Industry, Science, Energy and Resources (**DISER**) in relation to the extent to which, if at all, the approval of certain coal projects, including the proposed action, would affect the global level of consumption of coal in possible future scenarios (Attachment J of the Final Decision Brief) (**DISER Advice**).

348. The DISER Advice explains that the two primary uses of coal are for energy and steelmaking. Coal used for steelmaking is referred to as metallurgical or coking coal. Coke makers use multiple coals when formulating a coking coal blend in order to meet these specifications. Coal used for energy is referred to as thermal coal.

349. The proponent has advised that 60% of the saleable coal is to be used for steelmaking and 40% of the coal produced will be thermal coal for electricity production.

7.2.1 Global demand for steel

350. Steel is and will be critical for supplying the world with energy, as it is an integral ingredient for energy transition, with solar panels, wind turbines, dams and electric vehicles all depending on it to varying degrees. Steel is the main material used in onshore and offshore wind turbines. Almost every component of a wind turbine is made of steel. Steel provides the strength for taller, more efficient wind turbines. Each new MW of solar power requires between 35 to 45 tons of steel, and each new MW of wind power requires 120 to 180 tons of steel.

351. Transmission and distribution lines also require steel. As installations move further offshore more steel will be required. Demand is growing for electrical steels to serve this market.

352. Steel is also a fundamental building block for modern and developing economies. The construction of homes, schools, hospitals, bridges, cars and trucks rely heavily on steel for strength. The DISER Advice notes that steel demand is driven by construction and infrastructure development.

353. OECD modelling[13] predicts that global steel demand is not expected to peak until mid-century, with a growth rate for steel demand from about 1.4% per annum to 1.1%. Demand in mature economies will show zero to slightly negative growth rates over the period, while demand growth in emerging economies will be in the range 2.5% to 4%. Further, the modelling predicts that iron ore demand for steel making will peak in 2025-2030.

354. The IEA Iron and Steel Road Map notes that the steel sector is currently responsible for about 8% of global final energy demand and 7% of energy sector CO2 emissions (including process emissions). However, through innovation, low-carbon technology deployment and resource efficiency, iron and steel producers have opportunities to reduce energy consumption and GHG emissions, develop more sustainable products and enhance their competitiveness.

355. The proponent's Letter relies on independent modelling undertaken by CRU International Limited (**CRU**) and annexes a summary report prepared by CRU (**CRU Summary Report**). CRU's modelling suggests that steel will remain an important material for global development, particularly in South East Asia, and global demand for carbon crude steel is expected to grow steadily to 2040. Further, CRU state that blast furnace-basic oxygen furnace processes (which require coking coal) will still account for approximately 57% of global steel production by 2040.

7.2.2 Global demand for coal

356. The WEO 2020 identifies a number of scenarios for future global energy demand and supply to 2040. These scenarios include the:

- <u>Sustainable Development Scenario (SDS):</u> which assumes that global coal consumption will be constrained to a level consistent with the aims of the Paris Agreement and energy-related sustainable development goals (these are: affordable and clean energy (SDG 7), to reduce the severe health impacts of air pollution (part of SDG 3) and climate action (SDG 13)); and

[13] https://www.oecd.org/industry/ind/Item_4b_Accenture_Timothy_van_Audenaerde.pdf

- Stated Policies Scenarios (STEPS): which assumes that global coal consumption will not be constrained to a level consistent with the aims of the Paris Agreement or address sustainable development goals. This scenario takes into account the policies and implementing measures affecting energy markets that have been adopted as of mid-2020, together with relevant policy proposals which have not been fully implemented.

357. The DISER Advice notes that global demand for coal will gradually decrease to 2040 in either SDS or STEPS scenario. Global demand for coal is estimated to be 1850 Mtce in 2040 in the SDS scenario and 4735 Mtce in 2040 in the STEPS scenario. However, demand for coal varies by region.

358. Table 1 of the DISER Advice details predicted coal demand in the STEPS scenario and demonstrates that demand for coal in the Asia Pacific region will remain relatively steady up to 2040. The DISER Advice states:

> Coal consumption in India is expected to grow over the next 20 years by 182 Mtce. Coal consumption in South East Asia is also expected to grow rapidly over the same period, increasing by 157 Mtce. Coal use rebounds in China in the near term, peaking around 2025, before declining to 2040. Japan is expected to see the largest reduction in coal consumption over the period, declining by 55 Mtce. By 2040, the Asia Pacific region will account for 85 per cent of global coal consumption (Table 1).

359. Table 2 of the DISER Advice details predicted coal demand in the SDS scenario and demonstrates that demand for coal will decrease to 2040. Although in this scenario there is a decline in overall demand, WEO 2020 also projects that countries exporting to emerging Asian markets with higher exposure to coking coal will be less affected by lowered demand. Australia is also projected to remain the largest exporter of metallurgical coal.

360. The DISER Advice notes that, in either the SDS or STEPS scenario, the global demand for coal up to 2040 can be met by alternative sources of coal. Alternative sources of coal include all currently approved Australian coal mines, as well as all known or likely coal mines and coal deposits outside Australia, but excludes the Russel Vale project and other unapproved Australian coal mining developments.

361. The proponent's Letter also addresses coal demand and states that there is, and will remain for the foreseeable future, an ongoing demand for both coking and thermal coal. The proponent refers to WEO 2019 and WEO 2020 to support this position and the CRU Summary Report. The proponent's Letter is broadly consistent with the department's review of these reports and the findings of the DISER Advice.

362. The likely export destinations for the proposed action are Japan, South Korea and Taiwan. CRU notes that these countries have little to no domestic supply of coal and high quality coal from Australia is and will continue to be in demand to meet the electricity needs of these countries.

7.2.3 Iron and Steel Roadmap and Net Zero by 2050

363. The Iron and Steel Roadmap presents two pathways for the steel sector in the STEPS and SDS scenarios broadly in line with the WEO.

364. The Iron and Steel Roadmap, developed in conjunction with industry, indicates that opportunities to reduce emissions from the sector in the next 10 years will primarily rely on

improvements in material efficiency (light weighting of steel requirements in buildings), greater recycling of steel and iron (electric arc furnace), energy efficiency and performance improvements. Additionally, alternatives to steel (such as carbon fibre, engineered timber) and new methods for making steel without metallurgical coal, using hydrogen or electrolysis (using electricity) are being developed and piloted globally. However, these methods are not currently projected to be operating at scale until the 2030s.

365. The DISER Advice also notes that Direct Reduction Iron (DRI) and electric arc furnace (EAF) technologies currently present technical and cost challenges and are not yet available at the scale needed to meet global demand for steel.

7.2.4 NSW Strategic Statement on Coal

366. The NSW Government has developed a Strategic Statement on Coal Exploration and Mining in NSW. The statement identifies that coal mining in NSW is anticipated to continue for the next few decades. Although recognising that emissions reduction measures will be required, the statement notes that ending or reducing NSW thermal coal exports while there is still strong global demand for coal is likely to have little to no impact on global carbon emissions. The use of coking coal is likely to be sustained longer than thermal coal, as there are currently limited practical substitutes available.

7.2.5 Alternative sources of coal and related GHG emissions

367. The DISER Advice differentiates between the global coal market for thermal coal and metallurgical coal. The long term demand for metallurgical coal depends primarily on its price and the demand for steel. The long term demand for thermal coal depends primarily on its price and demand for energy (including the cost of alternative energy products and consumer preferences for energy types). Supply of both metallurgical and thermal coal depends on availability in nature, the technology used for extraction, the labour and capital costs associated with production, the cost of transporting the coal to the demand source (normally by rail and ship) and the regulatory costs associated with environmental protection and worker health and safety. However, the prices of metallurgical and thermal coal are linked because there is a degree to which the different coal types can be used in the alternative market. Steelmakers may substitute some metallurgical coal with high-end thermal coal.

368. The DISER Advice states that your decision to approve the proposed action does not affect any of the demand factors identified. The DISER Advice notes that recent trade disruptions have demonstrated the substitutability of coal, where coal destined for China has been resold or redirected to various countries and China has managed to source its coal needs in the absence of previously substantial Australian supply. The DISER Advice concludes:

> Regardless of any feasible scenario of future global demand, the small fraction of current global coal supply that these projects represent, combined with the relatively flat global seaborne coal cost curves indicates that the Decision will not have any discernible impact on global coal prices. The alternative sources of coal identified in sub-question 1 are readily substitutable for any coal that might be produced by the Coal Mining Projects.

369. Consistent with DISER's advice, the proponent's Letter also states that a decision to not approve the proposed action would not affect global demand because the loss of supply would be very small relative to the size of global consumption.

370. The DISER Advice emphasises that one of the most important factors for the emissions intensity of electricity produced from thermal coal is the energy content or calorific value of the coal. DISER states that:

> The CO2 emissions intensity of electricity generated from coal is dependent on a number of factors including the energy, moisture, ash content and sulphur content of the coal, how the coal is stored and treated, and the technology and operation of the coal generation unit. One of the most important factors for emissions intensity is the energy content or calorific value, which represents the energy contained in the coal. High energy content coal can be combusted more efficiently resulting in less emissions per unit of electricity generated (i.e., improved thermal efficiency).

371. The proposed action's thermal coal product has a calorific value of greater than 6400 kcal/kg. This is higher than the average calorific value of Australian coal and international alternatives identified in Table 9 of the DISER Advice. Using the example of Indonesia, the DISER Advice states that consumption of thermal coal from Indonesia rather than from the Coal Mining Projects (including the proposed action) could be expected to result in slightly more CO2 emissions.

372. The DISER Advice states that it is not possible to readily determine whether CO2 emissions from extraction and transport activities would be materially different from alternative sources of coal. Generally, the lower the calorific value of the coal, the greater mass of coal required to produce a given level of electricity. In this way, lower thermal efficiency results in higher mining and transport-related emissions per kilometre. DISER noted that these emissions depend on a large range of factors making it not possible to conclude that emissions will necessarily increase. However, DISER advised that, as a proportion of total emissions associated with any coal mining project, transport emissions comprise a small contribution compared to emissions from combustion of the coal.

373. The proponent relied on CRU's analysis that market substitution of the Extension Project's coal will result in higher emissions than if the Extension Project is approved. CRU estimated that between 6 and 50 million tonnes CO2-e of additional emissions, depending on if alternative sources come from low or high fugitive mines, will be emitted into the atmosphere over the life of mine due to market substitution if the proposed action is not approved. The department notes that CRU's modelling was described as commercially sensitive and was not provided to the department. However, the proponent's Letter contained analysis of CRU's findings and a summary from CRU. This identified a number of assumptions that the modelling relied on, including treating all of the Extension Project's product coal as thermal coal for the purpose of analysing market substitution (Vickery is expected to produce 40% thermal coal and 60% metallurgical coal) and that alternative sources are weighted averages of competitor countries' coal rather than a specific mine, identifying average distances that coal is transported by rail by region, average power consumption of coal mines by region and average coal volumes on an energy-equivalent basis. The proponent acknowledged that these estimates rely on available data and estimates can vary.

374. The department notes these limitations and has also taken into account DISER's advice that:

> It is not possible to identify specific mine sources that would be the alternative sources of coal in the event the Coal Mining Projects were not approved. This makes it not possible to conclude that

any Decision to approve the Coal Mining Project will necessarily increase greenhouse gas emissions associated with coal consumption.

375. The department agrees with DISER's conclusion that 'other things being equal, where coal from these projects (including the proposed action) is replaced by [thermal] coal of lower calorific value, emissions from consumption of this alternative source of [thermal] coal will tend to be higher'. The department notes that there does not seem to be a correlation between calorific value of metallurgical coal and emissions in steelmaking. The department therefore considers it is likely that at least the same amount of GHG emissions, and possibly greater amounts of GHG emissions, will result if the proposed action is not approved.

7.2.6 Impact of a decision to approve or refuse the propose action on global GHG emissions and climate change

376. The department considers that the available evidence indicates that a decision to approve the proposed action would be unlikely to cause an increase to global average surface temperatures. This is because the approval of the proposed action is not likely to cause more coal to be consumed (and therefore more GHG emissions) than if the proposed action was not approved.

377. The DISER Advice states that 'any decision of the Minister to approve one or more of the Coal Mining Projects (Decision) is not expected to materially impact on the total amount of coal consumed globally'. The department agrees with this conclusion. DISER notes that the approval or refusal of the proposed action will not affect global demand for coal (see DISER Advice Question 2) and there are sufficient alternative sources of coal to supply future demand for coal in projected future scenarios. In those circumstances, the rejection of the proposed action is unlikely to have an impact on total coal consumption, or to impact the price of coal.

378. The DISER Advice notes that the coal from the proposed action is of a higher calorific value than average calorific values of coal in Australia and other major exporters. The department agrees with DISER's conclusion that 'other things being equal, where coal from these projects is replaced by coal of lower calorific value, emissions from consumption of this alternative source of coal will tend to be higher'. The department considers it is likely that at least the same amount of GHG emissions, and possibly more, will result if the proposed action is not approved.

379. While the DISER Advice noted that it is not possible to identify specific mines that will be used in substitution for the proposed action's coal, the department considers that it is likely that at least the same amount of GHG emissions would result from the use of alternative sources, noting the high quality of the proposed action's coal. In circumstances where the refusal of the proposed action would not impact the total amount of coal consumed, and other coal sources will be available to meet demand, it is likely that a comparable amount of GHG emissions would occur even if the proposed action was refused.

380. The department has also considered the Steffen Reports in reaching the above conclusion. Professor Steffen acknowledges the argument that 'if a proposed new coal development is not allowed to proceed, another new coal resource, either in Australia or overseas, will be developed to take its place'. However, Professor Steffen states that this argument is flawed because it presumes that there is and will continue to be a demand for new coal resources beyond those that already exist, whereas he is of the view that

evidence demonstrates that coal production is in steady decline. The department notes that this is inconsistent with other available evidence which indicates that demand for coal is likely to continue (see paragraphs [356]-[362] above). Further, demand for metallurgical coal in particular is likely to remain in circumstances where alternative steelmaking methods are not available at scale, and are not anticipated to be available until the 2030s, and steel is required for the construction of safe buildings, infrastructure and energy infrastructure in developing economies.

7.2.7 Conclusion on coal markets and substitution

381. As found by the Court in *Sharma*, an increase to total global GHG emissions poses a risk to human safety by increasing total global average surface temperatures. The relevant risk to human safety found to exist in *Sharma* was the risk of death or personal injury from heatwaves or bushfires.

382. The department considers that the approval of the proposed action is not likely to cause harm to human safety because, if the proposed action is not approved, it is likely that a comparable amount of coal will be extracted and burned in substitution of the proposed action's coal. Therefore, the proposed action will not result in an increase to global GHG emissions.

7.3 How GHG Emissions are managed under international and national frameworks

383. Out of an abundance of caution, and in the event that (contrary to the above conclusion) the small amount of emissions from the proposed action are *additional* and are not substituted by emissions from other coal production, the department has considered the national and international frameworks within which those emissions will be managed and measures to mitigate their impacts. These matters further inform your consideration of your duty of care and your consideration of the impact of the proposed action on human safety.

7.3.1 International framework for climate change

384. The international climate treaties, the Paris Agreement, done at Paris on 12 December 2015, the Kyoto Protocol, done at Kyoto on 11 December 1997, and the United Nations Framework Convention on Climate Change (**UNFCCC**), done at New York on 9 May 1992, are the primary multilateral mechanisms governing the international response to climate change.

385. The Paris Agreement entered into force on 4 November 2016. 191 countries are Party to the Paris Agreement, including Australia.

386. The temperature goal of the Paris Agreement is to limit the increase in global average temperature to well below 2°Cand pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. All parties must prepare, communicate and maintain successive nationally determined contributions (**NDCs**) and pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions. In Australia, our emissions reduction targets and national climate mitigation policies are the responsibility of the Minister for Energy and Emissions Reduction, supported by DISER.

387. Projections in the IPCC Special Report, 'Global Warming of 1.5°C' (8 October 2018) indicate that, if NDCs in place in 2018 were implemented successfully, the world would reach 2.7-3.2 degrees Celsius above pre-industrial levels by 2100. Under the Paris Agreement successive NDCs are required to represent a progression beyond the current NDC and reflecting its highest possible ambition (Article 4.3).

388. Under Article 4 of the Paris Agreement, parties aim to reach global peaking of GHG emissions as soon as possible, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removal by sinks of GHG in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty. 137 governments around the world including Australia have announced intentions to reach net zero emissions which better align with the Paris Agreement temperature goal to limit the increase in global average temperature to well below 2°C and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

389. To respond to climate change, industry, legal and financial fiduciary bodies have also called on business to recognise, understand and respond appropriately to the risks and consequences posed by climate change, potentially independent of government policy. Many companies and businesses have also announced intentions to reach net zero by 2030 – 2050. Industry is increasingly acknowledging that effort across the whole supply chain is required to enable sectors to decarbonise.

7.3.2 Climate commitments made by markets for Vickery Extension coal

390. The majority of coal from the Vickery mine will be sent to Japan, South Korea and Taiwan.

7.3.3 Climate change framework in Japan

391. Japan's first NDC includes an emissions reduction target of 26% below 2013 levels in 2030. This equates to emissions of approximately 1.042 billion tCO2-e in 2030[14].

392. Japan's First NDC sets out a variety of measures to achieve its 2030 emissions reduction target. Measures in the energy conversion sector include:

- expanding renewable energy introduction to the maximum extent possible;
- utilizing nuclear power generation whose safety is confirmed; and
- pursuit of high efficiency in thermal power generation, including coal fuelled technologies such as ultra-supercritical (USC) and advanced ultra-supercritical (A-USC)

393. Measures relevant to the iron and steel industry include:

- efficiency improvement of electricity-consuming facilities;
- increased chemical recycling of waste plastic at steel plants;
- introduction of a next-generation coke making process (SCOPE21);
- improvement of power generation efficiency;
- enhanced energy efficiency and conservation facilities;

[14] Information regarding the climate change framework of Japan has been sourced primarily from Ashurst's Submission to the IPC, annexed to the Proponent's Letter (Attachment I)

- introduction of an innovative ironmaking process (Ferro Coke); and
- introduction of an environmentally harmonized steelmaking process (COURSE50).

394. Japan submitted its second/updated NDC on 31 March 2020. That NDC re-affirms Japan's commitment to reducing its greenhouse gas emissions by 26% by 2030 from 2013 levels and states that Japan "will strive to achieve a 'decarbonized society' as close as possible to 2050 with disruptive innovations, such as artificial photosynthesis and other CCUS [carbon capture, use and storage] technologies". At the US-hosted Leaders' Summit on Climate in April 2021, Japan announced it will reduce emissions 46% below 2013 by 2030.

7.3.3.1 Japan's current policies

395. Japan's Global Warming Countermeasures Law 2021 commits that "a decarbonised society will be realized by 2050". Japan's Ministry of Economy Trade and Industry (METI) released its Basic Energy Policy draft in July 2021. Under the plan by 2030:

- coal use will be reduced from 26% to 19%
- gas use will be reduced to 56% to 41%
- solar is set to increase to 15% from 6.7% in 2019
- wind is set to increase to 6% from 0.7% in 2019.

396. Japan's Long-term Low-carbon Vision refers to CCUS as a means of achieving emission reductions in the energy sector, as well as centralised/distributed energy management. The Long-term Strategy under the Paris Agreement states that the Government will work to reduce CO2 emissions from thermal power generation, including by accelerating "the efforts of a wide range of stakeholders, aiming to establish its first commercial scale CCU technology by 2023 as a trigger for wider usage in view of full social adoption in 2030 and thereafter."

397. The proponent notes that Japan's power plants are 95% high efficiency, low emissions (**HELE**) power plants. HELE power plants have lower GHG emissions of all types per unit of power produced, including CO2.

7.3.4 Climate change framework in South Korea

398. South Korea is a party to the Paris Agreement and submitted its Intended Nationally Determined Contribution (INDC) in June 2015. The submitted INDC was registered as its NDC, following its ratification of the Paris Agreement on November 3, 2016. This NDC stated that South Korea intended to reduce its GHG emissions by 37% from business-as-usual (BAU) levels by 2030.

399. South Korea's NDC indicated that it would subsequently develop a detailed plan to implement its mitigation target. South Korea released a revised roadmap for achieving the 2030 National Greenhouse Gas Reduction Goal in July 2018 (the Roadmap). The Roadmap sets out sectoral targets, including:

- emission reductions of 24 million tons in the energy conversion sector (power generation, group energy) through policies to reduce fine dust and promote the use of eco-friendly energy; and

- emission reductions of 99 million tons in the industry sector through the revision of industrial processes, energy use reduction, and sharing of emission reductions technologies.

400. In December 2020, South Korea communicated its updated NDC, committing to emissions reduction of 24.4% below 2017 emissions by 2030.[15] At the US-hosted Leaders' Summit on Climate in April 2021, South Korea announced a commitment to ending financing of overseas coal fired power plants. At the P4G Seoul Summit in May 2021, President Moon Jae-in stated that South Korea would strengthen its 2030 climate target and submit it to the UNFCCC ahead of COP26 in November 2021.

7.3.4.1 South Korea's Current Policies

401. South Korea has a range of current policies aimed at achieving emissions reductions, including through its Emissions Trading Scheme which covers 73.5% of national GHG emissions. In July 2020, South Korea announced its Green New Deal committing to investment in GHG emissions reduction and climate-resilient recovery.

7.3.5 Climate Change framework in Taiwan

402. Taiwan is not a party to the UNFCCC or the Paris Agreement. Nevertheless, Taiwan's Cabinet put forward an INDC on 17 September 2015. Taiwan's INDC has an emissions reduction target of 20% from the BAU level by 2030. The BAU level is 428 MtCO2-e and the 2030 target is 214 MtCO2-e by 2030[16].

403. Taiwan's INDC sets out measures for achieving sectoral mitigation measures. Relevantly, in relation to energy, the government will:

- reduce energy demand by introducing energy conservation measures;
- raise the renewable energy development target to 17,250MW in 2030;
- continue to phase out nuclear power plants;
- increase the use of natural gas;
- replace old power plants with the "best feasible technology";
- promote the construction of smart grids; and
- use low-carbon fuel and energy-efficient technologies in the refining sector.

404. Emissions reductions will be achieved in the industrial sector through:

- industrial structure adjustment;
- technical advice service of energy conservation and carbon reduction;
- integrated utilization of energy and resources in industrial zones;
- regulation of energy efficiency standards;
- alternative fuels;

[15] Republic of Korea, The Republic of Korea's Update of its First Nationally Determined Contribution (30 December 2020): https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Republic%20of%20Korea%20First/201230_ROK%27s%20Update%20of%20its%20First%20NDC_editorial%20change.pdf

[16] Information regarding the climate change framework of Taiwan has been primarily sourced from Ashurst Submission to the IPC, annexed to the Proponent's Letter (Attachment I)

- heat recovery; and
- a renewal of facilities.

7.3.5.1 Taiwan's Current Policies

405. Taiwan enacted its Greenhouse Gas Reduction and Management Act on 1 July 2015 with the long-term goal to reduce emissions 50% below 2005 levels by 2050.

406. The Act also required the Government to develop the National Climate Change Action Guideline (which was approved on 23 February 2017) and a GHG Reduction Action Plan. Under the GHG Reduction Action Plan, the authorities responsible for Taiwan's energy, manufacturing, transportation, residential, commercial, and agriculture sectors are required to formulate GHG Emission Control Action Programs. These Action Programs must include GHG emissions targets, timetables and economic incentive measures. These Action Programs are to be regularly reviewed and revised and are to propose improvement plans if sectors are failing to meet their emission targets.

7.3.6 Domestic measures

407. Under the UNFCCC, Kyoto Protocol and Paris Agreement, the Australian Government has committed to reduce national GHG emissions, track progress towards those commitments, and report annually on Australia's GHG emissions.[17] Australia first communicated its NDC under the Paris Agreement in 2015, committing to an economy-wide target to reduce GHG emissions by 26 to 28% below 2005 levels by 2030.

408. In preparing this brief, the department consulted with DISER who advised:

> Australia has a strong record of overachieving on its emissions reduction targets – we overachieved on our two previous targets, under the Kyoto Protocol and UNFCCC.
>
> Australia has in place a comprehensive suite of emissions reduction policies, which are working to reduce emissions in all sectors of the economy. Building on these policies, the government is currently focused on low emissions technologies globally scalable, commercial, and achievable.
>
> Australia's Technology Investment Roadmap will drive down the cost of low emissions technologies and accelerate their deployment, both in Australia and overseas. The Roadmap brings a strategic and system-wide view to future investments in low emissions technologies, in partnership with the private sector, states and territories, and key international partners.
>
> The Roadmap's first annual Low Emissions Technology Statement articulates five priority technologies (clean hydrogen, carbon capture and storage, low carbon materials like steel and aluminium, energy storage and soil carbon) and accompanying stretch goals – ambitious but realistic goals to bring priority low emissions technologies to economic parity with existing mature technologies.
>
> These technologies are expected to avoid in the order of 250 million tonnes of emission per year by 2040, through deployment in Australia and low emission exports. The Roadmap will guide the deployment of an estimated $20 billion of Government investment between now and 2030, including through the CEFC, ARENA, the Climate Solutions Fund, and the Clean Energy Regulator. The Government's investments through the Roadmap will help to secure around $80 billion in total investment from the private sector and governments over the next 10 years.

[17] https://www.industry.gov.au/policies-and-initiatives/australias-climate-change-strategies/tracking-and-reporting-greenhouse-gas-emissions.

409. Commonwealth legislation relating to the Australian Government's policies and programs to reduce emissions and fulfil its emissions reporting and target tracking obligations are regulated by the Clean Energy Regulator (**CER**). The CER is responsible for administering the *National Greenhouse and Energy Reporting Act 2007* (**NGER Act**), the *Carbon Credits (Carbon Farming Initiative) Act 2011*, the *Greenhouse and Energy Minimum Standard Act 2012*, and the *Australian National Registry of Emission Units Act 2011.*

410. Australia's National Inventory System (**NIS**) estimates and reports Australia's GHG emissions in accordance with Intergovernmental Panel on Climate Change (IPCC) guidelines and rules adopted by the Parties to the Paris Agreement. The NIS comprises an independent national monitoring system to compile Australia's national GHG inventory. The scheme established under the NGER Act is a primary data collection tool for the NIS, with high quality facility level NGER data used where possible for the energy, industrial processes and waste sectors. The UN climate treaties, including the Paris Agreement, specify that Parties are responsible for the emissions occurring within their jurisdictions.

411. This means that emissions across each jurisdiction, conceptually equivalent to scope 1 emissions, are aggregated to fulfil Paris Agreement emission reporting and target accounting obligations. Scope 2 and scope 3 emissions that occur within the same jurisdiction are not added to this calculation as it would result in double counting of emissions: one facility's scope 2 and 3 emissions are another facility's scope 1 emissions. Scope 3 emissions associated with Australian facilities that occur outside Australia's jurisdiction (e.g. emissions from the combustion of Australia's coal in an export destination) are accounted for in the countries where those emissions occur.

412. In January 2021, the Prime Minister announced that 'our goal is to reach net zero emissions as soon as possible, preferably by 2050'[18].

7.3.7 NSW

413. The NSW government has developed the NSW climate change policy framework (**CCPF**) and NSW Net Zero plan which provides guidance and measures to achieving net zero emissions in NSW by 2050.

414. The aim of the NSW Climate Change Policy Framework (**CCPF**) is to maximise the economic, social and environmental wellbeing of NSW in the context of changing national and international policy, with the aim to achieve net-zero emissions by 2050. The CCPF does not set prescriptive emission reduction targets, but sets policy directions for government action, for example, to improve opportunities for private sector investment in low emissions technology in the energy industry, which is needed for a transition to a net-zero emissions inventory.

415. The Net Zero Plan builds on the CCPF and sets out a number of initiatives to deliver a 35% cut in emissions by 2030, compared to 2005 levels.

416. In addition to the above policies, the NSW State Environmental Planning Policy (**SEPP**) for mining (**Mining SEPP**) requires the NSW consent authority to consider, in approving a development application:

- whether conditions should be attached to consents to ensure that the development is undertaken in an environmentally responsible manner, including conditions to ensure

[18] https://www.pm.gov.au/media/address-national-press-club-barton-act.

that GHG emissions are minimised to the greatest extent possible (clause 14(1) of the Mining SEPP); and

- an assessment of GHG emissions (including downstream emissions) from the development and must do so having regard to any applicable State or national policies, programs or guidelines concerning GHG emissions (clause 14(2) of the Mining SEPP).

417. As discussed above, the NSW IPC assessed the GHG emissions of the proposed action and imposed conditions relating to air quality and GHG regulation (B31-B37).

418. The IPC concluded that the GHG emissions of the project were adequately considered and that the impacts associated with the GHG emissions of the proposed action were acceptable and in the public interest.

7.4 Summary of GHG emissions for the proposed action, measures being undertaken by the company to manage the proposed action and IPC Assessment

419. A full description of the proposed action is contained above. The proposed action is to extend an existing approved open cut mine (the Vickery Coal Project EPBC 2012/6263) and related surface infrastructure and activities, and to process up to 10 million tonnes of coal per annum (Mtpa) for 25 years. The proposed action will produce greenhouse gas emissions, as stated in the NSW Assessment Report (Attachment G5). The emissions of the project are discussed above at [269]-[287]. The emissions of the proposed action consist of:

- approximately 620,000 t CO2-e of Scope 1 emissions
- 150,000 t CO2-e of Scope 2 emissions, and
- 100,000,000 t CO2-e of Scope 3 emissions, which would be generated by third parties who transport and consume the extracted coal.

420. The preparation of a comprehensive Air Quality and Greenhouse Gas Management Plan is a condition of the development consent granted for the Project under the *Environmental Planning and Assessment Act 1979* (NSW) (**EP&A Act**) (Condition B36). Condition B37 requires the proponent to implement the Air Quality and Greenhouse Gas Management Plan as approved by the Planning Secretary.

421. The NSW development consent states that the Air Quality and Greenhouse Gas Management Plan must:

a. be prepared by a suitably qualified and experienced person/s whose appointment has been endorsed by Planning Secretary;

b. be prepared in consultation with the EPA;

c. be submitted to the Planning Secretary for approval prior to carrying out construction under the development consent;

d. describe the measures to be implemented to ensure:

i. compliance with the air quality criteria and operating conditions of this consent;

ii. best practice management is being employed (including in respect of minimisation of greenhouse gas emissions from the site and energy efficiency) to:

- minimise the development's air quality impacts;
- minimise the development's Scope 1 and 2 greenhouse gas emissions; and
- improve the development's energy efficiency; and

iii. the air quality impacts of the development are minimised during adverse meteorological conditions and extraordinary events;

e. describe the air quality management system in detail; and

f. include an air quality management program, undertaken in accordance with the *Approved Methods for sampling and Analysis of Air Pollutants in New South Wales*, that:

i. uses monitors to evaluate the performance of the development against the air quality criteria in this consent and to guide day to day planning of mining operations;

ii. adequately supports the air quality management systems; and

iii. includes a protocol for identifying any air quality related-exceedance, incident or non-compliance and for notifying DPIE and relevant stakeholders of these events.

7.4.1 State assessment

422. As discussed above, the Project was assessed under Part 4 of the EP&A Act.

423. The DPIE AR considered the air quality and greenhouse gas assessment conducted by Ramboll on behalf of the proponent which was provided as part of the environmental impact assessment. DPIE notes the proposed action is predicted to generate approximately 150,000 t CO2-e of scope 2 emissions from the use of electricity over the mine life. The proposed action is also forecast to be associated with approximately and additional 100,000,000 t CO2-e of Scope 3 emissions, which would be generated by third parties who transport and consume the coal products.

424. The air quality and greenhouse gas assessment[19] indicated that the forecast scope 1 and 2 emissions from the combined Project would contribute to 0.099% of total GHG emissions for NSW and 0.024% of total GHG emissions for Australia. In the Submissions Report to the IPC, the proponent states that the project's annual average scope 1 emissions equate to less than 0.03% of Australia's 2030 commitment under the Paris Agreement.

425. The DPIE assessment report stated that DPIE does not consider the project to be inconsistent with Australia's commitments under the Paris Agreement.

426. The proponent has advised that coal produced as part of the proposed action would most likely be sold to customers in Japan, South Korea and Taiwan. The coal being sold would be approximately 60% metallurgical and 40% thermal.

[19] EIS Appendix E: Air Quality and Greenhouse Gas Assessment (Attachment A)

427. In accordance with the Mining SEPP, DPIE considered that the coal resource associated with the proposal, is significant based on the high quality of the coal and the overall socioeconomic benefits of the project. DPIE recommended that the proponent be required to prepare and implement an updated Air Quality and Greenhouse Gas Management Plan to detail measures to minimise GHG emissions during both the construction and operational phases of the project.

428. The IPC, in its statement of reasons, agreed with the DPIE assessment and also noted:

- Under the Paris Agreement, the Australian Government committed to a nationally determined contribution to reduce greenhouse gas emissions by 26 percent to 28 percent from 2005 levels by 2030. The IPC noted that Scope 3 emissions become the consumer country's Scope 1 and 2 emissions and would be accounted for under the Paris Agreement in their respective national inventories.
- The IPC considered that the project is not inconsistent with the CCPF, the net zero plan or Australia's obligations in respect to the nationally determined contributions.
- The project includes appropriate measures for minimising and managing Scope 1 and Scope 2 emissions to the greatest extent practicable.

429. The IPC was of the view that, in the absence of a viable alternative to the use of metallurgical coal in steel making, on balance the impacts associated with the emissions from the combustion of the proposed action's metallurgical coal are justified. The IPC found that on balance, the impacts associated with the GHG emissions of the project are acceptable and consistent with the public interest.

430. The IPC imposed conditions for air quality and greenhouse gas regulation (B31-B37), as discussed above.

7.5 RISKS OF A WARMING CLIMATE

431. The department sought internal advice from Climate Adaptation and Resilience Division regarding the current state of climate change and, in particular, the outcomes from the most recent IPCC Report 'Climate Change 2021: The Physical Science Basis' (**IPCC Report**). The Climate Adaptation and Resilience Division advised that the Government receives its primary advice on climate science from the Bureau of Meteorology (**BoM**) and the CSIRO. This advice aligns with information provided by the Intergovernmental Panel on Climate Change and other national and international organisations.

432. The IPCC Report provides an update on the latest climate science, including the rates, causes and likely future trajectories of global warming and other changes to the climate system. The Climate Adaptation and Resilience Division advised that the key findings in IPCC Report are consistent with the findings of the *State of the Climate 2020* report, produced by BoM and the CSIRO.

433. The IPCC Report finds that increasing global GHG emissions will increase global average surface temperatures with the consequences described. These consequences pose risks to human safety.

434. The department has also taken into account the expert evidence regarding the risks of a warming climate filed by the Applicants in *Sharma*. The expert evidence considered in the *Sharma* judgment included the Expert Report of Dr Ramona Meyricke, Expert Report of

Professor Anthony Capon, Expert Report of Dr Karl Mallon, and the Steffen Reports. This expert evidence is included at Attachment S of your brief and is summarised in the *Sharma* judgment, in particular from [29]-[90], [205]-[246] (at Attachment D). The department notes that you are appealing certain findings in the judgment which arguably go beyond aspects of the evidence that was before the Court, with particular reference to the Steffen reports. Those errors are identified in your notice of appeal, as follows, with references to paragraphs in *Sharma No 1*:

(a) the best available outcome that climate change mitigation measures can now achieve is a stabilised global average surface temperature of 2°C above pre-industrial levels ([31] and [74(ii)]);

(b) at a stabilised global average surface temperature above 2°C, there is an exponentially increasing risk of the Earth being propelled into an irreversible 4°C trajectory ([31], [74(iii)] and [75]);

(c) there is a real risk that even an infinitesimal increase in global average surface temperature above 2°C above pre-industrial levels may trigger a 4oC Future World ([253]);

(d) a decision under the *EPBC Act* to approve the Extension Project would cause an increase in CO_2 emissions of 100Mt above the CO_2 emissions that would otherwise occur ([79], [84], [247] – [249]);

(e) if the Extension Project were to proceed, any CO_2 emissions resulting from burning of coal extracted through that project would be outside the emissions contemplated by the “carbon budget” necessary to achieve a target of 2°C above pre-industrial levels ([86] – [87], cf [73]).

435. Dr Mallon analyses the possible future impacts resulting from climate change, including heatwaves and bushfires. Dr Meyricke also addresses the likely harms arising from increased heatwaves and higher daily temperatures. Professor Capon identifies direct, indirect and flow-on impacts on human health as a result of a warming climate, including from heatwaves and bushfires.

436. On the basis of this evidence, the Court found that the relevant risk to human safety from increases in global average surface temperature was the risk of death or personal injury from heatwaves or bushfires.

7.5.1 Contribution of the proposed action to climate change

437. It is acknowledged that the Court in *Sharma No 1* found that, even though the emissions of the Extension Project (100MT) were ‘tiny’ on a global scale, there was a real risk that even an infinitesimal increase in global average surface temperature may trigger a tipping point or a 4°C Future World: [253].

438. Thus, if, contrary to the DISER Advice, the proposed action were to cause additional coal to be consumed, the department considers that the proposed action risks a very small increase in global GHG emissions (see below), and, therefore, a small increased risk to human safety.

7.5.2 Reasonable measures to mitigate climate change

439. As outlined above at [383]-[389], climate change is a global problem that the international community has responded to through the UNFCCC and now the Paris Agreement. Parties to the Paris Agreement have committed to prepare, communicate and maintain their NDCs that they aim to achieve, with the goal of limiting the increase in global average

temperature to well below 2 degrees Celsius above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 degrees Celsius above pre-industrial levels.

440. As outlined above, the proponent has advised that the likely customers of the coal will be in Japan, South Korea and Taiwan. Japan and South Korea are parties to the Paris Agreement and have communicated NDCs. Whilst Taiwan is not party to the Paris Agreement, it has submitted an Intended Nationally Determined Contribution and has its own domestic emissions reduction policies.

441. The department has received advice from DISER titled 'Supplementary information – Vickery Extension Project (EPBC 2016/7649)' (Attachment J2 Final Decision Brief). This advice states:

> Projected emissions from the Vickery extension over the 2021-30 period were considered in the preparation of Australia's Emissions Projections 2020. That report states Australia is on track to meet and beat its 2030 Paris target.
>
> Emissions from the project occurring beyond that period (within Australia's jurisdiction) will be covered by future NDCs made by the Government consistent with Article 4.3 of the Paris Agreement.

442. The department considers that the approval of the proposed action is consistent with Australia's commitments under the Paris Agreement.

443. Further, Scope 3 emissions occurring overseas will become the consumer country's Scope 1 and 2 emissions and be accounted for under the Paris Agreement in their respective national inventories. The Paris Agreement does not require parties to take particular measures to achieve their NDCs, rather, parties may determine which domestic mitigation measures to pursue, with the aim of achieving the objective of their NDC. The likely customer country governments or jurisdictions of the coal have made a number of commitments to reduce GHG emissions, as discussed at [390]-[406]. Countries where the coal will be consumed have a discretion to determine what climate change mitigation measures they will pursue in accordance with their national policies and pursuant to their NDCs (or in the case of Taiwan, their INDC).

444. The department notes that the life of the project is estimated at 25 years; beyond the 2030 end date of the above mentioned NDCs. The department further notes DISER's Supplementary information (Attachment J2 Final Decision Brief) that it is expected that emissions associated with the project that occur after 2030 would also be covered by future NDCs submitted by the identified export markets. This expectation is based on Article 4.3 of the Paris Agreement, which provides "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."

445. The department has taken into account the Steffen Reports in considering the impact of the proposed action on climate change. Professor Steffen uses a carbon budget approach to determine the limited cumulative amount of additional CO2 emissions that can be emitted consistent with limiting global temperature rise to 2°C, consistent with the Paris Agreement.

446. The department disagrees with Professor Steffen's conclusion that, because the majority of the world's existing fossil fuel reserves cannot be burned in the 'carbon budget', this means that no new fossil fuel developments or extensions can be approved consistent with limiting warming to 2°C. The department notes the following:

  a. First, consistent with the Paris Agreement, national governments have a discretion to determine what measures will be employed to reduce GHG emissions. There is no government policy requiring approval of coal mines to be refused in order to meet Australia's commitments under the Paris Agreement, or to prevent coal being available to other countries to reduce other countries' emissions.

  b. Second, the scope 3 emissions from the burning of the coal are taken into account in the country where they are emitted, consistent with the Paris Agreement. The majority of the proposed action's emissions are scope 3 emissions, and the proposed consumers of the coal will be parties to the Paris Agreement.

  c. Third, evidence as discussed above indicates that there is an ongoing demand for coal. A decision to refuse the proposed action is likely to have no reduction of total GHG emissions.

  d. Fourth, while GHG emissions result from the burning of coal, there are many other sources. The department disagrees that the use of coal in particular cannot continue as a source of such emissions. The fact that *most* fossil fuels must remain unburned accepts that *some* proportion of the world's existing fossil fuel reserves can be exploited (see *Gloucester Resources v Minister for Planning* [2019] NSWLEC 9 at [551]), and does not take into account other measures that may be taken to reduce or offset emissions.

447. The department acknowledges that parties' current NDCs under the Paris Agreement are insufficient to limit global average temperatures to below 2°C. However, there are mechanisms under the UNFCCC and Paris Agreement (Article 4 to increase the commitments made for future NDCs) to achieve the Paris goal of well below 2 degrees.

7.5.3 Reasonable measures to mitigate human safety impacts posed by climate change

448. The NSW IPC has imposed a number of conditions directed at the reduction and mitigation of GHG emissions from the proposed action. Those measures are outlined above in [291], [420]-[421].

449. The department has considered all completed assessments and NSW development consent conditions relating to GHG emissions. The IPC concluded that the proposed action included appropriate measures for minimising and managing the scope 1 and scope 2 emissions of the proposed action 'to the greatest extent possible'.

450. The department agrees that these conditions address the proposed action's GHG emissions and help mitigate the risk to human safety caused by the proposed action. The department also recommends that you take into account the social and economic benefits of the proposed action which are discussed further below.

7.6 SOCIAL AND ECONOMIC CONSIDERATIONS

451. The department has outlined the relevant economic and social matters above in Part 6, noting that the assessment of economic and social matters was on a cumulative basis

incorporating the Approved Project and proposed action. However, consideration was also given to the economic and social matters attributable to the proposed action.

452. The department considers that the proposed action is estimated to result in an economic benefit to the NSW community. The refusal of the proposed action would prevent the opportunity for positive economic and social impacts.

453. The project is expected to deliver 500 jobs during peak construction, and up to 450 jobs at the project during operations. Of this, up to 440 construction jobs and 200 operational workers are attributable to changes arising from the proposed action.

454. The project is expected to provide an estimated:

a. increased disposable income of $316 million (Net Present Value (NPV)) associated with the direct and indirect jobs;

b. value added benefits of approximately $322 million NPV in other industries in NSW; and

c. a net economic benefit of $1.16 billion NPV from generation of additional tax revenue and royalties.

455. As discussed in the Assessment Report, the proponent estimates that approximately 70% of the workforce would be from the local area.

456. The department also considers that the proposed action would generate positive social and economic benefits from the steel production generated by the proposed action. Coking coal is considered an essential input in current primary production of steel and low emission alternatives are not currently available at commercial scale. As discussed at [350]-[354], steel is an essential material in the construction of safe buildings, infrastructure and renewable energy infrastructure and is of particular importance to developing countries. The department considers that the impacts associated with the combustion of the proposed action's coking coal are acceptable and justified in circumstances where there are no current viable alternatives to those emissions for the production of steel.

7.7 Conclusion

457. Even if, contrary to the DISER advice, the coal from the proposed action would not be substituted by other coal if the proposed action is not approved, the department still recommends approval, taking into account and balancing the other relevant considerations as detailed in the Assessment Report and the matters considered throughout this updated Legal Considerations Report.

458. For the reasons identified throughout this section, the department recommends that you find, after giving elevated weight to human safety, that approval of the proposed action is not likely to cause harm to human safety and should be approved.

459. The department further considers that approval is appropriate having regard to the social and economic benefits of the proposed action, the global need for steel and the absence of any currently viable alternatives to the use of metallurgical coal in steelmaking. The department has formed this view after taking into account the matters referred to in this attachment and that any contribution of the proposed action to global GHG emissions will be extremely small.

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29 July 2021

CONFIDENTIAL

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Dear Louise

VICKERY EXTENSION PROJECT (EPBC 2016/7649) – ASSESSMENT OF GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

1. PURPOSE

1.1 On 12 August 2020, the NSW Independent Planning Commission (**IPC**) granted a State significant development consent (**SSD Consent**) for the Vickery Extension Project (**Project**) under the *Environmental Planning and Assessment Act 1979* (NSW) (**EP&A Act**) and published its "Statement of Reasons for Decision" (**SoR**).

1.2 The Project, as approved by the IPC, incorporates the extraction of 135 Mt of ROM coal that was earlier approved as the Vickery Coal Project under the EP&A Act on 19 September 2014, as well as an additional 33 Mt of ROM Coal (i.e. a total of 168 Mt of ROM coal).

1.3 In its determination to approve the Project, the IPC was provided with a document by Ashurst on behalf of Whitehaven Coal Limited and Vickery Coal Pty Ltd titled "Vickery Extension Project (SSD 7480): Submission to the Independent Planning Commission on the consideration of greenhouse gas emissions and climate change" (**GHG Submission**): see SoR at [31]. A copy of the GHG Submission is **Annexure A** to this letter.

1.4 The Minister for the Environment is now required to decide whether to approve a proposed action (EPBC 2016/7649) under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) (the **Controlled Action**). The Controlled Action does not include the components and operations of the approved Vickery Coal Project, as this action was determined in 2012 not to be a controlled action if implemented in a particular manner (EPBC 2012/6243).

1.5 The Controlled Action involves the extraction of 33 Mt of ROM coal.

1.6 The purpose of this letter is to provide the Department with the GHG Submission and additional information relevant to the Minister's consideration of the greenhouse gas emissions (**GHG emissions**) associated with the Controlled Action.

1.7 Specifically, this letter:

(a) outlines the:

(i) higher quality of the Controlled Action's coal compared to the coal produced by other export countries;

(ii) global demand for coal;

(iii) likely consumers of the Controlled Action's coal;

(iv) impact of a decision not to approve the Controlled Action on global GHG emissions;

(v) assessment and regulation of the GHG emissions associated with the Project under the EP&A Act; and

(b) comments on three recent documents published by the International Energy Agency (**IEA**) subsequent to Ashurst's production of the GHG Submission. These publications are:

(i) the *World Energy Outlook 2020* (**WEO 2020**), which was released in October 2020;

(ii) the *Iron and Steel Technology Roadmap: Towards more Sustainable Steelmaking* (**Iron and Steel Roadmap**), which was also released in October 2020; and

(iii) the *Net Zero by 2050: A Roadmap for the Global Energy Sector Report*, which was released in May 2021 (**Net Zero Roadmap**).

2. THE HIGH QUALITY OF THE CONTROLLED ACTION'S COAL

2.1 The GHG Submission considers the Project's coal quality and provides a detailed justification as to why the Project's coal is considered to be of high quality, including in comparison to the coal produced by other coal export countries: see Part C of the GHG Submission.

2.2 Coal is not a standardised, homogenous commodity. The quality of the coal produced by different mines varies. This is an important factor to consider when assessing the environmental consequences of the production and use of coal.

2.3 There are four broad types of product coal: hard coking coal, semi-soft coking coal (**SSCC**), pulverised coal for injection, and thermal coal. In respect of each of these four coal products there is a significant variation in quality, particularly in terms of calorific value, and ash and sulphur content.

2.4 As stated above, the Controlled Action will produce approximately 33 Mt of ROM coal, which will be exported after being washed.

2.5 On average, approximately 40% of the Controlled Action's saleable coal will be thermal coal and 60% will be SSCC. Thermal coal is used by power stations to generate electricity. SSCC is consumed by blast-furnaces for the production of steel and is an essential input for steelmaking using blast furnace-basic oxygen furnace technology.

2.6 The quality of thermal coal is a function of its calorific value, as well as its ash and sulphur content. The term 'calorific value' refers to the energy density of the coal and determines the volume of coal that needs to be combusted to generate a given amount of energy.

2.7 More CO_2 is emitted per unit of energy output when coal of a lower calorific value is combusted because more coal is needed to achieve the same energy output that would be produced by combusting coal of a higher calorific value. Therefore, the use of high quality coal for electricity generation can reduce the amount of CO_2 released into the atmosphere per unit of electricity produced, compared to coal of an inferior quality.

2.8 The Controlled Action's thermal coal product has a calorific value of greater than 6400 kcal/kg on a life of mine basis. This is higher than the country weighted averages of all other thermal coal exporters, including Australia.[1]

2.9 The Controlled Action's thermal coal product contains 0.4% sulphur and less than 8% ash. Its ash content is lower than the country weighted average of Australian thermal coal and the thermal coal of other major seaborne thermal coal suppliers. Its sulphur content is lower than the country weighted average of all other major seaborne thermal coal suppliers, except Russia.[2]

2.10 The Controlled Action's SSCC product contains 6.5% ash and 0.4% sulphur. This is a lower ash content than the average ash content of all of the major exporting countries, except Canada.[3]

2.11 The sulphur content of the Controlled Action's SSCC product is lower than the average sulphur content of Australian coal and lower than the average of most major exporting countries.[4]

2.12 Ash is the non-combustible residue that is left after coal is combusted and affects the efficiency of power-plant operations.

2.13 Sulphur is a local air pollutant and contributor to acid rain.

2.14 The comparative high quality of the Controlled Action's coal is borne out by a reading of Part C of the GHG Submission.

2.15 If the Controlled Action does not proceed, there is a real likelihood the demand will be met by coal sourced from elsewhere of an inferior quality (in terms of Calorific Value, ash and sulphur content) resulting in higher GHG emissions.

3. GLOBAL DEMAND FOR COAL

3.1 It is important to recognise that there is, and will remain for the foreseeable future, an ongoing demand for coal (both coking and thermal coal) to meet the energy and industrial needs of human populations throughout the world. The demand for coal will remain irrespective of whether the Controlled Action proceeds.

3.2 The *World Energy Outlook 2019* (**WEO 2019**) included three scenarios: the Current Policy Scenario (**CPS**), Stated Policy Scenario (**STEPS**), and Sustainable Development Scenario (**SDS**). In the WEO 2019, the STEPS occupies a central position in the WEO analysis and reflects already implemented and announced policies, expressed in official targets and plans, including under countries' nationally determined contributions under the *Paris Agreement* (WEO 2019, pp 29, 96). By comparison, the SDS in the WEO 2019 presents a trajectory consistent with reaching global net zero CO_2 emissions in 2070 for a 66% chance of limiting the global average temperature rise to 1.8 degrees Celsius above pre-industrial levels while achieving universal access to modern energy by 2030 (WEO 2019, p 30). Projected coal use varies between scenarios; the CPS has the highest projected coal usage while the SDS has the lowest projected coal use.

3.3 The WEO 2020 used the STEPS and SDS as well as other scenarios as mentioned below.

[1] GHG Submission, [6.36].

[2] GHG Submission, [6.37]-[6.38].

[3] GHG Submission, [6.51].

[4] GHG Submission, [6.51].

3.4 The WEO does not make predictions about or forecast the future. Instead, it sets out what the future could look like in different scenarios that are based on specific assumptions.[5]

3.5 Part C of the GHG Submission explains the global demand for coal based on:

(a) the WEO 2019; and

(b) modelling by CRU International Limited (**CRU**).

3.6 In particular, the projected demand for thermal coal is considered at [6.13]-[6.22] of the GHG Submission and the projected demand for metallurgical coal is considered at [6.23]-[6.27].

3.7 Ashurst, on behalf of Whitehaven Coal Limited and Vickery Coal Pty Ltd, retained CRU to undertake an independent study of global coal demand and supply and the coal market to 2040, in the context of the Project (**CRU Study**). The CRU Study contains commercially sensitive and confidential information of CRU and therefore we only have CRU's permission to disclose a letter from CRU that summarises the main findings of the CRU Study. That summary letter is at Appendix 4 of the GHG Submission.

WEO 2019

3.8 In summary, the WEO 2019 relevantly sets out that:

(a) the global demand for energy is driven by structural trends of population growth, urbanisation and economic growth, particularly in Southeast Asia;

(b) there will continue to be a global demand for coal to 2040 under all three policy scenarios considered by the IEA (including the Paris-aligned SDS);

(c) demand for thermal coal is projected to increase in Southeast Asia in the STEPS (the WEO 2019's central scenario), where 40% of the projected rise in the region's electricity demand will be met by coal. Coal-fired power plants in Asia are approximately 12 years old on average, which is more than 20 years younger than the average age of coal-fired power plants in North America and Europe;[6]

(d) approximately 70% of all steel globally is produced using blast furnace-basic oxygen furnace technology which requires metallurgical coal, including hard coking coal and SSCC;[7] and

(e) coal will remain essential to steel manufacturing to 2040, as the scope to shift away from coal by making greater use of scrap-based or direct reduction of iron-based electric arc furnaces is limited by the availability and cost of scrap steel and the cost of electricity.[8]

CRU's modelling

3.9 In summary, the independent modelling undertaken by CRU forecasts that:

(a) coal will, in 2040, remain an important pillar of electricity generation in key centres of population growth and economic development, including in Southeast Asia, as well as in China and India;

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[5] WEO 2019 at 29; WEO 2020 at 165.

[6] WEO 2019, pp 27, 225, 238, 284.

[7] WEO 2019, p 231.

[8] WEO 2019, pp 231, 233.

(b) high quality coal from Australia (such as that produced by the Controlled Action) is, and will continue to be, in demand to meet the electricity generation needs in these regions in particular (as many of these countries, Japan, South Korea and Taiwan in particular, have little to no domestic supply), as well as global demand more generally;

(c) as the ability of existing mines to service global demand for coal declines (e.g. as a result of exhausting their environmentally recoverable reserves), it will be necessary for the coal demand to be met by expansions of approved coal mines or the development of new coal mines;

(d) steel will remain an important material for global development, particularly in South East Asia;

(e) global demand for carbon crude steel (crude steel, excluding stainless steel) is expected to grow steadily at a compound annual growth rate of approximately 1% from 2018 to 2040;

(f) despite the share of steel produced by blast furnace-basic oxygen furnace declining in the long term, there will continue to be a significant requirement for new iron units from coal (produced by blast furnace-basic oxygen furnaces);

(g) by 2040, the blast furnace-basic oxygen furnace process will still account for approximately 57% of global steel production; and

(h) SSCC's important role in steelmaking will continue into the future.

WEO 2020

3.10 At the time of preparing the GHG Submission, the most recent World Energy Outlook published by the IEA was the WEO 2019, which was published in November 2019.

3.11 On 13 October 2020, the IEA published the WEO 2020.

3.12 Due to the Covid-19 pandemic, the WEO 2020 is different in structure and content than the WEO 2019 described in the GHG Submission. In particular, the WEO 2020 has a novel focus on the impact of the Covid-19 pandemic and potential recovery pathways to 2030. The WEO 2020 includes four scenarios:

(a) the STEPS in which Covid-19 is gradually brought under control in 2021;

(b) the Delayed Recovery (from Covid-19) Scenario;

(c) the SDS in which net-zero emissions globally are reached by 2070 to put the world firmly on track to limit the rise in global average temperature to "well below 2°C", and limit it to 1.5°C in 2100 on the assumption that negative emissions technologies are deployed in the second half of the century; and

(d) the new Net Zero Emissions by 2050 case for a 50% chance of limiting the global average temperature rise to 1.5 degrees Celsius above pre-industrial levels (WEO 2020, pp 77, 415).

3.13 The WEO 2020 states that while global energy demand and global coal demand have declined in 2020, global demand for coal will remain relatively flat from 2020 to 2030 in the STEPS, with demand varying by region (WEO 2020, p 196). In the STEPS to 2030, the Asia Pacific region is the only region to see growth in coal demand, primarily in India and Southeast Asia (WEO 2020, p

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168).[9] This means that demand for coal will be either relatively stable or increase in many of the Project's expected export countries.

3.14 In summary, the WEO 2020 states that:

(a) coal demand in China remains fairly stable over the 2019-30 period in the STEPS, peaking near the middle of the decade, and ending the decade with a decline of around 85 Mtce (-3%) (WEO 2020, p 197);

(b) India sees coal use climb by over 120 Mtce between 2019 and 2030 in the STEPS, accounting for 14% of world coal demand by 2030, second only to China. Growth is roughly 50% from the power sector and 50% from industrial end use, with particularly large growth in the steel making sub-sector (WEO 2020, p 197); and

(c) Southeast Asian coal demand increases by nearly 30% in the STEPS and by 2030 accounts for 6% of global coal demand. This increase is largely driven by increased demand in the power sector, but around 25% is attributable to industrial production, particularly iron and steel (WEO 2020, p 198).[10]

3.15 In the SDS, the WEO 2020 projects that the share of coal in the global power generation mix falls from 37% in 2019 to 15% by 2030 and 10% by 2040 (WEO 2020, pp 19, 35). Demand for coal in the SDS is projected to decline by more than 75% in advanced economies and by around 40% worldwide by 2030, with more than 80% of the decline in coal use coming from reductions in the power sector (WEO 2020, pp 104-105).

3.16 Although the SDS intensifies pressure on all coal suppliers, in a more carbon constrained world our client would expect higher quality coals to exit the market last. Therefore, consistent with the WEO 2020's projection that Australia and Russia would fare better than other exporters in the STEPS (WEO 2020, pp 254, 282-283), our client also expect Australia to perform better compared to other producers of seaborne coal in the SDS. In this regard the WEO 2020 states that in the SDS, all exporting countries are heavily affected, but those serving the emerging Asian markets with higher exposure to coking coal see a lesser decline and Australia remains the largest exporter of coal (WEO 2020, p 284).

Iron and Steel Roadmap

3.17 In October 2020, the IEA published the Iron and Steel Roadmap.

3.18 The Iron and Steel Roadmap does not forecast demand for metallurgical coal but presents two pathways for the steel sector in the STEPS and SDS, which are broadly in line with the WEO (pp 55-56).

3.19 The Iron and Steel Roadmap identifies at present a strong market for metallurgical coal with embedded future demand:

(a) steel is an indispensable material in modern society. Buildings and infrastructure are a key source of demand, but steel is also used in transport (e.g. cars, ships and rail). It also plays a vital role in the global economy, with over USD 2.5 trillion in revenue, employing around 6 million people globally, and being the source of an estimated further 43 million jobs in other sectors (pp 16, 17, 23);

[9] The WEO 2020 defines Asia Pacific to be the Southeast Asia regional grouping and Australia, Bangladesh, China, India, Japan, Korea, Democratic People's Republic of Korea, Mongolia, Nepal, New Zealand, Pakistan, Sri Lanka, Chinese Taipei and other Asia Pacific countries and territories.

[10] The WEO 2020 defines Southeast Asia to be Brunei, Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam (p 439).

(b) while countries are in the early stages of development, their steel demand tends to rise rapidly to meet growing infrastructure needs and growing consumer demand (p 32);

(c) the most common primary production pathway is the blast furnace-basic oxygen furnace (BF-BOF) route, which relies on coking coal to reduce iron ore, accounts for 70% of global steel production (p 29);

(d) global crude steel production capacity has more than doubled over the past two decades. Three quarters of that growth was in China and around 85% of total capacity today is located in emerging economies (p 12);

(e) this rapid growth has resulted in a young global blast furnace fleet of around 13 years on average, which is less than a third of the typical lifetime of these plants (40 years) (pp 12, 36);

(f) China is currently the largest steel producer, accounting for more than half of global production in 2019 (p 33); and

(g) India is already the world's second-largest steel-producing country, producing around 5% of the world's steel today. India's existing production fleet is relatively young and growing at a faster pace than domestic scrap availability. Considerable growth in steel production in India is expected in the coming years, driven by economic development (p 14, 67).

3.20 In the STEPS, the Iron and Steel Roadmap projects that:

(a) demand for steel will increase by more than a third through to 2050. This demand growth is driven by emerging economies, which are still building up their per capita in-use stock of steel towards levels seen in advanced economies today (p 11, 57-58);

(b) by 2050, almost 20% of the steel produced globally is expected to come from India (p 14);

(c) India's production of steel increases nearly fourfold by 2050 (p 68);

(d) the blast furnace-basic oxygen furnace route remains the dominant pathway for producing steel in 2050 (p 73);

(e) coal demand for steel production remains relatively stable (p 71); and

(f) due to the increasing share of scrap-based production as well as process technology performance improvements, the direct CO_2 emission intensities of crude steel will reduce moderately, but direct CO_2 emissions will increase by 7% by 2050 as demand for steel increases (pp 71-72).

3.21 The Iron and Steel Roadmap projects that growth in demand for steel is reduced in the SDS, with production reaching a level in 2050 that is nearly 20% lower than in the STEPS, and only 10% higher than in 2019 (p 59). The SDS pathway relies primarily on improved material efficiency in building and manufacturing (e.g. changes in design of products and extending building lifetime) to reduce demand for steel, incremental improvements in the performance of existing production pathways, and widespread commercialisation of carbon capture and storage (Roadmap 2020, pp 12, 60-61, 75, 76).

3.22 The Iron and Steel Roadmap states that while coal remains a key input to the iron and steel sector, in the SDS, global consumption of coal for ironmaking – the most coal-intensive step in producing steel – is projected to drop by 8% by 2030 and almost 30% by 2050 relative to 2019. This is a result of reducing the share of primary production in total steelmaking, alongside shifts towards natural gas, biomass, electricity and hydrogen (p 78).

3.23 In relation to the role of new steelmaking technology, the Iron and Steel Roadmap states:

(a) scrap-based steel production is limited by the availability of scrap steel. While iron ore is mined all over the world (it is one of the most abundant elements on earth), scrap availability is limited by the rate at which steel products reach the end of their life and the effectiveness of scrap collection and sorting systems (pp 28, 48);

(b) in the SDS, technology improvements and material efficiency deliver 90% of the emission reductions from the steel sector in 2030, while innovative technologies that integrate CCUS and hydrogen technologies will be required for further emission reductions to 2050 (pp 53, 75, 81);

(c) in the SDS, hydrogen-based direct reduced iron reaches just under 15% of primary steel production globally in 2050 (pp 13, 88); and

(d) of the cumulative emission reductions to 2050 in the SDS, 30% come from steelmaking technologies that are at demonstration or prototype stages (pre-commercial) today (pp 14, 53).

NSW Government Strategic Statement on Coal

3.24 Finally, it is noted that the NSW Government published a Strategic Statement on Coal Exploration and Mining in NSW (the **Strategic Statement**) in 2020. A copy of the Strategic Statement is **Annexure B** to this letter.

3.25 The Strategic Statement shows the long term global thermal coal demand outlook to 2050 and states at page 6 that:

> Some developing countries in South East Asia and elsewhere are likely to increase their demand for thermal coal as they seek to provide access to electricity for their citizens. Under some scenarios, this could see the global demand for thermal coal sustained for the next two decades or more. The use of coal in the manufacture of steel (coking coal) is likely to be sustained longer as there are currently limited practical substitutes available.
>
> Ending or reducing NSW thermal coal exports while there is still strong long-term global demand would likely have little or no impact on global carbon emissions. Most coal consumers would be likely to source their coal from elsewhere, and much of this coal would be lower quality compared to NSW coal.

4. CONSUMERS OF THE CONTROLLED ACTION'S COAL

4.1 The likely export destinations for the Controlled Action's coal are Japan, South Korea and Taiwan.

4.2 Japan and South Korea are parties to the *Paris Agreement* and have adopted or are in the process of adopting domestic laws, policies and measures to implement and achieve their nationally determined contribution targets.

4.3 Taiwan is not recognised as an independent sovereign nation and therefore is not a member of the United Nations and cannot be a party to the *Paris Agreement*. Nonetheless, it has put forward an intended nationally determined contribution.

4.4 As the coal from the Controlled Action would be exported, almost all of the Controlled Action's Scope 3 GHG emissions will be generated overseas by the end-user combusting the coal.

4.5 As such, the Scope 3 GHG emissions of the Controlled Action will be appropriately accounted for as Scope 1 emissions in the consumer country (e.g. Japan, South Korea or Taiwan). If Australia were to also count the Scope 3 GHG emissions of the Controlled Action in calculating its GHG emissions, this would result in a double counting of GHG emissions which would be inconsistent with international carbon accounting principles and Australia's international commitments.

4.6 In this regard, the importance of avoiding double-counting of GHG emissions, including in the context of calculating a country's GHG emissions for the purpose of tracking progress towards achievement of its nationally determined contribution, is well-recognised under the *Paris Agreement*.

4.7 The GHG Submission outlines the domestic efforts of Japan, South Korea and Taiwan to achieve their (intended) nationally determined contribution targets in Appendix 3 and details their uptake of low emission coal technologies (including, in particular, high-efficiency, low-emissions and carbon capture, use and storage) in Part C.

5. IMPACT OF A DECISION NOT TO APPROVE THE CONTROLLED ACTION ON GLOBAL GHG EMISSIONS AND CLIMATE CHANGE

5.1 A decision by the Minister not to approve the Controlled Action would not affect the global demand for coal during the relevant period because the lost supply from the Controlled Action would be very small relative to the size of global coal consumption, so the impact on the cost curve would be minimal (if any).

5.2 If the Minister for the Environment was to decide not to approve the Controlled Action under the EPBC Act, two hypothetical scenarios arise.

5.3 The first scenario is that both the approved Vickery Coal Project and the Project are not carried out.

5.4 The second scenario is that the approved Vickery Coal Project is carried out rather than the Project.

5.5 For the purpose of the market substitution analysis in the CRU Study, CRU relevantly considered the corresponding hypothetical scenarios:

(a) the Project is not approved and does not go ahead and the approved Vickery Coal Project also does not go ahead (**Scenario 1**); and

(b) the Project is not approved and does not go ahead, but the approved Vickery Coal Project does go ahead (**Scenario 2**).

5.6 The GHG Submission discusses CRU's market substitution analysis in detail and is accompanied by a summary letter prepared by CRU (Appendix 4 of the GHG Submission).

5.7 With respect to Scenario 1, CRU's key findings include:

(a) in relation to Scope 3 emissions in Scenario 1, the substitution of the Project's product coal with coal from alternate producing countries will increase Scope 3 emissions by an estimated 8.1 to 24.8 million tonnes of CO_2-e for the life of mine; and

(b) overall (Scope 1, 2 and 3), non-Australian alternative supply is expected to release an additional amount of between approximately **14.0** to **64.8** Mt CO_2-e (low fugitive emissions case) and **20.1** to **120.4** Mt CO_2-e (high fugitive emissions case) into the atmosphere over the life of mine compared to the case where the Project is approved.

5.8 With respect to Scenario 2, CRU's key findings include:

(a) in relation to the Scope 3 emissions in Scenario 2, the alternative supply would release an estimated additional 3.4 to 10.2 million tonnes of CO_2-e into the atmosphere over the life of mine of the Project; and

(b) overall (Scope 1, 2 and 3), non-Australian alternative supply is expected to release an additional amount of between approximately **5.7** to **26.7** Mt CO_2-e (low fugitive emissions case) and **8.2** to **49.7** Mt CO_2-e (high fugitive emissions case) into the atmosphere over the life of mine compared to the case where the Project is approved.

6. ASSESSMENT AND REGULATION OF THE GHG EMISSIONS ASSOCIATED WITH THE PROJECT UNDER THE EP&A ACT

6.1 In considering the assessment of GHG emissions under the EP&A Act, it should be recognised that the assessment concerned the Scope 3 emissions associated with the whole Project (approximately 366 Mt CO_2-e), rather than only concerning the additional Scope 3 GHG emissions of the Project compared to the approved Vickery Coal Project (approximately 100 Mt CO_2-e).

*The NSW Department of Planning, Industry and Environment's (**DPIE's**) consideration of GHG emissions*

6.2 In May 2020, DPIE provided its final assessment report on the Project to the IPC for its consideration of whether to approve the Project under the EP&A Act (**Assessment Report**).

6.3 At [715] and [725] of the Assessment Report, DPIE relevantly concluded:

> Overall, the Department considers that the GHG emissions for the Project have been adequately considered and that, with the Department's recommended conditions, are acceptable when weighed against the relevant climate change policy framework, objects of the EP&A Act (including the principles of ESD) and socio-economic benefits of the Project.

6.4 DPIE's consideration of the GHG emissions associated with the Project is set out at [671]-[715] of the Assessment Report. Most relevantly, DPIE:

(a) observed that, under GHG emissions reporting and accounting frameworks, the Scope 2 and 3 emissions estimated for the Project are the Scope 1 emissions of other organisations/developments;

(b) recorded that, in comparison to the approved Vickery Coal Project, the Project would result in an increase of about 100 Mt CO_2-e of Scope 3 emissions over the life of the Project;

(c) emphasised that the Project's Scope 3 emissions would not contribute to Australia's nationally determined contribution to reduce national GHG emissions under the *Paris Agreement* because the product coal would be exported for combustion overseas, and would instead be accounted for as Scope 1 and 2 emissions in the national inventories of the consumer countries;

(d) observed that the global approach to nationally determined GHG emissions reduction targets is the appropriate mechanism for managing Australia's Scope 3 emissions, rather than regulating Scope 3 emissions on a project by project basis in Australia;

(e) emphasised that the NSW and Commonwealth Government's policy frameworks do not promote restricting private development as a means for Australia to meet its commitments under the *Paris Agreement*, or require any action to be taken by the private sector in Australia to minimise or offset the GHG emissions of any parties outside of Australia, including the emissions that may be generated in transporting or using goods that are produced in Australia;

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(f) noted that the Commonwealth Government had advised the NSW Minister for Planning that "any requirement to consider scope three emissions within a sub-national or state jurisdiction is inconsistent with long accepted international carbon accounting principles and Australia's international commitments";

(g) did not consider the Project to be inconsistent with Australia's commitments under the *Paris Agreement*;

(h) considered that the focus of the conditions of consent for the Project should be on the impacts that can be reasonably controlled by the applicant (such as the Scope 1 and relevant Scope 2 emissions) and not Scope 3 or downstream emissions, as these would be the Scope 1 or 2 emissions of another development (consistent with the global accounting framework for GHG emissions);

(i) commented that there is no NSW or Commonwealth policy that supports placing conditions on an applicant to minimise the Scope 3 emissions of its development, that any such policy is likely to result in significant implications for the NSW and Australian economy and that it is not clear that this would have any effect on reducing GHG emissions generated by parties in other jurisdictions outside Australia;

(j) noted that the Project would produce metallurgical coal (around 60% of the product coal) including semi-soft coking coal, pulverised coal injection coal and thermal coal (around 40% of the product coal) to supply Whitehaven's main export market customers in Japan, South Korea and Taiwan;

(k) noted that Japan and South Korea are signatories to the *Paris Agreement* and have developed GHG emissions reduction targets and that Taiwan has developed GHG emissions reduction targets that are comparable to those of countries who are signatories to the *Paris Agreement*; and

(l) noted that the majority of the Project's coal is of metallurgical quality and that the thermal coal quality is a high calorific / low ash / low sulphur coal, which is in stronger demand globally compared to lower quality coal.

The IPC's consideration of GHG emissions

6.5 At [223] and [436] of the SoR, the IPC concluded that, on balance, the impacts associated with the GHG emissions of the Project are acceptable when weighed against, inter alia, the socio-economic benefits of the Project.

6.6 The IPC's consideration of the GHG emissions associated with the Project is set out at [211]-[223] of the SoR. Most relevantly, the IPC:

(a) noted that, in comparison to the approved Vickery Coal Project, the Project would result in an increase of about 100 Mt CO_2-e of Scope 3 emissions over the life of the Project;

(b) agreed with DPIE's statement that the Project's Scope 3 emissions would not contribute to Australia's nationally determined contribution because the Project's product coal would be exported overseas;

(c) noted that the Scope 3 emissions of the Project would become the consumer countries' Scope 1 and 2 emissions and would be accounted for under the *Paris Agreement* in their respective national inventories;

(d) found that the Project includes appropriate measures for minimising and managing Scope 1 and Scope 2 GHG emissions to the greatest extent practicable;

(e) noted that the 'carbon budget' approach is not endorsed by the *Paris Agreement*, the Australian Government or the NSW Government, and that neither the Australian nor NSW Government have indicated that the development of new coal mines or the expansion of existing mines be prohibited or restricted in any way for the purpose of achieving Australia's nationally determined contribution;

(f) noted that between 60-70% of the coal proposed to be extracted is likely to be metallurgical coal, with the remainder being thermal coal, and that metallurgical coals are essential inputs for the current production of approximately 70% of all steel globally;

(g) considered that in the absence of a viable alternative to the use of metallurgical coal in steel making and on balance, the impacts associated with the emissions from the combustion of the Project's metallurgical coal are acceptable; and

(h) noted that the coal proposed for extraction is anticipated to be of relatively high quality and that the use of higher quality coal may result in lower pollutants.

Regulation of GHG emissions under the SSD Consent

6.7 The SSD Consent for the Project regulates the Scope 1 and Scope 2 emissions associated with the Project.

6.8 In this regard, condition B35 of the SSD Consent imposes a duty on the applicant to take all reasonable steps to reduce the Scope 1 and Scope 2 emissions of the Project.

6.9 Further, condition B36 requires the applicant to prepare an Air Quality and Greenhouse Gas Management Plan for the Project which must, inter alia, describe the measures to be implemented to ensure best practice management is being employed to minimise the Project's Scope 1 and 2 emissions. Condition B37 requires that the approved Air Quality and Greenhouse Gas Management Plan be implemented by the Applicant.

7. NET ZERO ROADMAP

7.1 The Net Zero Roadmap is a unique report prepared at the request of the UK President of the 26th UN Framework Convention on Climate Change Conference of the Parties. Its purpose is to provide a pathway, or roadmap, to achieve net-zero energy related and industrial process CO_2 emissions globally by 2050, which is consistent with the *Paris Agreement* goal of pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

7.2 In summary, the Net Zero Roadmap:

(a) examines a variant of the IEA's STEPS called the Announced Pledges Case (**APC**), which assumes that all of the net zero targets announced by countries around the world to date are met in full;

(b) presents a unique new scenario called the Net-Zero Emissions by 2050 Scenario (**NZE**) which describes how energy demand and the energy mix will need to evolve if the world is to achieve net-zero emissions by 2050; and

(c) examines the implications of the NZE for various sectors, including fossil fuel supply, the economy, the energy industry, citizens and governments.

7.3 With respect to the APC, global coal use falls significantly more rapidly in the APC than in the STEPS, from 5250 Mtce in 2020 to 4000 Mtce in 2030 and 2600 Mtce in 2050 (compared with 4300 Mtce in the STEPS in 2050).

7.4 With respect to the NZE states:

(a) "[t]here are many possible paths to achieve net-zero CO_2 emissions globally by 2050 and many uncertainties that could affect any of them; the NZE is therefore *a* path, not *the* path to net-zero emissions." (p 49);

(b) the NZE "involves a global energy system transformation that is unparalleled in its speed and scope" and recognises that "there is no single pathway to achieve net-zero emissions by 2050 and that there are many uncertainties related to clean energy transitions" (p 100);

(c) the global use of unabated fossil fuels in electricity generation is sharply reduced (p 116);

(d) coal use falls from 5250 Mtce in 2020 to 2500 Mtce in 2030 and to less than 600 Mtce in 2050 – an average annual decline of 7% each year from 2020 to 2050;

(e) the Net Zero Roadmap contains statements such as (at pp 21 and 51):

> Beyond projects already committed as of 2021, there are no new oil and gas fields approved for development in our pathway, and no new coal mines or mine extensions are required.
>
> …
>
> Projections of future energy prices are inevitably subject to a high degree of uncertainty. In IEA scenarios, they are designed to maintain an equilibrium between supply and demand. The rapid drop in oil and natural gas demand in the NZE means that no fossil fuel exploration is required and no new oil and natural gas fields are required beyond those that have already been approved for development. No new coal mines or mine extensions are required either. Prices are increasingly set by the operating costs of the marginal project required to meet demand, and this results in significantly lower fossil fuel prices than in recent years.

7.5 While the Net Zero Roadmap presents a mitigation pathway for the energy sector that may achieve the goals of the *Paris Agreement*, as the IEA states in the report it is not a forecast of what will happen and is not the only approach to achieve the *Paris Agreement*. It is useful to inform broad, economy-wide or global policy-making about energy, but it does not qualitatively or quantitatively assess the impact of a particular Controlled Action on the environment in terms of net GHG emissions. The pathway described in the Net Zero Roadmap is for net zero energy sector CO_2 emissions with no offsets and with low reliance on negative emissions technologies (p 13). The Net Zero Roadmap therefore has limited utility for the purpose of this assessment.

8. CONCLUSION

8.1 The WEO 2019 and WEO 2020 demonstrate that, because of the relatively young age of power stations and steel mills in Southeast Asia, there will be continued demand in that region for coal. This is a "baked in" demand.

8.2 As earlier shown in section 2 of this letter:

(a) coal is not a homogenous product – there is a large range in terms of key qualitative characteristics, such as calorific value, and ash and sulphur content; and

(b) the Controlled Action's coal is relatively high in calorific value and low in ash and sulphur content.

8.3 For thermal coal, more CO_2 is emitted per unit of energy output when coal of an inferior calorific value is combusted, because more coal is needed to achieve the same energy output that would be produced by combusting coal of a high calorific value.

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8.4 Metallurgical coal, including SSCC and hard coking coal are essential inputs for steelmaking using blast furnace-basic oxygen furnace technology, which produces approximately 70% of all steel globally.

8.5 If the Minister was to refuse approval for the Controlled Action, the operators of power stations and steel mills in Southeast Asia which have a "baked in" demand, would be denied access to 33 Mt of high quality coal. It is our client's view that denying an EPBC approval for Vickery on environmental grounds is illogical and would in all likelihood lead to higher CO_2 emissions.

Yours faithfully

Ashurst

ANNEXURE A

VICKERY EXTENSION PROJECT – SUBMISSION TO THE INDEPENDENT PLANNING COMMISSION ON THE CONSIDERATION OF GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE (INCLUDING CRU LETTER AT APPENDIX 4)

VICKERY EXTENSION PROJECT (SSD 7480)

Submission to the Independent Planning Commission on the consideration of greenhouse gas emissions and climate change

16 June 2020

ACKNOWLEDGMENTS

Whitehaven Coal Limited and Vickery Coal Pty Ltd provided guidance throughout the preparation of this submission.

We acknowledge the original contribution that Baker McKenzie made in respect of Part B and Appendix 3 of this submission and our reliance on the work of CRU International Limited in respect of Part C and Appendix 4 of this submission.

Mark Brennan (Partner) and s. 47F(1) **(Senior Associate)**
Ashurst

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GLOSSARY

Abbreviation/Acronym	Meaning
2006 IPCC Guidelines	2006 IPCC Guidelines for National Greenhouse Gas Inventories
2019 IPCC Refinement	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
ACA	Australian Coal Alliance
ACARP	Australian Coal Association Research Program
ACCUs	Australian carbon credit units
Amendment Report	Vickery Extension Project Amendment Report dated August 2019
Applicant	Vickery Coal Pty Ltd
Approved Project	Vickery Coal Project approved on 19 September 2014 under Part 4 of the EP&A Act (application no. SSD-5000)
Assessment Report	State Significant Development Assessment (SSD 7480): Vickery Extension Project published by the NSW Department of Planning, Industry and Environment in May 2020
A-USC	Advanced ultra-supercritical
BAU	Business-as-usual
Buckley Submission	Submission of Tim Buckley of the Institute for Energy Economic and Financial Analysis to the IPC dated February 2019
CCUS	Carbon capture, use and storage
CER	Clean Energy Regulator
CFI Act	*Carbon Credits (Carbon Farming) Act 2011* (Cth)
CHPP	Coal handling and preparation plant
COP	Conference of the Parties
CO_2-e	Carbon dioxide equivalent
CSR	Coke strength after reduction
CTSCo	Carbon Transport Storage Company
DPIE	NSW Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)

Abbreviation/Acronym	Meaning
ERF	Emissions Reduction Fund
ESD	Ecologically sustainable development
ETS	Emissions trading scheme
Export Countries	The most likely countries to which the Extension Project's coal will be exported: Japan, South Korea and Taiwan
Extension Project	Vickery Extension Project (application no. SSD 7480)
FoE	Friends of the Earth
GHG	Greenhouse gas
GHG Assessment	Air Quality and Greenhouse Gas Assessment by Ramboll Australia Pty Ltd dated June 2018, which is Appendix E to the EIS for the Extension Project
HCC	Hard coking coal (metallurgical coal)
HEL	Hunter Environment Lobby
HELE	High-efficiency, low-emissions
IEA	International Energy Agency
IEEFA Report	The Institute for Energy Economic and Financial Analysis' report titled "New South Wales Thermal Coal Exports Face Permanent Decline: Grim Outlook Prompts the Need for Transition" dated November 2018
INDC	Intended Nationally Determined Contribution
IPC	Independent Planning Commission
IPCC	Intergovernmental Panel on Climate Change
JCM	Japan's Joint Crediting Mechanism
LGA	Local government area
LULUCF	Land use, land-use change and forestry
Mining SEPP	*State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*
Mt	Million tonnes
Mtce	Million tonnes of coal equivalent
MW	Megawatts
NDC	Nationally Determined Contribution
Net Zero Plan Stage 1	NSW Department of Planning, Industry and Environment's *Net*

Abbreviation/Acronym	Meaning
	Zero Plan Stage 1: 2020–2030 (March 2020)
NGER Act	*National Greenhouse and Energy Reporting Act 2007* (Cth)
NSW	New South Wales
PAC	Planning Assessment Commission
Roadmap	South Korea's revised roadmap for achieving the 2030 National Greenhouse Gas Reduction Goal in July 2018
Rocky Hill	*Gloucester Resources Limited v Minister for Planning* (2009) 234 LGERA 257
ROM	Run-of-mine
SC	Supercritical
SEARs	Secretary's Environmental Assessment Requirements
SSCC	Semi-soft coking coal (metallurgical coal)
Steffen Report	Expert report produced by Emeritus Professor Will Steffen dated 9 February 2018
t	Tonnes
Territorial Limits Bill	The *Environmental Planning and Assessment Amendment (Territorial Limits) Bill 2019* (NSW)
Transparency Framework	Transparency Framework adopted under the Katowice Climate Package
UNFCCC	*United Nations Framework Convention on Climate Change*
USC	Ultra-supercritical
Wallarah 2	*Australian Coal Alliance Inc v Wyong Coal Pty Ltd* [2019] NSWLEC 31
WEO	World Energy Outlook
WEO 2019	World Energy Outlook 2019
Whitehaven	Whitehaven Coal Limited, the parent company of the Applicant
Xstrata	*Xstrata Coal Queensland Pty Ltd v Friends of the Earth* [2012] QLC 13

SUBMISSION TO THE INDEPENDENT PLANNING COMMISSION

1. INTRODUCTION

1.1 Vickery Coal Pty Ltd (the **Applicant**), a subsidiary of Whitehaven Coal Limited (**Whitehaven**), seeks consent to extend open cut mining operations at the site of the approved, but yet to be constructed, Vickery Coal Project (the **Approved Project**). The proposed extension is known as the Vickery Extension Project (the **Extension Project** or the **Project**). The Applicant has applied for consent to the Extension Project under the State significant development provisions of the *Environmental Planning and Assessment Act 1979* (NSW) (**EP&A Act**).

1.2 The Approved Project was approved on 19 September 2014 under Part 4 of the EP&A Act (application no. SSD-5000). That development consent authorises the extraction of up to 4.5 million tonnes (**Mt**) of run-of-mine (**ROM**) coal annually, totalling 135 Mt of ROM coal over 30 years.

1.3 The Approved Project has been "physically commenced" under the EP&A Act, and as a consequence, the development consent for the Approved Project has not lapsed. If follows, that if the IPC refuses to grant consent for the Extension Project, the Applicant will still be entitled to proceed with construction and operation of the Approved Project.

1.4 The Extension Project will expand the area of approved mining and increase the approved rate of extraction to authorise the extraction of up to 10 Mt of ROM coal per year, with an estimated total extraction of 168 Mt of ROM coal over 25 years.

1.5 The Extension Project will be carried out partly on land that has been disturbed by previous mining operations at the former Vickery Coal Mine and Canyon Coal Mine. Extraction from the former Vickery Coal Mine and Canyon Coal Mine ceased in 1998 and 2009 respectively. Those mines were rehabilitated to form five final voids.

1.6 The Applicant commissioned an Air Quality and Greenhouse Gas Assessment by Ramboll Australia Pty Ltd dated June 2018 (**GHG Assessment**), which is Appendix E to the Environmental Impact Statement (**EIS**) for the Extension Project.

1.7 The Applicant also commissioned an Economic Assessment by AnalytEcon Pty Ltd dated August 2018 (**Economic Assessment**), which is Appendix J to the EIS.

1.8 The initial stage of the public hearing on the Extension Project was held by the Independent Planning Commission (**IPC**) on 4 and 5 February 2019.

1.9 A number of written submissions opposing the Extension Project have been made to the IPC regarding the IPC's consideration of greenhouse gas (**GHG**) emissions and climate change.

1.10 In May 2020, the NSW Department of Planning, Industry and Environment (**DPIE**) published the State Significant Development Assessment (SSD 7480): Vickery Extension Project (the **Assessment Report**). The Assessment Report has been given to the IPC for its consideration. The development application for the Extension Project has been referred to the IPC for a further public hearing and determination.

1.11 This submission is the Applicant's response on GHG emissions and climate change issues which are relevant to the IPC's assessment and determination of the development application for the Extension Project.

2. **STRUCTURE OF THIS SUBMISSION**

2.1 This submission contains the following five parts:

(a) **Part A:** the law regarding the consideration of GHG emissions and climate change in determining development applications under the EP&A Act

(b) **Part B:** international, national and State climate change law and policy that the IPC may consider when determining the development application for the Extension Project

(c) **Part C:** the future demand for coal (including under future climate change policy scenarios), the characteristics of the Extension Project's coal, and the consequences of coal market substitution

(d) **Part D:** response to submissions made in respect of GHG emissions and climate change at, and following, the initial stage of the public hearing into the Extension Project

(e) **Part E:** weighing the benefits of the Extension Project against the consideration of GHG emissions and climate change

3. **EXECUTIVE SUMMARY**

The law regarding the consideration of GHG emissions and climate change in determining the development application under the EP&A Act

3.1 The following key points are made in **Part A** of this submission:

(a) pursuant to s 4.5(1) of the EP&A Act, the IPC must consider, among other things:

(i) the provisions of the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (**Mining SEPP),** including the aims of the Mining SEPP and cl 14;

(ii) the likely impacts of the Extension Project, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality; and

(iii) the public interest;

(b) the aims of the Mining SEPP include to facilitate the orderly and economic use and development of land containing mineral resources, and to promote the development of significant mineral resources;

(c) clause 14(2) of the Mining SEPP requires a consideration of an assessment of the GHG emissions (including downstream emissions);

(d) the NSW Land and Environment Court has said that the obligation to consider the public interest includes the principles of ESD in cases where issues relevant to those principles arise. The principle of intergenerational equity and the precautionary principle can, in turn, involve the consideration of GHG emissions;

(e) the IPC may take into account the *Paris Agreement*, Australia's Nationally Determined Contribution (**NDC**) under the *Paris Agreement*, and the NSW Government's Climate Change Policy Framework and its *Net Zero Plan Stage 1: 2020–2030* (March 2020) (**Net Zero Plan Stage 1**);

(f) however, GHG emissions and climate change are not the only considerations that inform the public interest. The public interest is broad and captures not only environmental considerations, but also the social and economic benefits associated with the Extension Project for the wider community and the State;

(g) as recognised by the NSW Court of Appeal, ESD is just one of many objects of the EP&A Act, including:

(i) to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources, and

(ii) to promote the orderly and economic use of land;[1]

(h) the IPC must consider and determine the development application for the Extension Project on its own merits, taking into account both the positive and negative impacts of the Extension Project and all of the relevant considerations under the EP&A Act;

(i) the IPC is not obliged to consider or follow any part of *Gloucester Resources Limited v Minister for Planning* (2019) 234 LGERA 257 (***Rocky Hill***), in which the NSW Land and Environment Court, exercising administrative power in Class 1 of its jurisdiction, found that the significant and unacceptable planning, visual and social impacts of the proposed project were sufficient reasons alone for refusing consent at [556]; and

(j) there are legal and policy reasons why the IPC should not impose conditions of consent that require the Applicant to offset GHG emissions, or that would restrict the export of the Extension Project's product coal. The Territorial Limits Bill, if enacted, would codify this position.

International, national and State climate change law and policy

3.2 The following key points are made in **Part B** of this submission:

(a) almost all of the Extension Project's Scope 3 emissions will be counted under the *Paris Agreement* as the Scope 1 GHG emissions of the Export Countries in which the coal is combusted. Any mitigation in relation to the use of coal in electricity generation or steelmaking within those countries will count towards those countries' Nationally Determined Contributions (**NDCs**) under the *Paris Agreement*;

(b) the Export Countries are parties to the *Paris Agreement* (save for Taiwan which is not a member of the United Nations) and have announced or adopted domestic laws and policies to achieve their targets to reduce their GHG emissions as set out in their NDCs or Taiwan's INDC;[2]

(c) Australia does not require monitoring or reporting of Scope 3 GHG emissions under the NGER Act and does not count Scope 3 GHG emissions in its national inventory of GHG emissions, as this would constitute double counting contrary to the Transparency Framework under the *Paris Agreement.* Consequently, refusing development consent to the Extension Project will not help to achieve Australia's NDC;

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[1] EP&A Act, s 1.3(a) and (c); *Minister of Planning v Walker* (2008) 161 LGERA 423 at [52].

[2] It should be noted, of course, that there may well be other countries to which the Project's coal is exported from time-to-time during the Project's life of mine. Nevertheless, the *Paris Agreement* has been adopted almost universally having been ratified by 187 countries, 184 of which have submitted NDCs.

(d) the carbon budget approach is not endorsed by the *Paris Agreement* as a method by which allocation or sharing of global mitigation efforts among countries can occur, indeed:

(i) it is inconsistent with the approach that has been adopted by the *Paris Agreement* for achieving the goal set under that agreement, namely NDCs;

(ii) its application to Scope 3 GHG emissions results in double counting, which is an outcome that the *Paris Agreement* seeks to avoid;

(e) neither the Australian Government nor the NSW Government have advocated the "carbon budget" approach, or indicated that the development of new coal mines, or expansion of existing coal mines, is to be prohibited or restricted in any way for the purpose of achieving Australia's NDC;

(f) the Extension Project's Scope 1 GHG emissions will be regulated under the Safeguard Mechanism of the Australian Government's *National Greenhouse and Energy Reporting Act 2007* (**NGER Act**). Once direct GHG emissions exceed 100,000 tCO_2-e/year, the Clean Energy Regulator will set an emissions baseline based on benchmark emissions intensities (that is, the best, least emissions intensive standard for production),[3] and the Applicant will be required to offset any emissions above its baseline in accordance with the NGER Act; and

(g) it is the NSW Government's policy:

(i) as embodied in the *Mining Act 1992* (NSW) and the Mining SEPP, that mineral resources in NSW continue to be developed in recognition of the significant social and economic benefits to NSW that result from the efficient development of mineral resources. The IPC is required by s 4.15 of the EP&A Act to take into consideration the aims of the Mining SEPP; and

(ii) as stated in the Department of Planning, Industry and Environment's *Net Zero Plan Stage 1: 2020–2030* (March 2020) (**Net Zero Plan Stage 1**) (at 22):

> New South Wales' $36 billion mining sector is one of our biggest economic contributors, supplying both domestic and export markets with high quality, competitive resources. Mining will continue to be an important part of the economy into the future and it is important that the State's action on climate change does not undermine those businesses and the jobs and communities they support.

Future demand for coal, the characteristics of the Extension Project's coal, and the consequences of coal market substitution

3.3 The following key points are made in **<u>Part C</u>** of this submission:

(a) the International Energy Agency's (**IEA**) *World Energy Outlook 2019* (**WEO 2019**) presents three policy scenarios for projecting global energy demand and energy supply:

(i) the Current Policies Scenario is the business-as-usual scenario and assumes that governments do not implement recently announced climate change or GHG mitigation policies and that no new policies are introduced in the future;

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[3] *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (Cth), cl 38(3); http://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/Baselines

(ii) the Stated Policies Scenario, the WEO 2019's central scenario, incorporates policies and measures that have been announced by governments but where the precise implementation measures have not yet been fully defined; and

(iii) the Sustainable Development Scenario, which incorporates a variety of hypothetical government policies compatible with achieving universal access to electricity while achieving the aim of the *Paris Agreement*;

(b) the Extension Project will produce approximately 150 Mt of saleable coal, comprising thermal coal and semi-soft coking coal (**SSCC**) at an indicative life of mine ratio of 40:60. Thermal coal is primarily used in electricity generation. SSCC is a type of metallurgical coal used in steelmaking;

(c) the IEA projects that, in the Stated Policies Scenario, primary energy demand grows by approximately 24% from 2018 to 2040, driven by structural trends of population growth, urbanisation and economic growth in developing economies, particularly in the Asia Pacific region;

(d) in relation to coal, the IEA projects that demand for coal in the Stated Policies Scenario will essentially remain flat and drop by 60 Mtce between 2018 and 2040, ending up in 2040 at around 5400 Mtce. Coal-fired electricity generation plateaus and its share of electricity generation declines from 38% in 2018 to 25% in 2040. However, this varies drastically by region. In advanced economies coal-fired electricity generation will more than halve over the period to 2040 while coal consumption will increase in Southeast Asia, where 40% of the projected rise in the region's electricity demand will be met by coal, and coal plants are currently around 12 years old on average (more than 20 years younger than those in advanced economies);

(e) under all three policy scenarios presented by the IEA (including the Sustainable Development Scenario), there will continue to be a global demand for coal. Absent new mines or brownfield expansions, the global production of coal would be approximately 600 Mtce in 2040. Under the Sustainable Development Scenario, global demand for coal would be 2,101 Mtce in 2040 of which 858 Mtce would be for electricity and 1,206 Mtce would be for industrial use, principally steelmaking.

(f) metallurgical coals, including hard coking coal (**HCC**) and SSCC are essential inputs for the current production of approximately 70% of all steel globally produced using blast furnace-basic oxygen furnace technology. HCC and SSCC are used together to produce coke, which is the primary source of carbon in steelmaking. The proportion of each coal used in the coking process is determined by various factors, including pricing differentials, blast furnace requirements and specific characteristics and qualities of the coals;

(g) the IEA projects that coal use in steelmaking declines in the Stated Policy Scenario by around 30 Mtce by 2040, reflecting efficiency gains and the gradual rise in the use of electricity-based routes for steel production. However, in both the Stated Policies Scenario and the Sustainable Development Scenario, coal remains the backbone of steel manufacturing, as the scope to shift away from coal by making greater use of scrap-based or direct reduction of iron (DRI)-based electric arc furnaces is limited by the availability and cost of scrap steel and the cost of electricity;

(h) the Applicant engaged CRU International Limited (**CRU**) to undertake a study of global coal demand and supply to 2040, the characteristics of the Extension Project's coal compared to the coal produced by other coal exporting countries, and the likely GHG consequences of coal market substitution if the Extension Project does not go ahead. CRU's forecasts for global coal demand to 2040 are similar to the IEA's projections for the Stated Policies Scenario. The relevant findings in the CRU study are:

(i) global demand for thermal coal will decline only slightly from 2018 to 2040, and coal will remain an important pillar of electricity generation in many regions, including in Southeast Asia, as well as in China and India in 2040;

(ii) high quality thermal coal from Australia (such as that produced by the Extension Project) is, and will continue to be, in high demand to meet the electricity generation needs in these regions;

(iii) as the ability of existing mines to meet the global demand for coal declines over time, it will be necessary for the demand to be met by expansions of approved coal mines or the development of new coal mines;

(iv) the Extension Project's thermal coal is higher quality (in terms of calorific value) than the country weighted averages of all other thermal coal exporters, including Australia;

(v) more GHGs are emitted when lower quality coal is used because more lower quality coal is needed to achieve an equivalent energy output than what would be produced from the combustion of higher quality coal;

(vi) demand for metallurgical coal is driven by demand for steel. Blast-furnace technology, which is dependent on HCC and SSCC, will still dominate the steelmaking industry to 2040;

(vii) HCC has superior coke strength after reduction (**CSR**) compared to SSCC. However, blast furnaces cannot run using only HCC. There is evidence that a coke blend containing approximately 15 to 20% SSCC is the likely technical, minimum level of SSCC that can be used in highly efficient blast furnaces. This means that SSCC's vital role in steel production will continue into the future;

(viii) the ash content of the Extension Project's SSCC is lower than the average ash content of Australian SSCC and all other major seaborne SSCC suppliers, save for Canada. The sulphur content of the Extension Project's SSCC at 0.4% is also near the bottom end globally and lower than the average sulphur content of Australian SSCC. The phosphorus content of the Extension Project’s SSCC at 0.003% is lower than the average of Australia and all other major seaborne SSCC suppliers. These qualities make the Extension Project's SSCC one of the most marketable SSCC products globally;

(ix) ash and CSR are the two attributes of HCC and SSCC that have the greatest impact on blast-furnace productivity and, consequently, the GHG emissions intensity of steelmaking. Given the Extension Project's SSCC’s low ash levels compared to other exporters, CO_2 emissions could be reduced by 13 kg per tonne of hot metal produced (compared to the emissions intensity based on average ash content of SSCC globally) if the Extension Project's coal were used as the only SSCC within the coke blend. CSR has not been measured for the Extension Project's SSCC at this stage because SSCC is generally selected for use in coking coal blends based on attributes other than CSR; and

(x) given its high energy content, SSCC can be used as premium quality thermal coal. At times during the life of mine, the prevailing pricing differential between SSCC and thermal coal may drive SSCC into the premium quality thermal coal market for power generation.

(i) coal investment and supply conditions in Australia have a limited impact on global market conditions, which means that failure to approve the Extension Project will not affect global demand for coal;

(j) the environmental impacts of substituting the shortfall in supply from the Extension Project with alternative sources of thermal coal would be adverse, because the Extension Project's thermal coal is high quality (including compared to the weighted average of Australian mines) in calorific terms and low in negative attributes such as ash and sulphur;

(k) this means that substitution by other coal sources is likely to result in more coal being mined and combusted to meet the same power needs, resulting in higher Scope 3 GHG emissions and higher concentrations of ash and sulphur;

(l) moreover, the direct emissions (Scope 1 and 2 emissions) of these alternative supply sources are also likely to be higher, due to favourable geology and efficient production processes and technologies used by the Australian mining industry;

(m) CRU modelled three hypothetical scenarios. They are:

(i) if neither the Extension Project nor the Approved Project go ahead (**Scenario 1**), the absence of coal supply from the Extension Project and the Approved Project is estimated to result in the release of an additional 14 to 120.4 million tonnes of CO_2-e into the atmosphere over the life of mine as the result of substituted inferior coal;

(ii) if the Extension Project is not approved, but the Approved Project does go ahead (**Scenario 2**), then the absence of the additional supply of coal from the Extension Project is estimated to result in the release of an additional 5.7 to 49.7 million tonnes of CO_2-e into the atmosphere over the life of mine as the result of substituted inferior coal; and

(iii) if no new Australian projects enter production and currently operating Australian mines naturally deplete during the period 2019-2030 (**Scenario 3**), then the non-Australian alternative supply is estimated to result in the release of an additional 68.6 to 124.1 million tonnes of CO_2-e into the atmosphere in that period to 2030;

(n) therefore, the failure to approve the Extension Project would likely result in a net increase in GHG emissions globally due to market substitution of the Extension Project's high quality coal with inferior quality coal.

Response to submissions made in respect of GHG emissions and climate change

3.4 In **Part D** of this submission we have:

(a) identified the key submissions made by opponents of the Extension Project that are based on GHG emissions and climate change; and

(b) identified and critically reviewed six common themes relied by on opponents of the Extension Project which are related to GHG emissions and climate change. Those six themes which are critically reviewed are:

(i) Theme 1 – anthropogenic climate change is a real phenomenon that is occurring and coal is one of the major sources of human-induced GHG emissions;

(ii) Theme 2 – in order for the "well below 2°C" goal of the Paris Agreement to be realised, no new fossil fuel developments should be approved, and those existing, already approved fossil fuel developments should be rapidly phased out;

(iii) Theme 3 – coal market substitution is speculative and should not be considered by the IPC;

(iv) Theme 4 – the approval of the Extension Project would be inconsistent with existing climate change laws and policies, particularly Australia's NDC and the NSW Climate Change Policy Framework;

(v) Theme 5 – approval of the Extension Project creates a financial risk for the Applicant, existing coal mines in NSW, Australia and the local community; and

(vi) Theme 6 – the IPC should follow *Rocky Hill* and refuse development consent for the Extension Project.

Weighing the benefits of the Extension Project against the consideration of GHG emissions and climate change

3.5 The following key points are made in **Part E** of this submission:

(a) the Extension Project will more efficiently extract ROM coal reserves and thereby maximise recovery of the valuable coal resource, enabling extraction of approximately 33 million tonnes of additional ROM coal compared to the Approved Project but over a shorter life of mine;

(b) the Extension Project would remove the need to transport coal on public roads to Whitehaven's Coal Handling and Preparation Plant (**CHPP**) located 5 km northwest of Gunnedah. The Extension Project will also reduce the GHG emissions intensity of the Tarrawonga Coal Mine as a result of reduced haulage distances to the Project CHPP instead of the Whitehaven CHPP;

(c) mitigation measures will be implemented to limit the impacts associated with the Extension Project, including Scope 1 and Scope 2 GHG emissions that are generated by the Extension Project;

(d) the Extension Project will improve the compatibility of the final landform with the surrounding landscape by reducing the number of final voids compared to both the Approved Project and the current landscape, better integrating the western emplacement with the surrounding landscape, and removing the need for the approved eastern emplacement;

(e) the Extension Project will generate significant social and economic benefits at a local, regional and State level for current and future generations, in the form of job creation and a total net economic benefit for the NSW community of approximately $1.16 billion (in net present value terms). The sensitivity analysis included in the Economic Assessment means that a significant net benefit will accrue to NSW even if coal prices are affected by climate change policies in the future;

(f) if the Extension Project is not approved, Whitehaven would still be entitled to carry out the Approved Project with a number of consequences, including that approximately 200 additional operational employment opportunities would be foregone, the operational efficiency improvements of the Extension Project (including its CHPP) would not be realised, the additional economic benefits to the State would be foregone, coal would be extracted over a longer timeframe which would extend past 2050, and three final voids would remain in the landscape as opposed to two following completion of the Extension Project;

(g) the failure to approve the Extension Project would likely result in a net increase in GHG emissions globally due to market substitution of the Extension Project's high quality coal with inferior quality coal; and

(h) based on the information provided by the Applicant to the IPC, the Applicant considers that there is more than sufficient information before the IPC to comfortably reach a conclusion that the benefits of the Extension Project outweigh its impacts.

4. PART A: THE LAW REGARDING CONSIDERATION OF CLIMATE CHANGE AND GHG EMISSIONS IN DETERMINING A DEVELOPMENT APPLICATION UNDER THE EP&A ACT

4.1 In Part A of the submission, the following is addressed:

(a) the law regarding the consideration of climate change and GHG emissions (particularly Scope 3 emissions) in determining a development application under the EP&A Act;

(b) the type and nature of conditions of consent that may be imposed by the IPC in relation to GHG emissions and climate change; and

(c) relevance of the Territorial Limits Bill to the IPC's assessment and determination of the development application for the Extension Project.

4.2 Each of these will be addressed in turn below.

The law regarding the consideration of climate change and GHG emissions in determining a development application under the EP&A Act

4.3 As a starting point, the exercise of the IPC's discretion under the EP&A Act is governed by the scope and subject matter of the EP&A Act.

4.4 The objects of the EP&A Act relevantly include:

(a) to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State’s natural and other resources (s 1.3(a));

(b) to facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment (s 1.3(b));

(c) to promote the orderly and economic use and development of land (s 1.3(c)); and

(d) to promote the sharing of the responsibility for environmental planning and assessment between the different levels of government in the State (s 1.3(i)).

4.5 In determining a development application, s 4.15 of the EP&A Act requires the consent authority to take into consideration certain matters as are of relevance to the development, including:

(a) the provisions of any relevant environmental planning instrument (s 4.15(1)(a)(i));

(b) "the likely impacts of the development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality" (s 4.15(1)(b)); and

(c) the public interest (s 4.15(1)(e)).

4.6 The main environmental planning instrument of relevance to the Extension Project is the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (**Mining SEPP**). The aims of the Mining SEPP "in recognition of the importance to New South Wales of mining, petroleum production and extractive industries" include:

(a) to provide for the proper management and development of mineral, petroleum and extractive material resources for the purpose of promoting the social and economic welfare of the State (cl 2(a));

(b) to facilitate the orderly and economic use and development of land containing mineral, petroleum and extractive material resources (cl 2(b));

(c) to promote the development of significant mineral resources (cl 2(b1)); and

(d) to establish appropriate planning controls to encourage ecologically sustainable development through the environmental assessment, and sustainable management, of development of mineral, petroleum and extractive material resources (cl 2(c)).

4.7 Clause 14 of the Mining SEPP relevantly states:

> **14 Natural resource management and environmental management**
>
> (1) Before granting consent for development for the purposes of mining… the consent authority must consider whether or not the consent should be issued subject to conditions aimed at ensuring that the development is undertaken in an environmentally responsible manner, including conditions to ensure the following—
>
> …
>
> (c) that greenhouse gas emissions are minimised to the greatest extent practicable.
>
> (2) Without limiting subclause (1), in determining a development application for development for the purposes of mining… the consent authority must consider an assessment of the greenhouse gas emissions (including downstream emissions) of the development, and must do so having regard to any applicable State or national policies, programs or guidelines concerning greenhouse gas emissions.

4.8 The following things should be noted about s 4.15 of the EP&A Act and cl 14(2) of the Mining SEPP:

(a) statutes are always read as being prima facie restricted in their operation within territorial limits.[4] This principle of interpretation is reflected in s 12(1) of the *Interpretation Act 1987* (NSW) which states that in any Act or instrument "a reference to a locality jurisdiction or other matter or thing is a reference to such a locality, jurisdiction or other matter or thing in and of New South Wales." This applies unless a contrary intention appears in the Act or instrument concerned;[5]

(b) the starting point to interpreting s 4.15 of the EP&A Act is that the impacts of the development (both direct and indirect) that are to be considered are impacts of the development in and of NSW;

(c) in relation to the provisions of any relevant environmental planning instrument, clause 14(2) of the Mining SEPP requires a consideration of an assessment of the GHG emissions (including downstream emissions), being prima facie GHG emissions in and of NSW;[6]

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[4] *Jumbunna Coal Mine NL v Victorian Coal Miners' Association* (1908) 6 CLR 309, 363 (O'Connor J).

[5] *Interpretation Act 1987* (NSW), s 5(2).

[6] This is supported by the *Guidelines for the economic assessment of mining and coal seam gas proposals* (dated December 2015), in which it appears to be suggested that the assessment of the economic aspects of a given project are to be considered at local, regional and State scale, but not at a higher scale.

(d) the expression "public interest", when used in a statute like the EP&A Act, imports a discretionary value judgment to be made by reference to undefined factual matters and is unconfined except by the scope and subject matter of the EP&A Act;[7]

(e) the public interest is, as a result, broad and captures not only environmental considerations associated with the Extension Project, but also the social and economic benefits associated with the Extension Project for the wider community and the State;

(f) the NSW Land and Environment Court has said that the obligation to consider the public interest under s 4.15(1)(e) of the EP&A Act obliges the consent authority to have regard to the principles of ESD in cases where issues relevant to those principles arise;[8]

(g) as acknowledged by the NSW Court of Appeal, ESD is just one of many objects of the EP&A Act, including:

(i) to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources, and

(ii) to promote the orderly and economic use of land;[9] and

(h) there is authority that consideration of the public interest and principles of ESD can involve consideration of Scope 3 GHG emissions.[10]

4.9 The Applicant accepts that the IPC may take into account the Paris Agreement, Australia's NDC under the Paris Agreement, the NSW Government's Climate Change Policy Framework and its Net Zero Plan Stage 1.

4.10 The Applicant accepts that the IPC can consider, as part of the public interest, the GHG emissions of the Extension Project (including Scope 3 emissions), and the Extension Project's contribution to climate change insofar as that contribution is likely to impact NSW. However, the Applicant submits that:

(a) climate change and GHG emissions are not the only considerations that inform the public interest and, certainly, are not to be solely determinative of the Extension Project;[11]

(b) it is for the IPC to determine how much weight is to be attributed to the relevant social, economic and environmental factors associated with the Extension Project (including the climate change impacts and GHG emissions of the Extension Project); and

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[7] *The Pilbara Infrastructure Pty Ltd v Australian Competition Tribunal* (2012) 246 CLR 379 at [42] per French CJ, Gummow, Hayne, Crennan, Kiefel and Bell JJ.

[8] *Telstra Corporation Ltd v Hornsby Shire Council* (2006) 67 NSWLR 256 at [121]-[124], cited with agreement in *Minister of Planning v Walker* (2008) 161 LGERA 423 per Hodgson J at [42]-[43]. However, the NSW Court of Appeal has been more circumspect at least in respect of decisions under Part 3A of the EP&A Act, stating that the principles of ESD "are likely to come to be seen as so plainly an element of the public interest, in relation to most if not all decisions, that failure to consider them will become strong evidence of failure to consider the public interest": *Minister of Planning v Walker* (2008) 161 LGERA 423 per Hodgson J at [56].

[9] EP&A Act, s 1.3(a) and (c); *Minister of Planning v Walker* (2008) 161 LGERA 423 at [52].

[10] See, e.g., *Gray v Minister for Planning* (2006) 152 LGERA 258 at [126], [135].

[11] This proposition also gains support generally from Justice Moore's recent decision in *Australian Coal Alliance Incorporated v Wyong Coal Pty Ltd* [2019] NSWLEC 31 at [96] to [105] and from the NSW Court of Appeal's decision in *Minister of Planning v Walker* (2008) 161 LGERA 423.

(c) the IPC's approach to considering and weighting the relevant factors is not prescribed, dictated or restricted by the decision in *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 (***Rocky Hill***).

4.11 The Applicant's position on the relevance of *Rocky Hill* is set out in detail in **Appendix 1** and is summarised as follows:

(a) the Court's decision in *Rocky Hill* was the determination of a "merit appeal" whereby the Court "stands in the shoes" of the consent authority and determines the merits of a development application. The Court's decision is, therefore, not a legal precedent that the IPC is obliged to follow;

(b) in contrast, *Australian Coal Alliance Inc v Wyong Coal Pty Ltd* [2019] NSWLEC 31 (***Wallarah 2***), which was decided after *Rocky Hill*, was the determination of judicial review proceedings, with the consequence that this case is a legal precedent and is, in the Applicant's submission, both binding on and instructive to the IPC as to how the issue of climate change and GHG emissions may be addressed by the IPC in determining the development application for the Extension Project;

(c) in *Wallarah 2*, the Court found that there was no legal error in a consent authority approving a new coal mine in circumstances where:

(i) the combustion of the project's coal was predicted to generate Scope 3 emissions significantly greater (by a factor of 7) than those of the Rocky Hill Coal Project;

(ii) there was no proposal to offset those emissions;

(iii) the consent authority considered and accepted the concept of coal market substitution; and

(iv) the consent authority considered that Scope 3 emissions should be dealt with at the location where those emissions are generated or at higher policy levels.

(d) *Rocky Hill* was concerned with the specific facts and circumstances of that proposed mining project, particularly being in the Gloucester Valley, close to the town of Gloucester;

(e) in *Rocky Hill*, climate change impacts and GHG emissions were not the essential reasons for the refusal of the Rocky Hill Coal Project, as the Court made clear at [556] that the significant and unacceptable planning, visual and social impacts of the proposed project were sufficient reasons alone for refusing the development application for the Rocky Hill Coal Project;

(f) the IPC is obliged to consider and determine the development application for the Extension Project on its own, individual merits, having regard to the environmental assessment material and information that is before it;

(g) the IPC, in determining the development application for the Extension Project, is not obliged to consider, adopt, distinguish or follow any aspect of the Court's decision in *Rocky Hill*, as the Court's decision in *Wallarah 2* (which is a binding, legal precedent) confirms;

(h) the IPC is required to assess all of the impacts of the Extension Project (both positive and negative) and all of the relevant considerations under the EP&A Act, which involves an "intuitive synthesis of the relevant factors";[12]

(i) as is evident from the judgment in *Wallarah 2*, the fact that a project generates GHG emissions does not mean that the starting position for consideration of a development application is that the Extension Project should be refused, and that fact is also not singularly determinative for the purposes of considering a development application made under the EP&A Act for any type of development, coal mining being only one of many types of development which generate GHG emissions;

(j) there is no government policy or legal principle that dictates the extent to which GHG emissions generated by the Extension Project, or the combustion of the Extension Project's coal by other developments, are to be considered and weighted in determining a development application under the EP&A Act, and there is no prescribed quantitative criteria against which the Extension Project's GHG emissions are to be assessed;

(k) it is for the IPC to determine how much weight it will accord to the climate change impacts and GHG emissions generated by the Extension Project or the combustion of the Extension Project's coal by other developments, compared to all the other relevant considerations under the EP&A Act; and

(l) for the reasons given in Parts C, D and E of this submission, it is submitted that the climate change impacts and GHG emissions generated by the Extension Project or the combustion of the Extension Project's coal by other developments do not outweigh the significant social and economic benefits that the Extension Project will deliver at a local, regional and State level (which are summarised in Part E of this submission and are addressed in other documents already before the IPC, such as the Environmental Impact Statement).

The type and nature of conditions of consent that may be imposed in relation to GHG emissions and climate change

4.12 DPIE has recommended conditions of consent for the Extension Project that:

(a) all reasonable steps are taken to improve energy efficiency and reduce Scope 1 and 2 GHG emissions of the Extension Project; and

(b) that an Air Quality and Greenhouse Gas Management Plan is prepared describing the measures to be implemented to ensure that best management practice is employed to minimise the Extension Project's Scope 1 and 2 GHG emissions and to improve the Extension Project's energy efficiency.

4.13 The Applicant welcomes these recommended conditions of consent and submits that the IPC should not impose any further conditions of consent relating to GHG emissions for the reasons set out below.

4.14 The case of *Hunter Environment Lobby Inc v Minister for Planning* [2011] NSWLEC 221 is relevant to the type and nature of conditions of consent that may be imposed. Whilst that decision was also in a merit appeal like in *Rocky Hill* (and thus, has no precedent value), the Applicant considers that certain aspects of that decision are worth bringing to the IPC's attention.

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[12] *Bulga Milbrodale Progress Association Inc v Minister for Planning and Infrastructure* (2013) 194 LGERA 347 at [41]–[42].

4.15 That case was a merit appeal brought in respect of the consolidation and expansion of the Ulan coal mine. At [32] of the judgment, Justice Pain noted that "some of the conditions that [Hunter Environment Lobby] seek to impose are novel, particularly in relation to measures to offset GHG emissions".

4.16 Hunter Environment Lobby (**HEL**) sought conditions of consent that would require an offset for Scope 1 and 2 emissions, but not for Scope 3 emissions.

4.17 Mr Kitto of the then Department of Planning and Environment (**DP&E**) gave evidence in the proceedings. His evidence was that the imposition of conditions on a planning approval requiring offset of GHG emissions would be "inconsistent with the government's policy of not using the development assessment process in the EP&A Act to impose obligations on proponents to offset the GHG emissions of their projects and contrary to the DP&E's practice of at least 5 years of applying this policy to the assessment and regulation of all major projects in NSW" (at [59]).

4.18 Mr Kitto summarised the DP&E's position as being that development approval conditions are unsuitable for implementing a regulatory regime to require proponents to offset some or all of the GHG emissions of their projects. Key reasons given for this position were (at [60]):

(a) such a regime would be inefficient, ineffective and inequitable because conditions could only be imposed on new projects, not existing ones;

(b) no existing mines in NSW are required to offset their GHG emissions (we believe that statement remains true today, to the extent that no existing mine is required by a condition of consent to offset its GHG emissions. Some mines will be subject to the Federal government's Safeguard Mechanism and will need to offset GHGs that are emitted above a certain baseline, as discussed in paragraphs 5.38 to 5.45 below);

(c) imposing a regulatory regime through conditions would make the coal supply from a few mines more expensive and would not drive change across the industry;

(d) in the absence of a national or international scheme for offsetting GHG emissions, the regulatory regime imposed by the conditions would need to rely on a collection of largely voluntary schemes to achieve offsets;

(e) the regime would be inflexible as consents could only be modified at the request of the proponent; and

(f) the regime would be complex to administer as it would not be uniform for all proponents.

4.19 Justice Pain held that it was within power to impose a condition on a planning approval requiring the offset of Scope 1 emissions generated by a project, finding that the fact that "the impact is felt within and also beyond NSW does not suggest that legally a condition should not be imposed under state legislation which seeks to ameliorate one contributor to that impact" (at [93]).

4.20 At [94], her Honour declined to determine whether it would be lawful to impose conditions requiring the offset of Scope 2 emissions, but clearly expressed doubts on the validity of such a condition:

> Scope 2 emissions are different to scope 1 emissions. By contrast scope 2 emissions result from diesel and electricity use at the project and are not emissions which Ulan can control entirely … [W]hile Ulan can minimise electricity and diesel use at the mine it cannot influence how an electricity generator and supplier chooses to generate the electricity Ulan uses … A condition framed to require offsetting of scope 2 emissions would be open to criticism that to the extent that those emissions are under the control of others, the requirement would not fairly relate to the development [one of the three criteria to be satisfied under the *Newbury* test for a valid condition of development consent]. It was not clear from the evidence how identifiable those parts of the scope 2 emissions are which Ulan has the ability to minimise or of any other form of control. The incentive for the electricity generator to reduce the production of GHG will also be removed if Ulan has to offset these, a poor policy outcome as identified in the Respondent's submissions.

4.21 It stands to reason that, if Justice Pain's logic in [94] is accepted (which it should be), it would be invalid to impose conditions of development consent on the SSD consent for the Extension Project which requires offset of Scope 2 or of Scope 3 GHG emissions, which may be even further beyond the control of the Applicant than Scope 2 GHG emissions.

4.22 At [100] et seq, her Honour resolved to impose a condition requiring offset of Scope 1 GHG emissions.

4.23 However, in a later judgment – *Hunter Environment Lobby Inc v Minister for Planning (No 2)* [2012] NSWLEC 40 – Justice Pain departed from the position of imposing a condition requiring offset of Scope 1 GHG emissions generated by the project following the passage of the *Clean Energy Act 2011* (Cth). It appears that the main reason why her Honour did not impose a condition requiring the proponent to offset the project's Scope 1 GHG emissions was that she was satisfied that the Commonwealth scheme as represented by the *Clean Energy Act 2011* (Cth) and related legislation, met "at a practical level the purpose of imposing a condition requiring the offset of Scope 1 GHG emissions" (at [16]).

4.24 In light of Justice Pain's observations in these cases, as well as the information contained in this submission, the Applicant submits that:

(a) the IPC should not impose a condition of consent requiring Scope 1 GHG emissions of the Extension Project to be offset because the Commonwealth Government's Safeguard Mechanism will apply to the Extension Project as described in Part B;

(b) it would be unlawful for a condition of consent to be imposed for the Extension Project requiring offset of Scope 2 and Scope 3 GHG emissions, because it would breach the *Newbury* tests for a valid condition of development consent;

(c) the position in paragraph 4.24(b) above will be codified by the Territorial Limits Bill, which will prohibit conditions of consent imposed for the purpose of achieving objectives relating to the impacts occurring outside Australia as a result of the development, or the impacts occurring in NSW as a result of development carried out outside Australia. The Minister for Planning in his second reading speech for the Bill said that the Bill is "consistent with the well-defined Newbury test for conditions of consent and the development of case law in line with the Newbury Principles";

(d) even if it was lawful to impose a condition of consent requiring the offset of Scope 2 and Scope 3 GHG emissions, there are strong policy reasons why it would be inappropriate for such a condition of development consent to be imposed (see paragraphs 4.17 and 4.18 above); and

(e) there are also strong policy reasons why it would be inappropriate for a condition of development consent to be imposed requiring offset of Scope 1 emissions, in that there are existing Commonwealth laws regulating GHG emissions (as set out in Part B of the submission) which will apply to the Extension Project.

4.25 Although the IPC imposed a condition of consent for the United Wambo Open Cut Coal Mine Project (SSD 7142) that requires the proponent to use all reasonable and feasible measures to ensure that coal is only exported to countries that are signatories to the *Paris Agreement*, the Applicant submits that:

(a) it would be unlawful for an export control condition to be imposed for the Extension Project, including because:

(i) it would breach one or more of the *Newbury* tests for a valid condition of development consent, including for the same reasons as set out in *Hunter Environment Lobby Inc v Minister for Planning* [2011] NSWLEC 221 at [94]. That is, the condition which would be aimed at minimising Scope 3 GHG emissions would not reasonably and fairly relate to the development the subject of the application;[13] and

(ii) the Commonwealth Government has comprehensively regulated the topic of foreign exports and the countries to which certain goods may lawfully be exported by reference to international treaty obligations. This is reflected in the detailed regime of the *Customs Act 1901* (Cth) and other legislation. Therefore, by reason of s 109 of the *Commonwealth Constitution*, s 4.38(1) of the EP&A Act does not authorise the imposition of conditions of consent regulating export permissibility;

(b) the position in paragraph 4.25(a) above will also be codified by the Territorial Limits Bill. The Minister for Planning in his second reading speech for the Bill said that:

> Whilst the United Wambo development consent related to overseas downstream greenhouse gas emissions, conditions like this one highlight a technical and jurisdictional issue with the Environmental Planning and Assessment Act 1979, which does not deal expressly with the extraterritorial impacts of development—that is, impacts of development outside the territorial limits of Australia and therefore outside the territorial capacity of the New South Wales planning system to effectively be involved with the enforcement of such conditions. When the United Wambo conditions were initially proposed, the Government expressed concern that consideration of downstream, or scope 3, greenhouse gas emissions did not automatically mean that those emissions should be controlled by the conditions of a development consent.
>
> …
>
> … As the secretary of the planning department correctly highlighted in his letter to the Independent Planning Commission in relation to the United Wambo proposal, it is not the Government's policy to regulate—either directly or indirectly—matters of international trade. They are matters for the Commonwealth Government… It is therefore important that we clarify the limitations of the New South Wales planning system to control the impacts of development that occurs overseas.

(c) as noted in DPIE's Assessment Report (at [706]), the Territorial Limits Bill "aligns with the intent that development consent conditions… are not an appropriate mechanism to control the impacts resulting from the activities of third parties in other countries";

(d) even if it were lawful to impose an export control condition, there are strong practical and policy reasons why it would be inappropriate for such a condition of development consent to be imposed:

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[13] See *Western Australian Planning Commission v Temwood Holdings Pty Ltd* (2004) 21 CLR 20 per McHugh J at [57].

(i) it would be inefficient and inequitable to impose export control conditions only on new projects, not existing ones (existing consents could only be modified at the request of the proponent); and

(ii) it is not compatible with the reality of the global coal trade where coal sales are not always made directly to end users, but also to traders, other producers, third parties and customers who operate in multiple jurisdictions, which means that the destination country is not always known to the mine operator and the mine operator does not have control over the on-selling and distribution of coal once it is exported. Coal might be on-sold and blended multiple times before it reaches its final destination.

Relevance of the Territorial Limits Bill to the IPC's assessment and determination of the development application for the Extension Project

4.26 The Territorial Limits Bill was introduced to NSW Parliament on 24 October 2019 following the IPC's decision to grant consent to the United Wambo Open Cut Coal Mine. That consent was granted subject to conditions that require the applicant to use all reasonable and feasible measures to ensure that any coal that is to be exported is only exported to countries that are parties to the *Paris Agreement*.

4.27 The Territorial Limits Bill, if enacted, will amend the EP&A Act and the Mining SEPP by:

(a) inserting a new condition 4.17A into the EP&A Act:

4.17A Prohibited conditions

(1) A condition of a development consent described in this section has no effect despite anything to the contrary in this Act,

(2) A condition imposed for the purpose of achieving outcomes or objectives relating to—

(a) the impacts occurring outside Australia or an external Territory as a result of the development, or

(b) the impacts occurring in the State as a result of any development carried out outside Australia or an external Territory.

(b) Omitting the words "(including downstream emissions)" from clause 14(2) of the Mining SEPP, which is relevantly extracted in paragraph 4.7 above, so that clause 14(2) as amended will require the IPC to consider only an assessment of the greenhouse gas emissions of the development.

4.28 The Territorial Limits Bill, if enacted and in force, will:

(a) render ineffective an export control condition as imposed by the IPC on the United Wambo Open Cut SSD consent, if such is purported to be imposed on a new development consent, and

(b) mean that the IPC is no longer required by the Mining SEPP to consider downstream GHG emissions. However, the IPC may still take into account the Scope 3 GHG emissions of the Extension Project and the Extension Project's impact on the climate as part of its consideration of the public interest under s 4.15 of the EP&A Act as discussed above.

5. **PART B: INTERNATIONAL, NATIONAL AND STATE CLIMATE CHANGE LAW AND POLICY**

5.1 There are a range of climate change laws and policies that may inform, where applicable, the IPC's consideration of climate change and GHG emissions as one of the many matters of relevance to the IPC's decision.

5.2 In Part B of this submission, the Applicant provides commentary on:

(a) the international climate change framework, focussing on the *Paris Agreement*;

(b) the issue of double counting of GHG emissions and how that is addressed in the international and Australian climate change frameworks;

(c) the carbon budget approach and its limited role as a tool in the international and Australian climate change frameworks;

(d) Australia's NDC under the *Paris Agreement*, and the national laws and policies that Australia has adopted to achieve its NDC;

(e) the domestic climate change laws, policies, NDCs and objectives of the countries that are most likely to be the export destinations for the Extension Project's coal; and

(f) the NSW Climate Change Policy Framework and the Net Zero Plan Stage 1.

The international climate change framework

5.3 The international framework that addresses GHG emissions, and more broadly the global response to climate change, comprises:

(a) the *United Nations Framework Convention on Climate Change* (**UNFCCC**);

(b) the *Kyoto Protocol*;

(c) the *Paris Agreement*; and

(d) associated decisions by the Conference of the Parties serving each of the above instruments.

5.4 The UNFCCC was adopted in 1992 and represented the first step by countries to address the issue of climate change. It set an overarching objective of stabilising GHG concentrations in the atmosphere at a level that would prevent "dangerous anthropogenic interference with the climate system". The *Kyoto Protocol* was adopted in 1997 and imposed limits on GHG emissions to be met by developed countries, both individually and collectively, during the first commitment period from 2008 to 2012. The second commitment period of the *Kyoto Protocol* runs from 1 January 2013 to 31 December 2020, but the amendment to the *Kyoto Protocol* that would introduce that second commitment period has not entered into force.

5.5 The *Paris Agreement* builds upon the UNFCCC and, for the first time, requires *all* parties (not just developed countries) to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. The *Paris Agreement* aims to strengthen the global response to climate change by holding the increase in global average temperatures to "well below 2°C" and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. To achieve this goal, countries aim to peak and then reduce emissions "as soon as possible" to "achieve a balance between anthropogenic emissions by sources and removals by sinks" in the second half of the century.

5.6 In contrast to the approach of the *Kyoto Protocol*, which imposed limitation or reduction commitments on certain parties, one of the key features of the *Paris Agreement* is the use of NDCs. NDCs are high-level policy plans setting out what approach each country will take to reduce emissions and contribute to the global "well below 2°C" goal. Parties' first NDCs were submitted in 2015 with new or updated NDCs to be submitted every five years. 186 parties to the *Paris Agreement* have submitted their first NDC (or INDC in the case of Taiwan), including Australia and the countries that are most likely to be the export destinations for the vast majority of the Extension Project's coal, being Japan, South Korea, Taiwan (**Export Countries**).[14] Eight countries, including Japan, have submitted a second or updated NDC in 2020. The NDCs of Australia and the Export Countries are addressed under separate sub-headings below in this Part B of the submission. Parties' updated or second NDCs are due to be submitted to the UNFCCC in 2020.

5.7 At the Conference of the Parties (**COP**) 24 in Katowice in December 2018, the Katowice Climate Change Package was adopted. That package contains, among other things, guidance on the features of NDCs, the information each country should provide to facilitate clarity, transparency and understanding of NDCs and accounting for NDCs. In general terms, they establish a common set of elements that each Party will apply, as appropriate, based on the type of its NDC. Importantly, the guidance ensures the avoidance of "double counting" of emissions. The issue of "double counting" is discussed below.

The issue of double counting GHG emissions and how that is addressed in the international and Australian climate change frameworks

5.8 For the purposes of the commentary which follows, it is useful to provide a high level overview of the three scopes of GHG emissions.

5.9 The three scopes of GHG emissions may be defined or described as follows:

(a) **Scope 1:** direct emissions occurring from sources that are owned or controlled by the proponent of the Extension Project (e.g. fuel use of on-site plant and equipment, fugitive emissions). These emissions are emissions over which the Extension Project has a high level of control.

(b) **Scope 2**: indirect emissions from the generation of purchased electricity consumed by the Extension Project.

(c) **Scope 3**: indirect emissions that are a consequence of the activities of the Extension Project, but occur at sources owned or controlled by other entities (e.g. outsourced services). Scope 3 emissions can include emissions generated upstream of the Extension Project by providers of energy, materials and transport. Scope 3 emissions can also include emissions generated downstream of the Extension Project by transport providers and product use (e.g. burning product coal).

5.10 A useful figure that highlights the degree of control the proponent of a mining project has over GHG emissions is produced at **Appendix 2** of this submission.

5.11 Double counting of GHG emissions occurs where the Scope 3 emissions generated by the burning of a mine's coal by other developments, are counted twice in the context of calculating a country's GHG emissions for the purpose of tracking progress towards achievement of its NDC. This can occur in two main circumstances:

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[14] It should be noted, of course, that there may well be other countries to which the Project's coal is exported from time-to-time during the Project's life of mine. However, given the broad adoption of NDCs, those countries (which may include China and South East Asian countries) are highly likely to have also submitted NDCs and be in the process of adopting and implementing laws and policies to achieve their NDCs.

(a) the Scope 3 emissions of a particular development or activity carried out in Country A, are actually generated in Country B as Scope 1 emissions associated with development or activities conducted in Country B, and both Countries A and B count the same GHG emissions towards their NDC; or

(b) the Scope 3 emissions of a particular development or activity carried out in Country A, are actually generated by another development or activity in Country A as Scope 1 emissions generated by that other development or activity, and Country A counts the same GHG emissions towards its NDC.

5.12 The issue of double counting, as arising in the context of the first main circumstance described in paragraph 5.11(a) above, can be illustrated by the example of the Extension Project.

5.13 Almost all of the Extension Project's Scope 3 emissions are generated by the burning or combustion of coal by the end-user of the coal. As the coal from the Extension Project is planned to be exported, the generation of Scope 3 emissions will occur outside of Australia. In this regard, the Scope 3 emissions of the Extension Project would count as Scope 1 emissions in the relevant Export Countries and, if Australia were to count the Scope 3 emissions from the Extension Project in calculating its GHG emissions, this would result in an unacceptable double counting of GHG emissions.

5.14 In relation to the second main circumstance described in paragraph 5.11(b) above, another example can be used to illustrate how double counting can occur in this context. If a coal mine was proposed to be constructed somewhere in Australia, and it was to supply coal to a power station which was also located in Australia and the coal was combusted by that power station, then:

(a) the Scope 1 emissions of the coal mine would need to be accounted for and reported; and

(b) the Scope 1 emissions of the power station would need to be accounted for and reported.

5.15 However, it would be double counting if the Scope 3 emissions of the coal mine were also accounted for and reported because those emissions are the same as the Scope 1 emissions of the power station.

5.16 The importance of avoiding double counting of GHG emissions generally, including in the context of calculating a country's GHG emissions for the purpose of tracking progress towards achievement of its NDC, is well-recognised under the *Paris Agreement* and the NGER Act.

5.17 At an international level:

(a) in respect of overarching obligations, article 4(13) of the *Paris Agreement* requires parties to ensure the avoidance of double counting consistent with the guidance adopted by the COP;

(b) in respect of the use of internationally transferred mitigation outcomes towards NDCs:

(i) article 6(2) of the *Paris Agreement* requires Parties to apply robust accounting to avoid double counting consistent with the guidance adopted by the COP;

(ii) the modalities, procedures and guidelines for the Transparency Framework adopted under the Katowice Climate Package (**Transparency Framework**), requires that each participating Party provide information on how their cooperative approach applies robust accounting to ensure the avoidance of double counting;

(c) in respect of accounting for Parties' NDCs, the guidance adopted by the Parties under the Katowice Climate Package requires that Parties avoid double counting when accounting for anthropogenic emissions and removals corresponding to their NDCs; and

(d) the guiding principles of the Transparency Framework also provide that double counting be avoided.

5.18 The clear intent of the *Paris Agreement* is to ensure a robust approach is taken to accounting of GHG emissions and it would undermine the integrity of that agreement for an approach to be taken to accounting of emissions which involved double counting.

5.19 At the domestic level, the NGER Act in Australia also precludes double counting by imposing reporting obligations upon companies only in respect of Scope 1 and Scope 2 emissions. There is no requirement or obligation imposed on companies under Australian law to report on Scope 3 emissions. The exclusion of Scope 3 emissions from the reporting requirements under Australian law effectively avoids double counting of Scope 3 emissions since the end-user who is responsible for a project's Scope 3 emissions will ultimately account for them as Scope 1 emissions.

5.20 Indeed, the letter from the Hon. Angus Taylor, Minister for Energy and Emissions Reduction to the Hon. Rob Stokes, Minister for Planning and Public Spaces dated 20 November 2019 being Appendix G2-3 to the Assessment Report states that:

> Emissions resulting from overseas actions are already managed through legislative frameworks by the countries where those actions are occurring. Any requirement to consider scope three emissions within a sub-national or state jurisdiction is inconsistent with long-accepted international carbon accounting principles and Australia's international commitments.
>
> …
>
> Any requirement for Australian businesses to report or manage scope three emissions would duplicate existing obligations on third parties, would be impractical to implement and would impose a high regulatory burden for indeterminate benefits.

The carbon budget approach and its limited role as a tool in international and domestic climate change frameworks

5.21 The "carbon budget" approach has been used by some members of the scientific community and non-governmental organisations to estimate the maximum cumulative amount of CO_2 (i.e. the budget of CO_2) that could be released into the atmosphere from human sources globally while limiting global average temperature increases to a desired level above pre-industrialised levels. Once the CO_2 concentration in the atmosphere reaches the estimated maximum amount (i.e. the budget is spent), global emissions of CO_2 must be "net zero" (i.e. the magnitude of emissions to the atmosphere is matched by the magnitude of removals of emissions from the atmosphere).

5.22 While the "carbon budget" approach is sometimes used by scientists and advocates to illustrate generally the global mitigation pathways that may achieve the goals of the *Paris Agreement*, it is not an approach that is required by the *Paris Agreement*, or Australian domestic laws (i.e. federal and NSW legislation) in the context of implementing, or measuring progress towards achievement, of Australia's NDC.

5.23 It would be inappropriate for the IPC to apply the "carbon budget" approach in determining the development application for the Extension Project. The Applicant makes this submission for the following reasons:

(a) the "carbon budget" is a highly-generalised analysis to inform broad, economy-wide or global policy-making. It does not qualitatively assess the impact of a particular project on the environment in terms of its GHG emissions. The "carbon budget" approach does not provide the IPC with any practical assistance in discharging the function it is required to perform (i.e. to determine the development application for the Extension Project), and is a matter that is best left to State, national and international policy makers;

(b) the "carbon budget" approach is inconsistent with the approach that has been adopted by the *Paris Agreement* for achieving the goal set under that agreement, in that:

(i) each country has made a commitment (in the form of a NDC) as to how it will contribute to achieving the goal set by the *Paris Agreement*;

(ii) the *Paris Agreement* does not prescribe the measures or mechanisms by which a particular country is to implement actions to facilitate the achievement of its NDC. Indeed, the *Paris Agreement* enshrines the principle of common but differentiated responsibility, allowing each party to determine its own contributions taking into account national circumstances; and

(iii) the application of the carbon budget approach results in double counting of GHG emissions, which is an outcome that the *Paris Agreement* seeks to avoid.

(c) the approach suffers from numerous deficiencies, including:

(i) **Uncertainty:** the approach suffers from uncertainties, such as:

(A) the evaluation of an appropriate historic baseline, which is affected by uncertainties in both historical emissions, and in deriving the estimate of globally averaged human-induced warming;[15] and

(B) accounting for non-CO_2 gases (i.e. if non-CO_2 gases are not reduced or reduced more slowly than CO_2, the budget is reduced accordingly). There is also uncertainty in the magnitude and geographical variation of radiative forcing of non-CO_2 climate forcers and the predicted temperature response.[16]

(ii) **Technology:** the approach can be susceptible to ignoring the role that technological advancements can play in reducing CO_2 levels globally (e.g. low emission coal technologies including carbon capture and storage, and HELE projects). Any failure of the carbon budget approach to account for such technological advancements would result in the CO_2 levels being recorded at levels higher than they actually are.

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[15] IPCC, Chapter 2: Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development in *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (2018) at 96, 107.

[16] Ibid at 96, 101–103 (2.2.1.1), 106 (2.2.2.2).

(iii) **Allocation:** the approach has not been accepted by the international community as a means of sharing global mitigation efforts among countries. The question of the contribution of individual countries in line with an overall carbon budget is rather complex. This is because the transition to a lower-carbon future must be equitably shared so as not to disproportionately damage the economies of countries or undermine the right to sustainable development. For this reason, and as explained above, the approach to allocation adopted under the *Paris Agreement* has been for each country to adopt a NDC and determine, for itself, the measures or mechanisms that will be implemented to achieve that NDC.

5.24 The Court in *Rocky Hill* did not adopt or apply the carbon budget approach. In considering Professor Steffen's opinion about the carbon budget approach, the Court stated that the carbon budget approach "admits that some fossil fuel reserves can be exploited and burned" (at [551]) and that the carbon budget approach (at [552]–[553]):

> assume[s] that all existing and approved fossil fuel developments will continue and there will be no reduction in GHG emissions from these sources. It gives priority to existing and approved fossil fuel developments, along the lines of "first in, best dressed". It also frames the decision as a policy decision that no fossil fuel development should ever be approved.
>
> I consider the better approach is to evaluate the merits of the particular fossil fuel development that is the subject of the development application to be determined. Should this fossil fuel development be approved or refused? Answering this question involves consideration of the GHG emissions of the development and their likely contribution to climate change and its consequences, as well as the other impacts of the development. The consideration can be in absolute terms or relative terms.

5.25 An alternative to adopting the carbon budget approach would be to consider the International Energy Agency's (**IEA**) Stated Policies Scenario and its Sustainable Development Scenario in the World Energy Outlook 2019. As discussed in detail in Part C of this submission, under both those scenarios, there would be continued demand for high-quality coal to 2040, not all of which would be satisfied by existing mines.

Australia's NDC and national climate change laws and policies

5.26 As a starting point, neither the *Paris Agreement* nor Australia's NDC are part of the law of Australia except to the extent that legislation has been passed to give effect to those documents within Australia.

<u>Australia's NDC</u>

5.27 Australia signed the *Paris Agreement* on 22 April 2016, and ratified it on 6 November 2016.

5.28 It is not bound under international law to achieve the emission reduction target in its NDC, although it is to be observed that countries are likely to face international pressure if they fail to meet NDC targets.

5.29 Australia has obligations under the *Paris Agreement* to:

(a) prepare, communicate and maintain an NDC that it intends to achieve (Article 4(2));

(b) pursue domestic mitigation measures, with the aim of achieving the objectives of its NDC (Article 4(2));

(c) communicate an NDC every 5 years (Article 4(3), (9)); and

(d) account for its NDC and, in the process, ensure the avoidance of double counting in accordance with the methodologies and common metrics assessed by the IPCC and adopted by the Katowice Climate Package (Article 4(13)).

5.30 With respect to the specifics of Australia's NDC, it is to be noted that Australia's NDC communicates an unconditional economy-wide target to reduce GHG emissions by 26-28% below 2005 levels by 2030. Australia's emissions reduction target represents a 50-52% reduction in emissions per capita and a 64-65% reduction in the emissions intensity of the economy between 2005 and 2030. Australia's NDC is summarised in the following table.

Summary of Australia's NDC	
Emissions reduction target	Economy-wide target to reduce greenhouse gas emissions by 26 to 28 per cent below 2005 levels by 2030
Coverage	Economy-wide
Scope	- Energy - Industrial processes and product use - Agriculture - Land-use, land-use change and forestry - Waste
Gases	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3

Mechanisms by which Australia's NDC is to be achieved

5.31 The policy document supporting Australia's NDC communicates that Australia will achieve its 2030 target through the Direct Action policy suite. The key component of the Direct Action policy suite is the Emissions Reduction Fund (**ERF**), which is complemented by the Safeguard Mechanism, the Renewable Energy Target (which requires 33,000 Gwh of electricity generation (or approximately 23.5% of total generation) to be produced from renewable resources by 2020), improvements in energy efficiency under the National Energy Productivity Plan, phasing out of synthetic GHGs and direct support for investment in low emissions technologies and practices.

5.32 Importantly, the Australian Government has not – in any climate change policy or law – indicated that the development of new coal mines, or expansions of existing coal mines, is to be prohibited or restricted in any way for the purpose of achieving Australia's NDC. As a corollary, it must follow that the Australian Government considers that Australia's NDC can still be achieved in circumstances where new coal mines, or expansions of existing coal mines, are approved.

5.33 It is also to be noted that the Federal climate change policy of the Australian Labor Party does not contain any measures that could constitute a prohibition on new coal mines or coal mining. Indeed, Labor leader Anthony Albanese recently stated that demand for coal around the world would not change if Australia stopped its exports, which meant that a ban on new coal mines would have no impact on emissions and that:

> We've got to consider what the actual outcome is from any proposal, and the proposal that we immediately stop exporting coal would damage our economy and would not have any environmental benefit.[17]

[17] David Crowe, 'Albanese says Australia should continue to export coal' *Sydney Morning Herald* 9 December 2019, available at: https://www.smh.com.au/politics/federal/albanese-says-australia-should-continue-to-export-coal-20191208-p53hyp.html

5.35 For present purposes, the most relevant mechanisms in the suite of existing law and policy are:

(a) the ERF; and

(b) the Safeguard Mechanism.

5.36 First, the ERF is a $2.55bn fund which purchases least cost emission reductions and abatement through a Commonwealth government procurement process, which includes reverse auctions. It is underpinned by the *Carbon Credits (Carbon Farming) Act 2011* (**CFI Act**) which creates a legislative framework for the development of offset projects and the creation of Australian carbon credit units (**ACCUs**). The CFI Act was initially enacted to support activities in the land sector but has been amended to now support a wider range of projects related to energy, transport and industry.

5.37 Separate from, but related to the ERF, it should be acknowledged that the Australian Government recently announced the Climate Solutions Package, which is a $3.5 billion plan to deliver Australia's 2030 emissions reduction target. As part of the package, a Climate Solutions Fund has been established to continue the work of the ERF with an additional $2 billion investment over 10 years. Approximately $200 million per year over ten years is expected to be allocated to abatement purchases through the ERF. The Climate Solutions Fund is also designed to be a fund that will partner with businesses, local communities and farmers in emissions reduction programs. The Package, and the ERF specifically, has been promoted as a key policy to contribute to the national 26% emissions reduction target by 2030.

5.38 Secondly, the Safeguard Mechanism, established under Part 3H of the *National Greenhouse and Energy Reporting Act 2007* (**NGER Act**), aims to ensure that emission reductions purchased by the Government through the ERF are not undermined by increases in emissions in other areas of the economy.

5.39 The Safeguard Mechanism sets a baseline on emissions for facilities that emit over 100,000 tonnes CO_2-e per year. When the Safeguard Mechanism was implemented, baselines were set for existing facilities using data reported under the NGER Act. For most facilities, baselines were the highest level of reported emissions for a facility over the historical period 2009-10 to 2013-14. These baselines could be adjusted to accommodate economic growth, natural resource variability and other circumstances where historical baselines will not represent future business-as-usual emissions. Baselines for new facilities are be based on an audited emissions forecast provided by the facility operator, with a reconciliation of the estimate against the actual performance of the facility at the end of the forecast period.

5.40 In 2019, the *National Greenhouse and Energy Reporting (Safeguard Mechanism Rule 2015* (Cth) was amended so that, for new facilities completed after 1 July 2020 (or existing facilities with new investments), baselines would be set to encourage facilities to achieve and maintain best practice in emissions intensity (known as benchmark baselines).[18] Baselines for existing facilities would also be brought up-to-date by transitioning all facilities to calculated baselines over 2018-19 and 2019-20. The amendments also allow baselines to be updated annually for annual production (known as a production-adjusted baseline), but facilities transitioning from a benchmark baseline must use the same emissions intensity that was used in the benchmark baseline.[19]

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[18] Australian Government (2018) Consultation on amendments to the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2017, available at: https://publications.industry.gov.au/publications/climate-change/climate-change/government/emissions-reduction-fund/consultation/safeguard-mechanism-legislative-amendments-2018.html

[19] See: http://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/Baselines/Production-adjusted-baseline

5.41 Due to Covid-19, the introduction of benchmark baselines for new facilities has been delayed to 1 July 2021, and the complete transition of existing facilities to calculated baselines will be delayed by a year to 1 July 2021.

5.42 If a facility exceeds its baseline, it is required to surrender a number of ACCUs equivalent to the exceedance to the Clean Energy Regulator (**CER**). It is also noted that there are other mechanisms by which a facility can manage baseline exceedance, including applying for multi-year monitoring periods and exemption for exceptional circumstances (i.e. natural disasters or criminal activity unrelated to the liable entity).

5.43 For example, if a facility has a FY2016/17 baseline of 1,000,000 tonnes CO_2-e and reported emissions of 1,500,000, the company with operational control of that facility would have to surrender 500,000 ACCUs, or be liable to the penalty under section 22XF of the NGER Act.

5.44 In its first year of operation (FY2016/17), 203 facilities were covered by the Safeguard Mechanism with combined emissions of 131.3 million tonnes of CO_2-e. Sixteen facilities exceeded their emissions limits and purchased and retired a total of 448,097 ACCUs to clear their liabilities.

5.45 The Air Quality and Greenhouse Gas Assessment for the Extension Project dated June 2018 estimates that the total Scope 1 emissions of the Extension Project will exceed 100,000 $tCO_{2\text{-}e}$ in its fifth year. As the Extension Project's first year of emitting more than 100,000 tCO_2-e will likely be after 1 July 2021, the baseline emissions number for the Extension Project to be set by the Clean Energy Regulator under the Safeguard Mechanism will not be based on reported emissions or on an audited emissions forecast, but will be based on benchmark emissions intensities (that is, the best, least emissions intensive standard for production).[20] The Applicant will be required to offset any emissions above its baseline, or otherwise manage compliance, in accordance with the NGER Act.

NGER Act

5.46 The NGER Act is a national system for reporting GHG emissions, energy production and consumption by corporations. The data gathered under the NGER Act assists with compiling Australia's national GHG inventory in order to meet Australia's reporting obligations under the UNFCCC.

5.47 Corporations that have operational control of facilities that emit more than a specified amount must report on the type of the source of their emissions, the methods used to estimate emissions and the amount of GHG emitted (in CO_2-e). The reporting requirements under the NGER Act apply to:

(a) an individual facility that emits 25kt or more of CO_2-e or produces or consumes 100tJ or more of energy; or

(b) an individual facility and other facilities under the operational control of the same corporate group that together emit 50kt or more of CO_2-e or produce or consume 200tJ or more of energy.

5.48 Failure to comply with these reporting obligations is a breach of the legislation and can result in the imposition of civil penalties on companies and executive officers.

5.49 The NGER Act covers each of the six classes of Kyoto Protocol gases:

- CO_2;

[20] *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (Cth), cl 38(3); See also, http://www.cleanenergyregulator.gov.au/NGER/The-safeguard-mechanism/Baselines

- CH_4;
- N_2O;
- SF_6;
- certain specified HFCs; and
- certain specified PFCs.

5.50 Reporting requirements cover both Scope 1 and Scope 2 emissions. The NGER Act does not cover Scope 3 emissions.

5.51 The parent company of the Applicant, Whitehaven, submits annual NGERs reports for the facilities over which it or a member of its corporate group has operational control. Typically these reports will include Scope 1 emissions related to fugitive emissions of CO_2 and CH_4, emissions from the combustion of diesel, LPG and other gaseous fuels for stationary and transport uses, and Scope 2 emissions related to electricity consumption.

5.52 Australia's GHG Inventory is prepared centrally by the Department of the Environment using the Australian Greenhouse Emissions Information System, including data reported under the NGER Act. Australia's National Greenhouse Accounts conform to the UNFCCC Reporting Guidelines on Annual Inventories and the supplementary reporting requirements under the Kyoto Protocol to prepare its national inventories. These guidelines establish standardised reporting formats and require detailed information on all aspects of each party's national inventory system, including measurement systems, data collection systems, estimation methodologies, reporting and data management.

5.53 Currently, emission estimates are compiled in accordance with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (**2006 IPCC Guidelines**), the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, and now the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (**2019 IPCC Refinement**). Parties may also use country-specific methodologies where these are consistent with the IPCC guidelines and improve the accuracy of emissions estimates. Australia predominantly uses country-specific methodologies and emissions factors, described in detail in its National Inventory Report.

5.54 The National Greenhouse Gas Inventory is reviewed annually by a team of international experts through the UNFCCC review process.

5.55 Notably, neither the 2006 IPCC Guidelines, the Revised Supplementary Methods, nor the 2019 IPCC Refinement require emissions data to be collected and reported or estimates to be made for Scope 3 emissions.

5.56 The NGER Act also does not provide any methodology for accounting for and reporting on Scope 3 emissions.

The NDCs and climate change laws and policies of the Export Countries

5.57 It is to be noted that of the most likely countries that the coal from the Extension Project will be exported to, both Japan and South Korea are parties to the *Paris Agreement* and either have or are in the process of adopting domestic laws, policies, and measures to implement and achieve their NDC targets. Taiwan is not recognised as an independent sovereign nation and therefore is not a member of the United Nations and consequently cannot be a party to the Paris Agreement. Nonetheless, it has put forward an INDC. Each Export Country's domestic efforts to achieve their NDC (or INDC) targets are summarised in the table below and set out in detail in **Appendix 3** to this submission. Specific details as to the uptake of HELE, CCUS and other low emission coal technologies are also addressed in Part C of this submission.

Country	Summary of the domestic climate change framework in the likely export customer countries for the Extension Project
Japan	• has highlighted carbon pricing and the use of CCUS technologies as key to achieving its emissions reductions NDC of 26% below 2013 levels by 2030. • Japan's second/updated NDC submitted to the UNFCCC on 31 March 2020 states that Japan "will strive to achieve a 'decarbonized society' as close as possible to 2050 with disruptive innovations, such as artificial photosynthesis and other CCUS technologies"; • made significant progress with several CCUS projects (see Part C); • has imposed import taxes for coal and LNG; • aims to pursue high efficiency in thermal power generation using high-efficiency technologies such as ultra-supercritical and advanced ultra-supercritical; and • is on track to halve its emissions by 2050 according to the IEA (WEO 2019, p 97).
South Korea	• is looking to increase the share of renewable energy to 20% by 2030 and natural gas while decreasing the share of coal as a key measure for achieving its NDC of 37% below business-as-usual (**BAU**) levels by 2030; and • has imposed import taxes for coal and LNG which act as a carbon tax and seeks to encourage a transition away from coal to renewables and LNG
Taiwan	• has legislated toward reducing reliance on both domestic and imported sources of coal, with plans to increase reliance on renewable energy and impose tax mechanisms on imported fossil fuels as a part of its plan to achieving emissions reductions of 50% below BAU levels by 2030 per its INDC.

5.58 For the purposes of the Extension Project, the key points for the IPC to appreciate in relation to the material produced in this submission on climate change laws and policies in the Export Countries are:

(a) the likely countries where the Extension Project's coal will ultimately be burned or combusted have numerous domestic laws and policies in place for how each respective country intends to achieve its NDC (or INDC in the case of Taiwan); and

(b) it is both appropriate, and consistent with the overarching international climate change framework, for the Extension Project's Scope 3 emissions to be accounted for, regulated and reported by the respective Export Countries as Scope 1 emissions generated in those countries.

The NSW Climate Change Policy Framework and Net Zero Plan Stage 1

5.59 The NSW Climate Change Policy Framework (October 2016) seeks to provide aspirational goals and broad policy directions to attain NSW's objective of achieving net-zero emissions by 2050 and ensuring that NSW is more resilient and responsive to climate change. Its other aspirational objectives include the implementation of policies consistent with the Commonwealth's plan for long-term emissions savings, to reduce emissions in government operations, and to advocate for Commonwealth, COAG and international action consistent with the *Paris Agreement*.

5.60 Under the NSW Climate Change Policy Framework, NSW has committed to both follow the *Paris Agreement* and to work to complement national action. The key policy directions under the NSW Climate Change Policy Framework and their rationales are summarised in the table below:

Policy Direction	Rationale/Goals
Creating an investment environment that manages the emissions reduction transition	Energy will be transformed and investment/job opportunities will be created in emerging industries of advanced energy, transport and carbon farming and environmental services
Boost energy productivity and put downward pressure on energy bills	Boosting energy and resource productivity will help reduce prices and the cost of transitions to net-zero emissions
Grow new industries and capitalise on competitive advantages	Capitalising on the competitive advantage and growth of industries in professional services, advanced energy technology, property management and financial services
Reduce risks and damage to public and private assets arising from climate change	Embed climate change considerations into asset and risk management as well as support the private sector by providing information and supportive regulatory frameworks for adaptation
Reduce climate change impacts on health and wellbeing	Recognise the increased demand for health and emergency services due to climate change and identify ways to better support more vulnerable communities to health impacts
Manage impacts on natural resources and communities	Coordinate efforts to increase resilience of primary industries and rural communities as climate change impacts water availability, water quality, habitats, weeds and air pollution

5.61 The Policy Framework is being delivered through:

(a) the Climate Change Fund;

(b) the development of a value for emissions savings that will be applied consistently in government economic appraisals;

(c) embedding climate change mitigation and adaptation across government operations including service delivery, infrastructure, purchasing decisions and regulatory frameworks;

(d) building on NSW's expansion of renewable energy; and

(e) developing action plans and strategies, including on advanced energy, energy efficiency, climate change adaptation, energy productivity, fugitive emissions, primary industry emissions and adaptation and health and wellbeing.

5.62 In March 2020, the Department of Planning, Industry and Environment published the Net Zero Plan Stage 1, which sets out how the NSW Government will deliver on its objective of achieving net zero emissions by 2050 over the next decade to 2030. The Net Zero Plan sets out GHG emission mitigation measures in relation to electricity generation, transport, agriculture, stationary energy (excluding electricity generation), fugitive emissions from mining, industrial processes, waste, and land use.

5.63 Significantly, for the IPC's consideration of the Extension Project, the Net Zero Plan Stage 1 states (at 22) (underline added):

> New South Wales' $36 billion mining sector is one of our biggest economic contributors, supplying both domestic and export markets with high quality, competitive resources. <u>Mining will continue to be an important part of the economy into the future and it is important that the State's action on climate change does not undermine those businesses and the jobs and communities they support.</u>

5.64 The Assessment Report states (at [696]):

> Importantly, the NSW or Commonwealth Government's current policy frameworks do not promote restricting private development as a means for Australia to meet its commitments under the Paris Agreement or the long-term aspirational objective of the [Climate Change Policy Framework] guidelines. Neither do they require any action to taken by the private sector in Australia to minimise or offset the GHG emissions of any parties outside of Australia, including the emissions that may be generated in transporting or using goods that are produced in Australia.

6. PART C: FUTURE DEMAND FOR COAL, THE CHARACTERISTICS OF THE EXTENSION PROJECT'S COAL, AND THE CONSEQUENCES OF COAL MARKET SUBSTITUTION

Overview

6.1 It is important to recognise that there is, and will remain for the foreseeable future, a demand for coal (both coking and thermal coal) as a reliable, affordable and efficient source of energy to meet the basic needs of human populations throughout the world. That demand for coal will remain irrespective of whether the IPC approves the Extension Project or not and, if the Extension Project is not approved, the demand will simply be met by coal sourced from elsewhere. In this regard, there is a real likelihood that the coal sourced from elsewhere will:

(a) be of inferior quality (in terms of calorific value, and ash and sulphur content) than the coal that will be produced by the Extension Project; and

(b) result in a higher level of GHG emissions than if the Extension Project is approved.

6.2 In this Part C of the submission, the Applicant will provide evidence for the points made in the paragraph immediately above and will:

(a) demonstrate that under all three policy scenarios presented by the IEA in WEO 2019 (including the Sustainable Development Scenario), there will continue to be a global demand for coal that will need to be met by expansions of approved coal mines (such as the Extension Project) or the development of new coal mines;

(b) provide commentary on the:

(i) Extension's Project's coal and cost of operations, having regard to the Extension Project's coal's qualities and tonnage profile;

(ii) relative importance of Australian coal exports in terms of meeting projected demand for thermal and coking coal;

(iii) likelihood of market substitution if:

(A) the Extension Project is not approved and neither the Approved Project nor the Extension Project go ahead;

(B) the Extension Project is not approved and does not go ahead, but the Approved Project does go ahead; or

(C) no new coal mines are approved in Australia, and Australia's existing coal mines naturally deplete;

(iv) consequences that would likely follow from substitution of the Extension Project's coal with product coal from alternative sources, particularly in respect of GHG emissions;

(v) energy policies, plans and initiatives of the Export Countries, including discussion of the uptake of HELE, CCUS and other low emission coal technologies in Asia and the impact that such technology is likely to have on global GHG emissions.

6.3 Ashurst, on behalf of the Applicant, retained CRU to undertake an independent study of global coal demand and supply and the coal market to 2040, in the context of the Extension Project. For reasons relating to confidentiality and intellectual property, the Applicant only has CRU's permission to publicly disclose a letter summarising the main findings of CRU's report. However, CRU has advised that it is prepared to give permission for its study to be disclosed to the IPC, if the IPC makes a direction under clause 5 of Schedule 2 to the EP&A Act that the study be treated as a confidential document that is not to be published.

6.4 A copy of the summary letter is produced at **Appendix 4** of this submission.

Global demand for coal to 2040

6.5 The global demand for coal to 2040 is addressed in detail by the IEA, an entity related to the Organisation for Economic Co-operation and Development (**OECD**), in its annually published reports known as the WEO. The IEA does analysis work for both the Intergovernmental Panel on Climate Change (**IPCC**) and under the UNFCCC.

6.6 At the time of preparing this submission, the most recent report published by the IEA is the WEO 2019, which was published in November 2019.

6.7 The purpose of the WEO is to provide a framework for thinking about the future of global energy. It does not make predictions about or forecast the future. Instead, it sets out what the future could look like on the basis of different scenarios or pathways, with the aim of providing insights to inform decision makers as they design new policies or consider new investments.[21]

6.8 The WEO 2019 presents three policy scenarios for assessing global energy demand and energy sources. Those three policy scenarios are described in the WEO 2019 (at pp 29 and 30) as follows (footnotes omitted):

> The aim of the **Stated Policies Scenario** (STEPS), which occupies a central position in the *WEO* analysis, is to hold up a mirror to the actions and intentions of today's policy makers, and to provide a candid assessment of their implications for energy markets, energy security and emissions. The scenario reflects:
>
> - The impact of energy-related policies that governments have already implemented.
> - An assessment of the likely effects of announced policies, as expressed in official targets and plans.
> - A dynamic evolution of the cost of energy technologies, reflecting gains from deployment and learning-by-doing.
>
> The Stated Policies Scenario, previously called the New Policies Scenario, is not an IEA forecast. It takes into account policies that have already been announced ("stated"), but does not speculate on how these might evolve in the future. The new name of this scenario in *WEO-2019* has been chosen with the aim of avoiding misunderstanding on this point.
>
> Policies announced by governments include some far-reaching commitments, including aspirations to achieve full energy access in a few years, to reform pricing regimes and, more recently, to reach net zero emissions in some countries and sectors. These ambitions are not automatically incorporated into the scenario: full implementation cannot be taken for granted, so the prospects and timing for their realisation are based upon our assessment of the relevant regulatory, market, infrastructure and financial constraints. Nonetheless, these targets and plans move the projections away from a business-as-usual trajectory, as a comparison with the **Current Policies Scenario**, in which such announcements are not considered, makes clear.

[21] WEO 2019 at 29.

The time horizon of the Stated Policies Scenario is to 2040. The design of this scenario, which relies on detailed bottom-up consideration of the impact of today's policies and plans, does not lend itself to very long-term horizons.

The **Sustainable Development Scenario** (SDS) is an essential counterpart to the Stated Policies Scenario. It sets out the major changes that would be required to reach the key energy-related goals of the United Nations Sustainable Development Agenda. These are:

- An early peak and rapid subsequent reductions in emissions, in line with the Paris Agreement (Sustainable Development Goal [SDG] 13).
- Universal access to modern energy by 2030, including electricity and clean cooking (SDG 7).
- A dramatic reduction in energy-related air pollution and the associated impacts on public health (SDG 3.9).

The trajectory for emissions in the Sustainable Development Scenario is consistent with reaching global "net zero" carbon dioxide (CO_2) emissions in 2070. If net emissions stay at zero after this point, this would mean a 66% chance of limiting the global average temperature rise to 1.8 degrees Celsius (°C) above pre-industrial levels (or a 50% chance of a 1.65°C stabilisation). In the light of the *Intergovernmental Panel on Climate Change Special Report on 1.5°C*, we also explore what even more ambitious pathways might look like for the energy sector, either via "net negative" emissions post-2070 or by reaching the "net zero" point even earlier.

6.9 It must be recognised that:

(a) the WEO is not, and never has been, a forecast of what will happen;[22]

(b) the IEA does not endorse any particular scenario in WEO 2019; and

(c) the Stated Policies Scenario is the central scenario in WEO 2019.[23]

6.10 Coal is generally characterised into two types – thermal coal which is used in the production of electricity, and metallurgical coal which is used for industrial purposes, principally steelmaking.

6.11 The Extension Project will produce approximately 150 Mt of saleable coal comprising thermal coal and semi-soft coking coal (SSCC), which is a type of metallurgical coal. The indicative life of mine average proportion of thermal coal to SSCC will be 40:60. The Economic Assessment included pulverised coal for injection (**PCI**) in the product mix. However, Whitehaven has since updated these plans and the product mix now only includes thermal coal and SSCC. It should be noted that the Economic Assessment applied the same forecast price per tonne of SSCC and PCI. Therefore, the net benefits of the Extension Project to NSW are not affected by the change to the intended coal product mix.

6.12 As the Extension Project will produce both thermal and metallurgical coal, it is necessary to separately consider the predicted demand for each type of coal.

<u>Projected global demand for thermal coal</u>

6.13 The IEA projects the global demand for thermal coal under the three policy scenarios. Table 1.1 of the WEO 2019 (p 38), which is reproduced below, sets out the global demand for all energy sources under the three policy scenarios. The entries for "coal" in Table 1.1 are in respect of thermal coal.

[22] WEO 2019 at 3, 23, 29 and 751.

[23] WEO 2019 at 29 to 30.

Table 1.1 ▷ World primary energy demand by fuel and scenario (Mtoe)

			Stated Policies		Sustainable Development		Current Policies	
	2000	2018	2030	2040	2030	2040	2030	2040
Coal	2 317	3 821	3 848	3 779	2 430	1 470	4 154	4 479
Oil	3 665	4 501	4 872	4 921	3 995	3 041	5 174	5 626
Natural gas	2 083	3 273	3 889	4 445	3 513	3 162	4 070	4 847
Nuclear	675	709	801	906	895	1 149	811	937
Renewables	659	1 391	2 287	3 127	2 776	4 381	2 138	2 743
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Solid biomass	638	620	613	546	140	73	613	586
Total	10 027	[illegible]	[illegible]	17 723	[illegible]	[illegible]	[illegible]	[illegible]
Fossil fuel share	80%	81%	77%	74%	72%	58%	79%	78%
CO_2 emissions	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Notes: Mtoe = million tonnes of oil equivalent; Gt = gigatonnes. Other includes wind, solar PV, geothermal, concentrating solar power and marine. Solid biomass includes its traditional use in three-stone fires and in improved cookstoves.

Source: WEO 2019

6.14 The relevant commentary on the data for the three policy scenarios, as outlined in Table 1.1 of the WEO 2019, is produced in part at pp 38–39 of the WEO 2019. The following relevant observations from that commentary are extracted below:

> Global primary energy demand grew by 2.3% in 2018, its largest annual increase since 2010. China, the United States and India accounted for 70% of the total energy demand growth. Despite the fact that growth in renewables has outpaced growth in all other forms of energy since 2010, the share of fossil fuels in global primary energy demand remains above 80% (Table 1.1).
>
> The energy debate is often focussed on the pace of change, but the forces of continuity in the energy sector should not be discounted. The **Current Policies Scenario** provides just such a "business as usual" picture, although 1.3% average annual growth in energy demand to 2040 is well below the rate seen in 2018. Growth in line with this scenario would mean greater consumption of all fuels and technologies, leading to a continuous rise in energy-related emissions and increasing strains on almost all aspects of energy security.
>
> In the **Stated Policies Scenario**, primary energy demand grows by one-quarter to 2040; the 1% annual average growth represents a slowdown compared with the 2% average seen since 2000. The global economy and the demand for energy move on diverging pathways due to structural shifts towards less energy-intensive output, energy efficient gains and saturation effects, particularly in terms of vehicle use.
>
> Low-carbon sources meet well over half of the increase in demand to 2040 in the Stated Policies Scenario, compared with 30% in 2017-2018. This is led by the power sector, where renewables dominate investment and capacity additions (Figure 1.2). However, demand for all sources of energy, except coal, continues to increase.
>
> After rising strongly in the medium term, growth in oil demand slows markedly post-2025 in the Stated Policies Scenario before flattening in the 2030s. Oil use in passenger cars peaks in the late-2020s, despite the number of cars on the road increasing by 70% between 2018 and 2040. Coal demand in 2040 is slightly below today's level, and its share in the primary mix is overtaken by gas around 2030. Gas demand rises by 30%, with industrial use of gas increasing at more than twice the pace of gas in power generation.

In the **Sustainable Development Scenario**, a relentless focus on improving efficiency and a shift away from combustion for power generation (reduces losses from waste heat) means that the projected increase in the size of the global economy and population (the same in all scenarios) is accommodated without any rise in primary demand, With no overall increase in demand, the rise of low-carbon sources comes at the expense of coal and oil.

Global oil demand peaks within the next few years in the Sustainable Development Scenario. Much greater fuel efficiency and fuel switching, with almost half the global car fleet powered by near-zero carbon electricity, means that in 2040 oil use in transport is 40% lower than today; only the (non-combustion) use of oil, mostly as a feedstock for chemicals production, shows any increase. Natural gas use grows to 2030 and then falls back. Coal demand is hit hard in this scenario, declining at more than 4% per year.

6.15 It is important to understand the structural trends that determine the increased energy demand. They are primarily population growth, urbanisation and economic growth in developing economies, particularly those in the Asia Pacific region. This is illustrated by Table 6.2 from the WEO 2019, which is reproduced below.

Table 6.2 ▷ Electricity demand by region and scenario (TWh)

			Stated Policies		Sustainable Development		Change 2018-2040	
	2000	2018	2030	2040	2030	2040	STEPS	SDS
North America	4 260	4 786	5 160	5 626	4 956	5 607	840	816
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Central & South America	660	1 081	1 445	1 837	1 331	1 660	757	579
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Europe	3 114	3 631	3 975	4 346	3 826	4 724	715	1 093
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Africa	380	703	1 086	1 653	1 073	1 696	950	993
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Middle East	361	954	1 309	1 817	1 389	1 621	863	667
Eurasia	809	1 084	1 302	1 474	1 132	1 220	390	137
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Asia Pacific	3 569	10 792	15 662	19 699	14 474	18 038	8 907	7 246
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
World	13 152	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: TWh=terawatt hour; STEPS = Stated Policies Scenario; SDS = Sustainable Development Scenario.

Source: WEO 2019

6.16 The Sustainable Development Scenario for electricity demand at 2040 in the WEO 2019 is predicated on achieving universal access to both electricity and clean cooking facilities in circumstances of strong population growth, such that an additional 1 billion people would have access to electricity by 2030, and more than 2.5 billion people would move away from the traditional use of biomass for cooking by the same date (at 86).

6.17 **Table 5.1** of the WEO 2019 (p 222) sets out the global coal demand, production and trade by scenario for each of thermal coal (i.e. steam coal) and metallurgical coal (i.e. coking coal).

Table 5.1 ▷ Global coal demand, production and trade by scenario (Mtce)

			[illegible]		[illegible]		[illegible]	
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Power	2 338	3 509	3 470	3 383	1 872	859	3 789	4 156
Industrial use	869	1 680	1 652	1 903	1 162	1 206	1 926	2 075
Other sectors	287	279	173	130	137	16	220	168
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Asia Pacific share	47%	75%	81%	83%	[illegible]	84%	79%	81%
Steam coal	2 608	4 342	4 393	4 394	2 672	1 515	4 753	5 260
Coking coal	445	955	857	790	571	497	885	854
Lignite and peat	302	270	247	214	123	85	287	332
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Asia Pacific share	48%	78%	79%	79%	80%	82%	77%	79%
Steam coal	312	855	733	726	381	157	888	964
Coking coal	175	316	316	331	258	257	332	408
[illegible]	472	[illegible]	[illegible]	[illegible]	683	415	[illegible]	[illegible]
Trade as share of production	14%	22%	19%	20%	16%	20%	20%	21%
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Notes: Mtce = million tonnes of coal equivalent; kcal/kg = kilocalories per kilogramme. Unless otherwise stated, industrial use in this chapter reflects volumes also consumed in own use and transformation in blast furnaces and coke ovens, petrochemical feedstocks, coal-to-liquids and coal-to-gas plants. Historical supply and demand volumes differ due to changes in stocks. World trade reflects volumes traded between regions modelled in the WEO and therefore does not include intra-regional trade. See Annex C for definitions.

Source: WEO 2019

6.18 The relevant commentary on the projections for the three policy scenarios, as outlined in Table 5.1 of the WEO 2019, is produced at pp 222-223 of the WEO 2019. The following relevant observations from that commentary are extracted below:

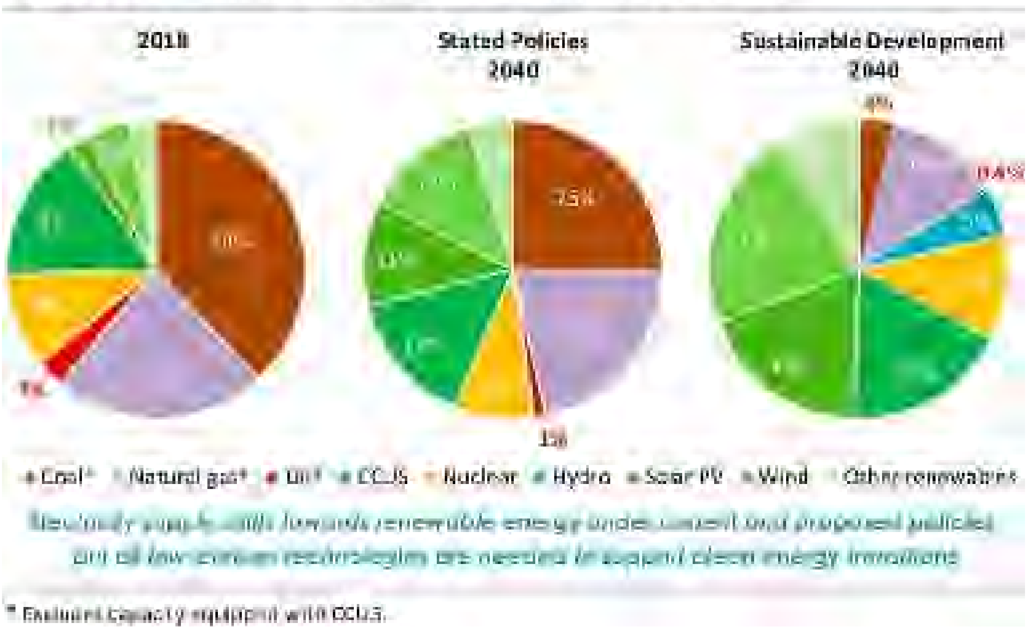
> Coal demand is essentially flat in the **Stated Policies Scenario**, ending up in 2040 at around 5400 Mtce, some 60 Mtce below where it is today (Table 5.1). This represents a slight downward revision compared with the World Energy Outlook (WEO)-2018 (IEA, 2018). Flat demand in an expanding energy system means that the share of coal in the global energy mix declines from 27% in 2018 to 21% in 2040, falling behind natural gas in the process.
>
> The strength of the economic and policy headwinds facing coal vary widely by scenario and, within each scenario, across different countries and sectors. The net effect in the Stated Policies Scenario is that global coal use in power generation decreases slightly, while its industrial use grows modestly. The **Current Policies Scenario**, in which energy demand is stronger and policy pressure on coal is weaker, sees coal use rise in both areas.
>
> …
>
> The outlook for coal is very different in the **Sustainable Development Scenario**. With a much more stringent focus on reducing emissions, coal use decreases steeply at an annual rate of 4.2%. By 2040, world coal use is 60% lower than in the Stated Policies Scenario and coal's share in the primary energy mix falls towards 10%.

Until the early 2010s, coal demand was aligned with economic growth. That is not the case in the future in either the Stated Policies or Sustainable Development scenarios (Figure 5.2). In advanced economies, e.g. European Union, United States, Japan, the trend in coal demand becomes detached from the overall economic outlook. By contrast, strong growth in incomes and energy needs in parts of developing Asia continues to go hand-in-hand with higher coal demand. China's position moves progressively closer to that of the advanced economy group, exerting a strong influence on the global decoupling of coal demand from economic growth.

With coal demand growth levelling off, CO_2 emissions from coal combustion flatten in the Stated Policies Scenario, but they do not reduce significantly. In the Sustainable Development Scenario, the deployment of CCUS and improvements in plant efficiencies result in coal-related CO_2 emissions falling faster than coal demand. By 2040, almost 160 gigawatts (GW) of coal-fired plants are equipped with CCUS, accounting for 40% of the electricity generated from coal, although today's policies fall far short of those which could stimulate needed investment in CCUS.

6.19 in the Stated Policies Scenario, coal-fired electricity generation plateaus and its share declines from 38% today to 25% in 2040 (as shown in **Figure 6.4** extracted below from p 265). However, this varies drastically by region. In advanced economies coal-fired electricity generation will more than halve over the period to 2040 while coal consumption will increase in Southeast Asia, where 40% of the projected rise in the region's electricity demand will be met by coal (WEO 2019, pp 225, 253, 256).

Figure 6.4 : Global electricity generation mix by scenario

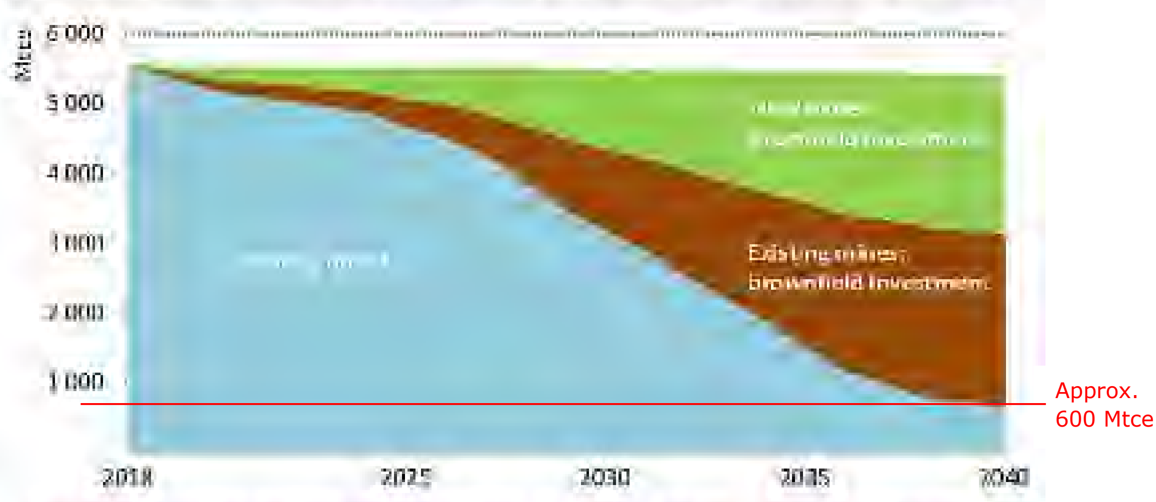


Source: WEO 2019

6.20 In 2018, around 70% of global coal power capacity and coal-based electricity generation was in Asia where electricity demand is rising fast and coal plants are around 12 years old on average, more than two decades younger than those in North America and Europe. In 2018, coal use rose for the second straight year in China, India and South East Asian countries. However, China would see a modest reduction in consumption of 0.4% per year on average from 2018 to 2040 due in large part to a strong policy push to improve air quality, but will remain the largest consumer of coal worldwide. China has a stock of more than 1000 GW of coal-fired capacity, much of it recently commissioned and highly efficient (WEO 2019, pp 220, 221, 224, 238).

6.21 It is evident that under all three policy scenarios presented by the IEA (including the Sustainable Development Scenario), there will continue to be a global demand for coal. Figure 5.13 (from WEO 2019, p 244) is reproduced below. Absent new mines or brownfield expansions, the global production of coal would be approximately 600 Mtce in 2040. We have drawn a red line on Figure 5.13 to illustrate that. Table 5.1 from the WEO 209 (p 222) reproduced above projects that even under the Sustainable Development Scenario, global demand for coal would be 2,101 Mtce in 2040 of which 858 Mtce would be for electricity and 1,206 Mtce would be for industrial use, including steelmaking.

Figure 5.13 ▷ Global coal production by type in the Stated Policies Scenario



As production from existing mines declines, so demand in the Stated Policies Scenario requires investment either to expand existing mines or to open new ones

Source: WEO 2019

6.22 The independent modelling undertaken by CRU (which aligns generally with IEA's Stated Policies Scenario) (see **Appendix 4**), forecasts that:

(a) coal will, in 2040, remain an important pillar of electricity generation in many of the world's regions, including in Southeast Asia, as well as in China and India;

(b) high quality coal from Australia (such as that produced by the Extension Project) is, and will continue to be, in demand to meet the electricity generation needs in these regions in particular (as many of these countries, Japan, South Korea and Taiwan in particular, have little to no domestic supply), as well as global demand more generally; and

(c) as the ability of existing mines to service global demand for coal declines (e.g. as a result of exhausting their environmentally recoverable reserves), it will be necessary for the coal demand to be met by expansions of approved coal mines or the development of new coal mines.

Projected global demand for metallurgical coal

6.23 SSCC is classified as metallurgical coal, along with hard coking coal (**HCC**).[24] Metallurgical coals are essential inputs for blast furnace-based steelmaking. HCC and SSCC are both used in the production of coke before entering the blast furnace. The proportion of each coal used in the coking process is determined by various factors, including pricing differentials, blast furnace requirements and specific characteristics and qualities of the coal.

6.24 As shown in Table 5.1 of the WEO 2019 extracted above, the IEA has projected that industrial coal use which today accounts for around one-third of coal consumption, increases by some 225 Mtce to 2040 in the Stated Policies Scenario, as coal remains the backbone of steel and cement manufacturing. In the Sustainable Development Scenario, overall use drops significantly, but coal remains important to several industrial processes, reflecting the difficulty and expense of finding substitutes for coal in these processes (WEO 2019, p 220, 225, 230).

6.25 The WEO 2019 states that 70% of global crude steel is produced through the blast furnace-basic oxygen furnace (BF-BOF) route which is heavily dependent on coking coal (SSCC and HCC) for the production of coke. The scope to shift away from coal by making greater use of scrap-based or direct reduction of iron (DRI)-based electric arc furnaces is limited by the availability and cost of scrap steel, as well as the cost competitiveness of electricity. Coal use in the iron and steel industry declines in the Stated Policy Scenario by around 30 Mtce by 2040, reflecting efficiency gains and the gradual rise in the use of electricity-based routes for steel production (WEO 2019, 231, 233).

6.26 As Table 5.1 from the WEO 2019 (reproduced above) shows, demand for coking coal in 2040 under the IEA's Stated Policies Scenario will be 790 Mtce.[25]

6.27 The IEA's projections in relation to metallurgical coal aligns with the independent modelling undertaken by CRU, which forecast that:

(a) steel will remain an important material for global development, particularly in South East Asia;

(b) global demand for carbon crude steel (crude steel, excluding stainless steel) is expected to grow steadily at a compound annual growth rate of approximately 1% from 2018 to 2040;

(c) despite the share of steel produced by blast furnace-basic oxygen furnace declining in the long term, as electric arc furnace steelmaking grows more quickly, there will continue to be a significant requirement for new iron units from coal (produced by blast furnace-basic oxygen furnaces as opposed to iron from recycled steel which is used in electric arc furnace steelmaking);

(d) given the relatively young age of the installed capacity of blast furnace-basic oxygen furnaces in Asia, much of the future demand for steel is forecast to be met by this existing capacity;

(e) by 2040, the blast furnace-basic oxygen furnace process will still account for approximately 57% of global steel production; and

---

[24] Pulverised coal for injection (PCI) is also used in steelmaking but, unlike HCC and SSCC, is injected directly into the blast furnace.

[25] Table 5.1 is titled "Global coal demand, production and trade by scenario". The projected world coal production in Table 5.1 is the same as world coal demand. However, as Figure 5.13 of WEO 2019 shows, global coal production will not meet demand. Therefore, it is clear that "world coal production" in Table 5.1 is to be interpreted as a breakdown of the projected demand for different types of coal under the IEA's three scenarios.

(f) although the decline in total demand for steelmaking coal will be driven by a greater fall in demand for SSCC than HCC (as HCC has a higher CSR which is a key determinant of blast-furnace productivity), there is a limit to the amount of HCC that can be used in a coke blend. This means that the percentage of HCC used in a coke blend can only increase to a certain point and cannot entirely replace SSCC. A coke blend containing approximately 15 to 20% SSCC is the likely technical, minimum level of SSCC that can be used in highly efficient blast furnaces. This means that SSCC's important role in steelmaking will continue into the future.

Evaluating the Extension Project's coal and cost of operations: coal qualities, tonnage profile and duration of the Extension Project

6.28 The Extension Project will involve the extraction of an additional 33 million tonnes of ROM coal over a shorter life of mine (25 years) compared to the Approved Mine (168 Mt of ROM coal in total), with the total production of 150 Mt of saleable coal, all of which will be exported.

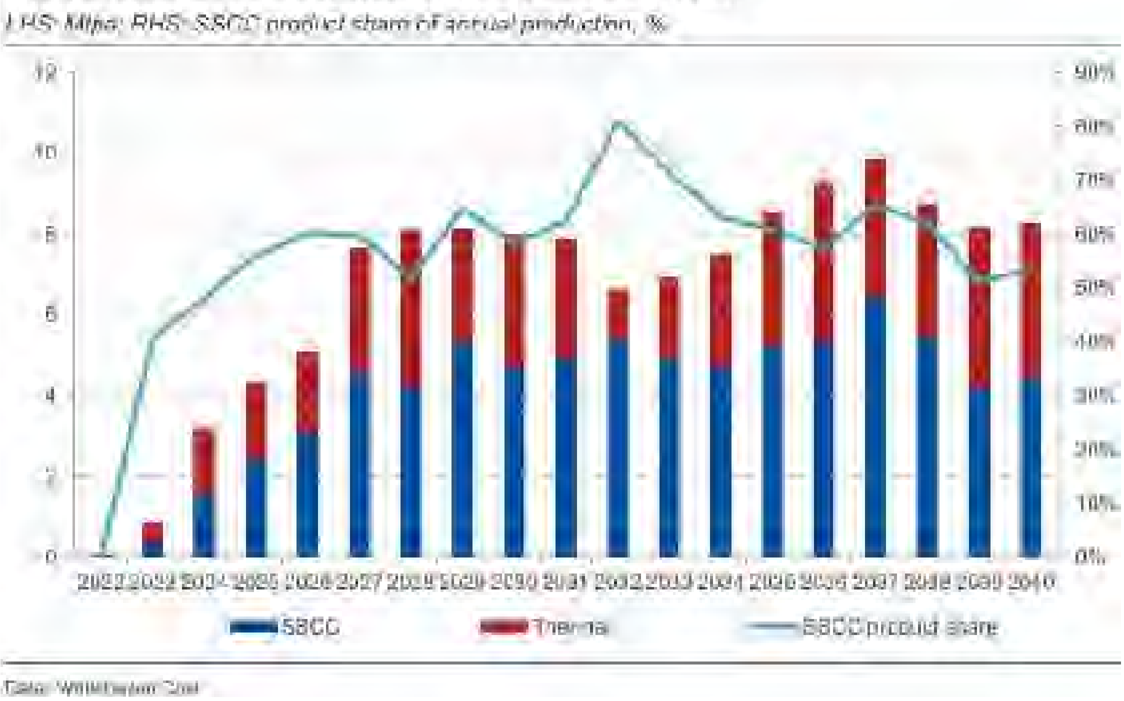
6.29 Coal produced by the Extension Project will be one of two coal categories:

(a) thermal; and

(b) semi-soft coking coal (**SSCC**) (metallurgical coal).

6.30 On average, 60% of the saleable coal for the life of mine will be SSCC. This is illustrated by **Figure 2** extracted from CRU's market substitution study, which shows the Extension Project's production profile up to 2040.

Figure 2 Annual saleable production of Vickery Extension Project



Source: CRU

6.31 Coal is not a standardised, homogeneous commodity, as the quality produced by different mines varies considerably. This is a critically important factor to recognise when comparing the environmental consequences of the production and use of coal.

6.32 The classification of thermal coal is dependent on the calorific value of the product. The term "calorific value" refers to the energy density of the coal and determines the volume of coal that needs to be combusted to generate a given level of energy. That is, the higher the calorific value of the coal, the less coal needs to be burned to generate electricity. The less coal burned, the less CO_2 is released into the atmosphere. Therefore, the use of high quality coal for electricity generation can reduce the amount of CO_2 that is released into the atmosphere per unit of electricity produced, compared to coal of an inferior quality. Ash and suphur content also play a role in the quality of and environmental impacts associated with burning coal (as set out in **Appendix 4**).

6.33 In order to appreciate the likely consequences of the substitution of the Extension Project's coal with product coal from alternative mines, it is essential to first acknowledge the quality of the Extension Project's coal. This is because the quality of the Extension Project's coal, compared to alternative markets and projects, is key for assessing the potential environmental impacts of any supply substitution that may arise.

6.34 There are three particular measures by which the Extension Project's coal can be evaluated. They are:

(a) calorific value (unit: kcal/kg);[26]

(b) ash content (unit: %);[27] and

(c) sulphur content (unit: %).[28]

6.35 The qualities of the Extension Project's coal products are presented in the following table.

	Unit	Life of Mine Weighted Average
Thermal Coal		
Calorific Value	kcal/kg	6420
Ash	%	7.6
Sulphur	%	0.4
Semi-soft Coking Coal		
Calorific Value	kcal/kg	7280
Ash	%	6.5
Sulphur	%	0.4
Phosphorus	%	0.003%

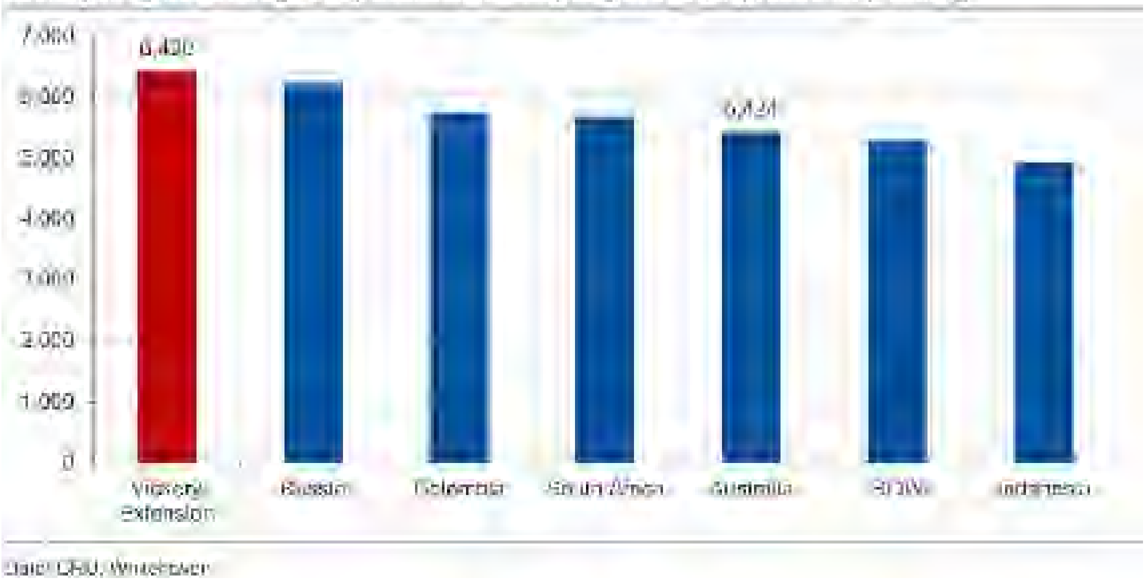
26 The energy density of different coal sub product is a key driver of the volume of coal that is needed to be burned to attain a given level of power demand.

27 This refers to the non-combustible residue left after the coal is burnt; it is a key driver of costs as it impacts power plant maintenance costs via equipment wear and ash-handling requirements.

28 This contaminant impacts the level of atmospheric oxides which are emitted (a key local air pollutant and contributor to acid rain).

6.36 **Figure 11** extracted from the CRU study below shows that the Extension Project's thermal coal has a higher calorific value than the country weighted averages of all major seaborne thermal coal suppliers, including Australia.

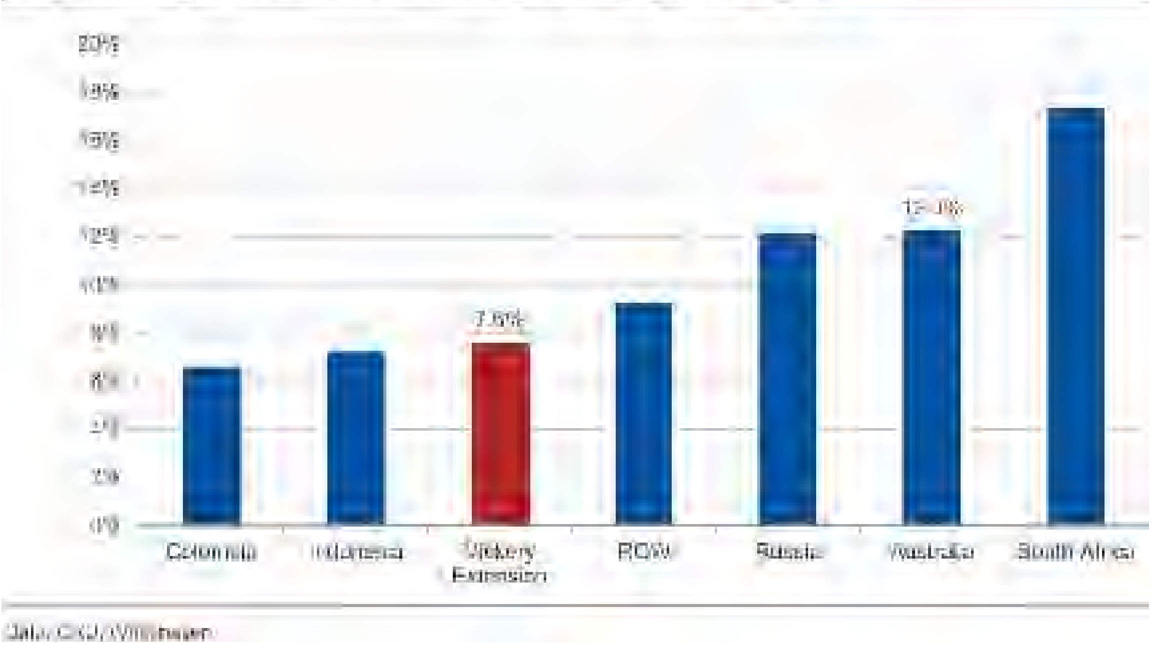
Figure 11 Thermal coal quality comparison (calorific value, CV) between Vickery Extension and country weighted average of operational mines (weighted: 2027 production), kcal/kg



Source: CRU

6.37 **Figure 12** extracted from the CRU study below shows that the Extension Project's thermal coal has a lower ash content than the country weighted average of Australia and other major seaborne thermal coal suppliers.

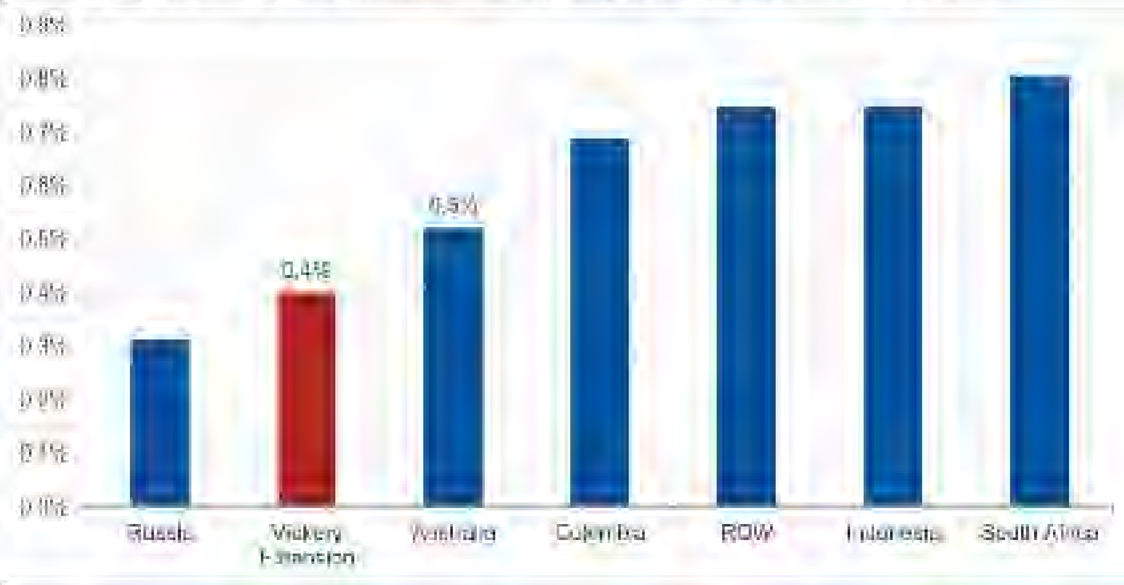
Figure 12 Thermal coal quality comparison (ash content) between Vickery Extension and country weighted average of operational mines (weighted: 2027 production), % ash



Source: CRU

6.38 **Figure 13** extracted from the CRU study below shows that the Extension Project's thermal coal has a lower sulphur content than the country weighted average of all seaborne thermal coal suppliers except Russia.

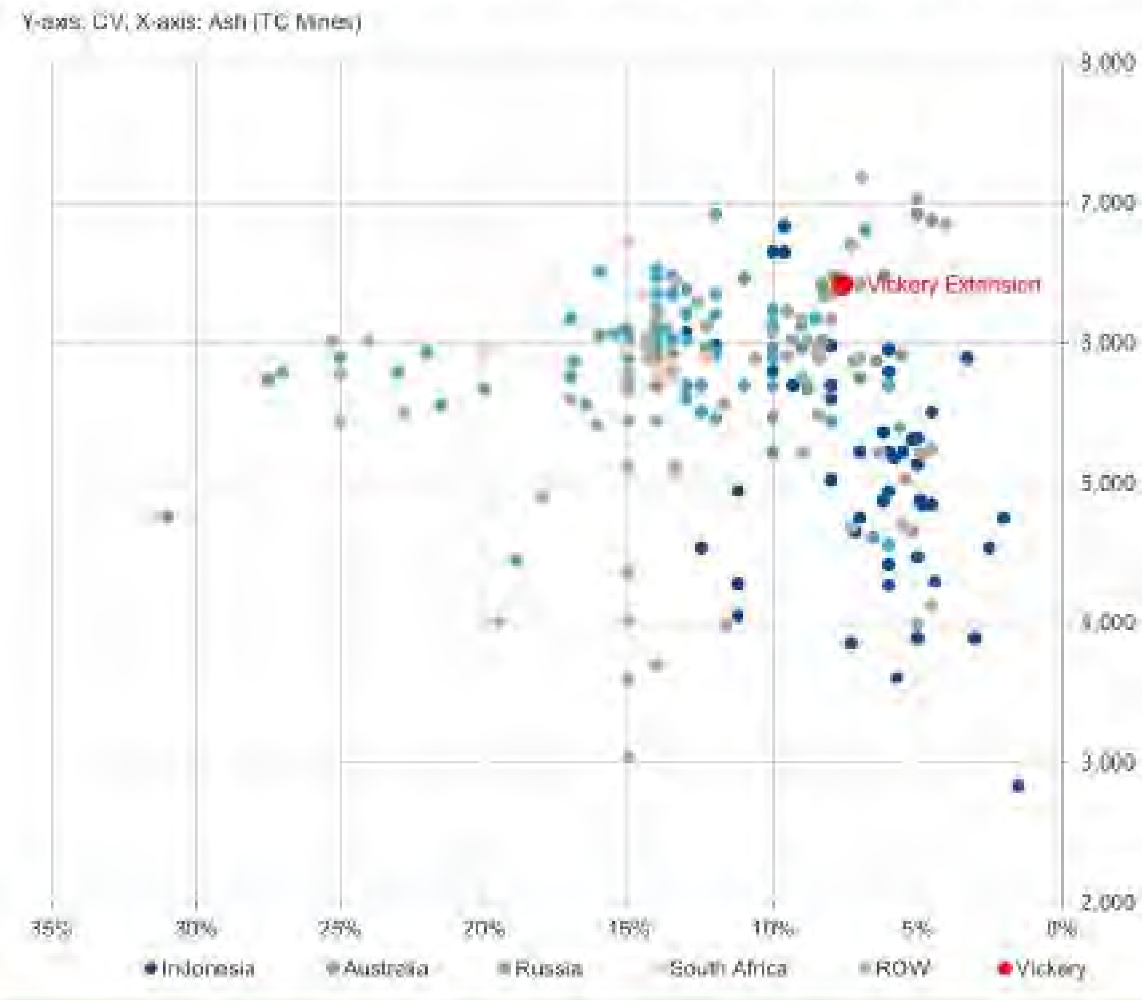
Figure 13 Thermal coal quality comparison (sulphur content) between Vickery Extension and country weighted average of operational mines (weighted: 2027 production), % sulphur



Source: CRU

6.39 **Figure 67** extracted from the CRU study below, is a scatter chart ranking the Extension Project's thermal coal product (in terms of calorific value and ash content) against the quality of coal products from operational mines.

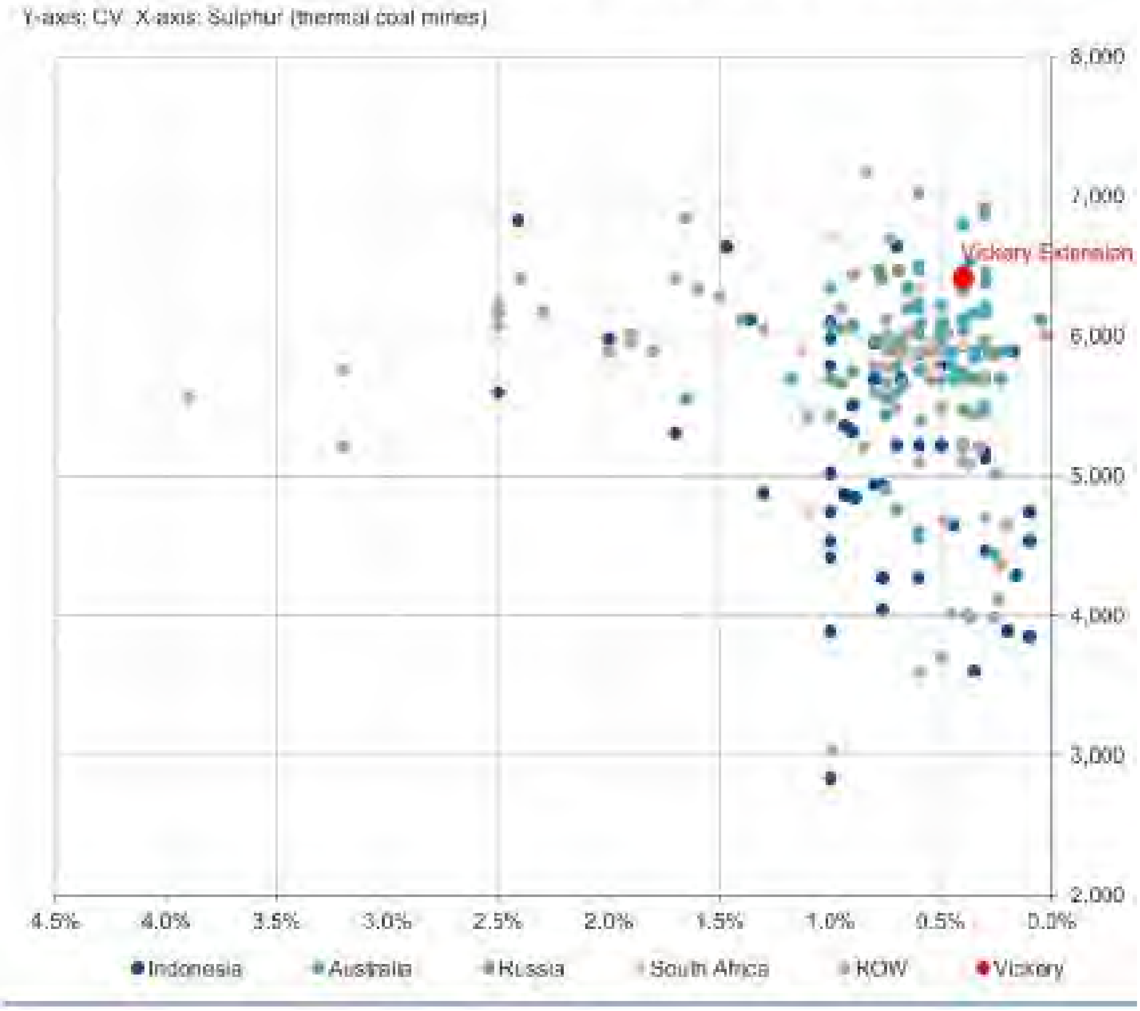
Figure 67 Thermal coal quality comparison between Vickery Extension and operational mines



Source: CRU

6.40 **Figure 68** extracted from the CRU study below is a scatter chart ranking the Extension Project's thermal coal product (in terms of calorific value and sulphur content) against the quality of coal products from operational mines.

Figure 68 Thermal coal quality comparison between Vickery Extension and operational mines

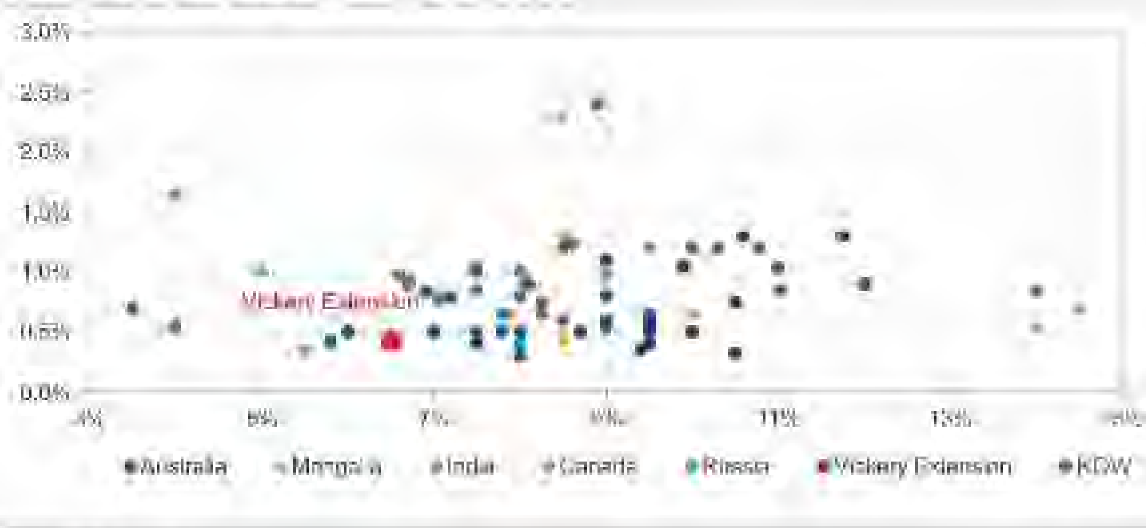


Source: CRU

6.41 **Figure 69** extracted from the CRU study below shows the quality of the Extension Project's SSCC product (in terms of ash and sulphur content) compared to operational mines.

Figure 69 SSCC quality comparison between the Vickery Extension and operational mines (weighted: 2027 production)

Y-axis: Sulphur content (%), X-axis: Ash content (%)

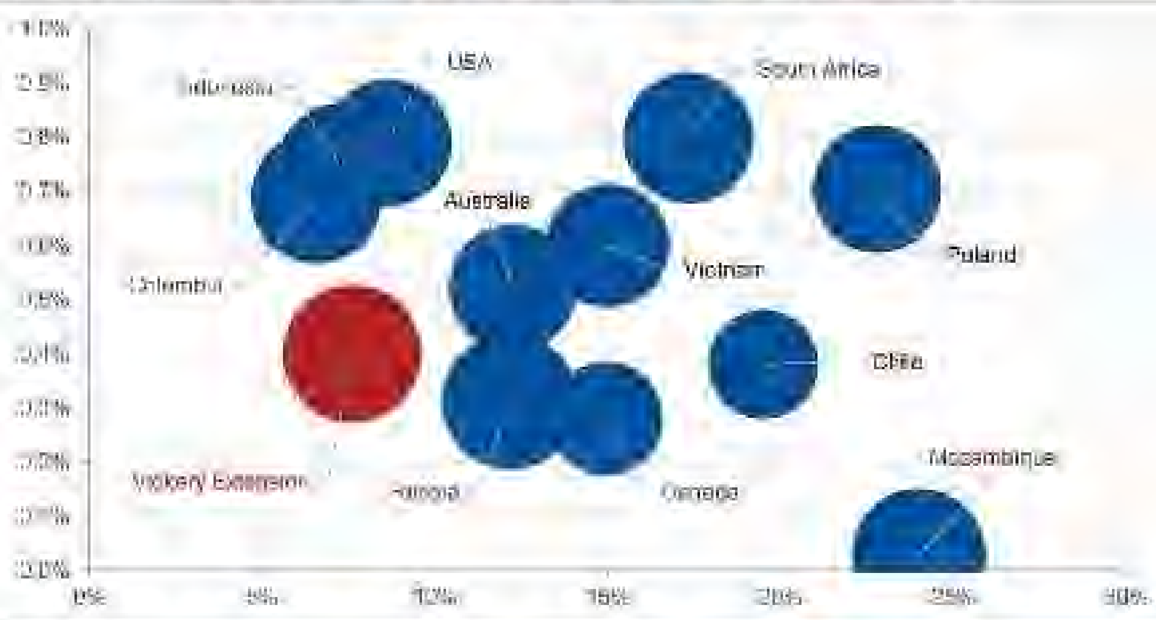


Data: CRU, Whitehaven

Source: CRU

6.42 **Figure 70** extracted from the CRU study below shows the quality of the Extension Project's thermal coal product compared to the country weighted average of operational mines.

Figure 70 Thermal coal quality comparison between Vickery Extension and country weighted average of operational mines (weight: 2027 production)



Data: CRU, Whitehaven

Source: CRU

6.43 The Extension Project's thermal coal has a calorific value of 9% above the 6,000kcal/kg benchmark. The calorific values of the Extension Project's thermal coal is also higher than the country averages of Australia and other major exporters of thermal coal such as Indonesia, Russia, South Africa, Colombia and the United States of America.

6.44 The Extension Project's thermal coal has low (<10%) ash content, which is lower than the Australian average and lower than other major thermal coal exporters: Russia, South Africa and the United States of America.

6.45 The sulphur content of the Extension Project's thermal coal (0.4%) is also at the bottom end of the range globally for seaborne suppliers of thermal coal,[29] with only Russia having a lower average sulphur content.

6.46 CRU has assessed the Extension Project's premium thermal coal product as being in the fourth percentile of the cost curve for mines producing thermal coal for export. It is a quality premium thermal coal which is very cost competitive.

6.47 The Extension Project will produce approximately 150Mt of saleable coal, comprising thermal coal and SSCC. The indicative life of mine average proportion of thermal coal to SSCC will be 40:60. However, given its high energy content, SSCC can be used as premium quality thermal coal. At times during the life of mine, the prevailing pricing differentials between SSCC and thermal coal may drive SSCC into the premium quality thermal coal market for power generation.

6.48 SSCC and HCC are essential inputs for steelmaking using blast furnace-basic oxygen furnace technology. HCC and SSCC are both used in the production of coke before entering the blast furnace. The proportions of each coal used in the coking process are determined by various factors, including pricing differentials, blast furnace requirements and specific characteristics and qualities of the coal.

6.49 One of SSCC's key contributions to the coke blend is its lower impurities such as ash, sulphur, and phosphorus as well as being lower in cost compared to HCC. Sulphur is a local air pollutant and contributor to acid rain. Ash is the non-combustible residue left after the coal is burnt – a waste which reduces blast-furnace efficiency, increases operating costs and has local environmental impacts.

6.50 **Figures 44, 45 and 46** extracted from CRU's study below, show the ash, sulphur and phosphorus content of the Extension Project's SSCC compared to the country weighted averages of all other major seaborne suppliers of SSCC.

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29 Noting, in practical terms, that the lower the level of sulphur in the coal product, the higher the quality of that coal product.

Figure 44 SSCC quality comparison between Vickery Extension and country weighted average of operational mines (weight: 2027 production), % ash

Data: CRU, Whitehaven
Source: CRU

Figure 45 SSCC quality comparison between Vickery Extension and country weighted average of operational mines (weight: 2027 production), % sulphur

Data: CRU, Whitehaven
Source: CRU

Figure 46 SSCC quality comparison between Vickery Extension and country weighted average of operational mines (weight: 2027 production), % phosphorus

Data: CRU, Whitehaven
Source: CRU

6.51 The ash content of the Extension Project's SSCC is lower than the average ash content of Australian SSCC and all other major seaborne SSCC suppliers, save for Canada. The sulphur content of the Extension Project's SSCC at 0.4% is also near the bottom end globally and lower than the average sulphur content of Australian SSCC. The phosphorus content of the Extension Project's SSCC at 0.003% is lower than the average of Australia and all other major seaborne SSCC suppliers. These qualities make the Extension Project's SSCC one of the most marketable SSCC products globally.

6.52 Ash and CSR are the two attributes of metallurgical coal that have the greatest impact on blast-furnace productivity and, consequently, the GHG emissions intensity of steelmaking (that is GHG emissions per tonne of hot metal produced). This means that the ash content and CSR of coking coal are important for the minimisation of GHGs and, in particular, CO_2 emissions from steel production. Sulphur and phosphorus levels also impact blast-furnace efficiency and hence emissions, however far less so, than ash and CSR.

6.53 For an average size blast-furnace operating at typical efficiencies, an increase of 1% in total coke ash results in an increase in coke consumption of approximately 15 kg per tonne of hot metal produced, which results in an increase of approximately 46 kg of CO_2 per tonne of hot metal produced. If SSCC is approximately 15% of the coke blend (the minimum percentage of SSCC used in advanced Asia Pacific countries excluding China), for every 1% reduction in the SSCC's average ash content, CO_2 emissions could be reduced by 6.9 kg per tonne of hot metal produced. Given the Extension Project's SSCC's low ash levels compared to the rest of the world, CO_2 emissions could be reduced by 13 kg per tonne of hot metal produced (compared to the average emissions intensity based on the average ash content of SSCC globally) if the Extension Project's coal were used as the only SSCC within the coke blend. CSR has not been measured for the Extension Project's SSCC at this stage because SSCC is generally selected for use in coking coal blends based on attributes other than CSR. CRU has assessed the Extension Project as being in the 60th percentile of the cost curve for mines producing SSCC for export to steelmaking customers. The relative low ash and sulphur content of the Extension Project's SSCC are important attributes.

The relative importance of Australian coal exports in terms of meeting projected demand for thermal and coking coal

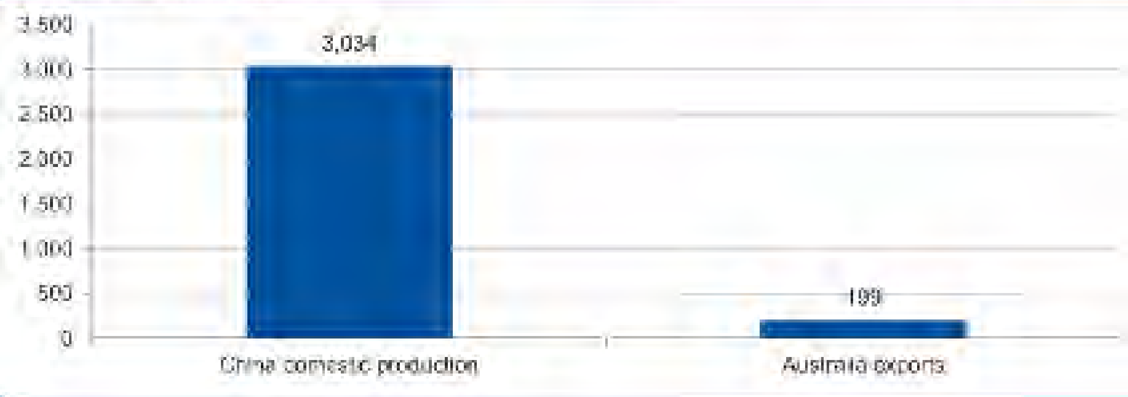
6.54 While Australia is the world's largest exporter of coal, it should be acknowledged that coal investment and supply conditions in Australia have a limited impact on the global demand for coal for several reasons:

(a) as a low-cost producer of thermal coal, it does not affect the price of thermal coal (which is determined by the marginal – typically Chinese coal producer);

(b) Australian coal supplies are small relative to domestic industries in the major importing countries: Chinese domestic coal production alone is more than 15 times larger than total Australian exports (see **Figure 53** extracted from the CRU study below); and

(c) there is a high degree of flexibility in the coal industries of major Asian demand centres, rendering it likely that any change in Australian exports would be offset by expansion in these domestic supplies. In 2017 alone, for example, China closed around 200 million tonnes of coal production capacity (roughly equivalent to the entire Australian export market). Such former producing assets can be readily restarted in response to any supply shortages. Similarly, the WEO 2019 (p 227) recognises that Indonesia is a swing producer that is able to quickly increase production in response to price signals from international markets.

Figure 53 Size comparison between China domestic market and Australian exports for thermal coal (2013-18 average), Mt



Source: CRU

Likelihood of coal market substitution

6.55 As noted above, thermal coal is differentiated based on calorific value. SSCC can fetch a higher price than thermal coal, which is why producers of coal sell SSCC as a separate product. However, it is not uncommon for SSCC to be sold as thermal coal when the respective pricing makes it attractive to do so. It is possible that this will become increasingly common as thermal coal importers become more willing to pay a premium for higher CV coals as climate change and environmental policies continue to intensify. CRU treated all of the Extension Project's product coal as thermal coal for the purpose of its analysis of market substitution. The results of that analysis therefore represent the increase in GHG emissions from the substitution of the Extension Project's entire coal product with alternative sources of thermal coal. The results nevertheless confirm that substitution of the Extension Project's thermal coal product with thermal coal from alternate sources would result in an increase in GHG emissions and that the increase in GHG emissions from market substitution would be greater where the price of SSCC drops to equal or below that for thermal coal.

6.56 For its market substitution analysis, CRU considered the following three different hypothetical scenarios:

(a) the Extension Project is not approved and does not go ahead and the Approved Project also does not go ahead (**Scenario 1**);

(b) the Extension Project is not approved and does not go ahead, but the Approved Project does go ahead (**Scenario 2**); and

(c) no new Australian mines enter production and Australia's current coal mines naturally deplete (**Scenario 3**).

6.57 Two of CRU's three hypothetical market substitution scenarios (Scenarios 1 and 2) considered below cover a forecast period for the life of mine of the Extension Project. Scenario 3 covers only a forecast period to 2030 because the coal production that may be substituted in Scenario 3 is much larger: 77Mt in 2030 and 330Mt in the period 2019 to 2030 and it would be difficult to forecast beyond 2030 without creating a detailed profile of where lost Australian production may be replaced from. In other words, in Scenarios 1 and 2, the shortfall in supply of coal would be small enough such that it could be substituted by any one single supplier country. Whereas in Scenario 3, the large supply shortfall is unlikely to be substituted by a single supplier country and would require more detailed modelling to forecast beyond 2030.

6.58 It should be noted that the analysis of the impacts of the three hypothetical market substitution scenarios considered below has been informed by various technical factors, including:

(a) the requisite coal volumes evaluated on an energy-equivalent basis;

(b) the relative average regional boiler efficiencies;

(c) the average fuel consumption and fuel emission intensity (Scope 1 GHG emissions) for coal mines by region;

(d) low and high fugitive emissions rates (Scope 1 GHG emissions) for underground and surface mines (see further explanation below);

(e) average power consumption of coal mines (Scope 2 GHG emissions) and average emissions intensity of grid power by region;

(f) the average distance coal is transported by rail by region (Scope 3 GHG emissions); and

(g) the Extension Project's product-specific energy content factor of 29GJ/t of product coal and the calculation of Scope 3 GHG emissions associated with energy production.

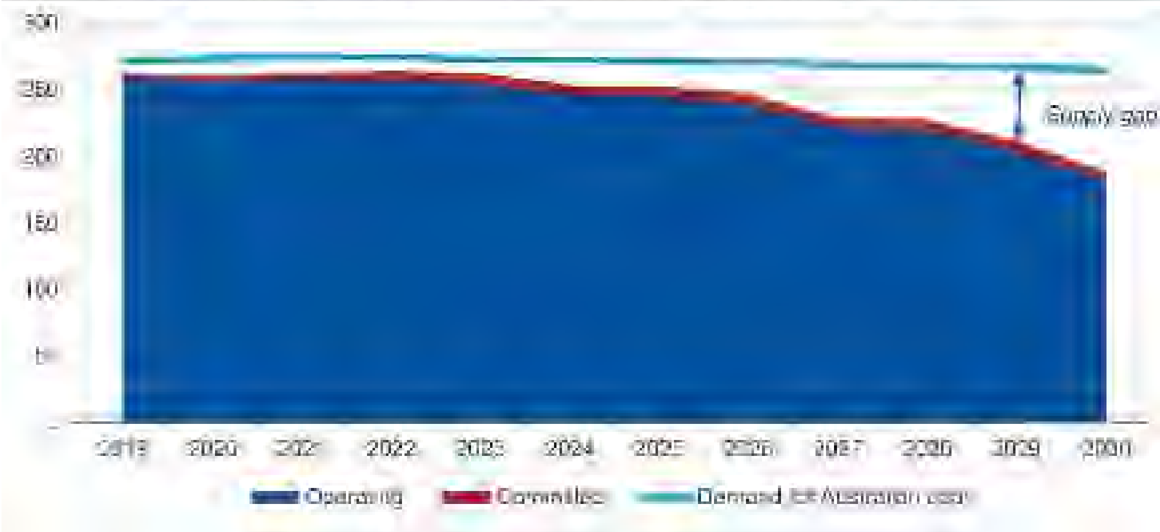
6.59 This analysis is reliant on the specific data that is available to CRU. It should be acknowledged that, like all market substitution analyses of this nature, the estimate of GHG emissions that is given can vary depending upon the data and parameters that are set for the particular analysis.

6.60 In relation to Scenarios 1 and 2, the shortfall in supply will be small: 8.3 Mtpa ROM coal and 3.8 Mtpa ROM coal respectively. There will remain a global demand for high quality Australian coal irrespective of whether or not the Extension Project is approved, as is evident from discussion of the three policy scenarios posited in the IEA's WEO 2019 discussed above. According to CRU, the projects most likely to supply coal as a substitute for the Extension Project's coal in the event that the Extension Project is not approved are in Russia and Australia. Alternative coal could also be sourced from other major producing countries, including China, India, Indonesia or Vietnam.

6.61 In relation to Scenario 3, there will, again, remain a global demand for high quality Australian coal irrespective of whether or not the Extension Project is approved. Based on CRU's modelling for the forecast period (i.e. 2019-2030), it is estimated that export thermal coal production in Australia will be 260 million tonnes in 2020 and 189 million tonnes in 2030.

6.62 CRU estimates that the demand for Australian export coal during the forecast period will be 274 million tonnes in 2020 and 265 million tonnes in 2030. Therefore, CRU forecasts that there will be a supply gap between export production and demand of 14 million tonnes in 2020, which will widen to 77 million tonnes in 2030, as shown in **Figure 60** extracted from the CRU study below. The shortfall represents 5% and 28.9% of demand for Australian thermal coal in 2020 and 2030 respectively.

Figure 60 Supply shortfall if no Australian projects are approved in the future, Mt



Source: CRU

6.63 Given the ongoing demand for coal forecast by CRU, this supply shortfall is likely to be substituted by alternative supplies of coal from China, Russia, Indonesia, India, South Africa and Vietnam. Because those countries are also major coal producing countries, it is considered that those countries will be capable of absorbing the supply shortage, as well as providing replacement coal volumes to non-producing countries in the Asia-Pacific region that normally are net importers of Australian thermal coal.

6.64 The substituting volumes to fill the gap left by the Australian shortfall were allocated using the following assumptions:

(a) producing countries will substitute a shortfall in import volumes by domestic production going forward. As China is the largest coal producer, it can react quickly to a shortfall (see Figure 53 extracted from the CRU study above for a comparison of China and Australia's coal production); and

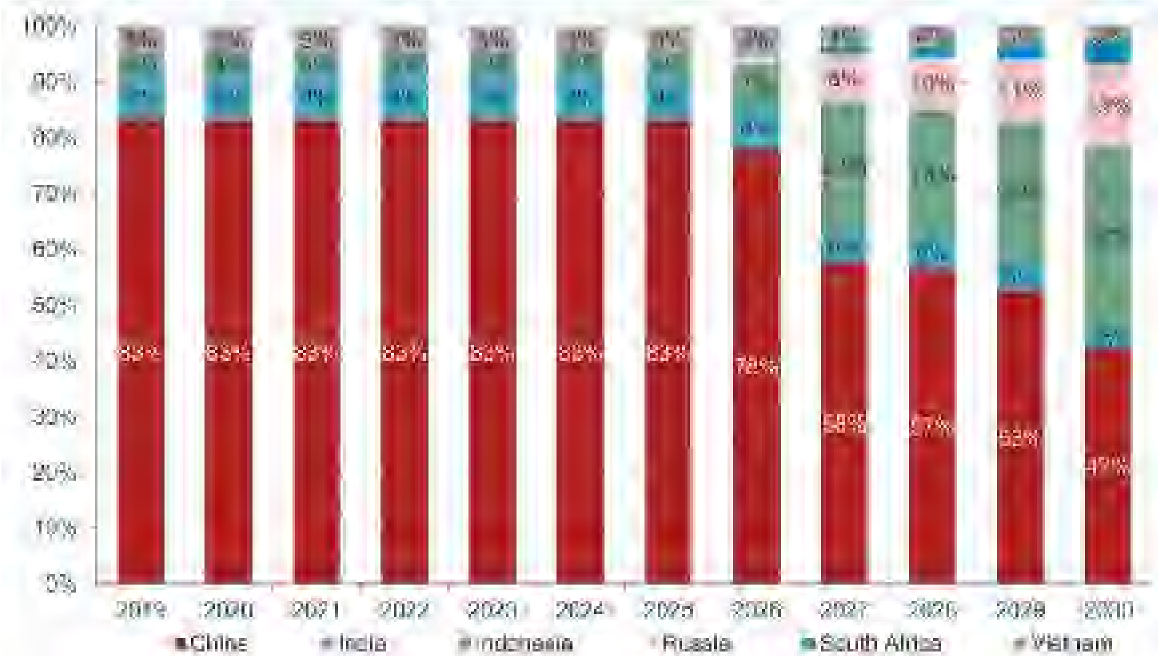
(b) non-producing countries keep sourcing coal from Australia for a few years until the volumes are not enough to meet demand, resulting in those non-producing countries turning to other producing countries to meet the demand.

6.65 **Figure 61** extracted from the CRU study below, shows the replacement production profile of major producers likely to replace Australian supply and **Figure 62** extracted from the CRU study below shows the country breakdown of the substituted production.

Figure 61 Production profile from major producers which replace Australian supply, Mt

Source: CRU

Figure 62 Country breakdown of the substituted production, %



Source: CRU

6.66 As is evident in Figures 61 and 62 above, early substitution will mainly come from China as it is able to respond quickly to the shortfall with large scale domestic production. As the shortfall grows, non-producing countries will start diversifying their imports away from Australia and the share of other exporters like Indonesia and Russia are set to increase. Nonetheless, Chinese coal is likely to remain the largest substitute for Australian coal.

Consequences of substitution of the Extension Project's coal with coal from alternative mines, particularly in respect of GHG emissions

6.67 The high quality of the Extension Project's thermal and SSCC product coal (as explained above), means that it performs at a higher level of boiler efficiency when burned at power stations, compared with alternative supply sources. This has important consequences for the purpose of calculating the GHG emissions that would occur if the Extension Project were to proceed compared to the three hypothetical scenarios in which development consent to the Extension Project is refused.

6.68 As mentioned in paragraph 6.55 above, for the purpose of assessing the GHG emissions if the Extension Project is not approved, the Extension Project's product coal has been treated as a single thermal coal product with the characteristics set out in **Table 5** extracted from the CRU study below.

Table 5 Properties of the Vickery Extension's coal: treated as a single thermal coal product for the scenarios

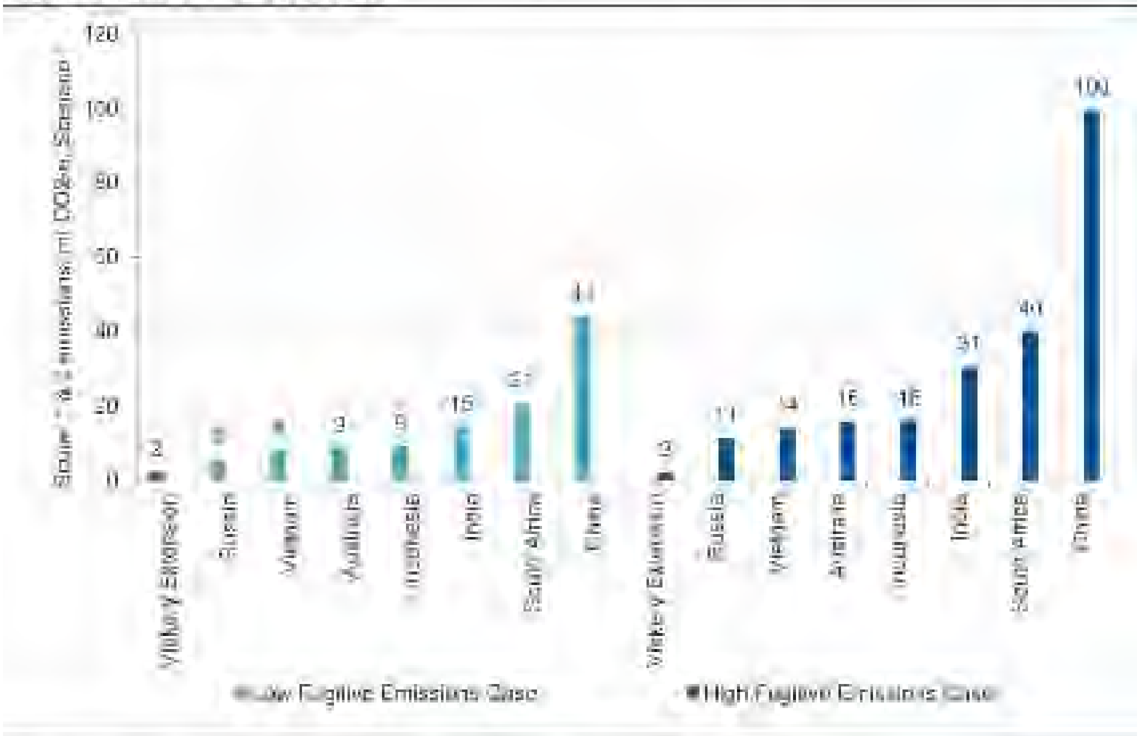
	Total Moisture	Inherent Moisture	Ash	Total Sulphur	Gross Calorific Value (ad)	NCV (ad)
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Vickery Extension average	[illegible]	[illegible]	[illegible]	0.4	[illegible]	[illegible]

Source: CRU

Scenario 1: Neither the Extension Project nor the Approved Project proceed

6.69 In relation to Scenario 1 (where neither the Extension Project nor the Approved Project were to proceed), the Scope 1 and Scope 2 GHG emissions (from fuel, fugitive emissions and power consumption) (in $MtCO_2$-e) of the Extension Project and the alternative sources of coal over the period of the life of mine are compared in **Figure 54** extracted from the CRU study below.

Figure 54 Scope 1 & 2 emissions from Vickery Extension and alternative supply sources for both fugitive emission cases, 2019-30



Source: CRU

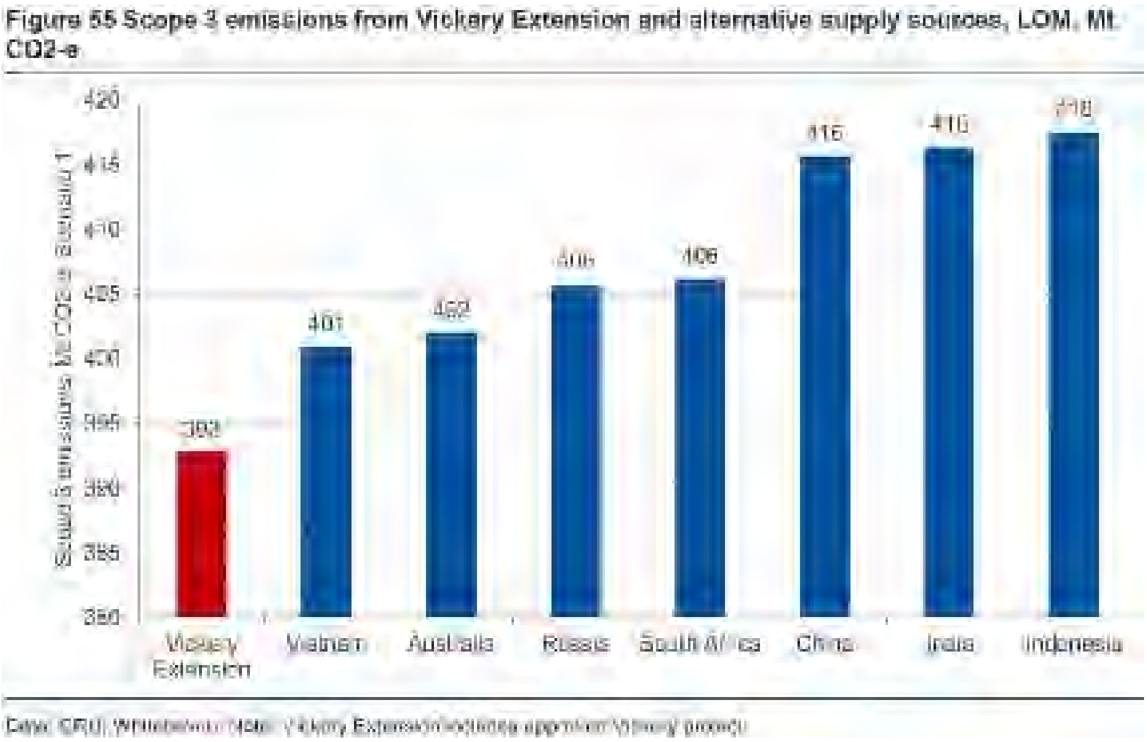
6.70 As a result of the absence of detailed estimates of fugitive emissions from a defined alternative supply source, a low and high fugitive emissions case needed to be adopted. The selection of the low and high cases was informed by the IPCC's estimates of fugitive methane emissions from coal mining, which range from 0.164 to 0.410 t CO_2-e per tonne of coal in the case of underground mining, and 0.005 to 0.033 t CO_2-e per tonne of coal in the case of surface mining. A range boundary of 0.005 to 0.164 t $CO_{2\text{-}e}$ per tonne of coal was applied to alternative coal sources for the low fugitive emissions case, and 0.033 to 0.410 t $CO_{2\text{-}e}$ per tonne of coal for the high fugitive emissions case.

6.71 In the low fugitive emissions case for Scenario 1, the Extension Project is expected to produce the lowest volume of Scope 1 and 2 GHG emissions compared to replacement sources from other countries, which would produce an additional 3.5 to 41.9 Mt $CO_{2\text{-}e}$ over the life of mine of the Extension Project. In the high fugitive emissions case, the Extension Project is expected to produce the lowest volume of Scope 1 and 2 GHG emissions compared to replacement sources from other countries, which would produce an additional 9.1 to 97.5 Mt CO_2-e over the life of mine of the Extension Project.

6.72 Scope 1 and 2 emissions also account for approximately 0.6% of all direct and indirect GHG emissions calculated for the Extension Project. Therefore, direct mining activity by the Applicant is responsible for only a small fraction of emissions of the coal value chain.

6.73 In relation to Scope 3 emissions in Scenario 1, the substitution of the Extension Project's product coal with coal from alternate producing countries will increase Scope 3 emissions by an estimated 8.1 to 24.8 million tonnes of CO_2-e for the life of mine (between 2022 and 2046) (see **Figure 55** extracted from the CRU study below).

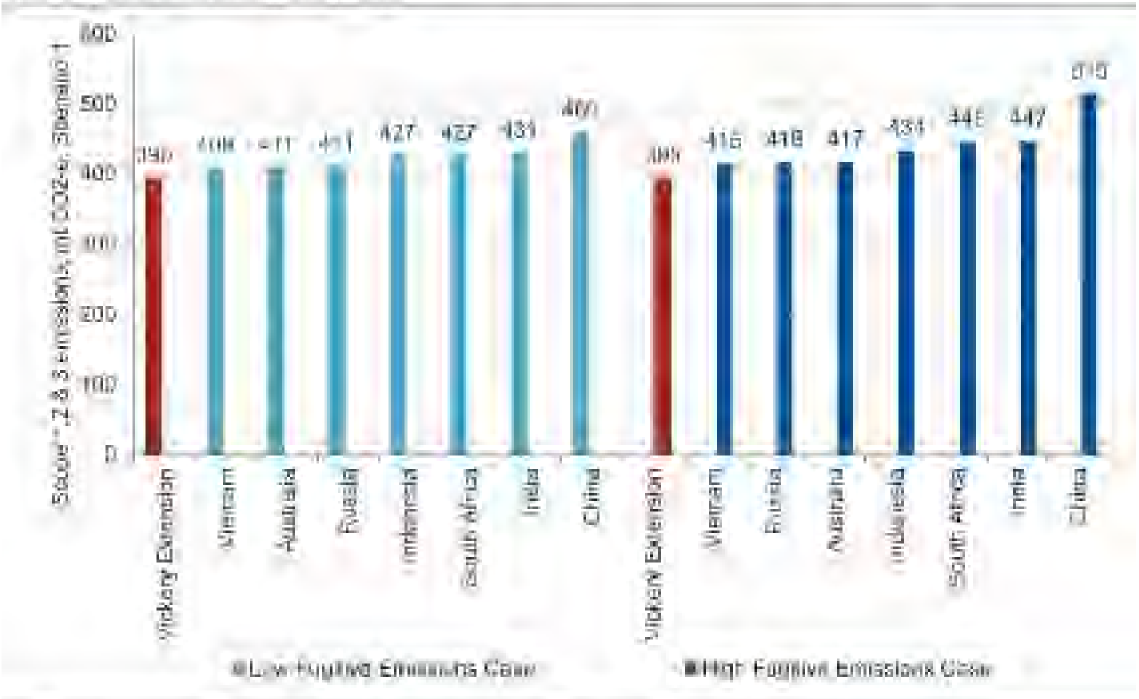
6.74 Scope 3 emissions account for 99.4% of all direct and indirect GHG emissions associated with the Extension Project. Therefore, the combustion of coal for power generation is responsible for almost all the emissions of the coal value chain.



Source: CRU

6.75 When combining Scope 1, 2 and 3 GHG emissions, Scope 3 emissions are the main driver of GHG emissions and are much larger than Scope 1 and 2 emissions. Overall, CRU estimated that market substitution of the Extension Project's coal will release between 14 and 120.4 million tonnes CO_2-e into the atmosphere over the life of mine (see **Figure 56** extracted from the CRU study below).

Figure 56 Scope 1, 2 & 3 emissions from the Vickery Extension and alternative supply sources for both fugitive emission cases, LOM

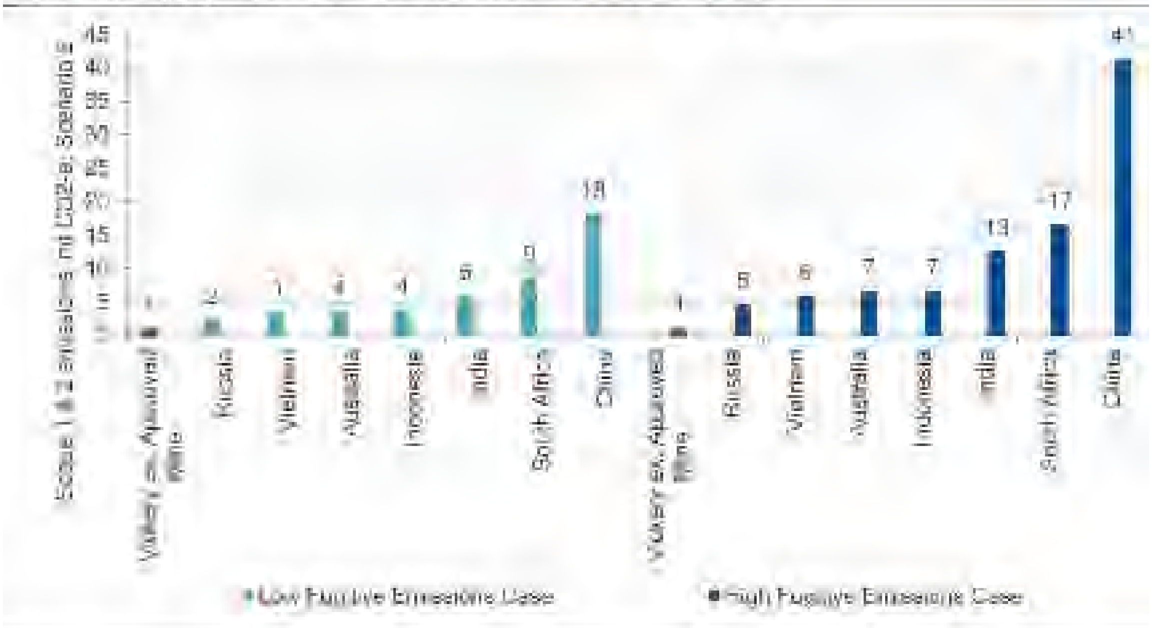


Source: CRU

Scenario 2: The Extension Project does not proceed but the Approved Project does proceed

6.76 In Scenario 2 (where the Extension Project (150 Mt saleable coal) is not approved, but the Approved Project (80 Mt saleable coal) still goes ahead), there would be a shortfall of 70 Mt of saleable coal over the life of mine. The Scope 1 and 2 emissions (from fuel, fugitive emissions and power consumption) of the Extension Project and the alternative sources of coal over the life of mine of the Extension Project are compared in **Figure 57** of the CRU study extracted below. Coal market substitution would increase Scope 1 and 2 emissions by 1.4 to 40.2 million tonnes CO_2-e depending on the fugitive emissions case.

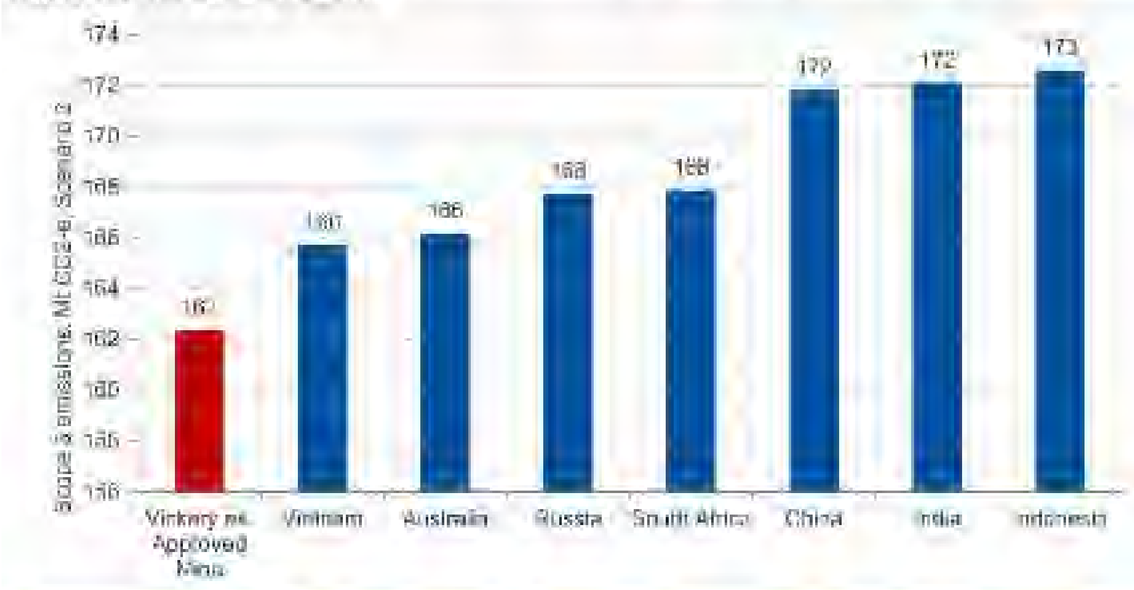
Figure 57 Scope 1 & 2 emissions from Vickery Extension (ex. approved Vickery mine) and alternative supply sources for both fugitive emission cases, LOM



Data: CRU, Whitehaven. Note: Vickery Project here excludes approved Vickery mine and only takes account of the Extension.
Source: CRU

6.77 In relation to the Scope 3 emissions in Scenario 2, the alternative supply would release an estimated additional 3.4 to 10.2 million tonnes of CO_2-e into the atmosphere over the life of mine of the Extension Project (see **Figure 58** extracted from the CRU study below).

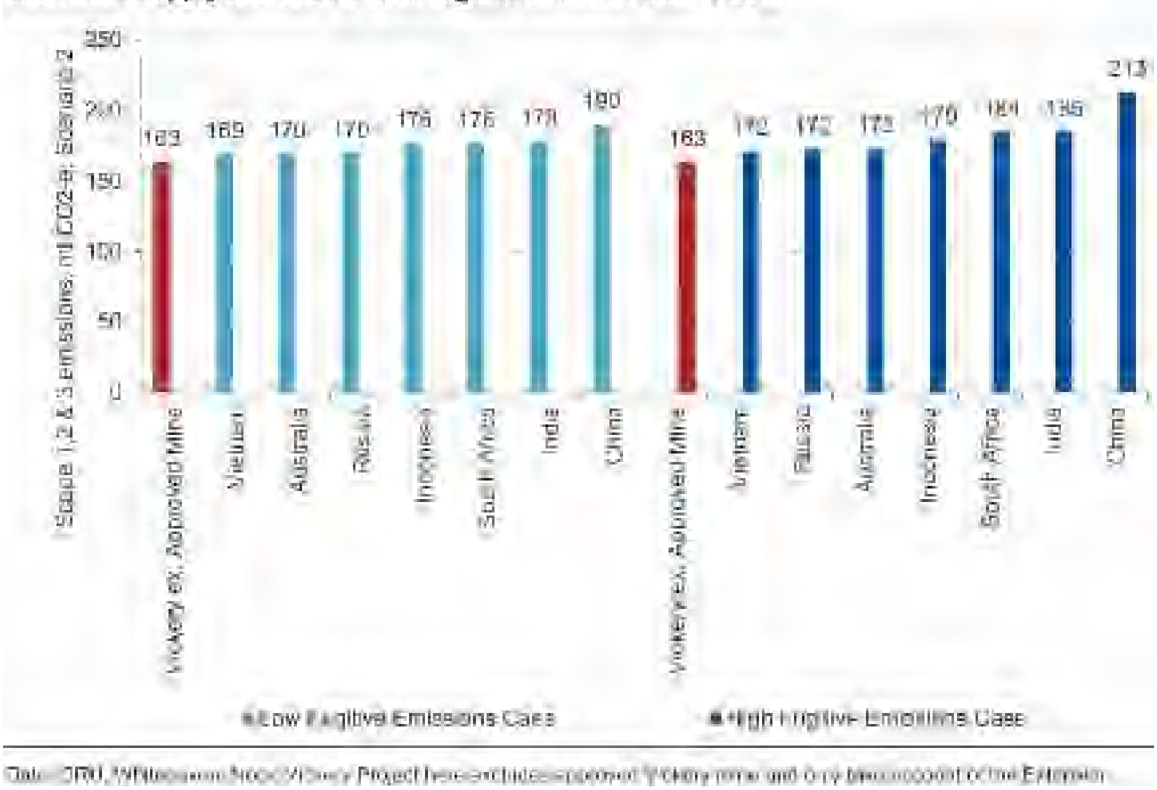
Figure 58 Scope 3 emissions from Vickery Extension (ex. approved Vickery mine) and alternative supply sources LOM, Mt CO2-e



Data: CRU, Whitehaven. Note: Vickery Project here excludes approved Vickery mine and only takes account of the Extension.
Source: CRU

6.78 When combining Scope 1, 2 and 3 emissions for Scenario 3, Scope 3 emissions comprise the vast majority of total GHG emissions associated with the Extension Project excluding the Approved Project. Overall, CRU estimated that substituting only the Extension Project's approximately additional 70 Mt saleable coal would result in the release of an additional 5.7 to 49.7 Mt CO_2-e depending on the fugitive emissions case (see **Figure 59** extracted from the CRU study below).

Figure 59 Scope 1, 2 & 3 emissions from Vickery Extension (ex. approved Vickery mine) and alternative supply sources for both fugitive emission cases, LOM

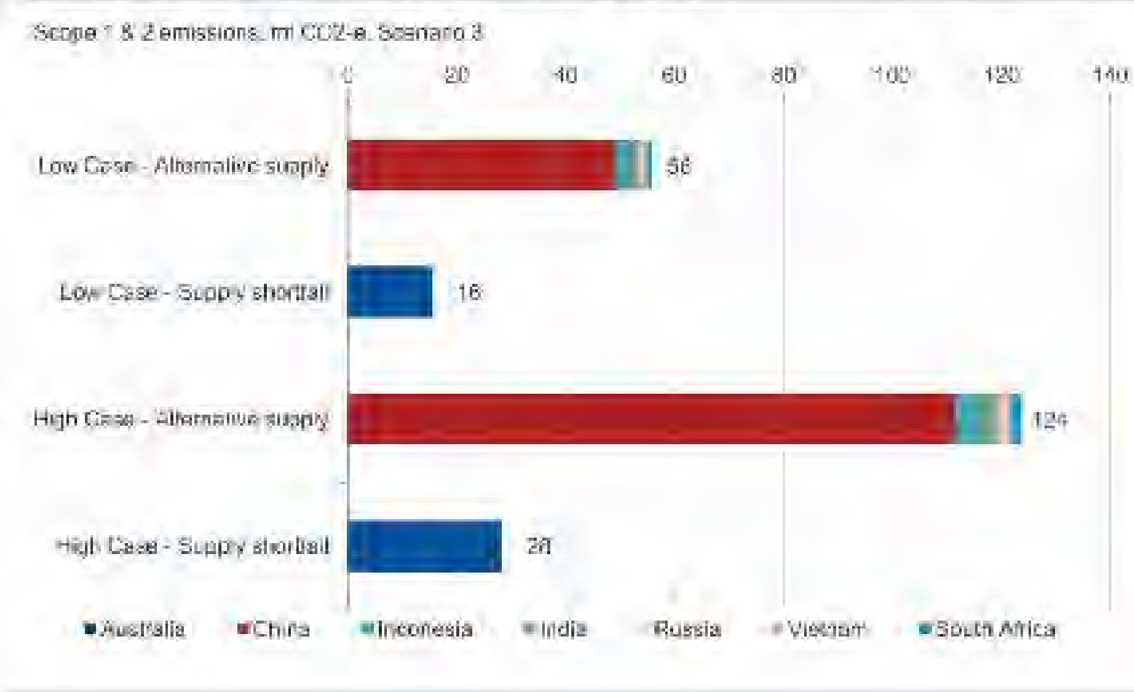


Source: CRU

<u>Scenario 3: No expansions of existing coal mines and no new coal mines in Australia</u>

6.79 In Scenario 3 (where the Extension Project is not approved and no new Australian coal projects enter production) CRU forecast that there will be a supply shortfall of 14 Mt in 2020 and 77 Mt in 2030 (see Figure 60 extracted from the CRU study at paragraph 6.62 above). The Scope 1 and 2 emissions (from fuel, fugitive emissions and power consumption) of the Extension Project and the alternative sources of coal over the period from 2019 to 2030 are compared in **Figure 63** of the CRU study extracted below. The coal substitution would increase Scope 1 and 2 emissions by 40.1 to 95.5 million tonnes CO_2-e depending on the fugitive emissions case.

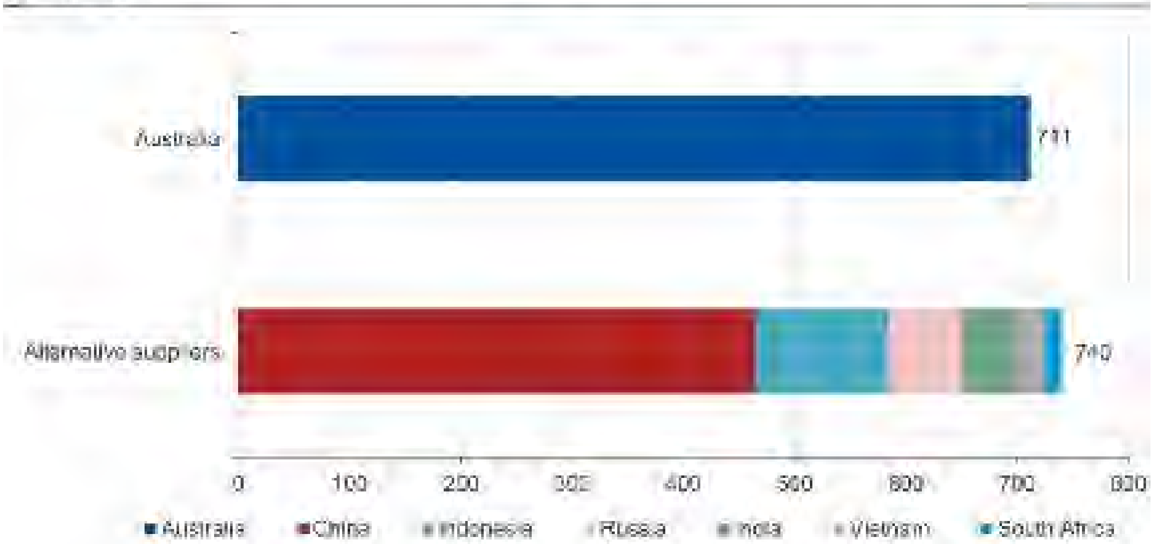
Figure 63 Scope 1 & 2 GHG emissions from Australian supply shortfall and alternative supply sources for both fugitive emissions cases, 2019-30, Mt CO_2-e



Source: CRU

6.80 In relation to the Scope 3 emissions in Scenario 3, the alternative supply would release an additional 28.5 million tonnes of CO_2-e into the atmosphere to 2030 (see **Figure 64** extracted from the CRU study below).

Figure 64 Scope 3 GHG emissions from coal use – Australia compared to alternative supply, 2019-30, Mt CO_2-e



Source: CRU

6.81 When combining Scope 1, 2 and 3 GHG emissions for Scenario 3, Scope 3 emissions comprise 96 to 98% of total GHG emissions. Overall, it is expected that substitution of the Australian supply shortfall by non-Australian coal will release between 68.6 and 124.1 million tonnes CO_2-e in the atmosphere over the 2019-2030 period (depending on the fugitive emissions case) (see **Figure 65** extracted from the CRU study below).

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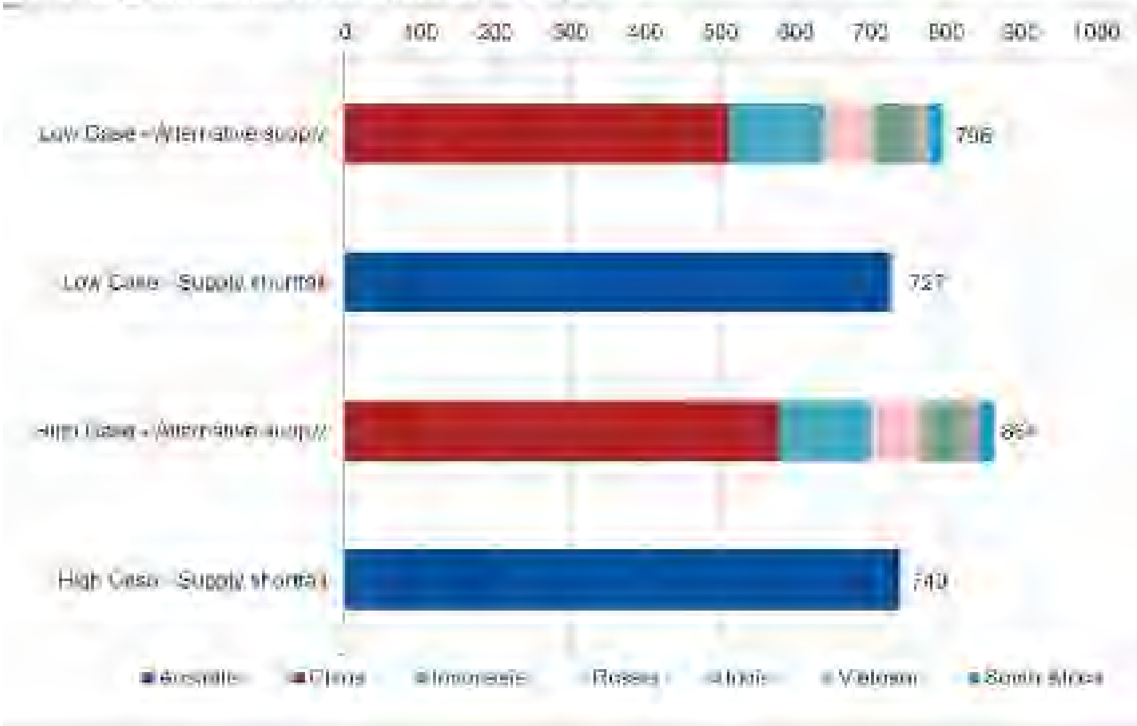
Figure 66 Scope 1, 2 & 3 emissions from Australian supply shortfall and alternative supply sources for both fugitive emission cases, 2019-30, Mt CO_2-e



Source: CRU

The uptake of HELE, CCUS and other low emission coal technologies in Asia and the Export Countries

6.82 In Part B of this submission, the Applicant provided an overview of the climate change laws and policies which have been adopted by the Export Countries (to which coal from the Extension Project is likely to be exported) to meet their respective NDCs under the *Paris Agreement*.

6.83 A detailed account of the domestic climate change laws and policies which have been adopted by these countries has been annexed to these submissions in **Appendix 3**.

6.84 Before providing a summary of the main initiatives that have been implemented by these countries in relation to low emission coal technologies, it is worth briefly explaining two of the more important low emission coal technologies that are being deployed in these countries. They are:

(a) high-efficiency, low-emissions (**HELE**); and

(b) carbon capture, use and storage (**CCUS**).

6.85 First, in relation to HELE:

(a) HELE power plants have lower GHG emissions of all types per unit of power produced, including CO_2. Subcritical coal-fuelled power plants are not considered HELE, while supercritical (**SC**) and ultra-supercritical (**USC**) coal-fuelled plants with advanced emissions controls are considered to meet the HELE technology classification. Advanced ultra-supercritical (**A-USC**) coal-fuelled power plants are nearing commercial status and will be the most efficient plants once they are fully available.

(b) Many coal-importing countries are leaders in the deployment of higher efficiency coal-fuelled power plants simply because power plants with higher efficiency require less coal per unit of electricity and reduce the fuel costs associated with electricity production.

(c) Importantly, the higher efficiency plants result in lower CO_2 emissions per unit of electricity. According to the International Energy Agency Clean Coal Centre, "if a power producer decides to build a new SC or USC unit, it involves 13% and 19% fewer CO_2 emissions than a brand new subcritical unit respectively; and up to 40% fewer CO_2 emissions if the HELE unit is replacing an older plant."

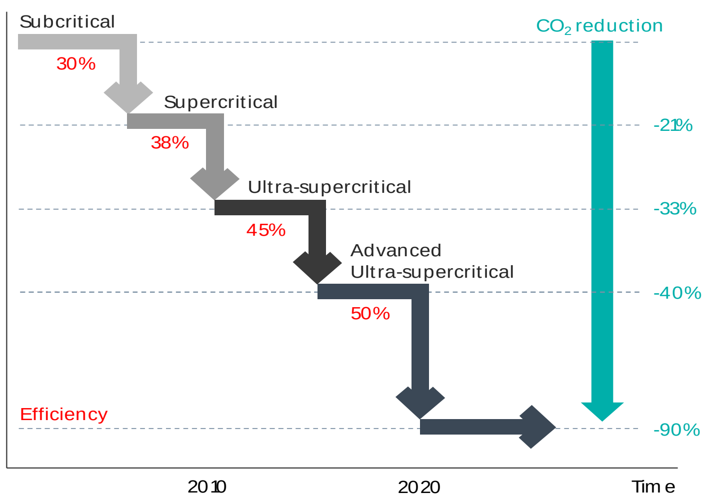
(d) Increasing the efficiency of coal-fuelled power plants is a well-understood approach to reducing CO_2 emissions. Under the Paris Agreement, it is the responsibility of each party to indicate how it will meet emissions reduction targets. Numerous countries that are major coal users (e.g. China, India and Japan) and customers of Australian coal have indicated a role for high-efficiency coal in their NDCs under the *Paris Agreement*.

6.86 Second, in relation to CCUS:

(a) CCUS refers to the technological ability to capture CO_2 emissions from large point sources such as power stations and to store them for long periods of time in underground geological formations where they will not enter the atmosphere. The CO_2 could also be prevented from entering the atmosphere through means of beneficial reuse. CCUS is recognised as a means of mitigating the contribution of fossil fuel emissions to climate change.

(b) CCUS applied to a contemporary power plant may prevent 90% or even more of CO_2 emissions from entering the atmosphere compared to power plants without CCUS. The two large-scale (i.e. at least 1 million tonnes per annum) CCUS projects operating at coal-fuelled power plants currently are designed to capture approximately 90% of the CO_2 from the treated flue gas.

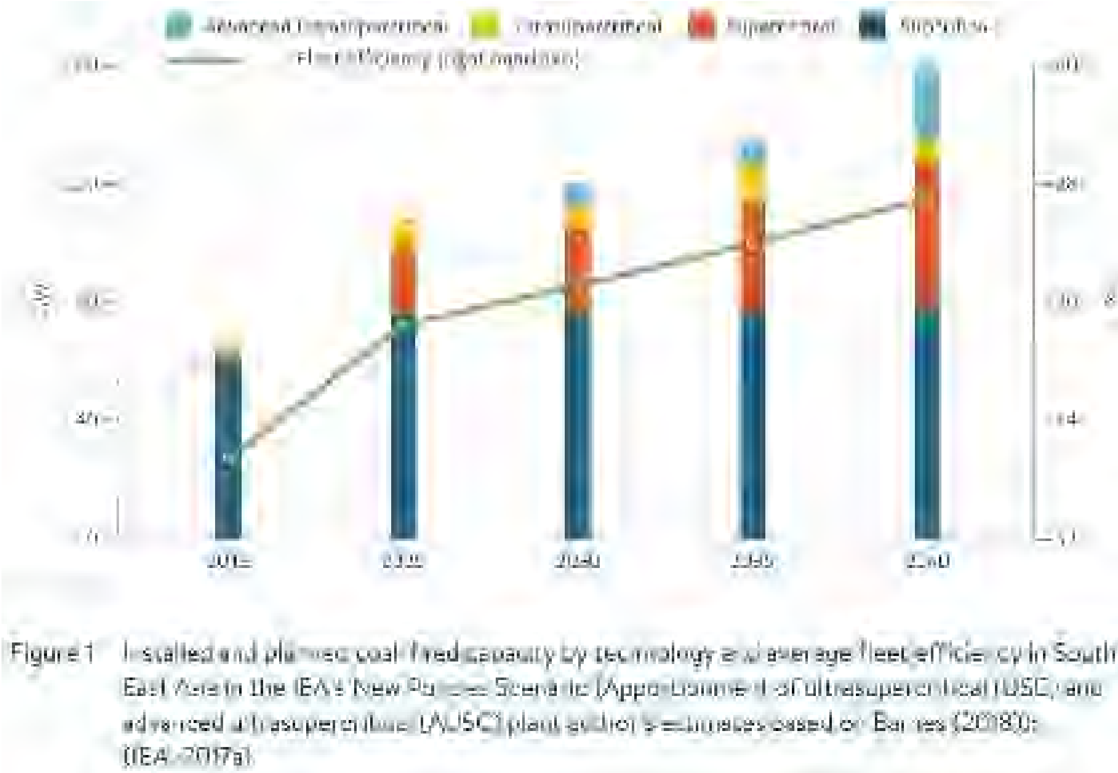
6.87 The below figure from the World Coal Association's Fact Sheet on Coal and Climate Change[30] shows the efficiency gains that can be realised to substantially reduce CO_2 emissions when HELE and/or CCUS technology is deployed.



Source: World Coal Association

30 https://www.worldcoal.org/file_validate.php?file=Coal%20and%20climate%20change.pdf.

6.88 The IEA's Clean Coal Centre estimates that the installed capacity of HELE coal-fired power plants in South East Asia will increase to 2040 as shown in the following figure extracted from the IEA's report.[31]



Source: IEA

6.89 The Applicant has summarised some of the main initiatives that have been implemented by these countries in relation to low emission coal technologies in the following table.[32]

Country	Implementation of HELE, CCUS and other similar technologies
Japan	• A global leader in the application of HELE coal-fueled power plants and built its first USC plant in 1993. • 95% of the country’s plants are HELE plants. • Included high-efficiency coal as part of its contributions to the *Paris Agreement*. • Japan's Fifth Strategic Energy Plan to 2050 recognises coal as an important fuel for baseload power generation. It is the stated policy of Japan to promote the conversion of its coal fleet to HELE technologies. • The 'Rational Use of Energy' Policy provides that State approval for new coal-fired power stations will only be considered if state-of-the-art technologies are adopted (ultrasupercritical). Every electric power company is required to have

[31] I Barnes, 'HELE Technologies and Outreach in Japan and South Korea' (International Energy Agency Clean Coal Centre, March 2019), https://www.iea-coal.org/hele-technologies-in-japan-and-south-korea-2/.

[32] The content referred to in the table immediately below has been informed by the following sources: S&P Global Platts World Electric Power Plants Database, December 2018; M Wiatros-Motyka, 'An overview of HELE technology deployment in the coal power plant fleets of China, EU, Japan and USA' (December 2016); I Barnes, 'HELE Perspectives for Selected Asian Countries' (International Energy Agency Clean Coal Centre, May 2018); Global CCS Institute's Global Status Reports of 2018 and 2019: https://www.globalccsinstitute.com/resources/global-status-report/; I Barnes, 'HELE Technologies and Outreach in Japan and South Korea' (International Energy Agency Clean Coal Centre, March 2019); International Energy Agency Clean Coal Centre, 'Who's "Environmentally Backward"? Japan is Developing these New Energy Technologies' 26 February 2020: https://www.iea-coal.org/whos-environmentally-backward-japan-is-developing-these-new-energy-technologies/.

Country	Implementation of HELE, CCUS and other similar technologies
	an average power generation efficiency of 44,3% or higher for all thermal power generation plants by 2030. This policy also required the power sector to agree on a GHG emissions cap consistent with Japan's 2030 energy mix and emissions targets. • As at March 2019, a number of new USC coal-fired power projects were at various stages of development. Japan has long been at the forefront of newer integrated gasification combined cycle (**IGCC**) technology development. The 543 MW IGCC unit at the Nakoso Power Plant is scheduled for completion in 2020 and the 543 MW Hirono Power Plant is due to be completed in 2021. IGCC is said to be capable of reducing CO_2 emissions by approximately 15% compared to USC systems. • Long-term Low-carbon Vision, published in March 2017, refers to CCUS as a means of achieving emission reductions in the energy sector, as well as centralised/distributed energy management. • Long-term Strategy under the Paris Agreement was adopted on 11 June 2019 states that the Government will work to reduce CO_2 emissions from thermal power generation, including by accelerating "the efforts of a wide range of stakeholders, aiming to establish its first commercial scale CCU technology by 2023 as a trigger for wider usage in view of full social adoption in 2030 and thereafter." • Roadmap for Carbon Recycling Technologies published 7 June 2019 sets out specific goals for improving the competitiveness of CCUS; aiming to reduce the costs of CCUS to JPY 1000-2000/tCO_2 by 2030 and to JPY 1000/tCO_2 or lower by 2050. • Japan's second/updated NDC submitted to the UNFCCC on 31 March 2020 states that Japan "will strive to achieve a 'decarbonized society' as close as possible to 2050 with disruptive innovations, such as artificial photosynthesis and other CCUS technologies". • According to the Global CCS Institute's Global Status Reports of 2018 and 2019, Japan has achieved the following major milestones: o commenced of CO2 injections at the Tomakomai CCUS facility by Japan CCUS with the Ministry of Economy, Trade and Industry's full support – this is Asia's first full-cycle CCUS hydrogen plant, which will capture more than 300,000 tonnes of CO2 by 2020. In 2019, it reached a capture milestone of 300,000 tonnes of CO2, and continued intensive monitoring of storages; o retrofitted the Toshiba Corporation 49MW Mikawa power plant in Omuta (Fukuoka Prefecture) to accept biomass (in addition to coal) with a carbon capture facility. Completion is expected in early 2020; o launched JPOWER and Chugoku Electric Power Company's Osaki CoolGen facility, a 166 MW oxygen-blown IGCC (integrated gasification combined cycle) plant in Osakikamijima (Hiroshima Prefecture), which will separate and capture CO2 from the end of 2019; o completed construction of Toshiba's carbon capture and utilisation system at the Saga City Waste Incineration Plant (on Japan's Kyushu Island), using captured CO2 for algae culture; and o commencement of construction of the gasifier for the Hydrogen Energy Supply Chain project that plans to gasify Australian brown coal in Victoria's Latrobe Valley and transport it by ship to Japan for future decarbonised hydrogen developments. This project being developed by Kawasaki Heavy Industries (KHI), Electric Power Development Co. (J-Power), Iwatani Corporation, Marubeni Corporation, Sumitomo Corporation and AGL, with the support of the Governments of Japan, Australia and the State of Victoria. First hydrogen production is expected by 2021.

Country	Implementation of HELE, CCUS and other similar technologies
South Korea	• As of December 2018, 83% of South Korea's coal-fuelled generation capacity was HELE and at least 90% of planned and under construction capacity is HELE. In the 5 years to 2023, at least 7 GW of HELE generating capacity is expected to come online in South Korea. • The South Korean coal fleet has one of the world's largest shares of SC or USC coal-fired power generation in a single country. • South Korea shares similarities with Japan in having a relatively young, high efficiency coal fleet in place. • South Korea has one of only seven commercial IGCC projects worldwide with an installed capacity of 346.3 MW, which commenced operation in August 2016. There are plans to improve and commercialise the technology to a wider customer base. • South Korea's NDC indicated that it would subsequently develop a detailed plan to implement its mitigation target. To this end, South Korea released a revised roadmap for achieving the 2030 National Greenhouse Gas Reduction Goal in July 2018 (the **Roadmap**). The Roadmap sets out sectoral targets, including emission reductions of 24 million tons in the energy conversion sector (power generation, group energy) through policies to reduce fine dust and promote the use of eco-friendly energy. • National CCS Comprehensive Plan announced in July 2011 to promote research and development on CCUS with a view to commercialising the technology by 2020.[33] • Final draft Integrated CCS Act published in 2018 will require yearly CCUS implementation plans.
Taiwan	• Taiwan is not a member of the United Nations, consequently it cannot be a party to the UNFCCC or the Paris Agreement. • Nevertheless, Taiwan put forward an intended nationally determined contribution (**INDC**) on 17 September 2015. • HELE is included in Taiwan's INDC. • As of December 2018, 31% of Taiwan's coal-fuelled generation capacity was HELE and 2.4 GW of planned and under construction capacity is USC HELE. • Taiwan's EPA established a national CCUS strategic alliance in 2011. This alliance brings together domestic experts from government, academia and industry, for the purpose of developing the technology and regulatory framework required for the commercial use of CCUS technology, with the ultimate goal of achieving widespread use of CCUS technology by 2020. Through the alliance, the Taiwan Cement Corporation (in partnership with the Industrial Technology Research Institute) commissioned the world's first CCUS pilot project in the cement industry in 2013, with the two entities agreeing in 2016 to extend their cooperation on the project.

[33] Moonhyun Koh, Eunhae Shin and Woongchan Seo, 'Outline of Korean Integrated CCS Act Draft and Its Implication' *Energy Procedia* 154 (2018) 15-21.

7. **PART D: RESPONSE TO SUBMISSIONS MADE IN RESPECT OF GHG EMISSIONS, CLIMATE CHANGE, AND COAL DEMAND**

Overview

7.1 The initial stage of the public hearing was held by the IPC into the Extension Project on 4 and 5 February 2019. Numerous submissions made by members of the public, NGOs and other stakeholders at, and following, the initial stage of the public hearing raised the issue of GHG emissions, climate change impacts and the future demand for coal. Those submissions include:

(a) the letter from the Environmental Defenders Office (**EDO**) to the IPC of 12 February 2019 (**EDO Letter**);

(b) the report by Emeritus Professor Steffen, dated 9 February 2019 and submitted by the Environmental Defenders Office on behalf of Lock the Gate Alliance (**Steffen Report**);

(c) the submission of Tim Buckley of the Institute for Energy Economic and Financial Analysis (**IEEFA**) dated February 2019 (**Buckley Submission**); and

(d) IEEFA's report titled "New South Wales Thermal Coal Exports Face Permanent Decline: Grim Outlook Prompts the Need for Transition" dated November 2018 (**IEEFA Report**)

(e) the letter from Lock the Gate Alliance dated 11 February 2019; and

(f) the letter from Boggabri Farming and Community Group (undated).

7.2 The EDO Letter states that the EDO was aware that Mr Roderick Campbell (among others) was also "providing advice to the IPC". However, no such advice from Mr Campbell appears to have been made available on the IPC's website. The Applicant reserves its right to make a response in respect of any submission from Mr Campbell.

7.3 Rather than address each submission individually, this Part D addresses the common themes or elements of those submissions.

Common themes raised by public submissions regarding GHG emissions, climate change and demand for coal

7.4 The following common themes or elements were contained in the public submissions that oppose the Extension Project:

(a) <u>Theme 1:</u> anthropogenic climate change is a real phenomenon that is occurring and coal is one of the major sources of human-induced GHG emissions;

(b) <u>Theme 2:</u> in order for the "well below 2°C" goal of the *Paris Agreement* to be realised, no new fossil fuel developments should be approved, and those existing, already approved fossil fuel developments should be rapidly phased out;

(c) <u>Theme 3:</u> coal market substitution is speculative and should not be considered by the IPC;

(d) <u>Theme 4:</u> the approval of the Extension Project would be inconsistent with existing climate change laws and policies, particularly Australia's NDC and the NSW Climate Change Policy Framework;

(e) <u>Theme 5:</u> approval of the Extension Project creates a financial risk for the Applicant, existing coal mines in NSW, Australia and the local community; and

(f) Theme 6: the IPC should follow *Rocky Hill* and refuse development consent for the Extension Project.

7.5 Each of these themes will be addressed in turn below.

Theme 1: anthropogenic climate change is a real phenomenon that is occurring and coal is one of the major sources of human-induced GHG emissions

7.6 Many of the submissions describe, at a high level, the science of climate change and the impacts that can be caused to the world's and Australia's climate and environments as a result of anthropogenic climate change. This was particularly the case in the Steffen Report: see especially paragraphs 7 to 32.

7.7 The Applicant does not contest that climate change is real and happening and that global GHG emissions must be reduced.

7.8 The Applicant considers that comments about the effects of anthropogenic climate change generally, which are not intelligently tied or made referrable to the determination of the development application for the Extension Project, are of little to no assistance to the IPC's consideration of the impacts of the Extension Project.

7.9 The relevant impact to be assessed is the impact of the Extension Project. That involves considering the difference to the environment if the Extension Project goes ahead and if it does not. In that regard, the Applicant submits that:

(a) its total contribution of Scope 1 emissions will be 0.099% of total GHG emissions in NSW and 0.024% of total GHG emissions for Australia, as set out in the Air Quality and Greenhouse Gas Assessment dated June 2018 (noting that the total ROM coal to be extracted has been revised downwards to 169 Mt ROM coal since the Air Quality and GHG Assessment was prepared, which resulted in a reduction of Scope 1 GHG emissions from 3.2 $MtCO_2$-e to 3.1 $MtCO_2$-e: see Amendment Report at 11);

(b) the improved operational efficiency and the shorter life of mine of the Extension Project compared to the Approved Project will reduce the Applicant's Scope 1 GHG emissions by approximately 1 $MtCO_2$-e;

(c) the life of the Extension Project will be completed before 2050, whereas the Approved Project would still be operating beyond that date, which is the target date for NSW achieving net zero emissions;

(d) the incremental increase in total GHG emissions (including Scope 3) compared to the Approved Project is estimated to be approximately 98.3 $MtCO_2$-e;

(e) the GHG Assessment did not take into account:

(i) the reduction in GHG emissions that would be attributable to the revegetation of previously cleared areas as part of biodiversity offset measures for the Extension Project; or

(ii) that the Extension Project will reduce the GHG emission intensities of the Tarrawonga Coal Mine by decreasing the distance that coal will need to be hauled by road from that mine for processing;

(f) to the extent that the total Scope 1 emissions for the Extension Project will exceed 100,000 $tCO_{2\text{-}e}$ in a year (which they are likely to after the fourth year of the Extension Project), then the Applicant must comply with the Federal government's Safeguard Mechanism by offsetting its emissions above a baseline set by the CER or otherwise managing compliance;

(g) if the Extension Project does not proceed there will be no corresponding reduction in global GHG emissions in the atmosphere because the global demand for coal will be satisfied by other sources. Indeed, refusal of consent would likely result in a net increase in GHG emissions globally due to market substitution of the Extension Project's high quality coal with inferior quality coal (lower calorific value and higher ash and sulphur content), as discussed in **Part C** of this submission.

7.10 The Applicant readily acknowledges that coal mining projects, like other forms of development, generate GHG emissions. However, many of the submissions characterise the generation of Scope 3 GHG emissions from the Extension Project as being direct of the product of the coal mining activity. This is not an accurate characterisation. Coal is currently, and will continue to be for several decades, vital to the provision of affordable, reliable energy particularly to countries in the Asia-Pacific region. It is the world's demand for coal-fired electricity generation that is the main cause of Scope 3 GHG emissions.

7.11 This point was recognised by Member Smith of the Queensland Land Court, in the context of considering the Alpha coal mine, in the decision of *Hancock Coal Pty Ltd v Kelly & Ors and Department of Environment and Heritage Protection (No 4)* [2014] QLC 12, where he relevantly observed:

> [230] … [I]t is the demand for electricity to the extent that it is met by coal-fired generators that causes the Scope 3 emissions, and the facts as set out in this case clearly show that Alpha is but one of a myriad of suppliers, both local and around the world, who will seek to meet this existing demand.
>
> [231] … I must on the evidence of this case determine that it is the demand for coal-fired electricity, and not the supply of coal from coal mines, which is at the heart of the problem.
>
> [232] … the clear and unambiguous facts of this case show that there will be no reduction of GHGs if the Alpha mine is refused, and, indeed, depending on the source of replacement coal, such replacement coal may well, on the evidence, result in an increase in GHG emissions.

7.12 The Applicant considers that the observations made by Member Smith are equally applicable to the Extension Project, and would submit that it is both open to, and appropriate for, the IPC to adopt the same approach to consideration of Scope 3 emissions that Member Smith did in the *Hancock Coal* case.

Theme 2: in order for the "well below 2°C" goal of the Paris Agreement to be realised, no new fossil fuel developments should be approved

7.13 The Applicant does not dispute that action needs to be taken to reduce GHG emissions globally in order for the "well below 2°C" goal of the *Paris Agreement* to be realised.

7.14 However, in circumstances where:

(a) the *Paris Agreement* has not been enacted as part of the law of Australia, and parties to the *Paris Agreement* individually determine their national contribution to its goal in the form of an NDC;

(b) the development of new coal mines, or the continuation of existing coal mines, is not prohibited by the operation of international, Australian or NSW law or policy;

(c) the prohibition of new coal mines is not one of the many measures that Australia has adopted as part of its NDC under the *Paris Agreement*;

(d) indeed, to the contrary, NSW law or policy:

(i) aims to "foster the significant social and economic benefits" to NSW "that result from the efficient development of mineral resources";[34] and

(ii) permits the carrying out of coal mining projects with development consent under the Mining SEPP; and

(iii) prescribes that the State's action on climate change will not undermine the NSW's $36 billion mining sector and the jobs and communities it supports;[35]

(e) the IPC must have regard to the objects of the Mining SEPP, which include:

(i) to facilitate the orderly and economic use and development of land containing mineral resources (such as coal); and

(ii) to promote the development of significant mineral resources; and

(f) the material produced in Part C of this submission demonstrates that the failure to approve the Extension Project would likely result in a net increase in GHG emissions (particularly Scope 3 emissions) due to market substitution of the Extension Project's high quality coal with inferior quality coal,

(g) the Applicant considers that any suggestion that the refusal of the development application would demonstrate a commitment on the IPC's part to take action to achieve the goal of the *Paris Agreement* is misconceived, at risk of giving rise to a legal error on the part of the IPC, and places at risk the realisation of the significant social and economic benefits that the Extension Project will deliver at a local, regional and State level.

7.15 In particular, the Applicant considers that the critique presented of the two arguments set out at paragraphs 59 to 62 of the Steffen Report is untenable in light of the detailed and specific material addressed in Part C of this submission.

7.16 In relation to the first argument critiqued in those paragraphs of the Steffen Report, Professor Steffen suggests that the argument of "my emissions are too small to matter" is flawed because all GHG emissions "are important because cumulatively they constitute the global total of greenhouse gas emissions, which are destabilising the global climate system at a rapid rate". There are some important points to make in response to that submission.

7.17 First, it is important to be clear as to which GHG emissions should be counted towards a given development's total of GHG emissions. Given that the intent of the climate change laws and policies set out in Part B of this submission is to avoid double counting of GHG emissions towards a country's NDC under the *Paris Agreement*, the GHG emissions that should be counted towards a development's total are the Scope 1 and 2 emissions, not Scope 3 emissions. In this regard, the Extension Project's Scope 1 and 2 emissions will be approximately 3 $MtCO_{2-e}$ representing approximately 1% of all direct and indirect emissions associated with the Extension Project.

[34] *Mining Act 1992* (NSW), s 3A.

[35] *Net Zero Plan Stage 1: 2020–2030* (March 2020) at 22.

7.18 Secondly, when one considers and compares the Scope 1 and 2 emissions generated from different types of development, it is evident that some developments may produce more GHG emissions than others. Professor Steffen's position in this regard would suggest that it does not matter whether a given development that is reliant on fossil fuels for energy is large or small: no matter what size the development is, it will contribute GHG emissions and these emissions matter in the context of seeking to reduce GHG emissions worldwide. As a corollary to that point, Professor Steffen appears to take the position that any development that is reliant on fossil fuels for energy generation should be either refused (in the case of new development) or may be maintained (in the case of existing development) for a short period of time only, before being phased out completely.

7.19 Professor Steffen's position has legal and practical problems.

7.20 Legally, it is problematic because NSW planning laws do not prohibit or restrict (as distinct from regulate, pursuant to development consent conditions) the carrying out of fossil fuel development, including coal mines (nor, for that matter, does any other climate change law or policy considered in Part B of this submission).

7.21 More specifically, the carrying out of the Extension Project here is permissible with development consent under the Mining SEPP. The objects of the Mining SEPP include:

(a) to facilitate the orderly and economic use and development of land containing mineral resources (such as coal); and

(b) to promote the development of significant mineral resources.

7.22 If Professor Steffen's approach of no new fossil fuel development is adopted by the IPC as a decision-making practice, it would mean that all development applications for fossil fuel developments would be rejected without being assessed on their own merits and such decisions would almost certainly be invalid in that:

(a) the EP&A Act, the Mining SEPP and the *Mining Act 1992* (NSW) all contemplate that fossil fuel developments may be carried out with lawful authority in NSW; and

(b) a failure to entertain a development application for such fossil fuel development on its merits would amount in numerous legal errors rendering the IPC's decision invalid, including:

(i) a failure to have regard to all relevant considerations set out in s 4.15 of the EP&A Act;

(ii) a failure to accord the proponent of the proposed project with procedural fairness;

(iii) a constructive failure to exercise its decision-making power or jurisdiction; and

(iv) rigid adoption and application of a decision-making practice or policy without due regard to the circumstances or merits of the development application before it.

7.23 Indeed, the Court in *Rocky Hill* did not go so far as to accept Professor Steffen's evidence (which, by and large, is the same as the material produced in the Steffen Report in respect of the Extension Project). In *Rocky Hill*, the Court remarked on this aspect of Professor Steffen's evidence that (underline added):

> [552] … It gives priority to existing and approved fossil fuel developments, along the lines of "first in, best dressed". It also frames the decision as a policy decision that no fossil fuel development should ever be approved.

> [553] I consider the better approach is to evaluate the merits of the particular fossil fuel development that is the subject of the development application to be determined. Should this fossil fuel development be approved or refused? Answering this question involves consideration of the GHG emissions of the development and their likely contribution to climate change and its consequences, as well as the other impacts of the development …

7.24 Thus, the Applicant suggests that the position of Professor Steffen is fundamentally at odds with the decision-making framework of NSW planning laws.

7.25 Further, Professor Steffen's position also has practical problems. If the approach is to be adopted that any form of development – new or existing – that will be reliant on fossil fuels (either directly or indirectly) should be refused, then this could have crippling and devastating consequences for human populations that rely on fossil fuels as a reliable, affordable and efficient means for energy or electricity. It could result in many different forms of development, such as schools and hospitals, being without electricity, which would, in turn, have flow-on effects for human development globally. Such consequences would give rise to distributive injustice to different populations and undermine the achievement of intra-generational equity, which is one of the principles of ecologically sustainable development. Moreover, as the Department of Planning recognised in its Addendum Report on the Wallarah 2 Coal Project in considering the principle of inter-generational equity:

> [The Department] recognises that there remains for the foreseeable future a clear need to continue to mine coal deposits to meet society's basic energy needs … The Department also acknowledges that the downstream energy and other socio-economic benefits generated by the amended project would benefit future generations, particularly through the provision of international energy needs.

7.26 If Professor Steffen's position were to be applied equitably to all development applications, then consent authorities should also refuse all other types of development whose Scope 1, 2 and 3 emissions contribute to climate change. For example, all new commercial buildings and residential developments that are not carbon neutral should be refused, as the construction industry accounts for almost 20% of Australia's GHG emissions.[36] So many sectors of the Australian economy contribute to GHG emissions that applying Professor Steffen's approach to planning decisions would virtually halt all major development in NSW.

7.27 Thirdly, while the Applicant does make the point in its EIS that its contribution to Australia's GHG emissions "would be relatively small", the Applicant would not suggest that the GHG emissions that are generated by the Extension Project "do not matter" or are irrelevant. The Applicant takes the GHG emissions generated by the Extension Project seriously, which is why the Applicant has committed to implementing the following measures to mitigate its Scope 1 and 2 GHG emissions:

(a) regular maintenance scheduling;

(b) limiting the length of material haulage routes;

(c) optimising ramp gradients for operating haul trucks;

(d) improving fuel efficiency of haulage trucks and mine equipment, including implementing high efficiency motors; and

(e) reducing engine idle times.

7.28 Further information about these mitigation measures can be found in the EIS for the Extension Project at section 4.10.3 (page 4-72).

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[36] See Man Yu, Thomas Wiedmann, Robert Crawford and Catriona Tait 'The Carbon Footprint of Australia's Construction Sector' (2017) 180 *Procedia Engineering* 211-220;

7.29 These mitigation measures will be implemented in accordance with DPIE's recommended conditions of consent for the Extension Project that:

(a) all reasonable steps are taken to improve energy efficiency and reduce Scope 1 and 2 GHG emissions of the Extension Project; and

(b) that an Air Quality and Greenhouse Gas Management Plan is prepared describing the measures to be implemented to ensure that best management practice is employed to minimise the Extension Project's Scope 1 and 2 GHG emissions and to improve the Extension Project's energy efficiency.

7.30 In addition to the mitigation measures outlined above:

(a) the improved operational efficiency and the shorter life of mine of the Extension Project compared to the Approved Project will reduce the Applicant's Scope 1 GHG emissions by approximately 1 $MtCO_2$-e;

(b) revegetation of previously cleared areas as part of biodiversity offset measures would also assist with reducing the Extension Project’s net GHG emissions although the effect of this has not been quantified;

(c) the Extension Project will reduce the GHG emissions intensity of the Tarrawonga Coal Mine as a result of reduced haulage distances to the Project CHPP instead of the Whitehaven CHPP (see section 4.10.2 of the EIS). This benefit was not quantified as part of the Air Quality and Greenhouse Gas Assessment for the Extension Project; and

(d) Whitehaven continues to integrate climate change considerations across its business, understanding potential risks, managing its operational energy and emissions footprint, supporting a suite of low emission technologies and playing a proactive role in public policy and regulatory developments, as set out in its 2019 Sustainability Report. Further details on Whitehaven's corporate initiatives concerning GHG emissions, including its support of HELE and CCUS may be found in **Appendix 5** to this submission.

Theme 3: Coal market substitution is speculative and should not be considered by the IPC

7.31 Professor Steffen argues (at [61] of the Steffen Report) that any suggestion that "another new coal resource… will be developed to take [the Extension Project's] place" is flawed because "it assumes that there is now, and will continue to be, a demand for new coal resources beyond those that already exist".

7.32 The Applicant has not *assumed* that there will be demand for coal as asserted by Professor Steffen. The independent IEA acknowledges that there will be continued demand for coal in both the Stated Policies Scenario and the Sustainable Development Scenario of the WEO 2019, which will need to be met by expansions of approved coal mines (such as the Extension Project) or the development of new coal mines (see paragraph 6.21 above). This has been confirmed by the independent forecasts prepared by CRU which are explained in **Part C** and summarised in **Appendix 4** of this submission.

7.33 The Applicant considers Professor Steffen's critique to be unconvincing and, in light of the evidence produced in Part C of this submission, unsustainable. In the absence of the Extension Project's coal becoming available on the market for export, the Applicant's prospective customers will simply source their coal from elsewhere and, as the evidence produced in Part C of this submission suggests, those customers would most likely need to rely upon, as a substitute, an inferior quality of coal which would, in relative terms, actually generate more GHG emissions than those that would be generated by the Extension Project.

7.34 In considering Scope 3 emissions as part of the public interest (alongside myriad other public interest considerations, including other objects of the EP&A Act), the IPC must have regard to the evidence before it and should not act against the weight of that evidence.

7.35 The Applicant has assessed the impacts of the Extension Project in absolute terms, as well as by comparing the estimated Scope 3 emissions if the Extension Project goes ahead and if it does not. Given that Scope 3 emissions are the result of third-party activities which are beyond the control of the Applicant, it is only reasonable and logical to compare the estimated Scope 3 emissions of the Extension Project to the estimated Scope 3 emissions that would likely occur in the absence of the Extension Project.

7.36 It would be inconsistent for the IPC to ignore the complexity of supply chain GHG emissions by, on the one hand, embracing the estimate of the Extension Project's Scope 3 emissions as incontrovertible fact and, on the other hand, rejecting the expert evidence of coal market substitution. In this regard, the Applicant reiterates that:

(a) Scope 3 emissions will be generated by third parties using the Extension Project's product coal. This means that Scope 3 emissions relate to activities that are outside the operational control of the Applicant and are not the subject of the development application;

(b) estimating Scope 3 emissions inherently involves hypothetical assumptions about the actions of third parties;

(c) there are inherent uncertainties in the estimation of Scope 3 emissions which are based on forecasts and assumptions about the actions of third parties, particularly when matters such as technology and end uses are taken into account. For example, if the coal were exported and used in a supercritical coal-fired power station or in conjunction with carbon capture and storage, then the actual GHG emissions would likely be quite different than if used in a less-efficient, unabated power station;[37] and

(d) because Scope 3 emissions will be generated by third parties, considering the Scope 3 emissions of the Extension Project, should logically also include a consideration of what those third parties would do if the Extension Project were not approved. That is, whether those third parties would still emit GHG emissions if they were unable to purchase the Extension Project's product coal. This has been estimated by experts as set out in Part C of this submission.

7.37 Further, the Applicant is not required to establish with certainty that there will be coal market substitution if the Extension Project is not approved. Section 4.15(1)(b) of the EP&A Act requires the IPC to consider the *likely* impacts of the Extension Project, not the certain impacts. The courts have determined that the word "likely" used in various provisions in the EP&A Act (including in s 79C (now s 4.15)) means a real and not remote chance or possibility, rather than proof to a probability greater than 50 per cent.[38] The Applicant has established in Part C of this submission that coal market substitution is likely to occur if the Extension Project is not approved. Based on the evidence in Part C, the impact to the environment if the Extension Project does not go ahead will likely be worse in terms of GHG, ash and sulphur emissions.

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[37] Uncertainty in the estimation of Scope 3 GHG emissions was pointed out in the letter from the Hon. Angus Taylor, Minister for Energy and Emissions Reduction to the Hon. Rob Stokes, Minister for Planning and Public Spaces dated 20 November 2019 being Appendix G2-3 to the Assessment Report.

[38] *Harika v Tupaea* (2003) NSWLR 675 per Mason P at [27]; *Hoxton Park Residents Action Group Inc v Liverpool City Council* (2011) 81 NSWLR 638 at [46]; *Fullerton Cove Residents Action Group Incorporated v Dart Energy No 2)* (2013) 195 LGERA 229 at [227]–[229]; *Harrison Perdikaris* [2015] NSWLEC 99 at [68].

Theme 4: Approval of the Extension Project would be inconsistent with existing climate change laws and policies

7.38 This theme has already been addressed in the context of discussing Theme 3 above. As pointed out there, and in Parts A and B of this submission:

(a) there is nothing in existing climate change laws and policies which prohibits the approval of new coal mining development; and

(b) the prohibition of new coal mines is not one of the specific mechanisms or measures that Australia has adopted for the specific purpose of meeting its NDC under the *Paris Agreement*;

(c) indeed, to the contrary,

(i) the Federal government's Safeguard Mechanism which will apply to the Extension Project when its GHG emissions exceed 100,000 tCO_2-e is one of the measures that Australia has adopted to meet its NDC under the *Paris Agreement;*

(ii) NSW planning laws recognise that the carrying out of coal mining projects is permitted with development consent; and

(iii) NSW's Net Zero Plan Stage 1 states that it is important that the State's action on climate change does not undermine the State's mining businesses and the jobs and communities they support; and

(d) the objects of the Mining SEPP include:

(i) to facilitate the orderly and economic use and development of land containing mineral resources (such as coal); and

(ii) to promote the development of significant mineral resources.

Theme 5: Approval of the Extension Project creates a financial risk for the Applicant, existing coal mines in NSW, Australia and the local community

7.39 This theme arises from the Buckley Submission and the IEEFA Report. The following arguments are made in those documents:

(a) the IEA's WEO 2019 Sustainable Development Scenario is the most likely future and it forecasts that the seaborne thermal coal market will more than halve by 2040;

(b) global financial institutions are increasingly divesting from coal projects;

(c) cheaper renewable energy technologies will make thermal coal uncompetitive;

(d) flooding the seaborne market with a new supply of thermal coal will lower the value of Australia's existing coal mining businesses; and

(e) the likelihood of stranded assets are creating significant risks for Australia and the local community.

7.40 The Applicant submits that Mr Buckley's and IEEFA's arguments are unpersuasive and not supported by the evidence.

7.41 First, the WEO 2019 is not and never has been a forecast of the likely future (but rather an illustration of different carbon reduction pathways). Mr Buckley offers no evidence to support his belief that the IEA's Sustainable Development Scenario is the most likely future, apart from the collection of announcements of new policy, all of which would already be captured in the IEA's Stated Policies Scenario. The economic forecasting carried out by CRU shows that future demand for coal actually aligns more closely with the IEA's Stated Policies Scenario. The IEA's commentary on the Stated Policies Scenario clearly states that, despite incorporating announced climate change policies, demand for coal is expected to continue to grow as a result of overarching structural trends of population growth, urbanisation and economic growth. As Part C of this submission demonstrates, there is a clear global demand for coal that will not be met by existing mines. Even in the Sustainable Development Scenario, there will be continued demand for coal that will not be met at 2040 by existing mines. Accordingly, any assertion that demand for coal will fall so as to make the Extension Project unviable, is not supported by the evidence.

7.42 Secondly, although some institutions are divesting from coal projects, the WEO 2019 states that financing restrictions for coal projects based on the preferences of lenders and their shareholders is not yet an issue affecting projects in China and India, and that financing restrictions in developed economies could provide an opening for Russian, Indian and Indonesian coal producers to increase their market share.

7.43 Thirdly, there is simply no evidence that the Extension Project would result in a flooding of the seaborne market with a new supply of thermal coal which would lower the value of Australia's existing coal mining businesses. Australian's export coal supply is small relative to global coal production and fluctuations in the supply of Australian coal have relatively little impact on demand (and therefore coal prices). In this regard, see paragraph 6.54 in Part C above. Whitehaven is a large and successful Australian mining company and its views on the economics of its projects should be preferred to those expressed by Mr Buckley.

7.44 Fourthly, in support of their assertion that the Extension Project is at risk of becoming a stranded asset, Mr Buckley and IEEFA proffer a list of policy announcements and new projects in India, Japan and South Korea relating to the uptake of renewable energy. Again, those policy announcements and any trends regarding the uptake of renewable energy are already captured by the Stated Policies Scenario of the WEO 2019, which recognises the increasing share of electricity generated by renewable sources but nevertheless projected a continuing demand (although declining share) for coal-fired power (as set out in Part C of this submission). These projections are supported by CRU's forecasts.

7.45 By including policy announcements only about renewable energy, Mr Buckley's submission is overly selective and does not provide an accurate picture of trends in demand for different sources of energy. Needless to say, energy policies are complex and often include a broad mix of energy-generation technologies. For example, although India seeks to increase electricity from renewable sources (as Mr Buckely has pointed out), India will also double its production of coal by 2040 on the strength of government output targets. Coal India Limited, a state-owned company, remains the largest coal producer in the world by tonnes and India will overtake China by the mid-2020s to become the world's largest coal importer (WEO 2019, pp 220, 225, 226, 240).

7.46 Coal is a commodity and potential future coal prices (taking into account all the factors that may cause fluctuation including competing sources of energy and climate change policy) have already been considered in the Applicant's investment decisions and indeed in the Economic Assessment for the Extension Project at Appendix J to the EIS. That Economic Assessment included a coal price sensitivity analysis to account for potential fluctuations in coal prices, including due to potential future climate change policies.

7.47 In any event, it is for the Applicant to make its own assessment of the economic viability of the Extension Project and then decide whether it wishes to proceed to seek development consent for the Extension Project. The Applicant has undertaken that course of action in lodging the development application for the Extension Project.

7.48 Lastly, it should be noted that the Buckley Submission and the IEEFA Report focus on thermal coal and they do not address demand for metallurgical coal. However, as established in Part C:

(a) the Extension Project's coal product will comprise thermal coal and SSCC at an indicative life of mine ratio of 40:60;

(b) steel will remain an important material for global development, particularly in South East Asia;

(c) 70% of global crude steel is produced through the blast furnace-basic oxygen furnace route which is heavily dependent on coking coal (SSCC and HCC);

(d) global demand for carbon crude steel (crude steel, excluding stainless steel) is expected to grow steadily at a compound annual growth rate of approximately 1% from 2018 to 2040;

(e) the IEA projects that industrial coal use which today accounts for around one-third of coal consumption, increases by some 225 Mtce to 2040 in the Stated Policies Scenario, as coal remains the backbone of steel and cement manufacturing;

(f) the scope to shift away from coal by making greater use of scrap-based or direct reduction of iron (DRI)-based electric arc furnaces is limited by the availability and cost of scrap steel, as well as the cost competitiveness of electricity;

(g) despite the share of steel produced by blast furnace-basic oxygen furnace declining in the long term, as electric arc furnace steelmaking grows, there will continue to be a significant requirement for new iron units from coal produced by blast furnace-basic oxygen furnaces (as opposed to iron from recycled steel which is used in electric arc furnace steelmaking);

(h) given the relatively young age of the installed capacity of blast furnace-basic oxygen furnaces in Asia, much of the future demand for steel is forecast to be met by this existing capacity;

(i) by 2040, the blast furnace-basic oxygen furnace process will still account for approximately 57% of global steel production; and

(j) there is a limit to the amount of HCC that can be used in a coke blend. A coke blend containing approximately 15-20% SSCC is the likely technical, minimum level of SSCC that can be used in highly efficient blast furnaces;

(k) the Extension Project's SSCC is low in sulphur, ash and phosphorus, which makes it one of the most marketable SSCC products globally;

(l) the GHG emissions intensity of steelmaking increases with ash content of the SSCC used; and

(m) given the Extension Project's SSCC's low ash levels compared to the rest of the world, the Scope 3 GHG emissions of the Extension Project's SSCC could be, on average, 13 kg CO_2-e lower per tonne of hot metal produced than other SSCC globally.

Theme 6: the IPC should follow *Rocky Hill* and refuse development consent for the Extension Project

7.49 Opponents of the Extension Project argue that the IPC should follow *Rocky Hill* having regard to the GHG emissions of the Extension Project and in the interest of consistency in administrative decision-making.

7.50 Consistency in administrative decision-making would not require the same outcome for the Extension Project as that which occurred in *Rocky Hill*. For consistency in administrative decision-making to be achieved, like cases need to be treated alike. The Extension Project and the Rocky Hill Coal Project are very different developments. The Rocky Hill Project was proposed to be developed in the Gloucester Valley, close to the town of Gloucester; a location that was considered to be incompatible with other land uses in the vicinity of the development, contrary to cl 12 of the Mining SEPP. The Department of Planning's assessment report recommended that development consent to the Rocky Hill Coal Project be refused. The Court found that the mine would have significant adverse impacts on the visual amenity and rural and scenic character of the valley, significant adverse social impacts on the community and particular demographic groups in the area, and significant impacts on the existing, approved and likely preferred uses of land in the vicinity of the mine. The Court also found that (at [421]):

> although the [Rocky Hill Coal Project] has the potential to generate some positive social benefits, including from the local economy and employment, these benefits will be outweighed by the significant negative social impacts that the Project will cause.

7.51 The purpose of this submission is not to describe all the differences between the Extension Project and the Rocky Hill Coal Project because, in determining the development application for the Extension Project, the IPC is not required to refer to *Rocky Hill*, distinguish *Rocky Hill* on its facts, or otherwise opine that the decision in *Rocky Hill* was wrong.[39] The differences set out in paragraph 7.50 above are not exhaustive. They merely illustrate that the Extension Project is different to the Rocky Hill Coal Project such that following *Rocky Hill* would not achieve consistency in administrative decision-making.

7.52 The IPC is required to consider the merits of the Extension Project itself, taking into consideration the matters set out in s 4.15 of the EP&A Act as are of relevance to the Extension Project. This is the best way to achieve consistency in planning decisions. Indeed, the NSW Court of Appeal has acknowledged that applying ministerial policy, such as the Mining SEPP, is one of the most useful aids in achieving consistency with other decisions in comparable cases.[40]

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[39] *Segal v Waverley Council* (2005) 64 NSWLR 177 at [56].

[40] *Segal v Waverley Council* (2005) 64 NSWLR 177 at [52].

8. **PART E: WEIGHING THE BENEFITS OF THE EXTENSION PROJECT AGAINST GHG EMISSIONS AND CLIMATE CHANGE CONSIDERATIONS**

8.1 The Extension Project has been subject to extensive environmental impact assessment that has been carried out over the course of the last four years, since the Project Description and Preliminary Environmental Assessment for the Extension Project was prepared and finalised in January 2016. The key features of the Extension Project have already been described and assessed elsewhere in documents before the IPC, particularly the Applicant's Environmental Impact Statement, its Submissions Report, Amendment Report and its submission in response to the points of interest raised by the IPC following the public meeting hearing held on 4 and 5 February 2019.

8.2 It is not intended, in this submission, to repeat the impact assessment material that is before the IPC. Rather, in this Part E of the submission, we only provide a brief summary of some of the benefits of the Extension Project that weigh against climate change considerations and, therefore, to assure the IPC that there is more than sufficient material before it to grant development consent to the Extension Project.

More efficient extraction of coal

8.3 Compared to the Approved Project, the Extension Project will maximise recovery and result in a more efficient extraction of ROM coal reserves within the mining tenements, with an additional 33 million tonnes of ROM coal extracted over a life-of-mine that is five years shorter than the Approved Project.

Land use and final landform

8.4 The Extension Project is located in a part of the Gunnedah Basin that has been subject to extensive coal mining operations for more than 30 years. The Extension Project is to be undertaken partly across two existing mine sites (for which the mining tenements are already held by the proponents) and there are other mining operations in the vicinity of the Extension Project, including the Rocglen Coal Mine (see Figure 2 of the Submissions Report). Mining is thus, for the purposes of clause 12 of the *Mining SEPP*, an already existing and approved use in the area where the Extension Project is proposed to be carried out, and is likely to continue to be a preferred land use in that area in the coming decades.

8.5 The EIS for the Extension Project concluded at section 5.1.5 of Annexure 5 that, while other land uses in the vicinity of the Extension Project include the Vickery State Forest and grazing and cropping, the Extension Project is not incompatible with existing, approved or likely preferred land uses in the vicinity of the development, including because there would be no significant impacts on land uses in the vicinity of the Extension Project. Similarly, the Assessment Report stated (at 154) that the Extension Project "could be managed to minimise any potential land use conflicts and meet the aims, objectives and provisions of clause 12" (see also p 13 of the Assessment Report).

8.6 The Extension Project is also an extension (over a shorter 25-year life of mine) of the Approved Project, which would involve open cut mining with annual ROM coal production of 4.5 million tonnes per annum (Mtpa) over a 30 year mine life. ROM coal from the Approved Project is approved to be transported by road to the Whitehaven Coal Handling and Preparation Plant (**CHPP**) located 5 km north-west of Gunnedah.

8.7 Once the Extension Project's CHPP, train load-out and rail spur infrastructure reach full operational capacity, the Extension Project will remove the need for ROM coal to be transported on public roads to be processed at the Whitehaven CHPP.

8.8 As noted in Section 1 of the EIS, parts of the area to be mined by the Extension Project have been disturbed by previous mining activities of:

(a) the former Vickery Coal Mine at which:

(i) a small underground mining operation was carried out from 1986 to 1991;

(ii) approximately 4 million tonnes (Mt) of coal was extracted from three additional open-cut areas from 1991 to 1998

(iii) extraction ceased in 1998; and

(b) the former Canyon Coal Mine, which was operated by Whitehaven between 2000 and 2009.

8.9 Following the cessation of extraction, the former Vickery Coal Mine and the Canyon Coal Mine were rehabilitated, returning disturbed areas to groundcover suitable for grazing and woodland areas. Five final voids and some supporting infrastructure and access roads associated with previous mining remain.

8.10 At the cessation of mining for the Extension Project, one final void would remain in the south-eastern corner of the open cut (in addition to the existing Blue Vale final void). The Extension Project would therefore reduce the number of final voids in comparison to the five final voids in the current landscape and three voids for the Approved Project. The final landform will be a contiguous undulating final landform that seeks to blend with the natural topography of the surrounding land.

Social and economic benefits

8.11 The Extension Project will result in significant social and economic benefits at a local, regional and State level. One of the key benefits of the Extension Project is the economic benefit to the State and region associated with job creation, capital expenditure, ongoing operational expenditure and employee expenditure.

8.12 As noted in the EIS, the Extension Project will provide approximately 450 full-time equivalent positions during peak production (an increase of approximately 200 personnel compared to the Approved Mine), plus additional contract personnel. Over the life of the Extension Project, it is projected to generate an additional approximately 181 full-time equivalent jobs in the region, and approximately 316 full-time equivalent jobs in NSW. The Extension Project may provide for the on-going employment of existing Whitehaven employees working at the Rocglen Coal Mine, which is nearing the end of its approved operational life.

8.13 The Extension Project will also require an additional construction workforce of up to approximately 500 full-time equivalent personnel during the construction phase.

8.14 The Extension Project will contribute an estimated total net economic benefit for the NSW community of approximately $1.16 billion (in net present value terms) with an increase of the net economic benefit to NSW of $454 million compared to the Approved Project. For the local region, the Economic Assessment estimated net economic benefits at $227 million or $203 million in the Project Region or SA3 region, respectively.[41] Importantly, this means that the benefits for both NSW and the local region in net present value terms are estimated to exceed the costs of the Extension Project borne by NSW and the local region.

[41] The Amendment Report p 11 states that there are no changes to employment benefits accrued to the NSW workforce, attributed to salaries and wages (including disposable income, personal income taxes and Medicare contributions); taxation benefits and land taxes/shire rates paid to NSW and local government; net benefits of the Project that would accrue to the local region; and potential economic impacts on agriculture in the local region.

8.15 The Economic Assessment dated August 2018 prepared by AnalytEcon at Appendix J to the EIS incorporated the cost of GHG emissions to NSW (modelling high, low and moderate carbon prices) and included a sensitivity analysis to account for potential fluctuations in coal prices, including due to potential climate change policies. The calculated net value to NSW incorporates this analysis, which means that a significant benefit will accrue to NSW even if coal prices are affected by climate change.

Consequence of not carrying out the Extension Project

8.16 Clause 7(c) of Sch 2 of the *Environmental Planning and Assessment Regulation 2000* (NSW) requires that an environmental impact statement include (underline added):

> an analysis of any feasible alternatives to the carrying out of the development, activity or infrastructure, having regard to its objectives including the consequences of not carrying out the development, activity or infrastructure.

8.17 Alternatives to the Extension Project (including a no-project alternative) were considered in sections 6.1.7 and 6.1.11 of the EIS. The IPC should have regard to that analysis.[42] In particular, if the Extension Project is not approved, Whitehaven would be entitled to carry out the Approved Project with the consequence that the benefits of the Extension Project compared to the Approved Project would be foregone, including:

(a) the additional 33 Mt of ROM coal would not be mined;

(b) the 33 Mt of ROM coal not mined to meet global demand would likely result in a net increase in GHG, sulphur and ash emissions due to market substitution of the Extension Project's high quality coal with inferior quality coal;

(c) approximately 200 additional operational employment opportunities would be foregone and the associated flow on effects would be lost;

(d) an incremental peak of up to 500 direct construction employment opportunities (from 60 for the Approved Project) and associated flow on effects would not be created;]

(e) the opportunity to reduce haul truck movements along public roads associated with transporting ROM coal from the Approved Project and Tarrawonga Mine to the Whitehaven CHPP, and the associated operational efficiency improvement, would not be realised;

(f) additional flow-on net benefits of $454 million compared to the Approved Project would be foregone;

(g) additional tax revenue from the Extension Project would not be generated;

(h) additional royalties to the State of NSW would not be generated;

(i) three final voids would remain in the landscape (five if the Approved Mine was not to proceed) as opposed to two following completion of the Extension Project;

(j) the potential incremental environmental and social impacts described in this EIS for the Extension Project would not occur;

(k) economic and social benefits to the Gunnedah and Narrabri LGAs associated with the Extension Project would not be realised;

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[42] See e.g., *Nessdee Pty Ltd v Orange City Council* [2017] NSWLEC 158, [92]–[121].

(l) the incremental benefits of the Extension Project biodiversity offset strategy and other revegetation areas would not be realised; and

(m) mining will extend beyond 2050, which is NSW's target date for achieving net zero emissions. This would not be the case with the Extension Project.

Conclusion

8.18 As noted in Part A of this submission, it is for the IPC to engage in an "intuitive synthesis" of weighing all of the various positive and negative impacts associated with the Extension Project. Climate change impacts and GHG emissions are just one of many different factors that the IPC may take into account. Certainly, climate change impacts and GHG emissions should not be the single determinative consideration for the IPC in making a decision in respect of the development application for the Extension Project.

8.19 The Applicant considers that, in light of the benefits of the Extension Project summarised above and as detailed elsewhere in the material before the IPC, the positive aspects associated with the Extension Project clearly outweigh the negative aspects associated with the Extension Project, and that the Extension Project should be approved.

8.20 Not proceeding with the Extension Project would result in a failure to realise these significant benefits for the local, regional and State economy, including approximately 450 operational employment positions and $1.16 billion in economic benefits to NSW (in net present value terms).

8.21 The Assessment Report states (at [715]):

> Overall, the Department considers that the GHG emissions for the Project have been adequately considered and that, with the Department's recommended conditions, are acceptable when weighed against the relevant climate change policy framework, objects of the EP&A Act (including the principles of ESD) and socio-economic benefits of the Project.

APPENDIX 1: COMMENTARY ON ROCKY HILL AND WALLARAH 2

Preliminary observations by way of context

1.1 In *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 (***Rocky Hill***), the Court refused consent to the Rocky Hill Coal Project for numerous reasons. In particular, the Court found that the "significant and unacceptable planning, visual and social impacts" of that project warranted refusal for those reasons alone (at [556]). While it was unnecessary for the Court to do so, and did not affect the outcome which the Court had already arrived at, the greenhouse gas (**GHG**) emissions of the Rocky Hill Project and their contribution to climate change was "a further reason for refusal" (at [556]).

1.2 As the IPC would be aware, there has been much commentary in the media about the decision of the Court in *Rocky Hill*. A significant proportion of that commentary has been misleading in reporting the findings of the Court in the case, or exaggerating the implications of the findings made on climate change and GHG emissions in that case for future coal mining projects in NSW and, to a lesser extent, other jurisdictions in Australia.

1.3 Generally speaking, a significant proportion of the media commentary has reflected the following observations about *Rocky Hill*:

(a) the decision sets a new precedent;

(b) the decision is the first time a court in Australia has considered the climate impacts of coal mining and is a landmark case that will set a very high hurdle for any future coal mine to obtain development consent;

(c) the decision will generally be applicable to any new coal mine in Australia; and

(d) a key reason given by the Court for refusing the Rocky Hill Coal Project was the climate change impacts and GHG emissions generated by the project.

1.4 Each of these observations is either wrong, misleading or overstated.

Rocky Hill did not set a new legal precedent

1.5 First, it should be recognised that *Rocky Hill* did <u>not</u> set a new, legal precedent that the IPC is obliged to follow or even consider in determining the development application for the Extension Project.

1.6 This is because *Rocky Hill* was a merit appeal in Class 1 of the Court's jurisdiction. When the Court determines these types of appeals, it exercises a form of administrative decision-making power, rather than judicial power.[43] The role of the Court in a merit appeal is to "stand in the shoes" of the consent authority and exercise the same functions as the consent authority to reach a determination about whether a particular project should, on its merits, be permitted.

1.7 This means that the decision in *Rocky Hill* is equivalent to a decision of a consent authority and therefore does not set any new, legal precedent. As far back as 1960, the courts in NSW have recognised that, in the context of applications made for development consent or planning permission, "each application must be considered on its individual merits and … there is no such thing as binding precedent in these matters".[44]

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[43] *Ku-ring-gai Council v Bunnings Properties Pty Ltd* [2019] NSWCA 28 at [182] per Preston CJ of LEC (Beazley P agreeing). See also Linda Pearson and Peter Williams, 'The New South Wales planning reforms: Undermining external merits review of land-use decision-making?' (2009) 26 EPLJ 19 at 27.

[44] *Shellcove Gardens Pty Ltd v North Sydney Municipal Council* (1960) 6 LGRA 93 at 104 per Sugerman J.

1.8 It follows that the IPC is not obliged to refer to or consider *Rocky Hill*, nor is it obliged to follow any of the Court's findings in *Rocky Hill* in determining the development application for the Extension Project.

1.9 The IPC is, in accordance with law, obliged to consider the development application for the Extension Project on its own individual merits. The IPC is entitled to take a different approach to the issues of climate change and GHG emissions than the Court did in *Rocky Hill*, as the decision in *Wallarah 2* confirms.

1.10 In *Australian Coal Alliance Inc v Wyong Coal Pty Ltd* [2019] NSWLEC 31 (***Wallarah 2***), the NSW Land and Environment Court upheld the Planning Assessment Commission's (**PAC's**) decision (as the Minister for Planning's delegate) to grant development consent to the Wallarah 2 Coal Project. The Court rejected all three grounds of judicial review concerning the PAC's consideration of GHG emissions and climate change.

1.11 The status of *Rocky Hill* can be contrasted with *Wallarah 2*. *Wallarah 2* was a judicial review challenge in Class 4 of the Court's jurisdiction. The Court's role was to exercise judicial power in reviewing the PAC's decision to determine whether any legal error was made by the PAC in approving that project.

1.12 Therefore, *Wallarah 2* constitutes binding legal precedent (established after the judgment in *Rocky Hill* was handed down) in which the Court found that there was no legal error in a consent authority approving a coal mining project that has Scope 3 emissions, even where:

(a) the combustion of its coal was predicted to generate Scope 3 emissions significantly greater (by a factor of 7) than those of the Rocky Hill Coal Project; and

(b) there was no proposal to offset those emissions by way of afforestation of land or otherwise.

1.13 Further, the consent authority, in determining the development application for the Wallarah 2 Coal Project:

(a) considered and applied the concept of market substitution in arriving at its decision to grant development consent;

(b) acknowledged that Scope 3 emissions from the combustion of coal (including any potential to abate those emissions) should be dealt with at the location where those emissions are generated or at higher policy levels; and

(c) in relation to the principle of ESD, the PAC's Determination Report under the heading "intergenerational equity" (extracted at [99] in the judgment), stated:

> The Department acknowledges that coal and other fossil fuel combustion is a known contributor to climate change, which has the potential to impact future generations. However, it also recognises that there remains for the foreseeable future a clear need to continue to mine coal deposits to meet society's basic energy needs. The Department also notes that climate change is a global phenomenon, the project's contribution to climate change would be very small and that WACJV has considered greenhouse gas mitigation measures. The Department also acknowledges that the downstream energy and other socio-economic benefits generated by the amended project would benefit future generations, particularly through the provision of international energy needs.

1.14 This approach did not give rise to any error of law on the part of the PAC.[45]

[45] (see generally [49]-[66] (at [79]) (at [84])

1.15 Even if *Rocky Hill* were legal precedent (which it is not), the findings made by the Court in *Rocky Hill* in relation to climate change and GHG emissions cannot be considered, on any fair reading of the decision, to form the essential reason for refusing development consent.

1.16 The Court's decision makes very clear (at [556]) that the "significant and unacceptable planning, visual and social impacts" were the essential reasons why the Court refused to grant consent to the Rocky Hill Coal Project. The remarks on climate change and GHG emissions were observations that did not form part of the essential reasons for the decision. Because of this, even if *Rocky Hill* were legal precedent (which it is not), only the parts of the judgment that constitute the essential reasons for the decision would be binding.

1.17 Although the Court in *Rocky Hill* engaged in an intuitive synthesis of the relevant factors before reaching a decision, it does not follow that all the factors were weighted equally by the Court in reaching its decision and are therefore all, equally, the essential reasons for the refusal of consent.

Rocky Hill is not the first time an Australian court has considered the impacts of coal mining on climate

1.18 Secondly, in relation to the claim that the decision is the first time a court in Australia has considered the climate impacts of coal mining and is a landmark case that will set a very high hurdle for any future coal mine to obtain development consent, this overstates the position.

1.19 *Rocky Hill* is <u>not</u> the first case to consider climate change issues associated with a new coal mine. Objections to new coal mines on climate change grounds have been relatively common over the past 10 years, and a number of courts throughout Australia have considered these issues previously, including both in the context of merit appeals (like *Rocky Hill*) and judicial review proceedings.

1.20 A non-exhaustive list of examples of Australian cases where climate change impacts have been considered in the context of coal mining projects is produced below:

(a) *Wildlife Preservation Society of Queensland Proserpine/Whitsunday Branch Inc v Minister for the Environment & Heritage* [2006] FCA 736;

(b) *Gray v Minister for Planning and Ors* [2006] NSWLEC 720;

(c) *Anvill Hill Project Watch Association Inc v Minister for the Environment and Water Resources* [2007] FCA 1480;

(d) *Hunter Environment Lobby Inc v Minister for Planning* [2011] NSWLEC 221;

(e) *Hunter Environment Lobby Inc v Minister for Planning (No 2)* [2012] NSWLEC 40;

(f) *Xstrata Coal Queensland Pty Ltd v Friends of the Earth, Brisbane Co-op Ltd & Ors* [2012] QLC 13 (***Xstrata***);

(g) *Hancock Coal Pty Ltd v Kelly & Ors and Department of Environment and Heritage Protection (No 4)* [2014] QLC 12;

(h) *Adani Mining Pty Ltd v Land Services of Coast and Country Inc & Ors* [2015] QLC 48;

(i) *Coast and Country Association of Queensland Inc v Smith* [2016] QCA 242;

(j) *Australian Conservation Foundation Incorporated v Minister for the Environment* [2016] FCA 1042;

(k) *Australian Conservation Foundation Incorporated v Minister for the Environment and Energy* [2017] FCAFC 134;

(l) *New Acland Coal Pty Ltd v Ashman & Ors and Chief Executive, Department of Environment and Heritage Protection (No 4)* [2017] QLC 24;

(m) *Wollar Progress Association Incorporated v Wilpinjong Coal Pty Ltd* [2018] NSWLEC 92; and

(n) *Australian Coal Alliance Incorporated v Wyong Coal Pty Ltd* [2019] NSWLEC 31.

1.21 Some of these cases were referred to by the Court in *Rocky Hill*, and others were not. On the whole, the climate change objections raised by persons in respect of new greenfield coal mines, or expansion of approved coal mines, were unsuccessful, generally because either:

(a) the Court, exercising administrative power in a merit appeal type context, was satisfied, on the evidence before it, that the mine should be approved on the merits and did not consider that the climate change impacts or GHG emissions generated by the mine, or the combustion of the mine's coal by other developments, outweighed the benefits of allowing the mine to proceed; or

(b) the Court, exercising judicial power in a judicial review context, was not satisfied that an approval authority committed an error of law by failing to consider the climate change impacts or GHG emissions generated by the mine, or the combustion of the mine's coal by other developments, when determining to grant approval to the mine. In this regard, *Wallarah 2* is a recent example where a court has rejected a challenge to a decision to grant planning approval to a coal mining project on grounds which, in part, related to an alleged failure of the decision-maker to consider the climate change impacts or GHG emissions generated by a proposed coal mining project, or the combustion of the coal produced by the proposed coal mining project.

Rocky Hill is not applicable to any new coal mine in Australia

1.22 Thirdly, for the reasons already given in relation to the issue of "precedent", it is <u>incorrect</u> to assert that the decision and reasoning in *Rocky Hill* case will be applicable to any new coal mine in Australia. *Rocky Hill* has no legal "precedent" value in NSW, much less so in the context of other Australian jurisdictions.

1.23 For example, the decision in *Rocky Hill* sits uncomfortably with a series of decisions of the Queensland Land Court (as to which, see paragraph 1.20 above) where climate change impacts and GHG emissions were considered but ultimately not found to outweigh the benefits associated with the particular mining project before the Queensland Land Court.

1.24 It would be useful, at this point, to provide a summary of the relevant decisions from the Queensland Land Court that have involved consideration of climate change issues in the context of coal mining proposals.

1.25 The most useful starting point for consideration of the Queensland cases is the decision of President MacDonald in *Xstrata*.

1.26 In that matter, Xstrata Coal (along with two other applicants) had applied for three mining leases and an associated environmental authority in respect of a proposed open cut coal mine near the Wandoan township in the Surat Basin. The role of the Land Court was to conduct a hearing into the applications for the grant of the mining leases and environmental authority and objections made to the grant of those statutory approvals, so as to then make recommendations to the relevant Minister about whether those statutory approvals should be granted and, if so, what conditions should be imposed on the grant of those approvals (at [18]). Thus, the Land Court's task was very much in the nature of a merits hearing, involving the exercise of administrative rather than judicial decision-making power.

1.27 As noted by the President (at [52]), there were two broad categories of objectors: landowners (who generally had private property concerns) and Friends of the Earth (FoE) (who raised concerns about the environmental impacts of the proposed project, including on climate change).

1.28 In relation to climate change, Xstrata (and the other applicants) submitted that (amongst other matters):

(a) a company is not responsible for Scope 3 emissions under either Commonwealth or international law. Rather, Scope 3 emissions are the legal responsibility of others who will account for them as Scope 1 or Scope 2 emissions (at [491]);

(b) emissions from coal sold to a power station for electricity generation will be reported by the power station as part of their Scope 1 emissions (at [497]);

(c) approximately 99% of the project's GHG emissions will be attributable to end-use of the coal for electricity production which will occur predominantly, if not totally, overseas (at [503]); and

(d) the demand for coal for electricity production would exist regardless of the location of the source – i.e. "stopping the project will not affect the amount of coal actually burned globally" (at [503]).

1.29 FoE's submissions in response included the following:

(a) the Court ought to recommend refusal of the project because GHG emissions will result from the project and will contribute to climate change (at [511]); and

(b) while the supply of coal from elsewhere in the world is a relevant consideration, the Court is primarily concerned with assessing the impact of this individual mine, not other mines that are not subject of this application and are not subject to the jurisdiction of the Court (at [512]).

1.30 President MacDonald made numerous findings in relation to climate change factors. Several of those findings were concerned with matters of the correct statutory construction of provisions contained in the relevant Queensland statutes (e.g. finding that Scope 3 emissions are not a relevant consideration under s 269(4)(j) of the *Mineral Resources Act 1989* (Qld) in determining whether to recommend the grant or refusal of a mining lease). Other findings were of a more general nature.

1.31 One of the findings that was of a more general nature concerned the issue of "carbon leakage". As the Court explained in *Rocky Hill* (at [535]):

> [carbon leakage can occur] where, as a result of more stringent climate policies or more stringent application of climate policies in a country, businesses move their production from that country to other countries with less ambitious climate policies or less ambitious application of climate policies, which can lead to a rise in global GHG emissions.

1.32 In *Xstrata*, President MacDonald stated (at [558]) that she was "not persuaded that the GHG impacts justify refusal of the proposal". The President then went on to say the following (underlining added):

[559] In the first place, it is difficult to see from the evidence that this project will cause any relevant impact on the environment. In the *Wildlife Preservation Society* case, Dowsett J said that "[t]he relevant impact must be the difference between the position if the action occurs and the position if it does not". In this case, the applicants say that stopping the project will have a negligible impact on climate change because other coal will be mined elsewhere which will in turn produce the same or higher amounts of emissions when burned. They rely on the evidence of Mr Simes and Mr Stanford, who are experts on the economics of coal markets. In general terms, their opinion was that if the project does not proceed, there will be no impact on global demand for coal because that demand will be satisfied from another source. In other words, stopping the project will have no impact on climate change because it will have no impact on the global demand for coal and therefore no impact on global GHG emissions.

…

[570] … [E]ven on the most favourable interpretation of the FoE's submissions, that is, if it is assumed that it is sufficient to establish a general adverse environmental impact, such as a contribution to increased global warming, the evidence indicates a comparatively minor impact on the environment in terms of its GHG emissions. I do not consider therefore that the extent of the impact of the scope 1 and 2 emissions of the operations has been proved to be such as to warrant refusal of the proposed MLs.

…

[581] The evidence has established that the project will make significant economic contributions on a local, State and Commonwealth level. Although it is not disputed that the project will generate GHG emissions that will contribute to climate change, the evidence was that stopping the project will not result in any, or any substantial difference, in the levels of GHGs in the atmosphere. As previously mentioned, if the project proceeds, the evidence indicated that it will have a comparatively minor impact on the environment in terms of its GHG emissions. Balancing all these factors, I am not persuaded that the FoE's climate change objections justify a refusal of the proposed mining leases on public interest grounds.

…

[603] Most of the evidence led by the FoE centred on GHG emissions from the use of the coal in power stations, ie. scope 3 emissions. In my view, this evidence is irrelevant to the Court's task under the EPA.

[604] The evidence establishes that the project's scope 1 and 2 emissions will contribute to climate change. The FoE contend that this issue should outweigh all other factors to be taken into account in the assessment of the project and that this should lead to a recommendation that the environmental authority be refused. I do not accept that submission. It also follows from what I have said above that I do not consider that the project is unsustainable within the meaning of s.3 of the EPA.

[605] As discussed above in the context of the MRA, the project will make significant economic contributions on a local, State and Commonwealth level which is relevant to a consideration of the public interest … Stopping the project will not result in any, or any substantial, difference in the levels of GHGs in the atmosphere. If the project proceeds, the evidence indicates that it will have a comparatively minor adverse impact on the environment in terms of its GHG emissions. In the circumstances, I do not consider that the climate change issue outweighs all other issues so as to justify a recommendation under the EPA that the EA be refused.

1.33 Thus, in this case, President MacDonald found that Scope 3 emissions were not relevant to the decision-making task before her concerning the mining leases but, if she was wrong in that finding, she accepted the "carbon leakage" argument that the project would not result in any, or any substantial, difference in the levels of GHGs in the atmosphere and that, if she was to refuse the project, it will have no impact on climate change because it will have no impact on the global demand for coal. She ultimately rejected FoE's submission that the Court ought to recommend that the statutory approvals for the project be refused on the basis of its GHG emissions and contributions to climate change.

1.34 The subsequent decision of a different member of the Queensland Land Court in *Hancock Coal Pty Ltd v Kelly & Ors and Department of Environment and Heritage Protection (No 4)* [2014] QLC 12 generally adopted the same approach as President MacDonald in *Xstrata*. In particular, at [221]-[232], Member Smith made the following observations of relevance (underlining added):

> [221] There is no dispute on the evidence that Hancock will mine thermal coal. Thermal coal is used for burning in power stations to cause the generation of electricity. It is also not in contention in this case that the burning of the thermal coal (or, in other words, the Scope 3 emissions) will occur overseas, in Asia, most probably in India or China.
>
> [222] As Hancock put it in its submissions:
>
>> The world has abundant coal resources. The amount of coal combusted in the world, including for the purposes of generating electricity, is driven by demand. That is to say, global supplies exceed demand such that preventing a particular mine from proceeding will not lead to demand not being met. Rather, the demand would be met from another source. To take a simple example, India's coal requirements for electricity generation will not abate merely because it is unable to source that coal from one mine in Australia. That is because, rather than leave its citizens without electricity, India would simply obtain the coal from another source. There was a substantial body of evidence to this effect.
>
> …
>
> [228] Hancock provides forceful submissions on this aspect in their reply submissions filed 23 October 2013 where they say:
>
>> But whatever figure is taken, this evidence which CCAQ itself refers to and therefore accepts as reliable, demonstrates the proposition that there are more than enough globally proven (in the sense of economically recoverable) reserves to supply demand in the event the Alpha mine does not proceed.
>>
>> Rather than address this matter as a relevant fact, CCAQ attempts to dismiss it in other parts of its submissions as "the hypothetical possibility of an alternative mine in a foreign country". CCAQ makes no attempt to meet the proposition. In consequence the evidence is all one way [in favour of Hancock] …
>
> [229] I agree with Hancock's reply submissions. This has the result that, even if both myself and President MacDonald are wrong in our assessment of the proper methods for dealing with climate change under the MRA and the EPA, the evidence [before the Court] would necessarily lead to the conclusion that global Scope 3 emissions will not fall if Alpha does not proceed as the coal will simply be sourced from somewhere else.
>
> [230] Put another way, <u>it is the demand for electricity to the extent that it is met by coal-fired generators that causes the Scope 3 emissions, and the facts as set out in this case clearly show that Alpha is but one of a myriad of suppliers, both local and around the world, who will seek to meet this existing demand</u>.
>
> [231] I can sympathise with the position of the objectors who see GHG emissions rising, and the likely adverse climate change consequences that will flow should nothing be done to alter the course that the world is heading down. I have no reason to doubt the eminent expert evidence that was presented in this case to that effect. However, I must on the evidence of this case determine that it is the demand for coal-fired electricity, and not the supply of coal from coal mines, which is at the heart of the problem.
>
> [232] Clearly, the possibility of dire consequences from climate change is a matter which falls to be addressed by the international community and the Federal Government. Even if it were within the jurisdiction of this Court (which apart from "Public Interest" principles I have found it not to be) then the clear and unambiguous facts of this case show that there will be no reduction of GHGs if the Alpha mine is refused and, indeed, depending on the source of replacement coal, such replacement coal may well, on the evidence, result in an increase in GHG emissions.

1.35 These findings of Member Smith were not disturbed on appeal to either the Supreme Court of Queensland or the Queensland Court of Appeal: see *Coast and Country Association Inc v Smith & Ors* [2016] QCA 242. In particular, Justice Fraser of the Court of Appeal (with whom Justice Morrison agreed) found that Member Smith was entitled, on the evidence before him, to find that, if the proposed mine did not proceed the power stations that would have burned coal from the mine would instead burn the same quantity of coal from other mines and there would be no difference in Scope 3 emissions. Further, the Member was entitled to have regard to that finding in making his decision.

1.36 Member Smith adopted the same approach in his decision in *New Acland Coal Pty Ltd v Ashman & Ors and Chief Executive, Department of Environment and Heritage Protection (No 4)* [2017] QLC 24. At [1091] to [1094], Member Smith relevantly said:

> [1091] Some points in this case are not contentious, just as they were not contentious in *Hancock*. For instance it is not contentious in this case that the burning of thermal coal (or in other words, Scope 3 emissions) will occur predominantly overseas, in Asia. Also, just like in *Hancock*, the science of climate change is not of itself an issue in this matter, although some of the objectors who object on the basis of climate change led evidence as to the global impact of climate change. It is therefore unnecessary for me to consider in any detail the exhibits tendered relating to climate change as a science.
>
> [1092] I accept the joint evidence of Mr Campbell and Mr Williams set out above, as well as the individual evidence of Mr Williams on climate change also set out above. In many respects, the evidence of Mr Williams that, in effect, if the Revised Expansion Project does not proceed New Hope's customers will obtain their coal from another source and that source will likely be of a lower quality than the NAC coal and so potentially greenhouse gas emissions may increase depending upon the country involved and the quality of the coal used for Stage 3 purposes, is telling.
>
> [1093] Having made the above findings of fact, it must follow as a logical consequence that I must accept the submissions of NAC regarding climate change. The law with respect to the considerations to be taken into account by this Court in hearing MRA and EPA climate change objections has clearly been settled by *Hancock* and the various appeals in that case. The facts as found in this case are in effect identical to the facts as I found at first instance in *Hancock*, so it follows that I must reach the same conclusion in this case as I did in *Hancock*.
>
> [1094] The objections in so far as they relate to climate change with respect to both the MRA and the EPA have not been made out.

1.37 Whilst Member Smith's decision in the *New Acland* case was set aside by the Supreme Court of Queensland (see *New Acland Coal Pty Ltd v Smith & Ors* [2018] QSC 88), it is relevant to note that the paragraphs extracted above from the Member's decision were not challenged or doubted by the Supreme Court. Member Smith's decision was set aside on other grounds.

1.38 Thus, the approach taken by the Queensland Land Court to considering the issue of climate change and GHG emissions has been endorsed by both the Supreme Court of Queensland and the Queensland Court of Appeal. One disappointing aspect of the *Rocky Hill* judgment was the absence of any detailed engagement with the Queensland case law, noting that an incomplete and selective reference was made to it at [502] in the Court's decision.

1.39 Even in NSW, it must be acknowledged that the most recent legal precedent on the requirement to consider climate change impacts and GHG emissions is *Wallarah 2*. In the Applicant's submission, that case is instructive to the IPC as to how the issue of climate change and GHG emissions may be addressed by the IPC in determining the development application for the Project.

1.40 In that case, the ACA raised 10 grounds of challenge in the proceedings. Three of these 10 grounds were related to climate change and GHG emissions (i.e. Grounds 1 to 3). Those grounds of challenge, in short, were:

(a) **Ground 1:** the PAC failed to consider the downstream GHG emissions (including Scope 3 emissions) generated by the combustion of the project's coal by other developments when determining to grant development consent for the project or determining whether or not to impose conditions on the development consent for the project to regulate GHG emissions;

(b) **Ground 2:** the PAC failed to consider clause 14(2) of the Mining SEPP (in effect or substance, this was the same allegation that formed Ground 1). Clause 14 of the Mining SEPP relevantly states:

> **14 Natural resource management and environmental management**
>
> (1) Before granting consent for development for the purposes of mining … the consent authority must consider whether or not the consent should be issued subject to conditions aimed at ensuring that the development is undertaken in an environmentally responsible manner, including conditions to ensure the following:
>
> (a) that impacts on significant water resources, including surface and groundwater resources, are avoided, or are minimised to the greatest extent practicable,
>
> (b) that impacts on threatened species and biodiversity, are avoided, or are minimised to the greatest extent practicable,
>
> (c) that greenhouse gas emissions are minimised to the greatest extent practicable.
>
> (2) Without limiting subclause (1), in determining a development application for development for the purposes of mining … the consent authority must consider an assessment of the greenhouse gas emissions (including downstream emissions) of the development, and must do so having regard to any applicable State or national policies, programs or guidelines concerning greenhouse gas emissions.

(c) **Ground 3:** the PAC failed to consider principles of ecologically sustainable development, including the precautionary principle and principle of intergenerational equity, by failing to consider the downstream GHG emissions (including Scope 3 emissions) generated by the combustion of the project's coal by other developments.

1.41 Justice Moore rejected all of Grounds 1 to 3.

1.42 In short, the key observations made by Moore J in addressing, and ultimately rejecting, Grounds 1 to 3 are as follows:

(a) it was common ground that the PAC was required to discharge, as the consent authority, the obligations imposed on it by clause 14(2) of the Mining SEPP (at [31]);

(b) that obligation required the PAC to consider an assessment of GHG emissions including Scope 3 emissions (at [32]);

(c) the proceedings before Chief Judge Preston in *Rocky Hill* were "entirely different in nature" from the proceedings brought before the Court concerning the Wallarah 2 Coal Project (at [36]);

(d) there was much material before the PAC that addressed climate change and GHG emissions, including Scope 3 emissions (see generally [49]-[66]). In particular, the Court identified and discussed the following material of relevance:

> [52] Critical to my consideration of Grounds 1 to 3 pressed by the Applicant, this portion of the PAC's Determination Report then continued saying:

The Commission also acknowledges the greenhouse gas emissions that would be produced from any future burning of the coal extracted, whether it is consumed locally or internationally. It is noted that presently there are alternative coal sources available to the market in the event that this mine does not proceed. Consequently, the downstream use of the coal (and any emissions abatement or capture technologies deployed) will need to be considered at that location.

…

[61] The next relevant document was the Department's Preliminary Assessment Report. The relevant section is reproduced below (Evidence Book, folios 1701 and 1702):

5.7.3 Greenhouse Gas Emissions

The EIS includes an assessment of greenhouse gas (GHG) emissions and potential impacts, undertaken by PAEHolmes.

The Department acknowledges the potential climate change impacts caused by the burning of coal and other fossil fuels to provide the energy needs of various human societies, but does not consider that these in themselves should necessarily preclude the approval of the project. Rather, consideration of potential GHG impacts needs to be balanced, with due consideration given to:

- the project's particular contribution to global warming/climate change
- whether refusing the development application would reduce global GHG emissions;
- the benefits of the project, including job creation and its contribution to the NSW economy;
- the objects of the EP&A Act, including the encouragement of ESD; and
- available GHG impact mitigation measures.

The GHG assessment calculates direct and indirect GHG emissions associated with the project, including 'Scope 1' emissions (ie direct GHG emissions from sources controlled by WACJV), 'Scope 2' emissions (ie indirect emissions associated with the import of electricity for use in the project) and 'Scope 3' emissions (ie other indirect emissions, such as those associated with the downstream combustion of the product coal). The calculated GHG emissions associated with the project are shown in Table 9.

The assessment indicates that the vast majority (97.76%) of the total GHG emissions generated as a consequence of the project are those associated with the downstream burning of the product coal for energy production purposes – ie Scope 3 indirect emissions. The Department is satisfied that the project's contribution to annual global GHG emissions, even when assessed on a full life-cycle basis (ie including downstream GHG emissions) would be very small.

[62] The Preliminary Assessment Report then reproduced a table which was, in effect, a summary of what had been set out in the greenhouse gas scope calculations in the EIS. It then continued:

It must be noted that if the project was not allowed to proceed, the resultant gap in the thermal coal supply would be almost certainly filled by another coal resource, sourced either from elsewhere in NSW, Australia or overseas. In other words, preventing GHG emissions from the project would not result in any decrease in global CO_2 emissions. This point illustrates the reality that the key response to the issue of climate change needs to be made at a national and international policy or strategic planning level, outside and above the project assessment process in NSW.

(e) the ACA was seeking to employ an impermissible "fine-tooth comb" approach to contending that the PAC's reasons for decision (as reflected, non-exhaustively, in its Determination Report) revealed legal error on the basis of a failure to consider climate change and GHG emissions as required by clause 14(2) of the Mining SEPP (at [79]);

(f) there was material before the PAC that addressed Scope 3 emissions either expressly or by necessary implication and, in particular, there were passages from the PAC's Determination Report which were "sufficient to establish that the PAC has had regard [to], as it was obliged to by cl 14(1) and (2) of the Mining SEPP, the question of downstream emissions that will arise from the burning of the coal proposed to be produced from this mine, and that it has considered what conditions were appropriate to consider imposing and then actually impose concerning greenhouse gas emissions" (at [84]);

(g) the existence of this material was considered to be "a complete answer to Grounds 1 and 2" (at [85]);

(h) it did not matter whether or not the text of clause 14(2) of the Mining SEPP was referred to frequently or infrequently. The absence of (repeated) references to clause 14(2) of the Mining SEPP would not invalidate the development consent granted by the PAC if the PAC's Determination Report "has adequately addressed the substance of what would be required to satisfy the terms of the provision despite the fact that it was not expressly referenced. I am satisfied that that is here the case" (at [86]-[87]);

(i) in relation to the ACA's contention that the downstream emissions should have been dealt with in the context of the coal mining development before the PAC, rather than being deferred for consideration in the context of GHG emissions at the location of the burning of the coal proposed to be extracted from the mining development, the Court observed that the material before the PAC supported the finding that the PAC:

> ... did consider the issue of whether or not it was appropriate or possible to apply conditions to this consent dealing with Scope 3 emissions but that the PAC concluded that the appropriate place to deal with such emissions was at the location where they were caused to be emitted by the burning of the coal proposed to be produced by this mine or at the higher policy levels discussed in the earlier extract at [62].

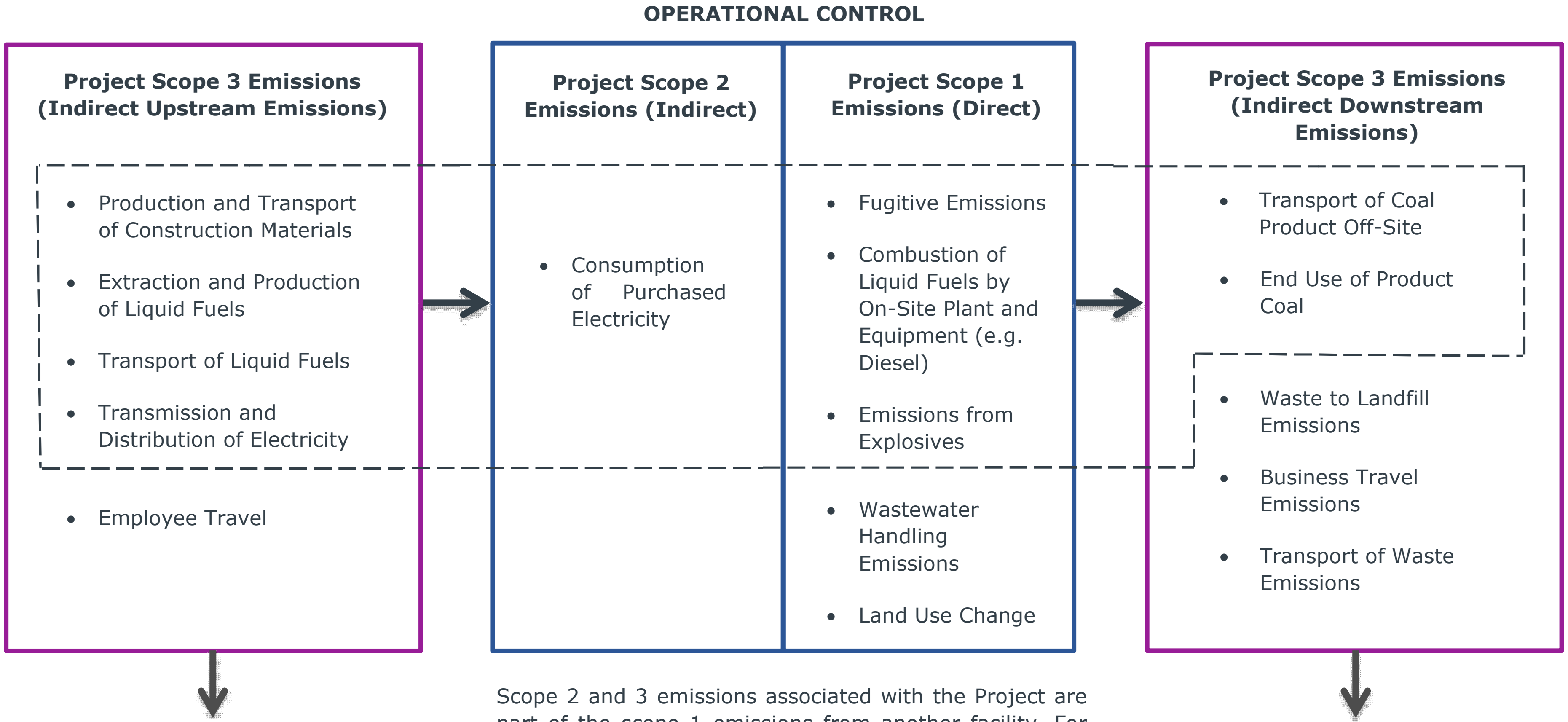
(j) there was, again, material before the PAC (and statements in its reports) which supported the conclusion being reached that principles of ecologically sustainable development (**ESD**) were considered as required by law (at [99]-[105]). In particular, the Court noted the following relevant observations made in the PAC's Determination Report under the heading "intergenerational equity" (extracted at [99] in the judgment):

> The Department acknowledges that coal and other fossil fuel combustion is a known contributor to climate change, which has the potential to impact future generations. However, it also recognises that there remains for the foreseeable future a clear need to continue to mine coal deposits to meet society's basic energy needs. The Department also notes that climate change is a global phenomenon, the project's contribution to climate change would be very small and that WACJV has considered greenhouse gas mitigation measures. The Department also acknowledges that the downstream energy and other socio-economic benefits generated by the amended project would benefit future generations, particularly through the provision of international energy needs.

The climate change impacts and GHG emissions were not a key reason that consent to the Rocky Hill Project was refused

1.43 Fourthly, commentators' statements that the key reason given by the Court for refusing the Rocky Hill Coal Project was the climate change impacts and GHG emissions associated with the Project, is wrong. As already noted, the Court (at [556]) indicated that the "significant and unacceptable planning, visual and social impacts" of the Rocky Hill Coal Project warranted refusal of that project in and of themselves. It was these impacts that were the key reasons for refusing the Rocky Hill Coal Project. Climate change impacts and GHG emissions were cited as a "further reason for refusal", but were certainly not the key reasons why the Rocky Hill Coal Project was refused.

APPENDIX 2: FIGURE SHOWING OPERATIONAL CONTROL THE PROPONENT OF A COAL MINING PROJECT HAS OVER GHG EMISSIONS



These Scope 3 emissions are Scope 1 emissions for the businesses that generate them

Scope 2 and 3 emissions associated with the Project are part of the scope 1 emissions from another facility. For example, a power station burns coal to power its generators and in turn creates electricity. Burning the coal causes greenhouse emissions to be emitted. These gases are attributed to the power station as scope 1 emissions. When the electricity is then transmitted to a mine and used there, the gases emitted as a result of generating the electricity are then attributed to the mine as scope 2 emissions.

These Scope 3 emissions are Scope 1 emissions for the businesses that generate them

Assessment Boundary

APPENDIX 3: DOMESTIC LAWS, POLICIES AND MEASURES OF EXPORT COUNTRIES DIRECTED TOWARDS CLIMATE CHANGE IMPACTS, GHG EMISSIONS AND ACHIEVEMENT OF THE COUNTRY'S NDC

<table>
<tr><th>Country</th><th>Summary</th></tr>
<tr><td>Japan</td><td>
Paris Agreement and NDC
Japan signed the Paris Agreement on 22 April 2016, and ratified it on 8 November 2016. The Paris Agreement entered into force for Japan on 8 December 2016. Japan's first NDC includes an emissions reduction target of 26% below 2013 levels in 2030. This equates to emissions of approximately 1.042 billion tCO_2-e in 2030.
Japan submitted its second/updated NDC on 31 March 2020. That NDC re-affirms Japan's commitment to reducing its greenhouse gas emissions by 26% by 2030 from 2013 levels and states that Japan "will strive to achieve a 'decarbonized society' as close as possible to 2050 with disruptive innovations, such as artificial photosynthesis and other CCUS technologies".
The table below sets out further information relating to Japan's First NDC:
<table>
<tr><td>Emissions reduction target</td><td>Emission reductions of 26% below 2013 levels in 2030.</td></tr>
<tr><td>Total emissions in 2030</td><td>Approximately 1.042 billion tCO_2e in 2030.</td></tr>
<tr><td>Coverage</td><td>100% (economy-wide)</td></tr>
<tr><td>Scope</td><td>All sectors, including:
energy;
industrial processes and product use;
agriculture;
Land Use, Land-Use Change and Forestry (LULUCF); and
waste.</td></tr>
<tr><td>Gases</td><td>CO_2, CH4, N2O, HFCs, PFCs, SF6 and NF3.</td></tr>
<tr><td>Sectoral targets</td><td>Japan has sector-specific emissions reduction targets. Relevantly, Japan's target for:
the industry sector is to reduce emissions from 429 $MtCO_2$ in 2013 to 401 $MtCO_2$ in 2030; and
the energy conversion sector is to reduce emissions from 101 $MtCO_2$ in 2013 to 73 $MtCO_2$ in 2030.
Japan also has a "removals target" for the LULUCF sector, of removing 37 $MtCO_2$ from the atmosphere by 2030. Japan did not provide a base year figure.</td></tr>
</table>
Japan's First NDC sets out a variety of measures to achieve its 2030 emissions reduction target. Relevantly, measures in the energy conversion sector include:

expanding renewable energy introduction to the maximum extent possible;
utilizing nuclear power generation whose safety is confirmed; and
pursuit of high efficiency in thermal power generation, including coal-

</td></tr>
</table>

Country	Summary
	fuelled technologies such as USC, A-USC, integrated gasification and combined cycle, etc. Measures in the industry sector are classified as measures which relate to the iron and steel industry, the chemical industry, the ceramics, stone and clay products industry, factory energy management and cross-sectoral/other. Measures in the iron and steel industry include: • efficiency improvement of electricity-consuming facilities; • increased chemical recycling of waste plastic at steel plants; • introduction of a next-generation coke making process (SCOPE21); • improvement of power generation efficiency; • enhanced energy efficiency and conservation facilities; • introduction of an innovative ironmaking process (Ferro Coke); and • introduction of an environmentally harmonized steelmaking process (COURSE50). Japan's second/updated NDC does not include a detailed set of further measures to meet its commitment but specifically mentions artificial photosynthesis, other CCUs technologies, and hydrogen. **Current policies** Plan for Global Warming Countermeasures The **Plan for Global Warming Countermeasures** was adopted by the Cabinet of Japan on 13 May 2016. The Plan incorporates the emissions reduction target in Japan's NDC of 26% below 2013 levels in 2030. The Plan also sets out strategic actions towards Japan's long-term goal of an 80% reduction by 2050. The base year of this long-term goal is not specified. The Plan incorporates the sectoral targets and measures set out in Japan's NDC (see above). The Plan also emphasises the key role of innovative technology, which the Government is promoting though its "Environmental and Energy Technology Innovation Plan" and its "National Energy and Environment Strategy for Technological Innovation towards 2050". The Plan will be revised every three years as necessary. Long-term Low-Carbon Vision Japan's **Long-term Low-carbon Vision**, published in March 2017, establishes that Japan's long-term goal of reducing emissions by 80% in 2050 will be met through energy efficiency, low-carbon energy supply and a switch to end-use low-carbon energies. This will be achieved through existing technologies and the development and deployment of new technologies. Carbon pricing is highlighted as a key policy direction. Relevantly, Japan's vision refers to CCUS as a means of achieving emission reductions in the energy sector, as well as centralised/distributed energy management. The Vision sets out that "now" is the time to act, and refers to concepts including: • the carbon budget, which is set in accordance with the total amount of cumulative emissions that can be emitted in order to allow Japan to achieve its 2°c target; • the avoidance of "lock-in" through introducing city structures and large-scale facilities; and • key principles of environmental policy including prevention, the precautionary principle and the polluter pays principle. Long-term Strategy under the Paris Agreement

Country	Summary
	The **Long-term Strategy under the Paris Agreement** was adopted by the Cabinet of Japan on 11 June 2019. The Strategy covers the period 2018 to 2050 and outlines the country's intention to reduce its GHG emissions by 80% by 2050. In relation to energy, the Strategy sets out a "future vision" in which renewable energy will become an "economically self-sustained and decarbonised main power source" and in which all options and innovations will be explored, including renewable energy, energy efficiency, storage batteries, hydrogen, and CCUS. Specifically with respect to thermal power, the Strategy states that the Government will: • "work to reduce reliance on coal-fired power generation as much as possible by fadeout inefficient coal-fired thermal power generation" (footnote omitted); • work to reduce CO_2 emissions from thermal power generation, including by accelerating "the efforts of a wide range of stakeholders, aiming to establish its first commercial scale CCU technology by 2023 as a trigger for wider usage in view of full social adoption in 2030 and thereafter." <u>Tax for Climate Change Mitigation</u> Japan implemented a **Tax for Climate Change Mitigation** (a carbon tax) on 1 October 2012. It currently has a value of JPY289/tCO_2e (US$3/$tCO_2e$). The tax covers all fossil fuels, which comprise 68% of Japan's emissions. Revenues earned from the tax are applied to bolstering mitigation activities, such as encouraging energy savings and increasing utilisation of renewable energy. Tokyo also has a cap and trade scheme and Saitama has an emissions trading system - these schemes are bilaterally linked and cover an additional 2% of Japan's emissions. In 2015, Tokyo's cap and trade scheme had reduced emissions by 26% compared to emissions in 2000, and Saitama's ETS had achieved a 27% reduction in emissions below 2005 levels. Both Tokyo’s cap and trade scheme and Saitama’s ETS cover large-scale facilities in all commercial and industrial sectors which consume more than 1,500KL of crude oil equivalent in energy per year. <u>Joint Crediting Mechanism</u> Japan has introduced a Joint Crediting Mechanism (**JCM**), through which Japan will cooperate with developing countries to achieve a reduction in greenhouse gas emissions through the diffusion of low-carbon technologies. The JCM's partnership document has been signed by 17 developing countries. Credits generated from emission reductions under the JCM will be allocated according to agreed terms between the participating countries. <u>Development of CCUS technologies</u> Japan is actively engaged in the **development of CCUS technologies**, including under its **Roadmap for Carbon Recycling Technologies** published 7 June 2019. According to the Global CCS Institute's Global Status Reports of 2018 and 2019, Japan has achieved the following major milestones: • commenced of CO_2 injections at the Tomakomai CCUS facility by Japan CCUS with the Ministry of Economy, Trade and Industry's full support – this is Asia's first full-cycle CCUS hydrogen plant, which will capture more than 300,000 tonnes of CO_2 by 2020. In 2019, it reached a capture milestone of 300,000 tonnes of CO2, and continued intensive monitoring of storages; • retrofitted the Toshiba Corporation 49MW Mikawa power plant in Omuta (Fukuoka Prefecture) to accept biomass (in addition to coal) with a carbon

Country	Summary
	capture facility. Completion is expected in early 2020; • launched JPOWER and Chugoku Electric Power Company's Osaki CoolGen facility, a 166 MW oxygen-blown IGCC (integrated gasification combined cycle) plant in Osakikamijima (Hiroshima Prefecture), which will separate and capture CO_2 from the end of 2019; • completed construction of Toshiba's carbon capture and utilisation system at the Saga City Waste Incineration Plant (on Japan's Kyushu Island), using captured CO_2 for algae culture; and • commencement of construction of the gasifier for the Hydrogen Energy Supply Chain project that plans to gasify Australian brown coal in Victoria's Latrobe Valley and transport it by ship to Japan for future decarbonised hydrogen developments. This project being developed by Kawasaki Heavy Industries (KHI), Electric Power Development Co. (J-Power), Iwatani Corporation, Marubeni Corporation, Sumitomo Corporation and AGL, with the support of the Governments of Japan, Australia and the State of Victoria. First hydrogen production is expected by 2021.
South Korea	**Paris Agreement and NDC** South Korea signed the Paris Agreement on 22 April 2016, and ratified it on 3 November 2016. The Paris Agreement entered into force for South Korea on 3 December 2016. South Korea's NDC has proposes an economy-wide target to reduce GHG emissions by 37% below BAU emissions of 850.6 $MtCO_2e$/year in 2030. The table below sets out key information relating to South Korea's NDC: **Emissions reduction target**: 37% below BAU by 2030. BAU emissions in 2030 are projected at 850.6 MtCO2e. **Coverage**: Economy-wide **Scope**: 100% (economy-wide) **Scope**: Energy, industrial processes and product use, agriculture and waste (A decision on whether to include land use, land-use change and forestry (LULUCF) will be made at a later stage.) **Gases**: CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 South Korea's NDC indicated that it would subsequently develop a detailed plan to implement its mitigation target. To this end, South Korea released a revised roadmap for achieving the 2030 National Greenhouse Gas Reduction Goal in July 2018 (the **Roadmap**). The Roadmap sets out sectoral targets, including: • emission reductions of 24 million tons in the energy conversion sector (power generation, group energy) through policies to reduce fine dust and promote the use of eco-friendly energy. The sector will create a detailed plan to reduce another 34 million tons before submitting the revised NDC in 2020 by establishing a third basic energy plan, revising the energy tax framework, and enhancing the dispatch of environmental power; and • emission reductions of 99 million tons in the industry sector through the revision of industrial processes, energy use reduction, and sharing of emission reductions technologies.

Country	Summary
	The Roadmap indicates that South Korea intends to achieve a 32.5% reduction on BAU emissions domestically, and the remaining 4.5% through international market mechanisms. **Current Policies** Act on the Allocation and Trading of Greenhouse Gas Emission Permits South Korea enacted the **Act on the Allocation and Trading of Greenhouse Gas Emission Permits** in 2012, and launched an ETS on 1 January 2015. It currently has a price of approximately US\$20/tCO_2e. The ETS covers 68% of Korea's emissions, including emissions from the industry, power, aviation, building and waste sectors. Liable emitters comprise companies and factories in the relevant sectors which produce over 125,000 tons of CO_2 per year and 25,000 tons of CO_2 per year (respectively). This represents approximately 600 companies, including 5 domestic airlines. During the first phase of the scheme (2015-2017), only domestic offset credits could be used for compliance. CERs generated from domestic CDM projects and credits from domestically certified projects (Korean Offset Credits) were allowed. These credits had to be converted to Korean Credit Units (KCUs) before being used for compliance. Offsets could only be used for up to 10% of each entity's compliance obligation. During the second phase of the scheme (2018-2020), CERs generated from international CDM projects developed by domestic companies can be used for compliance (up to 5% of each entity's emission volume). During the third phase of the scheme (2021-2025), credits of up to 10% of each entity's compliance obligation with a maximum of 5% coming from international offsets will be allowed. Framework Act on Low Carbon Green Growth South Korea enacted a **Framework Act on Low Carbon Green Growth** on 6 June 2016. Article 25 of the Act incorporates the 2030 emissions reduction target in South Korea's NDC. Article 4 of the Act requires the Government to establish a five-year National Strategy for Low Carbon Green Growth every five years. Article 39 of the Act requires the Government to gradually reduce the use of fossil fuels such as petroleum and coal. Third Energy Master Plan In June 2019, the government announced its **Third Energy Master Plan** which aims to increase the share of renewable energy to 20% by 2030 and 30 to 35% by 2040. Eighth Plan for Electricity Supply and Demand In December 2017, the government released its **Eighth Plan for Electricity Supply and Demand** which sets targets for increased electricity supply from renewables and natural gas, and decreases supply from coal and nuclear. The Plan sets an objective of 20% share of electricity production obtained from renewables by 2030, while natural gas would reach 18.8%, and both coal and nuclear decreasing to 36.1% and 23.9% respectively. These targets are intended to be achieved through the addition of 4.3GW in new LNG and pumped-storage hydroelectric generation facilities and an increase in the installed capacity of renewable energy (to be comprised mainly of wind and solar projects) from 11.3GW to 58.5GW, by 2030.
Taiwan	**Paris Agreement and NDC** Taiwan is not a party to the UNFCCC or the Paris Agreement. Nevertheless, Taiwan's Cabinet put forward an Intended Nationally Determined Contribution

Country	Summary
	(**INDC**) on 17 September 2015. Taiwan's INDC has an emissions reduction target of 50% from the BAU level by 2030. The BAU level is 428 $MtCO_2e$ and the 2030 target is 214 $MtCO_2$-e by 2030. The table below sets out key information relating to Taiwan's INDC:

Emissions reduction target	Emission reductions of 50% below BAU levels by 2030.
Total emissions in 2030	Approximately 214 $MtCO_2e$ in 2030.
Coverage	Economy-wide
Scope	All sectors, including: ▪ energy; ▪ industrial processes and product use; ▪ agriculture; ▪ Land Use, Land-Use Change and Forestry (LULUCF); and ▪ waste.
Gases	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3.

Taiwan's INDC sets out measures for achieving sectoral mitigation measures. Relevantly, in relation to energy, the government will:

- reduce energy demand by introducing energy conservation measures;
- raise the renewable energy development target to 17,250MW in 2030;
- continue to phase out nuclear power plants;
- increase the use of natural gas;
- replace old power plants with the "best feasible technology";
- promote the construction of smart grids; and
- use low-carbon fuel and energy-efficient technologies in the refining sector.

Emissions reductions will be achieved in the industrial sector through:

- industrial structure adjustment;
- technical advice service of energy conservation and carbon reduction;
- integrated utilization of energy and resources in industrial zones;
- regulation of energy efficiency standards;
- alternative fuels;
- heat recovery; and
- a renewal of facilities.

Current policies

Greenhouse Gas Reduction and Management Act 2015

Taiwan enacted its Greenhouse Gas Reduction and Management Act on 1 July 2015. Key features of the Act are:

- Article 4 of the Act sets a goal to reduce GHG emissions to no more than

Country	Summary
	50% of 2005 emissions by 2050; • Article 5(1) requires the Government to draft mid- to long-term strategies for gradually reducing dependence on fossil fuels, with a mid-to long-term aim of improving renewable energy policies, and the gradual realization of a nuclear-free homeland; • Article 5(3)-(4) recommends that the Government implement tax mechanisms on imported fossil fuels based on their CO_2-e emissions, and actively help traditional industries achieve energy conservation and carbon reduction or transition, develop green technology and green industry, create new employment opportunities and green economies, and promote a low-carbon, green growth plan for Taiwan's infrastructure; • Article 8 requires relevant government agencies to promote GHG reduction and climate change adaptation through, relevantly, development of renewable energy and energy technology, reduction in GHG emissions by industrial sectors, establishment of GHG cap-and-trade scheme and facilitation of international emission reduction cooperation mechanism, and research, development and implementation of GHG reduction technologies; and • Article 18 requires Taiwan's Environmental Protection Administration (EPA) to implement a domestic cap and trade scheme, and Article 20 outlines matters to be considered in the development of the scheme, including trade intensities of various sectors, avoiding carbon leakage and overall national competitiveness. <u>National Climate Change Action Guideline/GHG Reduction Action Plan</u> The Act also required the Government to develop the **National Climate Change Action Guideline** (which was approved on 23 February 2017) and a **GHG Reduction Action Plan**.[46] The National Climate Change Action Guideline is to include periodic regulatory goals, implementation timetables, implementation strategies and an evaluation mechanism.[47] Under the GHG Reduction Action Plan, the authorities responsible for the Taiwan's energy, manufacturing, transportation, residential, commercial, and agriculture sectors are required to formulate GHG Emission Control Action Programs. These Action Programs must include GHG emissions targets, timetables and economic incentive measures. These Action Programs are to be regularly reviewed and revised and are to propose improvement plans if sectors are failing to meet their emission targets. Multiple subsidiary regulations have been introduced, including the: • Regulations Governing Incentives for Landfill Sites to Reduce Greenhouse Gas Emissions (announced 25 December 2015). • Regulations Governing Greenhouse Gases Offset Program Management (announced 31 December 2015). • Management Regulations Governing Greenhouse Gas Emission Inventories and Registration (announce 5 January 2016). • Greenhouse Gas Reduction and Management Enforcement Rules (announced 6 January 2016). • First Batch of Emission Sources Required to Report Greenhouse Gas

[46] Taiwan, *Greenhouse Gas Reduction and Management Act*, Article 9.

[47] Taiwan, *Greenhouse Gas Reduction and Management Act*, Article 9.

Country	Summary
	Emission Inventory and Registration (announced 7 January 2016). • Greenhouse Gas Management Fund Revenues and Expenditures, Safekeeping, and Utilization Regulations (announced 30 January 2016). Annual Emission Reports Since 1 January 2012, Taiwan's EPA has been, in batches, requesting major enterprises to submit annual emission reports. As of the end of 2015, the EPA had added 269 firms to the list, and the reporting rate has been 100%. These enterprises account for approximately 80% of CO_2 emissions from industry and fossil-fuel energy generation in Taiwan. National CCUS Strategic Alliance Taiwan's EPA established a national CCUS strategic alliance in 2011. This alliance brings together domestic experts from government, academia and industry, for the purpose of developing the technology and regulatory framework required for the commercial use of CCUS technology, with the ultimate goal of achieving widespread use of CCUS technology by 2020. Through the alliance, the Taiwan Cement Corporation (in partnership with the Industrial Technology Research Institute) commissioned the world's first CCUS pilot project in the cement industry in 2013, with the two entities agreeing in 2016 to extend their cooperation on the project. Renewable Energy Development Act Taiwan introduced a **Renewable Energy Development Act** in 2009, which encourages renewable energy use and promotes energy diversification.

APPENDIX 4: CRU'S SUMMARY LETTER

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16th June 2020

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VICKERY EXTENSION PROJECT – INDEPENDENT STUDY ON COAL MARKET SUBSTITUTION AND CARBON LEAKAGE

Dear Mr Brennan,

Vickery Coal Pty Ltd ("VCPL"), a subsidiary of Whitehaven Coal Ltd ("Whitehaven") proposes to extend the Vickery approved coal mine (life of mine, “LOM”, up to 4.5 Mtpa over 30 years). The proposed Vickery Extension Project aims to produce a LOM average of 6.7 Mtpa over 25 years. The development application for the Extension Project is currently subject to an assessment process under the Environmental Planning and Assessment Act 1979 (“EP&A Act”).

CRU Consulting ("CRU") has prepared a report in response to a request from Ashurst Australia, on behalf of VCPL and Whitehaven, to carry out an independent study on coal market substitution and carbon leakage over the long term ("CRU Report").

The purpose of this letter is to provide a summary of the main findings we have made in the CRU Report. This letter is permitted to be shared with the New South Wales Independent Planning Commission (“IPC”) and placed in the public domain.

We note that, for reasons relating to intellectual property protection, we are not prepared to grant permission for the CRU Report to be placed in the public domain. However, CRU is prepared to grant Ashurst Australia, VCPL and Whitehaven permission to disclose this report to the IPC if the IPC makes a direction under Clause 5 of Schedule 2 to the EP&A Act, that the CRU Report is to be treated as a confidential document that is not to be published.

Structure of the CRU Report

The study conducted by CRU comprised **six** main components:

(Unless otherwise stated, long term forecasts are provided to 2040; cost comparisons are provided for 2027 – the expected first year of full production).

1. **Thermal coal: long term demand**

CRU's forecast of the long term demand for thermal coal to 2040, key drivers of trends, and a comparison of CRU's demand forecasts with the Current Policies Scenario, Stated Policies Scenario and Sustainable Development Scenario of the International Energy Agency's ("IEA") World Energy Outlook 2019 ("WEO 2019"). This component also includes an overview of the main end uses of thermal coal.

2. **Thermal coal: long term supply**

CRU’s forecast for long term seaborne thermal coal supply to 2040 and the links to seaborne demand; the Extension Project’s position (including quality) in relation to the global market.

3. **Steelmaking coal: long term demand**

CRU's forecast of the long term demand for steelmaking coal to 2040, with a focus on semi-soft coking coal (“SSCC”) which will be produced by the Extension Project. This includes an analysis of existing steelmaking technologies and the potential for alternative technologies in the future.

4. **Steelmaking coal: long term supply**

CRU’s forecast for long term seaborne SSCC supply to 2040 and the links to seaborne demand; the Extension Project’s position (including quality) in relation to the global market.

5. **Cost competitiveness of the Vickery Extension**

CRU's analysis of the cost competitiveness of the Extension Project and other competing supply sources in 2027, for both thermal coal and SSCC.

6. **Carbon leakage and scenario analysis**

An assessment of three coal supply substitution scenarios and their impact on greenhouse gas ("GHG") emissions:

a. **Scenario 1:** Vickery Extension is not approved, and Vickery approved mine does not go ahead.
b. **Scenario 2:** Vickery Extension is not approved, but Vickery approved mine goes ahead.
c. **Scenario 3:** No new Australian projects enter production in the 2019-30 period.

Summary of key findings of CRU Report

In relation to the **First Component: thermal coal long term demand**, the main findings made by CRU were:

1. Long term thermal coal demand to 2040 was modelled using a top-down approach incorporating primary energy demand, including the share of primary energy demand for electricity versus other sources of energy, and the share of electricity generation from thermal coal-fired generation compared to other electricity-generating technologies;
2. Primary energy demand growth is projected to continue over the medium and longer term (1.1% compound annual growth rate “CAGR” to 2040), as a result of population growth, industrialisation and economic development. India and Southeast Asia will be the biggest contributors to this growth in demand;
3. Electricity's share of primary energy demand is expected to rise from 15.6% in 2018 to 18.4% in 2040. China will be the largest driver as rural areas are electrified and the whole economy shifts to a greater reliance on electricity;
4. Coal accounted for 38% of total power generation in 2018. It will continue to be a critical part of the global energy system but its share will fall to 24% in 2040. Developed regions, in particular, will shift away from coal-fired generation to reduce carbon emissions and as the levelized cost of electricity from renewables falls;
5. Although subject to downside risks to demand forecasts arising from policy response and technological innovation, CRU actively seeks to appraise the implications and forecasts that total thermal coal demand is expected to remain relatively flat between 2019 and 2040, with a CAGR of -0.4% over the period. Electricity's increasing share of primary energy demand almost entirely offsets the decline in coal’s share of electricity generation. Our view of long term thermal coal demand is largely consistent with the IEA's Stated Policies Scenario (“STEPS”) in the WEO 2019.

In relation to the **Second Component: thermal coal long term supply**, the main findings made by CRU were:

1. In line with total thermal coal demand, global seaborne demand is forecast to fall by -0.3% CAGR (-67 Mt) during 2018-40. Significant declines in demand are expected from Japan, South Korea and Taiwan (“JKT”), China and Europe through the shift to non-coal generation; significant growth in Southeast Asia and India will not completely offset this;
2. Seaborne supply is expected to decline by 180 Mt between 2018 and 2040 due to mine depletion and a lack of recent investment in new projects. Most notably, seaborne supply is expected to decline by more than 200 Mt in Indonesia, as domestic demand is expected to rise considerably;

3. Based on the current global supply landscape, new projects will be required in the long term to satisfy demand – these will most likely come from high quality producers, such as Australia and Russia;
4. The Extension Project would account for ~0.3% of global thermal coal seaborne supply in 2027 and 1.3% of expected Australian seaborne supply in 2027.
5. Understanding the quality of the Extension Project's coal, relative to alternative markets and projects, is key for assessing the potential environmental impacts of any supply substitution arising from a given investment decision;
    a. It is important to understand the calorific value ("CV") of coal, from both the Extension Project and competing supply sources, as this will determine how much coal will need to be mined from different regions to replace a given weight of the Extension Project's coal;
    b. The CV of the Extension Project's thermal coal is 9% above the 6,000 kcal/kg benchmark (historically, coal of this quality has been the most traded globally, and therefore provides the most liquid market prices, suitable for use as the benchmark);
    c. The CV of the Extension Project's thermal coal is higher than the country average of Australia and other major seaborne thermal coal suppliers such as Indonesia, Russia, South Africa, Colombia and the United States;
    d. The ash content of the Extension Project's thermal coal is lower than the Australian average, as well as other major seaborne exporters, Russia and South Africa, although slightly higher than Colombia and Indonesia. Ash is the non-combustible residue left after coal is burnt; it is a key driver of costs as it impacts power plant maintenance costs via equipment wear and ash-handling requirements;
    e. The sulphur content is also competitive, at the lower end of the range of major seaborne exporters – only Russia has a lower average. Sulphur content impacts the level of atmospheric oxides that are emitted (a local air pollutant and contributor to acid rain);
    f. The Extension Project's thermal coal, as a result of its high CV and low ash content, performs at a higher level of boiler efficiency, when burned at power stations, compared to competing coal supply sources.

In relation to the **Third Component: steelmaking coal long term demand**, the main findings made by CRU were:

1. Demand for steelmaking coal (hard coking coal (“HCC”) and semi-soft coking coal ("SSCC") combined) is driven by steel demand trends and the choice of steelmaking technology. Currently around 70% of

steel globally is produced via the blast furnace-basic oxygen furnace (“BF-BOF”) route, with the remainder from non-coal consuming technologies such as the scrap-electric arc furnace (“scrap-EAF”) or natural gas-direct reduced iron-EAF (“NG-DRI-EAF”) routes;

2. Metallurgical coals are essential inputs for the production of 70% of all steel globally using BF-BOF technology. HCC and SSCC are used together to produce coke, which is the primary source of carbon in steelmaking. The proportion of each coal used in the coking process is determined by various factors, including price, blast furnace requirements and the specific characteristics and qualities of the coal. One of SSCC's key contributions to the coke blend is its lower impurities such as ash and sulphur, as well as being lower cost compared to HCC;
3. Carbon crude steel (crude steel, excluding stainless) demand is expected to grow steadily at 1.0% CAGR from 2018 to 2040, driven by economic development and rising steel intensity per capita in the developing economies, particularly India and Southeast Asia. With an increasing focus on lowering emissions and with rising scrap availability in developed economies (including China), there will be a greater preference for scrap-EAF steelmaking in the future. As a result, the BF-BOF share will fall to 57% in 2040;
4. Demand for steelmaking coal is forecast to fall from 983 Mt in 2018 to 790 Mt in 2040 (-193 Mt), driven by falling BF-BOF steel production. SSCC demand will account for 88% (169 Mt) of the decline in demand because of the increasing share of HCC, which has superior coke strength after reduction (“CSR”), and changing coke requirements for steelmaking;
5. However, BFs cannot run using only HCC. BFs require a blend of coking coals, which means that SSCC's important role in steel production will continue into the future. There is evidence that a coke blend containing approximately 15-20% SSCC is the likely technical, minimum level of SSCC within highly efficient coke making facilities running under best practice operating procedures;
6. Other than the existing steelmaking technologies that do not require coal (scrap-EAF or NG-DRI-EAF routes), research is ongoing into the possibility of fossil fuel free steelmaking via a hydrogen-DRI-EAF route with renewable energy used to produce electricity. Technology is under development, funded by a number of major steel producers, but this is still on a very small scale and at very high cost compared to commercial requirements;
7. Based on the current stage of development, we do not expect widespread adoption of hydrogen-DRI-EAF technology until the late 2030s at the earliest. Existing EAF technology will gain share in the long term, but the BF-BOF route will still dominate to 2040, supporting the demand for steelmaking coal (including SSCC).

In relation to the **Fourth Component: steelmaking coal long term supply**, the main findings made by CRU were:

1. Australia, Mongolia and Canada are expected to be the largest contributors to growing seaborne SSCC supply in the long term to 2040 (partially offsetting declines in China). Along with Indonesia and Russia, these countries account for 95% of global seaborne supply;
2. Australia is expected to contribute around 16 Mtpa of new production between 2018 and 2030, with new projects in Queensland and New South Wales. The Tavan Tolgoi expansion in Mongolia will grow by almost 9 Mt and there are a number of greenfield Canadian projects expected to come online over this period. Beyond 2030, we expect seaborne supply from Australia and Mongolia to decline as various operations reach the end of their mine lives.
3. The Vickery Extension Project will account for ~5.7% of global SSCC seaborne supply and ~10.5% of expected Australian seaborne supply in 2027;
4. Understanding the quality of the Project's coal, relative to alternative markets and projects, is key for assessing the marketability of the product;
    a. The Extension Project's SSCC has a lower ash content than all of the major exporting countries, except Canada;
    b. The sulphur content of the Extension Project's SSCC at 0.4% is also near the bottom end globally and lower than the average sulphur content of Australian SSCC;
    c. The phosphorus content of the Extension Project's SSCC at 0.003% is lower than the average of Australia and all other major seaborne SSCC suppliers.

These qualities make the Extension Project's SSCC one of the most marketable SSCC products globally;

5. Ash and CSR are the two key quality attributes of metallurgical coals that have the greatest impact on BF productivity and, consequently, the GHG emissions intensity of steel production. Given the Extension Project's SSCC's low ash levels compared to the rest of the world, CO2 emissions could be reduced by 13kg per tonne (of hot metal produced (compared to the average emissions intensity inferred from ash content of SSCC globally) if the Extension Project's coal were used as the only SSCC within the coke blend. The measurement of CSR for SSCC is less important than in the HCC segment because SSCC is generally used in coking coal blends for attributes outside of CSR. For this reason an analysis of the Extension Project's SSCC's CSR has not been performed at this stage.

In relation to the **Fifth Component: cost competitiveness of the Vickery Extension**, the main findings made by CRU were:

1. Coal is not a standardised homogeneous commodity, as the quality produced by different mines varies considerably. This is a critically important factor to recognise when comparing both the costs of production of different mines as well as the environmental consequences of its production and use;
2. CRU's proprietary methodology – the Value Based Costing (VBC)™ system – takes differences in quality and their impacts on producers (and, indirectly, consumers) of coal into account in analysing the business performance and competitive position of individual production facilities in the extractive industries. A core principle of the VBC is that each commodity market has a benchmark price and the costs of all production facilities are compared against this benchmark. In the case of coal, the key 'benchmarks' are 6,000 kcal/kg CV for thermal coal and premium HCC grade for coking coal;
3. In order to allow for a 'like for like' value comparison with CRU's Business Cost curve, the Extension Project's Business Cost incorporates a negative adjustment (premium) of US$ -13.55/t, because its thermal coal product is of higher quality than the benchmark. Compared to other global thermal coal producers, the Extension Project has a low Business Cost, positioned in the lower first quartile (4^{th} percentile) of the 2027 cost curve (2027 being the expected first year of full production);
4. The Extension Project's cost of SSCC is presented on the global metallurgical coal (total production of HCC, SSCC and pulverized coal for injection ("PCI") Business Cost Curve. Compared to other metallurgical coal producers, the Extension Project is medium to high cost, in the third quartile (60^{th} percentile) of the 2027 cost curve.

In relation to the **Sixth Component: carbon leakage and scenario analysis**, the main findings made by CRU were:

1. The Extension Project will produce approximately 150 Mt of saleable coal, comprising thermal coal and SSCC. The indicative life-of-mine average proportion of thermal coal to SSCC will be 40:60. However, given its high energy content, SSCC can be used as premium quality thermal coal. At times during the life of mine, the prevailing price differentials between SSCC and thermal coal can drive SSCC into the premium quality thermal coal market for power generation. For the purpose of analysing coal supply substitution, we have treated the Extension Project as producing a single thermal coal product;
2. In order to measure the GHG emissions associated with the coal value chain, CRU uses definitions consistent with the GHG Protocol Corporate Accounting and Reporting Standard:
    a. In relation to Scope 1 (direct) emissions, comparison with other coal sources requires a low and high case value for fugitive emission rates; fuel use has also been included;

b. In relation to Scope 2 (indirect) emissions, Australian coal mining consumes less power compared to many other regions;

c. In relation to Scope 3 (indirect) emissions, this focusses on the downstream impacts of coal substitution from the alternate countries.

3. Scenarios (*the lower and upper range of emissions from the low/high case for Scenarios 1 & 2 is due to coal substitution in a number of alternative supply countries)*:

a. In **Scenario 1** (neither the approved Vickery project nor the Vickery Extension Project go ahead), non-Australian alternative supply is expected to release an additional amount of between **14.0 to 64.8 Mt** CO_2-e (low fugitive emissions case) and **20.1 to 120.4 Mt** CO_2-e (high fugitive emissions case) into the atmosphere over the **LOM of Vickery Extension** (Scope 1, 2 and 3 combined), compared to the case where Vickery Extension is approved;

b. In **Scenario 2** (Vickery goes ahead, but Vickery Extension not approved), non-Australian alternative supply is expected to release an additional amount of approximately **5.7 to 26.7 Mt** CO_2-e (low fugitive emissions case) and **8.2 to 49.7 Mt** CO_2-e (high fugitive emissions case) into the atmosphere over the **LOM of Vickery Extension** (Scope 1, 2 and 3 combined), compared to the case where Vickery Extension is approved;

c. In **Scenario 3** (no further Australian supply approved), non-Australian alternative supply is expected to release an additional amount of approximately **68.6 Mt** CO_2-e (low fugitive emissions case) and **124.1 Mt** CO_2-e (high fugitive emissions case) into the atmosphere over the **2019-30** period (not LOM for Scenario 3).

4. The environmental impacts of substituting the supply shortfall from the Extension Project's coal with alternative supply sources would be **adverse**, because Australian coal (including the Extension Project's thermal coal) is high quality, in calorific terms, and low in negative attributes, such as ash and sulphur. This means that substitution by other coal supply sources is likely to result in more physical coal being mined and combusted to meet the same power needs, resulting in higher Scope 3 emissions and concentrations of ash and sulphur globally. Moreover, the direct emissions (Scope 1 and 2) of these alternative supply sources are also likely to be higher, largely due to favourable geology and highly efficient production processes and technologies commonly employed in the Australian mining industry.

5. The impacts of these scenarios on Scope 1, 2 and 3 emissions, as well as total emissions, are detailed in Table 1. Overall, these results confirm the **material increase in total GHG emissions** that is likely to arise from lower investments in the Australian coal industry.

Table 1: Summary of scenarios

Scenario 1:	**LOM GHG emissions, million tonnes CO_2-e**				
	Scope 1 & 2	**Scope 1 & 2**	**Scope 3**	**Total emissions**	
Fugitive Emissions	*Low case*	*High case*	*n/a*	*Low case*	*High case*
Vickery Extension	2	2	393	395	395
Alternative suppliers	6-44	11-100	401-418	409-460	415-515
*Additional emissions**				14-65	20-120

Scenario 2:	**LOM GHG emissions, million tonnes CO2-e**				
	Scope 1 & 2	**Scope 1 & 2**	**Scope 3**	**Total emissions**	
Fugitive Emissions	*Low case*	*High case*	*n/a*	*Low case*	*High case*
Vickery Extension	1	1	162	163	163
Alternative suppliers	2-18	5-41	166-173	169-190	172-213
*Additional emissions**				6-27	8-50

Scenario 3:	**2019-30 GHG emissions, million tonnes CO_2-e**				
	Scope 1 & 2	**Scope 1 & 2**	**Scope 3**	**Total emissions**	
Fugitive Emissions	*Low case*	*High case*	*n/a*	*Low case*	*High case*
Australia shortfall	16	28	711	727	740
Total alternative suppliers	56	124	740	796	864
*Additional emissions**				69	124

Note: * Additional emissions calculated from difference between Vickery Extension & alternative suppliers.
Rounded numbers - totals may not align with total of emission ranges. Scenario 1 & 2 over LOM, Scenario 3 for 2019-30.
The lower and upper range of emissions from the low/high case for Scenarios 1 & 2 is due to coal substitution in a number of alternative supply countries.

If you wish to discuss any aspect of this letter, or require further information, please do not hesitate to contact me.

Yours sincerely,

s. 47F(1)

Alex Tonks
Head of CRU Australia & New Zealand

APPENDIX 5: WHITEHAVEN'S CORPORATE INITIATIVES CONCERNING GHG EMISSIONS (INCLUDING SUPPORT OF HELE AND CCUS)

Overview

The deployment of a range of low emission technologies will be critical to achieving significant carbon emission reductions and the transition to a low carbon economy including the goals of the *Paris Agreement*.

Whitehaven participates in a number of organisations that support the development and demonstration of low emission technologies.They include the following:

Member of Australian Coal Association Research Program (ACARP)

ACARP is a mining research program that has been running in Australia since its establishment in 1992. It is 100% owned and funded by all Australian black coal producers through a five cents per tonne levy paid on saleable coal. Whitehaven contributes a levy to this research program that includes working groups on mine site greenhouse gas mitigation and low emission coal use. Research work via the greenhouse committee of ACARP primarily focuses on estimating fugitive methane emissions from open cut operations and mitigating the methane in underground mine ventilation air. The ACARP program was also instrumental in designing regulation for insitu calculation of emissions for open cut coal mines as part of NGERs.

Further information: https://www.acarp.com.au/

Member of COAL21

The COAL21 Fund was established in 2006 by the Australian black coal industry for the demonstration of low-emissions coal technologies, such as carbon capture and storage. The Fund is supported by a voluntary levy on coal production and includes 26 investors from among Australia's black coal producers, including Whitehaven.

COAL21 primarily invests in the development of low-emissions technologies for the coal-fired power generation sector and in emissions reduction from coal mines.

Up to 30 June 2018, COAL21 has seen $374m committed to demonstrating low-emission technologies in the coal-fired power generation sector, and safe fugitive emissions abatement from coal-mining operations.

COAL21 is now preparing to commit a further $255m for the period to June 2027, to meet its objectives to:

- Build community confidence in CCUS technology for safe, long-term CO_2 storage
- Demonstrate safe abatement of fugitive emissions from coal mines
- Assist in making the case for coal to remain a key part of Australia's future energy supply.

Projects funded by COAL21 include the CTSCo Carbon Capture and Storage Project in the Surat Basin near Wandoan in Queensland. CCUS can capture and store carbon dioxide from coal and gas fired power stations, as well as a wide range of other industrial processes, such as steel making and chemical processes. The CTSCo project is trialling the injection and underground storage of approximately 60,000 tonnes of carbon dioxide over 3 years.

Further information: https://coal21.com/

Coal Mining Projects – Technical Analysis

Introduction

The following coal mining projects (hereinafter collectively referred to as **the Coal Mining Projects**) are currently pending possible approval from the Minister under the *Environmental Protection and Biodiversity Conservation Act 1999 (Cth)* (EPBC Act):

- (EPBC 2020/8702) Russell Vale Colliery in NSW (Wollongong Coal Limited);
- (EPBC 2016/7649) Vickery Coal Mine Extension Project in NSW (Whitehaven Coal limited);
- (EPBC 2017/8084) Tahmoor South Project in NSW (Tahmoor Coal Pty Ltd);
- (EPBC 2018/8280) Mangoola Coal Continued Operations Project in NSW (Mangoola Coal Operations Pty Ltd).

(See attached for further information on each of these coal projects)

The Department of Agriculture, Water and the Environment (DAWE) is considering the extent to which, if at all, the approval of the Coal Mining Projects would affect the global level of consumption of coal in certain possible future scenarios, with particular attention being paid to the contribution of coal mining and coal consumption to the generation of greenhouse gases.

This analysis is based on the following scenarios

- the **sustainable development scenario (SDS)**, based on the International Energy Agency's Sustainable Development Scenario, assumes that global coal consumption will be constrained so that the energy-related United Nations Sustainable Development Goals are achieved: universal access to affordable, reliable and modern energy services by 2030; a substantial reduction in air pollution, and effective action to combat climate change[1]
- the **stated policies scenario (STEPS)**, based on the International Energy Agency's Stated Policies Scenario, assumes that global coal consumption is determined by the IEA's assessment of stated policy ambitions, including the energy components of announced economic stimulus or recovery packages (as of mid-2020) and the Nationally Determined Contributions under the Paris Agreement .[2]

[1] In the SDS, annual energy sector and industrial process CO_2 emissions fall continuously over the period to 2050 from around 33 gigatonnes (Gt) in 2020 to 26.7 Gt in 2030 and 10 Gt in 2050, on course towards global net-zero CO_2 emissions by 2070. If emissions were to remain at zero from this date, the SDS would provide a 50% probability of limiting the temperature rise to less than 1.65 °C, in line with the Paris Agreement to limit global warming to well below 2 °C, preferably 1.5°C, compared to pre-industrial levels. (If negative emissions technologies are deployed after 2070 in the SDS, the temperature rise in 2100 could be limited to 1.5 °C with a 50% probability.)

[2] In the STEPS, broad energy and environmental objectives (including country net-zero targets) are not automatically assumed to be met. They are implemented in this scenario to the extent that they are backed up by specific policies, funding and measures. The STEPS also reflects progress with the implementation of corporate sustainability commitments. In the STEPS, emissions from new and existing energy infrastructure lead to a long-term temperature rise of around 2.7 °C in 2100.

Having regard to:

- the known and likely coal resources in the world (including those currently being mined and those available for development) but excluding the Coal Mining Projects (and also excluding any other unapproved Australian coal mining developments), and
- the current and reasonably anticipated coal demand arising in the two scenarios outlined above, and
- the nature and manner of operation of the global market for coal,

DAWE is considering the prospects that the approval of one or more of the Coal Mining Projects would affect the total amount of coal consumed globally or affect the amount of greenhouse gas emissions generated in the process of mining and conveying coal from mine to consumer prior to the year 2100, or, if not possible to answer this question up to the year 2100 using the available modelling, by reference to the point in time to which reasonable inferences can be drawn on the available modelling.

In answering this question, consideration is being given to:

- whether there are sufficient known alternative sources of coal, Australian or otherwise, (alternative coal sources) that could supply the global demand for coal in either or both of the scenarios outlined above (alternative coal sources should include all currently approved Australian coal mines, as well as all known or likely coal mines and coal deposits outside Australia, and should exclude the Coal Mining Projects and any other unapproved Australian coal mining developments);
- whether the level of global coal consumption would be unaffected by the approval or commencement of supply associated with the Coal Mining Projects, recognising that the approval might affect the composition of global coal consumption;
- whether the amount of CO2 emissions likely to be generated by the coal extracted from the Coal Mining Projects would be greater or less than, or the same as, the amount of CO2 emissions likely to be generated from alternative coal sources that would be likely to be exploited if the Coal Mining Projects were not approved (this might, for example, be the case if the quality or characteristics of alternative coals sources were materially different from coal available from the Coal Mining Projects in generating the same power or in achieving the same production objects of coal use);
- whether the amount of CO2 emissions likely to be associated with the mining undertaken at the Coal Mining Projects and the amount of CO2 emissions likely to be associated with transporting the coal from the Coal Mining Projects to coal consumers is likely to be materially different than the amount of CO2 emissions likely to be associated with the mining and transport of coal to the same consumers from alternative coal sources (insofar as the alternative sources would replace the supply that might have been met by the Coal Mining Projects);
- whether, apart from CO2 emissions, the consumption of coal from alternative coal sources would be likely to create dangers to human safety that are different to any such dangers that would be likely to be associated with the consumption of the coal from the Coal Mining Projects (for example, because of the different grades of coal that might be used in substitution).

[Note that references to "approved" means approved under the EPBC Act.]

The Department of Industry, Science, Energy and Resources (DISER) provides the following report to aid DAWE in consideration of this question.

Primary question:

Having regard to the known and likely coal resources in the world (including those currently being mined and those available for development) but excluding the Coal Mining Projects (and also excluding any other unapproved Australian coal mining developments), and

- *the current and reasonably anticipated coal demand arising in the two scenarios outlined above, and*
- *the nature and manner of operation of the global market for coal,*

the Department of Agriculture, Water and the Environment (DAWE) is considering the prospects that the approval of one or more of the Coal Mining Projects would affect the total amount of coal consumed globally or affect the amount of greenhouse gas emissions generated in the process of mining and conveying coal from mine to consumer prior to the year 2100, or, if not possible to answer this question up to the year 2100 using the available modelling, by reference to the point in time to which reasonable inferences can be drawn on the available modelling.

Response

DISER notes that this response is provided in conjunction with the advice and limitations identified in the responses to the sub-questions that follow this response.

For the reasons explained below, any decision of the Minister to approve one or more of the Coal Mining Projects (Decision) is not expected to materially impact on the total amount of coal consumed globally.

Demand for metallurgical coal is determined primarily by the demand for steel. Steel demand is driven by construction and infrastructure development, which is dependent on population and economic growth as well as government policies that support these industries. The demand for thermal coal is determined primarily by its price, and the demand for energy, which again, depends in part on population and economic growth, the cost of alternative energy products, such as oil, gas and renewables, as well as consumer preferences for different types of energy. The Decision affects none of these factors.

There are many alternative sources of coal both within Australia and overseas - both metallurgical and thermal. There is enough known coal reserves to last for 200 years at current production levels (see sub-question 1).

These sources of supply are varied. No one country or company dominates the market for seaborne coal supply. The speed at which trade has recently realigned in response to trade disruptions shows that regional coal markets are highly integrated. Over the last 10 years, competition has increased in the seaborne market for both thermal and metallurgical coal, as lower-cost supply has entered the market and production costs at existing mines have declined.

Regardless of any feasible scenario of future global demand, the small fraction of global supply that the annual output the Coal Mining Projects represent, combined with the competitiveness of global coal markets, indicate that alternative sources of coal are readily substitutable for any coal that might be produced by the Coal Mining Projects (see sub-question 2).

It is not possible to identify specific mine sources that would be the alternative sources of coal in the event the Coal Mining Projects were not approved. This makes it not possible to conclude that any Decision to approve the Coal Mining Project will necessarily increase greenhouse gas emissions associated with coal consumption.

s. 47(1) / s. 47G(1) the coal from the Coal Mining Projects is of relatively high calorific value. Other things being equal, where coal from these projects is replaced by coal of lower calorific value, emissions from consumption of this alternative source of coal will tend to be higher (see sub-question 3).

Emissions from mining and transport of coal depend on a large range of factors including mining method, transportation method and distance, making it not possible to conclude that the Coal Mining Projects will necessarily increase emissions. As a proportion of total emissions associated with the projects, transport emissions are significantly less than from the combustion of the coal (see sub-question 4).

Sulphur dioxide emissions are another potential danger to human health from the consumption of coal, contributing to acid rain and respiratory illnesses.[3] These emissions depend on the sulphur content of the coal and any sulphur emission controls used in conjunction with the coal consumption. The lack of information on the sulphur characteristics of the alternative coal and the use of any sulphur emission controls means that it is not possible assess the impacts of the Decision on this danger.

[3] https://www.eia.gov/energyexplained/coal/coal-and-the-environment.php

Sub-question 1

*Whether there are sufficient known alternative sources of coal, Australian or otherwise, (**alternative coal sources**) that could supply the global demand for coal in either or both of the scenarios outlined above (**alternative coal sources** should include all currently approved Australian coal mines, as well as all known or likely coal mines and coal deposits outside Australia, and should exclude the Coal Mining Projects and any other unapproved Australian coal mining developments);*

Under the IEA scenario of greatest coal demand (STEPS), there are sufficient known alternative coal sources to supply global demand for coal beyond 2040. It logically follows that there are also sufficient known alternative coal sources to supply global demand in any scenario in which demand is expected to be lower than in STEPS.

In the IEA's STEPS, it is estimated that aggregate annual global coal consumption gradually declines to 2040, reaching 4,735 million tonnes of coal equivalent (Mtce) with an associated 12.4 gigatonnes (Gt) of CO2 emissions. In the Asia-Pacific, annual coal consumption is also expected to experience a small decline of 101 Mtce by 2040.

This conceals stark regional variations in the outlook for coal. Coal consumption in India is expected to grow over the next 20 years by 182 Mtce. Coal consumption in South East Asia is also expected to grow rapidly over the same period, increasing by 157 Mtce. Coal use rebounds in China in the near term, peaking around 2025, before declining to 2040. Japan is expected to see the largest reduction in coal consumption over the period, declining by 55 Mtce. By 2040, the Asia Pacific region will account for 85 per cent of global coal consumption (Table 1).

Under the IEA's Sustainable Development Scenario, the world is projected to consume 1,850 Mtce in 2040 (Table 2) with an associated 3.3 Gt of CO2 emissions. Aggregate global consumption falls more rapidly and more consistently across different regions. All of Australia's major coal export destinations experience substantial falls in coal consumption: China by 340 Mtce; India by 292 Mtce; Japan by 116 Mtce; and Southeast Asia by 167 Mtce.

It is not possible to explicitly identify from these projections the individual demands for thermal and metallurgical coal. The IEA does distinguish between power use of coal and industrial use of coal (see the last two rows of Tables 1 and 2). The coal used in power generation is thermal coal. However, industrial use of coal includes both thermal coal used to generate energy and metallurgical coal used for steel making. As noted by the IEA, steel and cement production accounted for around 70 per cent of industrial coal end use in 2019 (IEA World Energy Outlook 2020, page 196). However, DISER has no additional information as to how this demand is split between steel and cement uses or how this proportion is projected to evolve over the next twenty years.

Coal reserves are generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions. Publically available coal reserves with global geographic coverage normally classify coal by its level of coalification – anthracite, bituminous, sub-bituminous and lignite - rather than its anticipated end-use.

As shown in Table 3, in 2020, there were 923,881 million tonnes of proved coal reserves in known alternative coal sources outside of Australia. These reserves are 113 times greater than global coal production in 2019[4]. There were also substantial proved coal reserves within Australia (Table 4), although the share of these reserves that would require additional approvals by the Minister under the EPBC Act has not been identified.

The share of anthracite and bituminous coal is approximately three quarters of total coal reserves. Given this abundance of coal and the projected gradual decline in coal demand in all of the IEA's scenarios, it is highly unlikely that coal used for the production of steel or energy might be in short supply over the coming decades, even excluding the approval of the Coal Mining Projects.

Coal exploration and development is likely to add to these reserves over time. Exploration and development gives a more complete picture of a particular coal resource, and often results in sufficient confidence that a coal resource is economically mineable, i.e., a resource becomes a reserve. For example, in 2019, total coal reserves were 1,054,782 million tonnes. In 2020, despite approximately 7,741 million tonnes of production, coal reserves grew to 1,074,108 million tonnes (BP Statistical Review of World Energy 2021).

[4] While coal is stored at various times and places, these stocks are not large and the difference between global consumption and production of coal in any one year is normally a few percentage points.

Table 1 – IEA Stated Policy Scenario coal demand

	Stated Policies Scenario						Shares (%)			CAAGR (%)	
	2010	2018	2019	2025	2030	2040	2019	2030	2040	2019-30	2019-40
Coal demand (Mtce)											
North America	770	497	431	266	204	125	8	4	3	-6.6	-5.7
United States	718	458	393	247	188	113	7	4	2	-6.5	-5.8
Central and South America	35	43	43	38	38	42	1	1	1	-1.1	-0.1
Brazil	19	21	22	21	22	24	0	0	1	0.1	0.4
Europe	538	450	387	250	202	163	7	4	3	-5.7	-4.0
European Union	360	309	251	155	106	60	5	2	1	-7.5	-6.6
Africa	155	142	167	165	164	161	3	3	3	-0.1	-0.2
South Africa	144	120	142	134	121	96	3	2	2	-1.5	-1.9
Middle East	3	5	5	8	9	12	0	0	0	5.0	3.8
Eurasia	197	231	225	208	206	198	4	4	4	-0.8	-0.6
Russia	145	171	164	147	141	132	3	3	3	-1.4	-1.0
Asia Pacific	3 512	4 092	4 135	4 176	4 182	4 034	77	84	85	0.1	-0.1
China	2 567	2 837	2 864	2 877	2 779	2 524	53	56	53	-0.3	-0.6
India	399	592	590	631	712	772	11	14	16	1.7	1.3
Japan	165	163	157	139	119	102	3	2	2	-2.5	-2.0
Southeast Asia	122	220	246	273	314	383	5	6	8	2.2	2.1
OECD	1 559	1 219	1 079	733	602	445	20	12	9	-5.2	-4.1
Non-OECD	3 652	4 241	4 313	4 379	4 403	4 290	80	88	91	0.2	-0.0
Advanced economies	1 580	1 235	1 094	746	609	450	20	12	10	-5.2	-4.1
Emerging market & developing economies	3 631	4 225	4 299	4 366	4 395	4 285	80	88	90	0.2	-0.0
World	**5 211**	**5 460**	**5 392**	**5 112**	**5 004**	**4 735**	**100**	**100**	**100**	**-0.7**	**-0.6**
Power	3 099	3 509	3 449	3 218	3 148	2 974	64	63	63	-0.8	-0.7
Industrial use	1 239	1 138	1 151	1 135	1 128	1 107	21	23	23	-0.2	-0.2

Source: IEA World Energy Outlook 2020, all rights reserved.

Table 2 – IEA Sustainable Development Scenario coal demand

	Sustainable Development Scenario						Shares (%)			CAAGR (%)	
	2010	2018	2019	2025	2030	2040	2019	2030	2040	2019-30	2019-40
Coal demand (Mtce)											
North America	770	497	431	101	59	42	8	2	2	-16.5	-10.5
United States	718	458	393	84	48	32	7	2	2	-17.3	-11.3
Central and South America	35	43	43	28	22	18	1	1	1	-6.1	-4.0
Brazil	19	21	22	16	14	12	0	0	1	-4.2	-2.8
Europe	538	450	387	180	116	73	7	4	4	-10.3	-7.6
European Union	360	309	251	104	60	39	5	2	2	-12.1	-8.5
Africa	155	142	167	137	115	80	3	4	4	-3.3	-3.5
South Africa	144	120	142	117	94	51	3	3	3	-3.7	-4.8
Middle East	3	5	5	7	6	5	0	0	0	1.3	-0.5
Eurasia	197	231	225	165	124	68	4	4	4	-5.3	-5.5
Russia	145	171	164	120	90	55	3	3	3	-5.3	-5.1
Asia Pacific	3 512	4 092	4 135	3 581	2 762	1 564	77	86	85	-3.6	-4.5
China	2 567	2 837	2 864	2 539	1 952	1 045	53	61	57	-3.4	-4.7
India	399	592	590	516	454	298	11	14	16	-2.4	-3.2
Japan	165	163	157	104	57	41	3	2	2	-8.8	-6.2
Southeast Asia	122	220	246	234	170	79	5	5	4	-3.3	-5.3
OECD	1 559	1 219	1 079	432	240	165	20	7	9	-12.8	-8.5
Non-OECD	3 652	4 241	4 313	3 767	2 965	1 685	80	93	91	-3.4	-4.4
Advanced economies	1 580	1 235	1 094	439	242	166	20	8	9	-12.8	-8.6
Emerging market & developing economies	3 631	4 225	4 299	3 760	2 962	1 684	80	92	91	-3.3	-4.4
World	**5 211**	**5 460**	**5 392**	**4 199**	**3 204**	**1 850**	**100**	**100**	**100**	**-4.6**	**-5.0**
Power	3 099	3 509	3 449	2 448	1 686	706	64	53	38	-6.3	-7.3
Industrial use	1 239	1 138	1 151	1 035	903	697	21	28	38	-2.2	-2.4

Source: IEA World Energy Outlook 2020, all rights reserved.

Table 3 - Key 2020 coal statistics (physical units)

		Australia	OECD	World
Resources				
Proved reserves (at end of year)	Mt	150,227[b]	508,433	1,074,108
of which: Black coal (anthracite and bituminous)	Mt	73,719[b]	331,303	753,639
of which: Brown coal (sub-bituminous[a] and lignite)	Mt	76,508[b]	177,130	320,469
Share of world coal reserves	%	14.0[b]	47.3[b]	100
World ranking	no.	3[b]	na	na
Production				
Annual production	Mt	477	1,422	7,742
Share of world annual production	%	6.2	18.4	100
CAGR from 2009-2019	%	1.8	-2.1	1.4
World ranking	no.	5	na	na

Notes:
a Sub-bituminous coal has properties that range from those of brown coal to those of black coal—there is therefore some variation in this terminology across countries.
OECD - Organisation for Economic Co-operation and Development countries; CAGR - compound annual growth rate; Mt - million tonnes; na - not applicable.

Source: BP Statistical Review of World Energy 2021.

Table 4 - Australia's coal reserves at operating mines in 2019

No. of operating mines[a]	Ore Reserves[b] (Mt)	Measured and Indicated Mineral Resources[c,e] (Mt)	Inferred Mineral Resources[d,e] (Mt)	Mine Production[f] (Mt)	Reserve Life[g] (years)	Reserve Life 1[h] (years)	Reserve Life 2[i] (years)
96	11,670	30,586	14,227	588	20	52	76

Notes:
a The number of operating mines counts individual mines that operated during 2019 and thus contributed to production. Some of these mines may belong to larger, multi-mine operations and some may have closed during or since 2019.
b The majority of Australian Ore Reserves and Mineral Resources are reported in compliance with the JORC Code, however there are a number of companies that report to foreign stock exchanges using other reporting codes, which are largely equivalent. In addition, Geoscience Australia may hold confidential information for some commodities. Not all operating mines report Ore Reserves. Ore Reserves are as at 31 December 2019.
c Measured and Indicated Mineral Resources are inclusive of the Ore Reserves. Not all operating mines report Mineral Resources. Mineral Resources are as at 31 December 2019.
d Inferred Mineral Resources are as
e Measured, Indicated and Inferred Mineral Resources for black coal are presented on a recoverable basis (these are Geoscience Australia estimates unless provided by the company).
at 31 December 2019. Not all operating mines report Mineral Resources.
f Mine production refers to raw coal.
g Reserve Life = Ore Reserves ÷ Production.
h Resource Life 1 = Measured and Indicated Resources ÷ Production.
i Resource Life 2 = Measured, Indicated and Inferred Resources ÷ Production.
Source: a-d - Geoscience Australia; e - Resources and Energy Quarterly, September 2020, Department of Industry, Science, Energy and Resources.

Sub-question 2

Whether the level of global coal consumption would be unaffected by the approval or commencement of supply associated with the Coal Mining Projects, recognising that the approval might affect the composition of global coal consumption;

As established in sub-question 1, there are many alternative sources of coal outside of Australia - both metallurgical and thermal. There are enough coal reserves to last for approximately 200 years at current production levels (see sub-question 1). This is in addition to any coal reserves in Australia that do not require approval by the Minister under the EPBC Act to mine.

As already noted above, coal is primarily used in two ways; for producing steel and for producing energy. Coal used in the production of steel is referred to as metallurgical (or coking) coal. Coal used for producing energy is referred to as thermal (or steaming) coal.

The long-term demand for metallurgical coal depends primarily on its price, and the demand for steel, which in turn depends on demand for steel uses, including construction and infrastructure, which, in part, depends on population and economic growth as well as government policies that support these industries.

The long-term demand for thermal coal depends primarily on its price, the demand for energy, which, again, depends in part on population and economic growth, the cost of alternative energy products, such as oil, gas and renewables, as well as consumer preferences for different types of energy.

In additional to its price, the long-term supply of metallurgical and thermal coal depend on the availability of the resource in nature, the technology used for extraction (the two main methods are open-cut or underground), the labour and capital costs associated with production, the cost of transporting the coal to the demand source (normally by rail and ship) and the regulatory costs associated with environmental protection and worker health and safety.

The characteristics required for coal to be suitable for steel making means that metallurgical coals are rarer in nature, which makes metallurgical coal more expensive than thermal coal. In the last ten years, the average price of exported Australian metallurgical coal was approximately double the average price of exported Australian thermal coal (IHS Markit, 2021).

However, the prices of metallurgical and thermal coal are linked because there is a degree to which the different coal types can be used in the alternative market. When the price differential is small, the cost of beneficiation of low-grade bituminous coal that makes the coal suitable for steel-making is less than the return from beneficiation. When the price differential is large, steel-makers will find it profitable to substitute some metallurgical coal with high-end thermal coal, where the reduction in blast efficiency is more than offset by the reduced input cost.

Putting aside prices of metallurgical and thermal coal, the decision by the Minister under the EPBC Act to approve one or more of the Coal Mining Projects effects none of the demand factors listed above.

In consideration of price, the feasibility of alternative sources of coal substituting for coal supplied by the Coal Mining Projects as a result of a decision by the Minister under the EPBC Act must be considered. Limiting supply of a product will, in standard markets, lead to higher prices and lower demand if there are no readily available substitutes to replace this supply. If on the other hand, there are readily available substitutes to replace that supply, i.e. if markets are competitive, then there is not expected to be any meaningful impact of reduced supply on price or demand. The coal markets, both metallurgical and thermal are highly competitive global markets.

The coal that is expected to be produced by the Coal Mining Projects is a mix of thermal and metallurgical coal primarily for sale into the seaborne coal trade. The supply of each of these coal types will now be considered separately.

China dominates the global production of metallurgical coal, accounting for over half of all production in 2020. Despite this, China's demand for coal makes it a net importer (its imports of metallurgical coal, exceeds its exports). Imports accounted for approximately 10 per cent of metallurgical coal consumption in China in 2020 (Table 5).

Australia dominates the global supply of seaborne metallurgical coal. Australia accounted for over half of all seaborne coal trade in 2020. Other major suppliers include United States, Canada, Russia and Mongolia.

Table 5 – Production and Export of metallurgical coal in 2020, million tonnes

Region	Production		Region	Exports
Asia Pacific	**812**		Australia	167
China	605		United States	38
India	6		Canada	33
Australia	170		Russia	30
Indonesia	6		Mongolia	26
North America	**88**		Mozambique	4
United States	51		Rest of world	13
Central and South America	**4**		**World**	**309**
Europe	**12**			
European Union	11			
Middle East	**1**			
Eurasia	**105**			
Russia	98			
World	**1029**			

Source: IEA Coal 2020 Report

China also dominates the global production of thermal coal and lignite, accounting for almost half of all production in 2020. Also similar to the seaborne metallurgical coal market, China is a net importer of thermal coal (it imports more than it exports). Imports accounted for almost 10 per cent of thermal coal consumption in China in 2020 (Table 6).

The supply of seaborne thermal coal is less concentrated than for seaborne metallurgical coal. No individual country dominates supply. Indonesia is the largest supplier of seaborne thermal coal and lignite, accounting for 31 per cent of global supply in 2020. Australia and Russia are other important suppliers, accounting for 29 per cent and 16 per cent of global supply, respectively.

Table 6 – Production and Export of thermal coal in 2020, million tonnes

Region	Production		Region/country	Exports
Asia Pacific	**4780**		Australia	366
China	3086		Canada	36
India	737		Colombia	58
Australia	290		Indonesia	404
Indonesia	523		Russia	207
North America	**469**		South Africa	75
United States	439		United States	59
Central and South America	**61**		Rest of world	88
Europe	**439**		**World**	**1292**
European Union	286			
Middle East	**0**			
Eurasia	**419**			
Russia	297			
Africa	**241**			
World	**6409**			

Source: IEA Coal 2020 Report

Substitutability of coal

The recent experience of trade disruptions associated with COVID-19 and China's informal trade restrictions in the metallurgical and thermal coal markets has shown that geography is not a key consideration for coal end-users. Coal that was destined for China has been resold or redirected to an array of countries. These countries include Japan, South Korea and India. Similarly, China has managed to source its coal needs from other countries, including United States, Canada and Russia in the absence of previously substantial Australian supply. That is to say, companies that supply seaborne metallurgical and thermal coal compete in the one marketplace.

Over the last 10 years competition has increased in the seaborne market for coal, as lower-cost supply has entered the market and production costs at existing mines have declined (Figure 1). Reflecting this, globally over the past decade, unit production costs have become more uniform over a wider range of production levels; any increase in coal price is expected to be met with a greater increase in supply.

Table 7 shows the anticipated volume of metallurgical and thermal coal that each of the Coal Mining Projects will produce and how much that represents as a share of global production and exports. The Vickery Coal project's annual metallurgical coal production represents 0.4 per cent of global metallurgical coal production and 1.3 percent of global metallurgical coal exports in 2020. The share of global coal represented by the annual coal production of the other projects are all smaller than that of the Vickery Coal project.

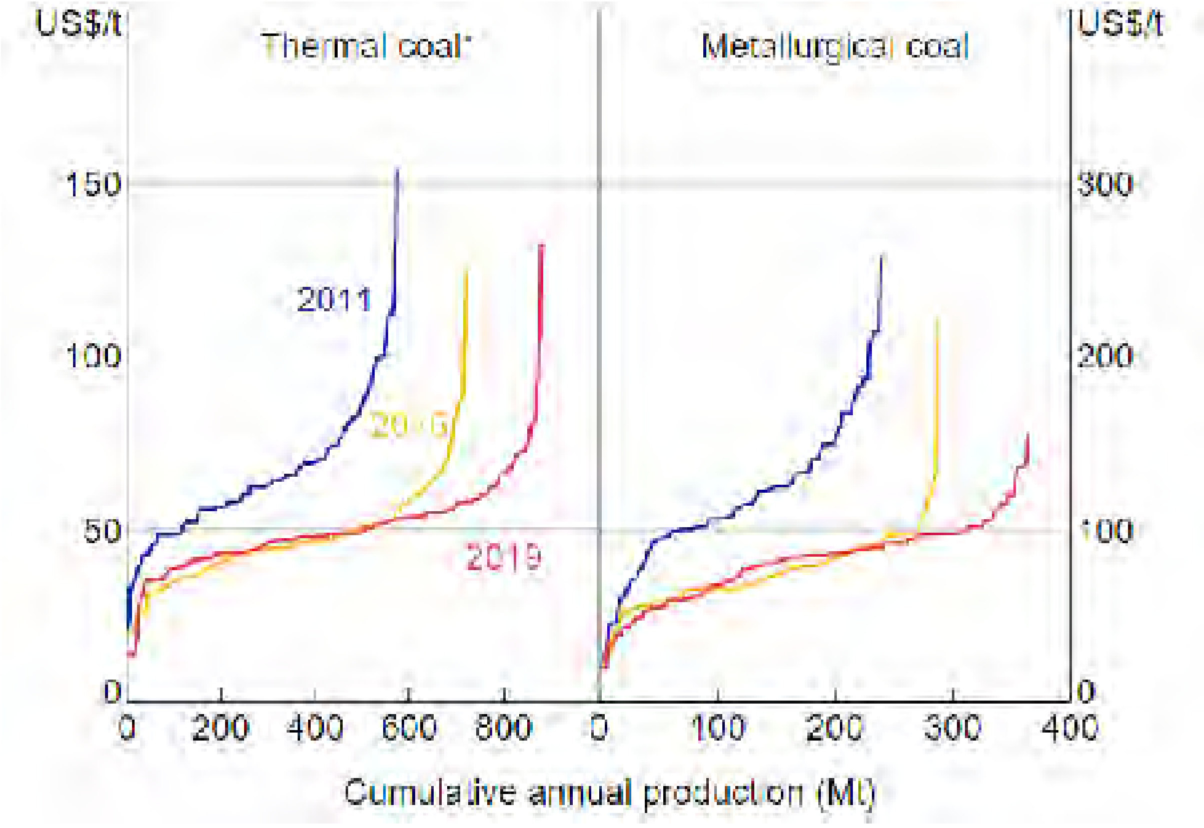
Table 7 – Coal Mining Project production as a share of global coal production and exports in 2020

	Units	Russell Vale	Tahmoor South	Mangoola	Vickery
Total volume	Mt	3.7	33	52	168
Duration of project	Years	5	10	8	25
Project share of metallurgical coal	%	100	90-95	0	60
Project's annual metallurgical production	Mt	0.74	2.97-3.14	0	4.03
Share of global metallurgical coal production	%	0.07	0.29-0.3	-	0.39
Share of metallurgical coal exports	%	0.24	0.96-1.01	0	1.30
Project share of thermal coal	%	0	5-10	100	40
Project's annual thermal coal production	Mt		0.17-0.33	s. 47(1) / s. 47G(1)	2.69
Share of global thermal coal production	%	0	0.003-0.005	0.10	0.04
Share of thermal coal exports	%	0	0.017-0.034	0.66	0.27

Source: DAWE and IEA Coal 2020 Report

Regardless of any feasible scenario of future global demand, the small fraction of current global coal supply that these projects represent, combined with the relatively flat global seaborne coal cost curves indicates that the Decision will not have any discernible impact on global coal prices. The alternative sources of coal identified in sub-question 1 are readily substitutable for any coal that might be produced by the Coal Mining Projects.

Figure 1: Seaborne Coal Production Costs (FOB basis)



*Notes: * Costs are quality adjusted*

Sources: AME Research; Reserve Bank of Australia

Sub-question 3

Whether the amount of CO_2 emissions likely to be generated by the coal extracted from the Coal Mining Projects would be greater or less than, or the same as, the amount of CO_2 emissions likely to be generated from alternative coal sources that would be likely to be exploited if the Coal Mining Projects were not approved (this might, for example, be the case if the quality or characteristics of alternative coals sources were materially different from coal available from the Coal Mining Projects in generating the same power or in achieving the same production objects of coal use);

Mine development decisions by both governments and industry are generally linked to broader considerations, including future global coal demand, the coal mine construction pipeline, capital availability and social licence. It is not possible to identify specific mine sources that would be the alternative sources of coal in the event the Coal Mining Projects were not approved.

Industry estimates that if Australian coking coals were not available and had to be replaced by coking coal from alternative sources, which would be of inferior quality, it is estimated that the amount of CO2 produced from blast furnaces that currently use the Australian products may increase by 7-25 million tonnes per annum or 0.8-2.8 per cent.[5]

While technically possible to replace coking coal in the steel making process through the combination of a Direct-Reduced Iron (DRI) facility and an Electric Arc Furnace (EAF) using either zero-emission electricity or green hydrogen, such a process currently presents technical challenges, and is not yet available at the scale needed to meet global demand for steel particularly in developing economies.

The CO2 emissions intensity of electricity generated from coal is dependent on a number of factors including the energy, moisture, ash content and sulphur content of the coal, how the coal is stored and treated, and the technology and operation of the coal generation unit. One of the most important factors for emissions intensity is the energy content or calorific value, which represents the energy contained in the coal. High energy content coal can be combusted more efficiently resulting in less emissions per unit of electricity generated (i.e., improved thermal efficiency). Table 8 shows that, based on industry estimates, Australia's exported thermal coal has a high calorific value compared with other major coal exporters (noting the United States is on par with Australia).

In particular, Australian coal has a much higher calorific value than Indonesia, which would tend to result in slightly lower emissions per unit of electricity generated from the use of Australian coal compared to Indonesian coal, based on the data in Table 8. As a consequence, it could be concluded that consumption of thermal coal from Indonesia rather than thermal coal from the Coal Mining Projects, s. 47(1) / s. 47G(1) could be expected to result in slightly more CO2 emissions, based on DAWE estimates of calorific value contained in Table 10.

[5] Minerals Council of Australia, 2020. *Best In Class: Australia's Bulk Commodity Giants. Australian Metallurgical Coal: Quality Sought Around the World.*

Sub-question 4

Whether the amount of CO_2 emissions likely to be associated with the mining undertaken at the Coal Mining Projects and the amount of CO_2 emissions likely to be associated with transporting the coal from the Coal Mining Projects to coal consumers is likely to be materially different than the amount of CO_2 emissions likely to be associated with the mining and transport of coal to the same consumers from alternative coal sources (insofar as the alternative sources would replace the supply that might have been met by the Coal Mining Projects);

It is not possible to readily determine whether CO2 emissions from the Coal Mining Projects' extraction and transport activities would be materially different to emissions from such activities undertaken by alternative overseas coal sources. It can be stated however that, transport emissions associated with any coal mining project would represent a relatively small percentage of emissions from the combustion of the final product (ie coal). To illustrate using the data provided by the Coal Mining Projects with the highest (Russel Vale) s. 47(1) / s. 47G(1) calorific value coal: estimated transport emissions would represent approximately 4-5 per cent of estimated emissions from the combustion of coal (source: *Russell Vale Colliery Air Quality and Greenhouse Gas Management Plan*, table 7.3; *EIS Appendix 22 – Greenhouse Gas and Energy Assessment Appendix B*, page 2).

International coal supply chains normally involve some combination of conveyor, truck, rail, cargo vessel to transport coal. The inability to identify specific mine sources that would be the alternative sources of coal in the event the Coal Mining Projects were not approved in addition to the varied mining environments, transportation choices and distances make any estimation of the impact of the Decision on mining and transportation emissions infeasible.

Such a comparison would require, for example, a level of detail in emissions data reporting by Australia's developing country competitors which is not currently available. Difficulties in attributing transport sector emissions to specific coal mines presents a further obstacle to preparing a reliable comparison. As a consequence, it is not possible to determine whether global CO2 emissions from the extraction and transport of coal to consumers would increase or decrease if the coal mining projects were not approved.

It is noted, however, that the calorific value of coal has implications for related transport emissions. That is, the lower the calorific value (energy content) of coal, the greater mass of coal required to produce a given level of electricity. It follows that – for a given electricity requirement – supplying coal with lower thermal efficiency would result in higher transport related emissions per kilometre travelled compared to supplying coal with higher thermal efficiency (such as coal from the Coal Mining Projects, s. 47(1) / s. 47G(1) due to the greater mass of coal to be transported.

Sub-question 5

Whether, apart from CO2 emissions, the consumption of coal from alternative coal sources would be likely to create dangers to human safety that are different to any such dangers that would be likely to be associated with the consumption of the coal from the Coal Mining Projects (for example, because of the different grades of coal that might be used in substitution).

Apart from CO2 emissions, consumption of coal from alternative coal sources may create dangers to human safety that are different from the dangers associated with the consumption of coal from the Coal Mining Projects. For example, combustion of coal from alternative sources may result in greater sulphur dioxide emissions, a contributor to acid rain and respiratory illnesses.[6]

Australian export coals have comparable levels of sulphur to our major export competitors (see Tables 7 and 8).

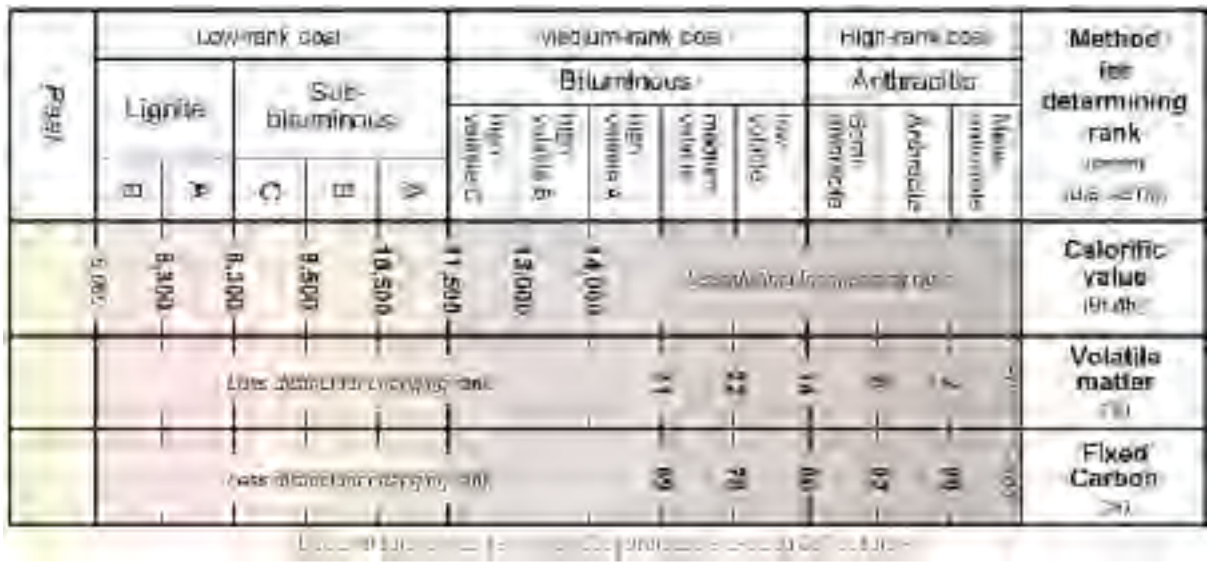
It is not possible to readily determine whether sulphur dioxide emissions from the consumption of coal from alternative sources would be materially different to sulphur dioxide emissions from the consumption of coal from the Coal Mining Projects as it is not possible to identify specific mine sources that would be the alternative sources of coal in the event the Coal Mining Projects were not approved. This determination would also be informed by any sulphur emission controls used in conjunction with the coal consumption such as the flue-gas desulphurization technologies that can be used to remove sulphur dioxide from exhaust flue gases of fossil-fuel power plants.

[6] https://www.eia.gov/energyexplained/coal/coal-and-the-environment.php

Annex A: Background

Coal is formed from the physical and chemical alteration of peat. Peat is composed of plant materials that accumulate in wetlands. When peats are buried, the weight of the overlying sediments squeezes out much of the water from the peat and reduces its volume (called compaction). Continued burial deeper into the earth also exposes the material to higher temperatures. Heating, and to a lesser extent, time and pressure act on the buried peat to change it into coal. The stages of coalification proceed through different ranks of coal (lignite, sub-bituminous coal, bituminous coal, anthracite coal). The more advanced the stage of coalification, the higher the calorific value (energy content) of the coal, the lower the volatile matter (the amount of non-water gases formed from a coal sample during heating) and the higher the fixed carbon (the amount of non-volatile carbon remaining in a coal sample) (Figure 2).

Figure 2: US coal rank system



Source: University of Kentucky, https://www.uky.edu/KGS/coal/coal-rank.php

The production and consumption of coal, like most commodities is determined by the interactions between numerous producers and consumers trading a relatively homogeneous good.

Demand factors for coal depend on the value of the end use of the product – this varies from producing steam to drive turbines to produce electricity, to producing gaseous and liquid fuels, through coal gasification and liquefaction, to using coal as a chemical source from which numerous synthetic compounds (e.g., dyes, oils, waxes, pharmaceuticals, and pesticides) can be derived, or in the production of coke for metallurgical processes.

The two primary uses of coal (energy and steel making) have led to the development of two major coal markets, reflecting the specific characteristic requirements associated with these uses.

Coal used for steel making is referred to as metallurgical (or coking) coal. It is used as a fuel and reductant (in the form of coke) in a blast furnace to produce iron. Blast furnace operators greatly value consistent coal quality as variable quality can create furnace instability. It is rare for coke makers to charge a single coal into a blast furnace as a single coal will not possess all of the properties required to produce coke suitable to meet blast furnace specifications for ash, sulphur, phosphorus, size and coke strength. Coke makers use multiple coals when formulating a coking coal blend in order to meet these specifications.

Metallurgical Coal

Metallurgical coals are primarily bituminous coals. As shown in figure 2, these coals are categorised primarily by their volatile matter rather than their calorific content. This feature of metallurgical coal markets is also demonstrated by metallurgical coal indexes such as those constructed by S&P Global Platts[7], which include coke strength reaction, volatile matter, total moisture, ash and sulphur as measures of quality. While all metallurgical coals have relatively high calorific value, this is not one of the measures that determines metallurgical coal value.

Table / outlines the important commercial properties of coking coal and compares Australian coking coal to international alternatives.

Table 8: Properties of Australian Coking Coals and Comparison to International Alternatives

COKING COAL PROPERTY	SIGNIFICANCE	TYPICAL AUSTRALIAN QUALITY	COMPARISON TO INTERNATIONAL ALTERNATIVES
Ash	Increases slag volume in the blast furnace and reduces blast furnace productivity. Lower ash is preferred.	6.0–10.5 per cent (air-dried basis)	Comparable
Sulphur (S)	S is deleterious to steel quality and costly to remove in the steelmaking process. Lower S is	0.3–1.3 per cent (air-dried basis)	Comparable
Phosphorus (P)	P is deleterious to steel quality and costly to remove in the steelmaking process. Lower P is	0.01–0.12 per cent (air-dried basis)	Comparable
Alkalis (K_2O + Na_2O)	Alkalis condense in the blast furnace shaft and build-up or form accretions on the furnace wall which can detach suddenly causing operational problems. Lower alkali content is preferred.	1.5 per cent in ash (dry basis)	Comparable
Rheology	Fluidity – viscosity of plastic phase during heating. Dilatation – expansion and contraction during heating. Both assist coke makers in formulating coal blends that produce strong	Broad range	US coals superior but Australian comparable to others
Coke cold strength	Abrasion and breakage resistance for optimisation of blast furnace permeability.	Broad range	Superior
Coke hot strength (Coke Strength after Reaction -	Hot strength for optimization of BF permeability. Preferred coke CSR for large BF 65-70 per cent.	55-74 per cent	Superior

Source: Adapted from MCA Best in Class: Australia's Bulk Commodity Giants – Metallurgical Coal

Thermal Coal

[7] https://www.spglobal.com/platts/plattscontent/_assets/_files/en/our-methodology/methodology-specifications/metcoalmethod.pdf

Coal used to produce steam to run turbines to generate electricity is referred to as thermal (or steaming) coal. Thermal coal (like metallurgical coal) is mainly composed of carbon, hydrogen and oxygen, however it also contains variable quantities of other elements that can impact the value of the coal as a fuel source. Important elements that can impact this value are the moisture content, sulphur content, ash content and other pollutants, as well as the coal's calorific value.

Thermal coals are primarily sub-bituminous coals. These coals are characterised primarily by their calorific value (or energy density). The calorific value of coal is also the most important determinant of a coal's ability to create steam and generate power, representing the amount of energy produced from burning a given quantity. A greater quantity of low calorific value coals are needed in order to produce the same amount of electricity that can be obtained from higher calorific value coals.

Thermal coal also contains variable quantities of other elements that can impact the quality and efficiency of the coal as a fuel source. In addition to calorific value, important elements that can impact the quality and emissions from coal are the moisture content, sulphur content and ash content.

Total moisture is the total amount of water in the coal including inherent and surface moisture. Moisture is measured as a percentage of the "air dried" coal (that is, the moisture in the coal after achieving equilibrium with the atmosphere around it). As the moisture uses heat to be evaporated on combustion, the lower the level the better. Higher moisture coals have lower boiler efficiencies.

Ash remains after the complete combustion of all organic matter and the oxidation of the mineral matter present in the coal – it is therefore the incombustible material present in the coal. Ash in coal acts as a diluent, which needs to be disposed of after combustion as fly ash or bottom ash. Lower levels are therefore preferred.

Volatile matter in coal is the proportion of the air-dried coal released as gas or vapour during a standardised heating test. Higher volatile matter content indicates coal that is easier to ignite and which will burn with a large, steady flame However, if volatile content is too high (exceeding 30 per cent of the air dried coal), it increases the potential risk of spontaneous combustion.

Table 9 outlines the important properties of thermal coal and compares Australian export thermal coal to international alternatives.

Table 9: International Comparison of Export Thermal Coal Quality

Country	Australia	Indonesia	Russia	Colombia	South Africa	USA
Total Moisture (per cent ar)	10.6	24.9	10.2	11.8	8.3	11.7
Ash (per cent ad)	13.7	5.5	12.2	7.1	13.8	7.9
Volatile Matter (per cent ad)	31.2	38.9	30.8	35.9	25.8	37.5
Calorific value (Kcal/Kg nar)	5980	4640	5590	5860	5780	5980
Sulphur (per cent ad)	0.57	0.49	0.40	0.62	0.80	1.40

Notes: ar – as received; ad – air dried; nar – kilocalories per kilogram net as received
Source: Adapted from MCA Best in Class: Australia's Bulk Commodity Giants – Thermal Coal

Table 10 outlines the coal characteristics of the Coal Mining Projects from two sources: DAWE and AME Research.

Table 10 – Coal characteristics of the Coal Mining Projects

Project	Source	Ash (% adb)	Total Sulphur (% adb)	Calorific Value NAR (kcal/kg)
Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	AME Research	13	0.39	7,025[a]
	DAWE	26-32	0.42-0.45	6,300-7,400
Tahmoor South Coal Project (2017/8084)	AME Research	13	0.4	6,640
	DAWE	12	0.3	6,300
Mangoola Continued Coal Operations Project (2018/8280)	AME Research	15-27	0.35-0.40	5,014
	DAWE	Na	Na	4775-5800
Vickery Extension Project (EPBC 2016/7649)	AME Research	10	0.55	6,521
	DAWE	8	0.4	6,420

Notes: adb – air-dried basis; NAR – net as received;
a Russell Vale coal is not expected to produce thermal coal.
b – gross as received

Source: AME Research (April 2021) and DAWE

Lignite is also used to produce energy. However, because of its low energy density and typically high moisture content, lignite is inefficient to transport and is not traded extensively on the world market compared with higher coal grades. As a result it is not a focus of this report.

Coal Mine Investment Factors

Coal supply is associated with capital intensive investments and long lead times. In the short-term, the response of an operating coal mine to changes in market prices will be small. The operational costs of a coal mine represent a relatively small portion of the mines costs, making production at capacity most profitable over a wide range of prices. Even at price extremes, there is a limit to any potential supply response related to price changes. Putting a mine into care and maintenance is a costly exercise as many costs associated with mining are incurred regardless of the sale of coal. Similarly, there are production capacity constraints above which mines cannot operate regardless of prices. Of course, coal supply may fluctuate in the short-term as a result of unanticipated events such as weather disruptions or mining accidents.

Longer-term, these features mean that the decision to invest in additional coal mine capacity, either as a greenfield site, as an expansion to an existing operation or as a replacement for an expiring mine is taken with a long-term view of coal markets and coal prices. Time horizons can differ depending on the resource being considered for development, but investment horizons normally range from 5 to 25 years. While time horizons can extend beyond this point, the net present value of revenue streams thirty or more years into the future are insignificant at standard rates of return. That is to say, projections of future coal supply and coal demand more than 30 years into the future are irrelevant for most economic decision making purposes, and, as such, are not readily available publicly or privately.

The absence of economic modelling of coal markets beyond 30 years limits the ability of DISER to inform DAWE as to the operation of coal markets out to 2100. The most comprehensive long-term modelling of global energy systems that can inform the questions under consideration by DAWE is the International Energy Agency's (IEA's) annual World Energy Outlook report as the basis for drawing inferences on future global energy demand and supply.

The IEA's World Energy Outlook publications assess medium to long-term energy projections using the IEA's World Energy Model (WEM). The WEM is a large-scale simulation model designed to replicate how energy markets function and is the principal tool used to generate detailed sector-by-sector and region-by-region projections for the WEO scenarios. Updated every year, outputs from the model include energy flows by fuel, investment needs and costs, CO2 emissions and end-user prices.

The World Energy Outlook makes use of a scenario approach to examine future energy trends relying on the WEM. For the World Energy Outlook 2020, detailed projections for scenarios out to 2040 were modelled and presented.

At one end of the spectrum, the IEA's Sustainable Development Scenario (SDS) assumes that global coal consumption will be constrained to a level consistent with the aims of the Paris Agreement and the sustainable development goals (SDG 3, 7 and 13).

At the other end of the spectrum, the IEA's Stated Policies Scenario (STEPS) assumes that global coal consumption will not be constrained to a level consistent with the aims of the Paris Agreement or address the sustainable development goals (SDG 3, 7 and 13). The STEPS takes into account the policies and implementing measures affecting energy markets that had been adopted as of mid-2020, together with relevant policy proposals, even though specific measures needed to put them into effect have yet to be fully developed.

In addition to the above scenarios, projections for a Net Zero Emissions by 2050 Scenario (NZE) are also presented at a more aggregated regional level out to 2030. The NZE shows what is needed for the global energy sector to achieve net-zero CO2 emissions by 2050. Alongside corresponding reductions in GHG emissions from outside the energy sector, this is consistent with limiting the global temperature rise to 1.5 °C without a temperature overshoot (with a 50 per cent probability).

Projections for the STEPS and NZE scenarios are also presented at this more aggregated level, over a longer time frame in its *Net Zero by 2050* report. However, the level of regional aggregation associated with the scenario projections that are reported out to 2050 gives insufficient information to inform the questions posed by DAWE.

Annex C: Technical Expertise

The above advice was developed by Officers within areas of DISER:

- The Onshore Minerals and Energy Branch within the Resources Division utilised publicly available information including market intelligence subscription services, publicly available reports and documentation provided by the Coal Mining Projects. The analysis was compiled by employees with technical qualifications in geology, economics and law. The analysis was also reviewed by the Resources and Energy Insights Branch within DISER's Analysis and Insights Division.

- The National Inventory Systems and International Reporting Branch of the Climate Change Division. The Branch comprises employees with technical qualifications including science, engineering, economics and law, who are responsible for fulfilling the Australian Government's international emissions reporting obligations under the UN climate treaties, including the Paris Agreement. The advice provided in this response relating to emissions was prepared by, and in consultation with, employees with international accreditation in the review of countries' greenhouse gas inventories for consistency and compliance with UN climate treaty rules and guidance for the estimation and reporting of greenhouse gas emissions.

Annex D: Glossary

Tonnes of coal equivalent - one tonne of coal equivalent is the energy content of 1 tonne of 7,000 kilocalories per kilogram coal. One tonne of coal equivalent is equal to 29.3076 gigajoules (GJ). As reported under The National Greenhouse and Energy Reporting (Measurement) Determination 2008, Australian bituminous coal has an energy content of 27.0 GJ/tonne and Australian sub-bituminous coal has an energy content of 21.0 GJ/tonne.

Alternative coal sources - known and likely coal resources in the world (including those currently being mined and those available for development) but excluding the Coal Mining Projects (and also excluding any other unapproved Australian coal mining developments).

Mineral Resource - a concentration or occurrence of solid material of economic interest in or on the Earth's crust in such form, grade (or quality), and quantity that there are reasonable prospects for eventual economic extraction. Mineral Resources are sub-divided, in order of increasing geological confidence, into Inferred, Indicated and Measured categories.

Inferred Mineral Resource - that part of a Mineral Resource for which quantity and quality are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and quality continuity. Geological evidence is based on exploration, sampling and testing information. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration.

Indicated Mineral Resource - that part of a Mineral Resource for which quantity, quality, densities, shape and physical characteristics are estimated with sufficient confidence to support mine planning and evaluation of the economic viability of the deposit. Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing, and is sufficient to assume geological and quality continuity between points of observation where data and samples are gathered.

Measured Mineral Resource - that part of a Mineral Resource for which quantity, quality, densities, shape, and physical characteristics are estimated with confidence sufficient to support detailed mine planning and final evaluation of the economic viability of the deposit. Geological evidence is derived from detailed and reliable exploration, sampling and testing, and is sufficient to confirm geological and quality continuity between points of observation where data and samples are gathered.

Proved Reserve - the economically mineable part of a Measured Mineral Resource. A Proved Ore Reserve implies a high degree of certainty in the factors that influence the economic viability of the resource.

Stated Policy Scenario (STEPS) – an IEA World Energy Outlook scenario in which broad energy and environmental objectives (including country net-zero targets) are not automatically assumed to be met. They are implemented in this scenario to the extent that they are backed up by specific policies, funding and measures. The STEPS also reflects progress with the implementation of corporate sustainability commitments. In the STEPS, emissions from new and existing energy infrastructure lead to a long-term temperature rise of around 2.7 °C in 2100.

Sustainable Policy Scenario (SDS) - an IEA World Energy Outlook scenario in which energy sector and industrial process CO_2 emissions fall continuously over the period to 2050 from around 33 gigatonnes (Gt) in 2020 to 26.7 Gt in 2030 and 10 Gt in 2050, on course towards global net-zero CO_2 emissions by 2070. If emissions were to remain at zero from this date, the SDS would provide a 50% probability of limiting the temperature rise to less than 1.65 °C, in line with the Paris Agreement to limit global warming to well below 2 °C, preferably 1.5°C, compared to pre-industrial levels.

Coal types - coal is classified into four main types, or ranks: anthracite, bituminous, sub-bituminous, and lignite. The ranking depends on the types and amounts of carbon the coal contains and on the amount of heat energy the coal can produce. The rank of a coal deposit is determined by the amount of pressure and heat that acted on the plants over time.

Anthracite - contains 86%–97% carbon and generally has the highest heating value of all ranks of coal. Anthracite accounted for less than 1% of the coal mined in Australia in 2019.

Bituminous - contains 45%–86% carbon. Bituminous coal is the most abundant rank of coal found in Australia, and it accounted for about 86% of total Australian coal production in 2019. Bituminous coal is used to generate electricity and is an important fuel and raw material for use in the iron and steel industry.

Sub-bituminous - typically contains 35%–45% carbon, and it has a lower heating value than bituminous coal. About 5% of total Australian coal production in 2019 was sub-bituminous. Sub-bituminous coal is mostly used to generate electricity.

Lignite - contains 25%–35% carbon and has the lowest energy content of all coal ranks. Lignite is crumbly and has high moisture content, which contributes to its low heating value. Lignite accounted for 9% of total Australian coal production in 2019. Lignite is mostly used to generate electricity.

Annex E: Details of proposed NSW Coal Mining Projects – under EPBC Act consideration as at 8 July 2021

Project Name and (EPBC Reference)	**Russell Vale Colliery Revised Underground Expansion Project (2020/8702)**	**Tahmoor South Coal Project (2017/8084)**	**Mangoola Continued Coal Operations Project (2018/8280)**	**Vickery Extension Project (EPBC 2016/7649)**
1. Company	Wollongong Coal Limited/Jindal steel	SIMEC	Mangoola Coal Operations Pty Ltd (MCOPL), a subsidiary of Glencore Coal Pty Ltd	Vickery Coal Pty Ltd, a subsidiary Whitehaven
2. Project description	Proposed expansion of existing underground operations. Proposal will extract 3.7 Mt of ROM coal over 5 years Mining at a rate of no more than 1.2Mt of ROM per annum The ROM coal meets specification for unwashed coking coal	Proposed underground mine expansion will produce an additional 33 Mt of ROM coal over 10 years. Mining at a rate of up to 4 million tonnes (Mt) per annum of ROM coal.	Extension project which will provide access to 52 Mt of ROM coal over 8 years s. 47G(1)	Extension Project will account for an additional 33 Mt of ROM coal over 25 years. Approved Mine 168 Mt of ROM coal Total Production of 150 Mt of saleable coal all to be exported- 40% Thermal 60% semi soft

Project Name and (EPBC Reference)	Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	Tahmoor South Coal Project (2017/8084)	Mangoola Continued Coal Operations Project (2018/8280)	Vickery Extension Project (EPBC 2016/7649)
	that would be exported as a lower ash, single product coal for use in iron and steel making. The mine has been in care and maintenance since December 2015.			coking coal (SSCC is also classified as metallurgical coal). (SSCC can also be used as premium quality thermal coal)
3. Metallurgical Coal %	84 % coking coal (16% coal rejects when washed – washing will be done by the end user in India)	90-95% coking coal	N/A	60% coking coal
4. Metallurgical coal classification **a. Hard coking Coal (mt)** **b. Soft coking coal (mt)**	100% hard coking coal Gross calorific value: 6300-7400 kcal/kg raw coal ash: 26 – 32%	100% hard coking coal Hard coking coal is expected to account for 22.6 Mt of the saleable coal output.	N/A	The Extension Project will account for an additional 33 Mt of ROM coal. There will be a reduction of approx. 10% of the Total ROM to saleable

Project Name and (EPBC Reference)	**Russell Vale Colliery Revised Underground Expansion Project (2020/8702)**	**Tahmoor South Coal Project (2017/8084)**	**Mangoola Continued Coal Operations Project (2018/8280)**	**Vickery Extension Project (EPBC 2016/7649)**
c. PCI (mt)	total sulphur: 0.42 – 0.45 ROM moisture:9-12%			coal leaving 29.7 MT of saleable coal. Using the 60/40 ratio of Metallurgical Coal Versus Thermal Coal the Estimate for coal production for the Extension Project would be Approx. 17.82 Mt of saleable semi-soft coking coal Vickery Extension ash content is lower than average ash content of Aus SSCC and all other major seabourne SSCC suppliers apart from Canada. Sulphur content at 0.4% is at lower end globally,

Project Name and (EPBC Reference)	**Russell Vale Colliery Revised Underground Expansion Project (2020/8702)**	**Tahmoor South Coal Project (2017/8084)**	**Mangoola Continued Coal Operations Project (2018/8280)**	**Vickery Extension Project (EPBC 2016/7649)**
				Indonesia and Columbia have lower ash content. Vickery Extension coal has a low sulphur content only Russia has a lower sulphur content of thermal coal globally.
5. Thermal Coal %	N/A	5-10% thermal	100% low and high ash thermal	40% (used for power generation)
6. Thermal coal quality properties: **a. Ash Content (%)** **b. Volatile Matter (%)** **c. Total Sulphur (%)**	N/A	a. Ash Content: 23% b. Volatile Matter: 25% c. Total Sulphur: 0.3% d. Calorific Value NAR: 6300(kcal/Kg)	Mangoola markets primarily two thermal coal types, a relatively low ash thermal rated at about 5,800 kcal (per kilogram) and a high ash thermal with 4,775 kcal. [Economic impact assessment page 4]	a. Ash content: 7.6% b. Volatile matter: unknown c. Sulphur: 0.4% d. Calorific Value: 6420 Kcal/kg

Project Name and (EPBC Reference)	Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	Tahmoor South Coal Project (2017/8084)	Mangoola Continued Coal Operations Project (2018/8280)	Vickery Extension Project (EPBC 2016/7649)
d. Calorific Value NAR (kcal/Kg)			Low Ash: 24.8 High Ash: 16.3 Total: 41.1 ROM: 52.3 [Economic impact assessment Table 30: page 56] Yearly break down also provided in table 30	Vickery Extension thermal coal is of higher quality in terms of calorific value than country weighted averages of all other coal exporters including within Australia. (pg. 12, Ashurst Submission to IPC, 2020)
7. When mine extension will commence (life of project) **a. Timeframe for exporting the coal**	15 July 2021 (five years) a. Coal exported in September 2021 b. Coal combusted in November-	2022 (10 years) Extraction - Currently scheduled for secondary extraction (i.e. longwall extraction of coal) in September 2022. It takes 1 to 2 months for	2022 (eight years)	TBA (25 Years)

Project Name and (EPBC Reference)	Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	Tahmoor South Coal Project (2017/8084)	Mangoola Continued Coal Operations Project (2018/8280)	Vickery Extension Project (EPBC 2016/7649)
b. When coal is likely to be used (combusted)	December 2021 (for the first development panel and assume remaining coal will be combusted within the 5 year life of the project)	the coal to be processed and loaded onto ships. Combustion – for the furthest customer, it would be approximately 3 months (assuming the customer uses the product relatively quickly, which Tahmoor Coal assumes they do).		
8. Emissions a. Scope 1 b. Scope 2 c. Scope 3	a. 1,419,000 t CO2-e b. 104,000 t CO2-e c. 9,600,000 t CO2-e	d. 26.7 Mt $CO_{2\text{-}e}$ (19Mt CO2-e abated) e. 1.24 Mt $CO_{2\text{-}e}$ f. 65.8 Mt $CO_{2\text{-}e}$	a. 3.25 Mt CO2-e(table 6.35 EIS) b. 402,192 t $CO_{2\text{-}e}$ (table 6.35 EIS) c. 104.3 Mt $CO_{2\text{-}e}$(table 6.35 EIS)	a. 0.0 Mt $CO_{2\text{-}e}$ (Legal Cons p52) b. 0.15 Mt $CO_{2\text{-}e}$(Legal Cons p52) c. 100 Mt $CO_{2\text{-}e}$(Legal Cons p52)

Project Name and (EPBC Reference)	Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	Tahmoor South Coal Project (2017/8084)	Mangoola Continued Coal Operations Project (2018/8280)	Vickery Extension Project (EPBC 2016/7649)
9. Customer (JV/owner)	Jindal Steel and Power PTY limited (owner)	Whyalla Steel Works BlueScope's Port Kembla steelworks	Unknown	Unknown
10. Contracts in place in place with customer(s)	N/A as the mine is part of the customer's corporate structure.	Tahmoor Coal advised that the usual practice for coal mines is to secure contracts approximately one year in advance. The Tahmoor Coal mine does negotiate longer term contracts from time to time. One key customer is BlueScope Steel (Port Kembla), and the two operations are strategically close in	Unknown	Unknown

Project Name and (EPBC Reference)	Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	Tahmoor South Coal Project (2017/8084)	Mangoola Continued Coal Operations Project (2018/8280)	Vickery Extension Project (EPBC 2016/7649)
		distance. This alliance is important for the ongoing viability of BlueScope Steel operations, as presented by BlueScope Steel at the IPC Hearings.		
Product Destination	Orissa India	25% domestic (South Australia and Port Kembla), 75% to international markets	81% of product coal for export to China, India, Japan, Malaysia, Philippines, South Korea, Taiwan, Vietnam 19% of product coal to go domestically (Bayswater, Liddell Power Stations)	Taiwan, South Korea, Japan

Project Name and (EPBC Reference)	Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	Tahmoor South Coal Project (2017/8084)	Mangoola Continued Coal Operations Project (2018/8280)	Vickery Extension Project (EPBC 2016/7649)
11. Source of Replacement Coal and GGE Intensity of that coal	Jindal Steel advised it has no replacement option for this coal.	Tahmoor Coal advised that the Tahmoor Mine extracts premium quality coking coal from the Bulli Seam. The same coal seam is mined by South32. It is worth noting that South32 Dendrobium Mine has a limited life with approval to approximately 2024.		
7. Information sources	EPBC Act referral [link] Refence no. 2020/8702 Russell Vale Underground Expansion Project	EPBC Act referral [link] Refence no. 2017/8084 NSW Assessment reports & EIS [link]	EPBC Act referral [link] Refence no. 2018/8280 NSW Assessment reports & EIS [link]	EPBC Act referral [link] Refence no. 2016/7649 NSW Assessment report and EIS [link]

Project Name and (EPBC Reference)	Russell Vale Colliery Revised Underground Expansion Project (2020/8702)	Tahmoor South Coal Project (2017/8084)	Mangoola Continued Coal Operations Project (2018/8280)	Vickery Extension Project (EPBC 2016/7649)
	public environment report [link] The NSW State Assessment report [link] Documents provided as part of the NSW assessment [link]	Independent Planning Commission site [link]	Independent Planning Commission site [link] EIS Appendix 25 – Glencore Position on Climate Change [link] EIS Appendix 22 – Greenhouse Gas and Energy Assessment [link]	Independent Planning Commission site [link] Ashurst Submission to IPC – Consideration of Greenhouse Gas Emissions and Climate Change (16 June 2020). [link]

Supplementary information – Vickery Extension Project (EPBC 2016/7649)

Question	**Advice**
1. Would CO_2 emissions associated with the project, which occur in Australia, be covered by the Australian Government's emissions reduction commitments under the Paris Agreement?	Yes. CO_2 emissions associated with the project that occur within Australia's jurisdiction over the period 2021-30 would be covered by the Australian Government's Paris Agreement Nationally Determined Contribution (NDC) for that period (2030 Paris target). The Government has committed to an economy-wide 2030 Paris target to reduce emissions to 26 to 28 per cent below 2005 levels by 2030, expressed as an emissions budget over the period 2021-30. Emissions from the project occurring beyond that period (within Australia's jurisdiction) will be covered by future NDCs made by the Government consistent with Article 4.3 of the Paris Agreement.
2. Would the project's CO_2 emissions affect the Australian Government's ability to meet its emissions reduction commitments under the Paris Agreement?	Projected emissions from the Vickery extension over the 2021-30 period were considered in the preparation of Australia's Emissions Projections 2020. That report states Australia is on track to meet and beat its 2030 Paris target.
3. Would CO_2 emissions associated with the project's exported coal, which occur in the proposed export markets, be covered by commitments under the	For the purposes of this assessment, it is assumed that the project's coal would be exported to one or more of Whitehaven Coal's key export markets, as identified in the *Whitehaven Coal Sustainability Report* (2020). Only those key export markets that are identified as individual countries or jurisdictions are considered in this advice.[1]

[1] 5 per cent of Whitehaven Coal's key export markets for thermal coal are not attributed to individual countries or jurisdictions. They are instead identified as "Other SE Asia" (2 per cent) and "Other" (3 per cent).

Paris Agreement to reduce or limit emissions?	On this basis, it can be confirmed that such emissions would be expected to be covered by NDCs to limit or reduce emissions over the period to 2030.[2] It is noted that one of the export markets, Taiwan, is not a Party to the Paris Agreement. The Department notes that Taiwan submitted an (Intended) NDC in 2015 to reduce emissions that would be expected to cover emissions associated with the project that occur in Taiwan.[3] It is noted that the life of the project is estimated at 25 years; beyond the 2030 end date of the above mentioned NDCs. It is expected that emissions associated with the project that occur after 2030 would also be covered by future NDCs submitted by the identified export markets. This expectation is based on Article 4.3 of the Paris Agreement, which provides "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.".

4. Describe any emission reduction/limitation commitments/goals/policies (eg net zero goal) made by importing country governments or jurisdictions (Japan, South Korea, Taiwan) that are additional to their NDC	**Japan**
	
	Japan's official NDC commits to emissions reduction of 26% below 2013 by 2030. In addition,
	• Japan's Global Warming Countermeasures Law 2021 commits that "a decarbonised society will be realized by 2050".
	• At the US-hosted Leaders' Summit on Climate in April 2021, Japan announced it will reduce emissions 46% below 2013 by 2030.
	• Japan's Ministry of Economy, Trade and Industry (METI) released its Basic Energy Policy draft in July 2021. Under the plan, by 2030:
	  ○ coal use will be reduced from 26% to 19%
	  ○ gas use will be reduced to 56% to 41%
	  ○ solar is set to increase to 15% from 6.7% in 2019
	  ○ wind is set to increase to 6% from 0.7% in 2019

[2] Information on Paris Agreement NDCs was sourced from the UNFCCC website on 8 August 2021 (www4.unfccc.int/sites/NDCStaging/Pages/All.aspx).
[3] Sources: https://ghg.tgpf.org.tw/files/team/Submissiom_by_Republic_of_China_(Taiwan)INDC.pdf and https://www.mofa.gov.tw/Upload/RelFile/1390/158470/2016%20UNFCCC%e8%8b%b1%e6%96%87%e8%aa%aa%e5%b8%966%e9%a0%81.pdf

	The Republic of Korea (South Korea) South Korea's official NDC commits to emissions reduction of 24.4% below 2017 emissions by 2030. In addition, • At the US-hosted Leaders' Summit on Climate in April 2021, South Korea announced a commitment to ending financing of overseas coal fired power plants. **Taiwan** Taiwan is not a Party to the Paris Agreement. On 17 September 2015 Taiwan announced its INDC (intended Nationally Determined Contribution) that committed to reduce its emissions by 20% below 2005 levels by 2030. In addition, • Taiwan legislated its Greenhouse Gas Reduction and Management Act in 2015 with the long-term goal to reduce emissions 50% below 2005 levels by 2050.

NOTICE OF FILING

This document was lodged electronically in the FEDERAL COURT OF AUSTRALIA (FCA) on 4/12/2020 5:14:59 PM AEDT and has been accepted for filing under the Court's Rules. Details of filing follow and important additional information about these are set out below.

Details of Filing

Document Lodged:	Expert Report
File Number:	VID607/2020
File Title:	ANJALI SHARMA & ORS (BY THEIR LITIGATION REPRESENTATIVE SISTER MARIE BRIGID ARTHUR) v MINISTER FOR THE ENVIRONMENT (COMMONWEALTH)
Registry:	VICTORIA REGISTRY - FEDERAL COURT OF AUSTRALIA

Dated: 4/12/2020 5:15:06 PM AEDT

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Important Information

As required by the Court's Rules, this Notice has been inserted as the first page of the document which has been accepted for electronic filing. It is now taken to be part of that document for the purposes of the proceeding in the Court and contains important information for all parties to that proceeding. It must be included in the document served on each of those parties.

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4 December 2020

David Barnden
david@equitygenerationlawyers.com

Dear David

Expert opinion: Anjali Sharma v Minister for the Environment

Thank you for your letter of engagement dated 16 November 2020 and follow up email dated 18 November 2020. A copy of both is included in Appendix A. I am pleased to attach my expert opinion on the questions put to me in that letter.

In preparing my response I acknowledge that:

- I have read and complied with the Expert Evidence Practice Note (GPN-EXPT) including the Harmonised Expert Witness Code of Conduct ("Code") and agree to be bound by the Code
- My opinions are based wholly or substantially on specialised knowledge arising from my training, study and experience
- I have made all the inquiries which I believe are desirable and appropriate (save for any matters identified explicitly in the report), and no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Court.

In the following sections the specific questions that I was asked to address in the letter of engagement are reproduced under subheadings 1, 2, 3, and 4.

Yours sincerely

RMeyricke

Ramona Meyricke

Fellow of the Institute of Actuaries of Australia

PhD (Cantab)

1 Question 1: Please describe your academic qualifications, professional background and experience in the fields of actuarial and economic analysis, and any other training, study or experience that is relevant to this brief

1.1.1 I have summarised my relevant academic qualifications, professional background and experience in the fields of actuarial and economic analysis in Appendix B.

2 Question 2

2.1 Please describe the function of an actuary

2.1.1 As set out by the International Actuarial Association (2013):

"Actuaries fulfil many roles in a broad range of environments, including insurance companies, health organizations, pension plans, risk management, government, regulatory regimes, and in other fields. They have a detailed understanding of economic, financial, demographic and insurance risks and expertise in:

- Developing and using statistical and financial models to inform financial decisions
- Pricing, establishing the amount of liabilities, and setting capital requirements for uncertain future events.

Actuaries also provide advice on the adequacy of risk assessment, reinsurance arrangements, investment policies, capital levels and stress testing of the future financial condition of a financial institution."

2.1.2 The function of an actuary may vary depending on several factors including:

- The area of practice in which they work (for example, superannuation, general insurance, life insurance etc.)
- The specific organisation where they work and the role they perform in that organisation (for example, actuarial roles can specifically focus on pricing, valuation, reserving, financial reporting, risk management etc.).

2.1.3 For example, in Australia insurance companies (whether general, life or health insurance) are required by law (the Insurance Act and the Life Insurance Act) to have an Appointed Actuary (AA). The function of the AA within each insurance company is set out in APRA Prudential Standard CPS 320[1] (CPS 320). An AA must provide advice to the insurer on the valuation of the insurance liabilities, the insurer's financial condition, and matters specified under the insurer's actuarial advice framework. The purpose of the AA role is to ensure that the senior management and Board of an insurer access expert and impartial actuarial advice to assist with the sound and prudent management of the insurance company.

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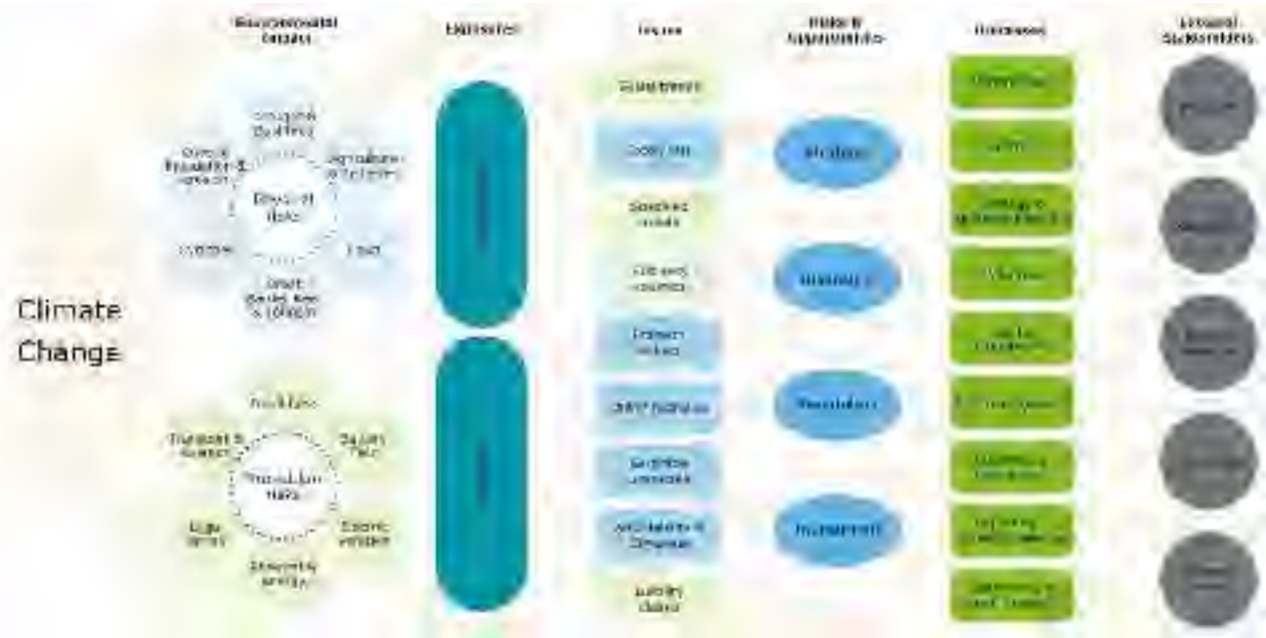
[1] APRA has developed a comprehensive framework of prudential standards which set out minimum capital, governance and risk management requirements. See: https://www.apra.gov.au/sites/default/files/cps_320_standard_only.pdf

2.2 Please describe the role of an actuary with respect to the assessment or quantification of future impacts of climate change, if any

2.2.1 Climate change may have a wide range of impacts on insurance exposures, risks and opportunities, processes and stakeholders, as illustrated in Figure 1.

Figure 1 – An illustration of the wide-ranging impacts that climate change may have on insurers[2]



2.2.2 The role of an actuary with respect to the assessment or quantification of future impacts of climate change varies depending on several factors including:

- The area of practice in which they work (for examples, general insurance, life insurance or private health insurance)
- The specific organisation where they work and the role they perform in that organisation.

2.2.3 The Actuaries Institute's Information Note for AAs (Actuaries Institute, 2020) provides an outline of how insurance operations may be impacted by climate change and offers suggestions for how to address these issues in an Financial Condition Report (FCR).

2.2.4 Below I illustrate a few roles an actuary may fill with respect to the assessment or quantification of future impacts of climate change. The following list is not exhaustive.

2.2.5 **Insurance pricing**: Actuaries play a role in setting the price of an insurance contract and assessing the adequacy of insurance premium receipts to cover expected future claim payments. There is a role, therefore, for an actuary to assess whether the premiums being charged adequately price for climate change risk. As insurance pricing is risk-based, climate change may drive premium increases, for example as natural hazards risk changes. The actuary's assessment should assess additional relevant factors such as:

- The extent to which mitigation and adaptation are expected to reduce future claim costs related to climate change
- The likelihood that climate change could create growing affordability pressure due to material increases in premiums over time

[2] Source: https://actuaries.asn.au/Library/Standards/MultiPractice/2020/INCCFinal121120.pdf

- Regulatory and reputational risks.

2.2.6 **Capital and risk management**: Actuaries play a role in assessing an insurer's current and future profitability and capital adequacy. This requires consideration and assessment of the impacts of climate change through the capital management framework and the company's risk management strategy (Actuaries Institute, 2020). Actuaries may assess specific areas such as:

- Whether the methodologies and models for determining capital adequacy adequately allow for the uncertainties associated with climate change
- Whether the business they work for has an effective plan or strategy to assess and address climate risk
- Whether climate related customer considerations and reputation risk have been adequately considered and addressed by the business.

2.2.7 **Investment management**: As discussed in *Section 3.4*, climate change creates risks that may impact the value of investment asset portfolios and the assessment of credit risk. Actuaries working in investment management may play a range of roles relating to the assessment of possible impacts of climate change. For example:

- Stress testing portfolio returns under different future scenarios, to understand the risks of inadequate future investment returns given the nature of the insurance liabilities
- Reviewing whether future macroeconomic assumptions related to growth, interest rates and inflation are appropriate given the possible systemic impacts of climate change
- Assessing the impacts of climate change on default risk and loss-given-default, given climate related risks might reduce some borrowers' ability to repay their debts (Bolton et al., 2020).

2.3 Please describe your experience and research as an actuary with respect to climate change

2.3.1 Please see response to Question 1.

3 Question 3: Can you assess possible future impacts of the type/s referred to in paragraph 16 of the Concise Statement of any one or more of the drivers described in paragraph 15.1 to 15.3 of the Concise Statement? If so, what is your analysis of the effect of such impacts on individuals currently under 18 years of age?

3.1 Background information

3.1.1 This report is based on research I published in October 2019 titled *'Climate Change, Mortality and Retirement Incomes'* which is attached in full in Appendix C and referred to from here on as Meyricke and Chomik (2019).

3.1.2 The evidence and conclusions of Meyricke and Chomik (2019) still stand but in this report some arguments are expanded on to (a) address the questions asked of me and (b) reflect advances in research on the possible mortality, economic and/or financial consequences of climate change, as outlined below.

3.1.3 This report should be considered together with the paper included in Appendix C and not in isolation.

3.1.4 Some answers to *Questions 3* and *4* are exclusively in relation to Australia; where this is the case it is explicitly stated.

3.2 Possible future impacts of heatwaves on mortality, including analysis of the effect of such impacts on individuals currently under 18 years old

3.2.1 Heatwaves significantly increase mortality across the globe but estimates of the impact vary with, among other things, the definition of heatwaves[3], heatwave intensity and heatwave duration (Xu et al., 2016). For the purpose of this report a heatwave is defined by three or more days of unusually high maximum and minimum temperatures in any area.

3.2.2 In Australia, heatwaves have caused more deaths since 1890 than bushfires, cyclones, earthquakes, floods and severe storms combined (Climate Council, 2016).

3.2.3 In addition to deaths, heatwaves also drive an increase in heat-related illness (or morbidity) as shown in Table 1. Table 1 illustrates the numbers of excess deaths[4], emergency department presentations, after hours doctor consultations and ambulance dispatches during two separate weeklong heatwaves in Melbourne. To put these numbers into context, the 374 excess deaths in Victoria between 26 Jan 2009 and 1 Feb 2009 was a 62% increase in total all-cause mortality during the heatwave; the total number of deaths was 980, compared to a mean of 606 for the previous 5 years (Victorian DHHS, 2012).

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[3] Heatwave definitions can vary by
- Whether the daily temperature measure is based on max, minimum or mean temperatures
- Where any thresholds are set (e.g. days over 30°C or 35 °C, 95th percentile or 99th percentile)
- The definition of the study period over which daily temperature observations are included and/or averaged (e.g. over summer data vs. the warm season or the whole year data).

[4] Excess deaths are the number of deaths over what would normally be expected for the same period. This measure controls for the population size and demographics (such as age and gender).

Table 1 – Excess deaths and impact on public health and services during two Victorian heatwaves[5]

Nature of impact	2009 (26 Jan to 1 Feb)	2014 (12 Jan to 18 Jan)
Excess deaths	374	167
Heat-related emergency department presentations	714	621
After Hours doctor consultations	1,955	3,687
Ambulance dispatches (metropolitan Melbourne)	7,035	8,359

3.2.4 The health and mortality effects of heatwaves are more pronounced in older people. For example, while individuals aged 75 years or older made up 6.5% of the Victorian population by count in 2008 and 2009[6], in the 2009 heatwave in Victoria (impacts shown in Table 1, column 2):

- 61% of the 7,035 ambulance dispatches were for those 75 years or older
- 65% of the 1,955 after hours doctor consultations were for those 75 years or older
- 46% of the 714 Emergency Department heat-related presentations were for those 75 years or older
- 66% (or 248) of the 374 excess deaths occurred in those 75 years or older.

The increased vulnerability of the elderly to heatwaves relates to a combination of altered homeostatic mechanisms and the higher prevalence of chronic diseases among the elderly (Kovats and Hajat, 2008).

Possible future impacts of heatwaves on individuals currently under 18 years of age

3.2.5 As the risk of heat-related mortality increases with ageing (Kovats and Hajat, 2008), it is my opinion that individuals currently under 18 years of age would be most at risk from heatwaves in their late adulthood (i.e. around when they reach age 65, in 47 to 65 years' time).

3.2.6 At an individual level, future impacts of heatwaves on individuals currently under 18 years of age will depend on the extent and success of adaptation measures over their lifetimes. Adaptation to heatwaves could include things such as:

- Increasing the use of air-conditioning
- Strengthening of building standards to make indoor climates healthier
- Changing working practices (such as the hours people work and where they work from).

3.2.7 Factors such as the increased use of air-conditioning, for example, would likely decrease absolute excess mortality from heatwaves.

3.2.8 With ongoing improvement in public awareness and risk mitigation, the amount of excess mortality from climate change could be limited. In Australia, current public health advice to individuals on protecting themselves from the risks of extreme heat primarily involves getting out of the heat by spending more time in air-conditioned buildings or indoors[7]. Australians currently under 18 years of age, if they heed this advice, are therefore likely to spend more time indoors over the course of their lifetimes, on average, than past generations. While not directly

[5] Source: https://www.audit.vic.gov.au/sites/default/files/2017-07/20141014-Heatwave-Management.pdf
[6] See ABS 3105.0.65.001 - Australian Historical Population Statistics, 2019 - Population Age and Sex Structure
[7] See for example https://www2.health.vic.gov.au/public-health/environmental-health/climate-weather-and-public-health/heatwaves-and-extreme-heat/heatwave-community-resources & https://www.health.nsw.gov.au/environment/air/Pages/bushfire-protection.aspx

related to mortality, this an illustration of how Australian lifestyles could adapt to mitigate an increase in heat-related mortality risk.

3.2.9 While human capacity to adapt to varied climates is considerable, there are absolute limits to the amount of heat exposure an individual can tolerate[8]. Even with highly effective adaptation (for example, all time spent indoors in air-conditioned environments) there are residual risks, such as air conditioning system failure or power failure. It is my opinion, therefore, that even with effective adaptation and risk mitigation there will still be excess mortality in future, amongst individuals currently under 18 years of age, from heatwaves.

3.2.10 An increase in mortality risk globally, even after allowing for adaption, is also expected by the World Health Organisation (WHO, 2014) which states:

"Overall, climate change is projected to have substantial adverse impacts on future mortality, even considering only a subset of the expected health effects, under optimistic scenarios of future socioeconomic development and with adaptation".

[8] The theoretical limit to human survival, or upper physiological limit, is a wet-bulb temperature of 35°C; above this dissipation of metabolic heat becomes impossible. See: https://www.pnas.org/content/107/21/9552

3.3 Possible future impacts on mortality of higher daily temperatures, including analysis of the effect of such impacts on individuals currently under 18 years old

Possible future impacts of higher daily temperatures on mortality

3.3.1 While there is no consistent definition of a heatwave, it is agreed that a single day of high temperatures does not make a heatwave. Therefore, the possible future impact of daily temperatures on mortality is a distinct question to the possible future impact of heatwaves on mortality. This question was not explicitly addressed in Meyricke and Chomik (2019), so I address it below.

3.3.2 The IPCC Fifth Assessment Report (IPCC 2014) states with *high confidence*[9] that climate change is expected to lead to increased risk of heat-related mortality compared to a baseline without climate change. While: "Positive effects [of climate change] are expected to include modest reductions in cold-related mortality and morbidity in some areas due to fewer cold extremes (*low confidence*) ... globally over the 21st century, the magnitude and severity of negative impacts are projected to increasingly outweigh positive impacts (*high confidence*)".

3.3.3 Guidance to the Lead Authors of IPCC (2014) states that presentation of findings with "low" and "very low" confidence should be reserved for areas of major concern[10] with low levels of evidence and/or low degrees of agreement. It follows that there was low levels of evidence and/or low degrees of agreement in 2014 that climate change could be expected to drive modest reductions in cold-related mortality and morbidity, in some areas, due to fewer cold extremes.

Recent research on temperature related excess mortality under climate change scenarios

3.3.4 Academic research published from 2014 onwards remains broadly consistent with IPCC (2014) regarding the possible future impacts of temperature on mortality under climate change scenarios. Some studies forecast net reductions in mortality under climate change scenarios, in some areas of the world, driven by forecast reductions in cold-related mortality. However, many other studies produce contradictory results and conclude that either (a) cold-related mortality will not decline as temperatures increase in a warming climate or (b) cold-related mortality will decline a small amount, but additional heat-related mortality will offset any benefit.

3.3.5 Below I expand on academic studies published since 2014 on the topic of projections of temperature-related mortality under climate change scenarios.

3.3.6 Overall, the relative role of different temperature exposures (i.e. heat, cold, and temperature variability) in affecting morbidity and mortality remains unclear (Cheng et al., 2019). Furthermore, there are no widely accepted approaches to predict the future relationship between temperature and mortality or to forecast mortality impacts under future climate scenarios (WHO, 2014); this is an active area of ongoing work and methodological refinement (Gasparrini et al., 2019; Shaffer et al. 2019).

3.3.7 Several studies including Kinney et al. (2015) and Staddon et al. (2014) conclude that mortality during winter in the UK, US and France is not strongly influenced by temperature.

- Kinney et al (2015) analysed multi-decadal data from 39 cities in the US and France and concluded that mortality was not strongly influenced by temperature during winter. Further they showed that inadequate control for seasonal factors (such as influenza) in analyses of the effects of cold temperatures on mortality led to spuriously large assumed cold effects and erroneous attribution of mortality to cold temperatures.
- Staddon et al (2014) shows that in the UK, while winter deaths are still higher than summer deaths, how harsh a winter is no longer predicts excess deaths. They found that in the UK

[9] The IPCC Fifth Assessment report expresses level of confidence using five qualifiers: "very low," "low," "medium," "high," and "very high." It synthesizes the author teams' judgments about the validity of findings as determined through evaluation of (a) evidence and (b) agreement. Increasing levels of evidence and degrees of agreement are correlated with increasing confidence.
[10] https://wg1.ipcc.ch/docs/AR5_Uncertainty_Guidance_Note.pdf

from 1986 onwards housing quality and the incidence of influenza-like illnesses were the main drivers of year-to-year variation in excess deaths in winter in the past decade. They conclude that climate change will not reduce excess deaths in winter in England[11].

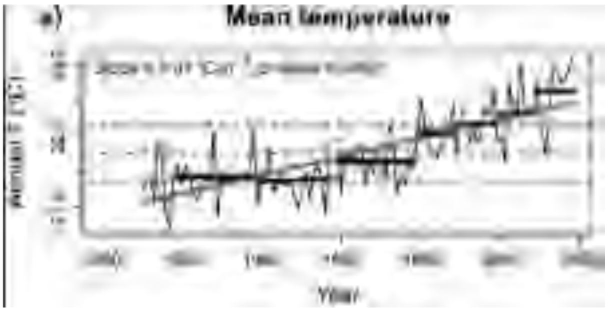
3.3.8 For Australia, the results are mixed. Some multi-country studies (Gasparrini et al., 2017; Vicedo-Cabrera et al., 2018) have suggested climate change will result in a net decrease in temperature-related deaths in Australia as fewer deaths from cold temperatures are expected to offset higher deaths from higher temperatures. While a related multi-country study (Gasparrini et al., 2015) finds that in Australia more deaths are attributable to cold weather than hot weather. In contrast Longden (2018, 2019) finds that most deaths in Australia are heat-related implying that climate change will result in a net increase in temperature-related deaths in Australia.

3.3.9 The conclusions of Gasparrini et al. (2015), Gasparrini et al. (2017) and Vicedo-Cabrera et al. (2018) are, in my opinion flawed, due to the issues outlined in paragraphs *3.3.10 to 3.3.14.*

Critique of academic studies on temperature related excess mortality under climate change scenarios in Australia

3.3.10 First, the method used to estimate the relationship between temperature and mortality in Gasparrini et al. (2017), Vicedo-Cabrera et al. (2018) and Gasparrini et al. (2015) is to fit statistical time-series regression models of daily average temperature against daily death counts for all causes of death or non-external causes of death only[12] (over the period 1 January 1988 to 31 May 2009 for Sydney, Melbourne and Brisbane). It is important to note that long-term Australian temperature time-series are non-stationary (Ukkola et al 2019). As shown in Figure 2, the mean and variability of temperatures in Australia are changing over time.

Figure 2 – Annual temperature (T) time series averaged for Australia, with the linear trend in blue and decadal means as black bars[13]



3.3.11 When variables are non-stationary, appropriate methods should be used to allow for non-stationarity[14] otherwise regressions are often spurious (Clements and Hendry, 1998) and standard statistical inference (for example, t- and F-tests) is generally not valid (Phillips, 1986). The academic studies listed above do not test for, or control for, non-stationarity. Therefore, the results of such studies may not be valid, and using them to forecast future impacts could also be misleading.

3.3.12 Second, recent research using more recent Australian data (Longden, 2018, 2019) has contradicted the finding that climate change will result in a net decrease in temperature-related deaths in Australia, instead forecasting a net increase in mortality in Australia due to climate

[11] Staddon et al. (2014) suggest that climate change could increase excess deaths in winter if extreme events, including cold spells and storms, increase in frequency; if this occurs then winters could be generally warmer, but with more days of severe cold. The effects of extreme cold and more variable temperatures on mortality could be substantial, for example, if vulnerable people are caught off-guard by abrupt changes in temperature.

[12] See details here: https://www.thelancet.com/cms/10.1016/S0140-6736(14)62114-0/attachment/3daac933-d843-4742-95cd-07cae706f14f/mmc1.pdf & https://www.thelancet.com/cms/10.1016/S2542-5196(17)30156-0/attachment/7e87b414-1503-4371-b4b0-5c6a4406adf0/mmc1.pdf

[13] Source Ukkola et al. (2019)

[14] Such as error correction models or cointegration techniques.

change. Longden (2018, 2019) use a dataset covering all of Australia from January 2006 to October 2017. The key difference driving the contradictory results of Longden (2018, 2019)[15] is the method used to set the 'reference temperature'. Studies that attribute deaths to either 'cold weather' or 'hot weather' need to define 'cold' and 'hot' relative to a reference temperature. The reference temperature is commonly chosen as the minimum mortality temperature (MMT) - which is the temperature at which mortality risk is lowest in the study dataset. However, the reference temperature can be set different ways (for example, using pre-determined percentiles such as the 50th percentile temperature in each location, or using fixed thresholds such that days over 30°C are defined as hot).

3.3.13 Gasparrini et al. (2015), Gasparrini et al. (2017) and Vicedo-Cabrera et al. (2018) all set the reference temperature as the MMT. As illustrated in the top panel of Figure 3, in Melbourne the MMT was equivalent to a (daily average) temperature of 22.4°C[16] which meant almost 90% of Melbourne's historical daily average temperatures were classified as cold. These studies found that most of the temperature-related mortality burden in Australia was attributed to cold temperatures. Longden (2019) set the reference temperature two ways – using the MMT and using the median. When the reference temperature was set to the MMT far more deaths were attributed to cold than when the reference temperature was set to the median. This comparison is shown in Figure 3. When the reference temperature was set to the median, Longden (2019) found that most deaths related to temperature in Australia are caused by heat.

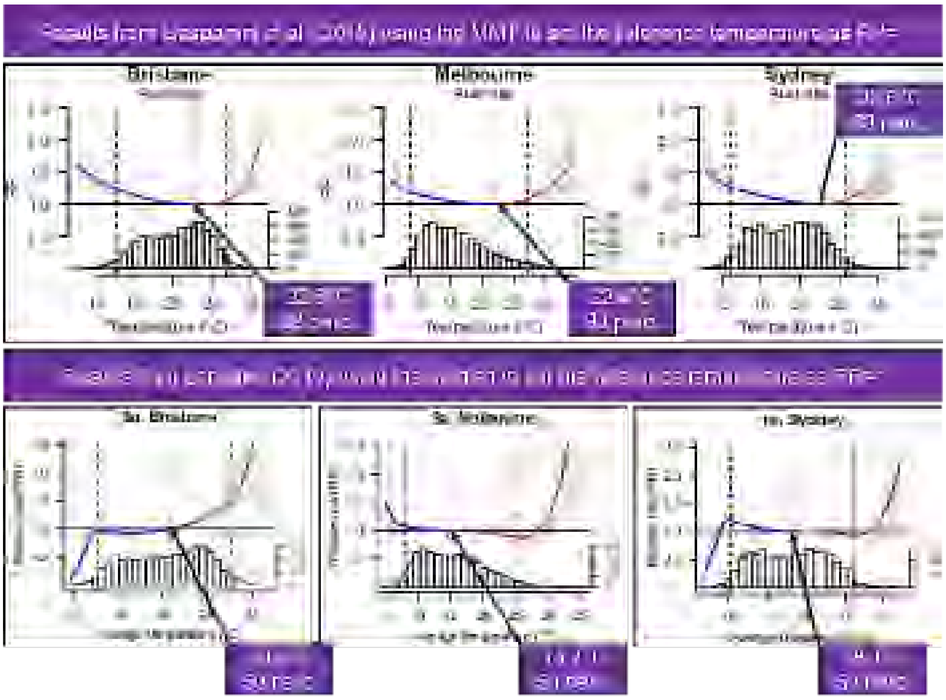
3.3.14 The result of studies concluding that climate change will result in a net decrease in temperature-related deaths in Australia are not robust to the way in which the reference temperature is set. Furthermore, as shown in Kinney et al. (2015) inadequate control for seasonal factors (such as influenza) in analyses of the effects of cold temperatures on mortality could lead to spuriously large assumed cold effect and erroneous attribution of mortality to cold temperatures.

3.3.15 Finally, there is significant under-reporting of heat-related mortality in Australia. As noted in Meyricke and Chomik (2019) and Longden et al. (2020) there is material under-reporting of deaths from heat. This is primarily because hospital administrative data and death certificates typically record only the direct cause of death (for example, heart attack) without any reference to the indirect causes (i.e. heart attack triggered by heat stress). As noted by Longden et al. (2020) the scarcity of resources necessary to maintain or improve the data quality and a lack of physician training in death certificate completion also contribute to the under-reporting of heat-related mortality in Australia.

[15] Versus Gasparrini et al. (2015), Gasparrini et al. (2017) and Vicedo-Cabrera et al. (2018)

[16] Over the study period which was 1 Jan 1988 to 31 May 2009

Figure 3 – A comparison of relative risk (RR) of mortality at different temperatures from Gasparrini et al. (2015) and Longden (2019)[17]



Summary of the possible future impacts of higher daily temperatures on mortality in Australia on individuals currently under 18 years of age

3.3.16 On the balance of this evidence, it is my opinion that if daily temperatures continue to increase in Australia in future this will result in higher mortality risk and more deaths overall compared to a baseline without climate change.

3.3.17 In relation to individuals currently under 18 years of age, similar to my response in *paragraphs 3.2.5 to 3.2.9*, they would be most at risk from sub-optimal temperatures in their late adulthood (i.e. around when they reach age 65, in 47 to 65 years' time). Between now and then many factors will affect the risk to which individuals currently under 18 years of age in Australia may be exposed to in the future; chief among these is the efficacy of measures to adapt to hotter temperatures. However, it is my opinion that even with highly effective adaptation there will still be net excess mortality from increasing temperatures in Australia.

[17] Source: https://theconversation.com/heat-kills-we-need-consistency-in-the-way-we-measure-these-deaths-120500

3.4 Assessment of possible future impacts of the drivers referred to in paragraphs 15.1 to 15.3 of the Concise Statement on economic growth and investment returns.

Possible future impacts of climate change on economic growth and investment returns

3.4.1 As noted in Meyricke and Chomik (2019) climate change poses a risk to economic growth and investment returns. Economic impacts occur through two main channels: **physical damage** arising from more frequent and intense natural disasters and higher temperatures ('physical risk'), and the risks associated with a **transition of the economy** from dependence on fossil fuels to a low-carbon economy ('transition risk').

3.4.2 Physical risk covers the many ways that changes in temperature, natural disasters and extreme weather affect human health, land, assets and other economic factors of production. For example, sea level rises threaten to damage land, infrastructure and other capital in coastal regions; higher temperatures have been shown to cause substantial labour productivity loss in Australia (Zander et al., 2015) and China (Zhang et al., 2018) and lower growth in aggregate economic output globally (Burke and Tanutama, 2019).

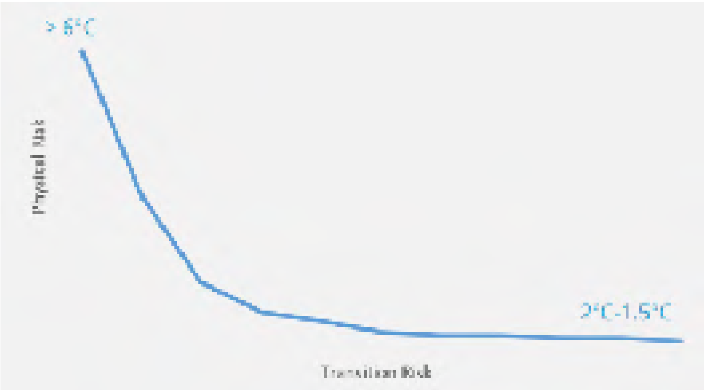
3.4.3 Transition risk covers a wide range of impacts resulting from the policy, legal, technological and market changes that would be likely to occur during a transition to a low-carbon economy. Some examples of these risks include:

- The transition to a low-carbon could result in divestment from industries that are emissions-intensive
- Growth or contraction of sectors of the economy because of a transition to a low-carbon economy may affect employment, wages and aggregate economic output.

3.4.4 Temporally, transition risk is more immediate than physical risk, as it relates to the policy, legal, technological and market changes that are more likely to occur over the next 30 years.

3.4.5 There is a trade-off between transition risk and physical risk. As shown in Figure 4, a faster global transition to a low-carbon economy would involve more transition risk in the short-term but lower physical risk over the long-term; vice-versa, a slower transition to a low-carbon economy will mean lower transition risk but higher physical risk over the long-term.

Figure 4 – Conceptual trade-off between physical risk and transition risk[18]



3.4.6 At a national level, many studies have found the long-term cost of high transition risk scenarios to be far lower than the long-term costs of low transition risk scenarios (DAE 2020, Stern 2006, Garnaut 2008). As summarised on the Australian Treasury website:

"Every credible review, including Stern and the Garnaut Climate Change Review, has found the long-term economic costs of inaction are greater than the costs of action. By not acting, we will also miss out on the investment, innovation and jobs that the global transformation to clean

[18] Source: https://assets.bbhub.io/company/sites/60/2020/10/FINAL-TCFD-Technical-Supplement-062917.pdf

energy will bring. As one of the nations likely to suffer the most from unmitigated climate change, we must act."[19]

Recent research on possible future impacts of climate change on Australian economic growth and investment returns

3.4.7 Meyricke and Chomik (2019) state: "Studies looking at the effect of historic temperature variations also suggest that a warming climate could negatively affect GDP growth (IMF, 2017; Carleton & Hsiang, 2016; Dell et al., 2014). Temperature shocks appear to affect growth via various channels, including lower agricultural and industrial output, higher energy demand and lower labour productivity. However, the relationships are complex, and most studies emphasise the greater impact on developing countries."

3.4.8 At the time of writing Meyricke and Chomik (2019) one of the most comprehensive studies of the impact of climate change on investment returns was Mercer (2015, 2019). This work concludes that: "for nearly all asset classes, regions and timeframes, a 2ºC scenario leads to enhanced projected returns versus 3ºC or 4ºC and therefore a better outcome for investors" Mercer (2019).

3.4.9 Research on climate economics and climate finance is a fast-developing field. Since publication of Meyricke and Chomik (2019), several studies have been published that specifically consider the impacts of climate change on the Australian economy and financial markets.

3.4.10 Deloitte Access Economics (DAE 2020) published the results of modelling of the cost to Australia's economy of inaction on climate change. The assumptions made in DAE (2020) about physical risk and transition risk are summarised in Appendix D. They estimate the cost of a future where Australia and the rest of the world do not mitigate the worst effects of climate change. The results show that climate change scenarios Representative Concentration Pathways[20] (RCPs) 6.0 and 8.5 are expected to *reduce* Australia's GDP growth by 3% p.a. and cost around 310,000 jobs p.a. on average from 2020 to 2070.

3.4.11 On the other hand, DAE (2020) results show that actions to transition the Australian economy to net zero emissions by 2050 are expected to *reduce* Australia's GDP growth by only 0.1% p.a. on average from 2020 to 2050. In other words, DAE (2020) show that the costs of inaction outweigh the costs of a transition to net zero by 2050. This is consistent with international studies which expect total global output to be higher under a lower emissions scenario (Dietz et al. 2016).

3.4.12 In 2020, international asset manager Schroders released long-term return forecasts reflecting the expected future impacts of climate change on Australian asset returns. Schroders (2020) produced 30-year return forecasts, for a range of asset classes globally, making explicit adjustments for the physical and transition costs associated with climate change. The assumptions made in Schroders (2020) about physical risk and transition risk are summarised in Appendix D. For Australia, 10-year Australian government bond returns are forecast to reduce

[19] https://treasury.gov.au/publication/p2011-sglp-overview/costs-of-inaction Cited 1 December 2020.

[20] IPCC (2014) used four possible scenarios for GHG emissions. Known as Representative Concentration Pathways (RCPs), each corresponds to a different level of warming. RCP2.6 is a 'best case' scenario, in which GHG emissions are cut back sufficiently such that global warming is capped at around 1.5 to 2 degrees above the pre-industrial average. At the other end of the scale, RCP8.5 is a worst case, 'business as usual' scenario in which no effort is made to rein in emissions and as a result global temperatures increase by 4 degrees compared to the pre-industrial average by 2100.

by 1.2% p.a. over the next three decades (2020-2049) and Australian equity returns to reduce by 1.8% p.a. over the next three decades (2020-2049).

Table 2 – Schroder's global return forecasts with and without climate change[21]

	Nominal			Real	
% p.a. 2020-49	No climate change	Climate change	Inflation	No climate change	Climate change
Government bonds (10yr)					
US Treasury	3.5	3.7	2.0	1.5	1.6
UK Gilt	2.9	3.5	2.0	0.9	1.4
Australia	3.2	2.0	2.5	0.7	-0.5
Equity markets					
US	5.4	5.4	2.0	3.3	3.4
UK	7.8	8.1	2.0	5.7	6.0
Australia	8.7	6.9	2.5	6.0	4.3

3.4.13 The modelling framework in Schroders (2020) extends the model of Burke and Tanutama (2019)[22] to equity returns (via a Gordon's growth model approach) and to fixed income assets (by modelling the flow-on effects of lower productivity on interest rates).

3.4.14 Important assumptions are made in order to model the impacts of transition risk. It is assumed the world adopts carbon pricing in the form of a carbon tax in the year 2030, imposing a price of $50 per ton of carbon emitted; the revenues from this tax are assumed to be used to make lump sum payments to the electorate and maintain political support, weighing on efficiency further. In addition it is assumed that 60% of oil and gas reserves, and 80% of coal reserves are left in the ground resulting in a $4 trillion reduction in global market capitalisation; although a larger quantity of oil, gas and coal is assumed to be consumed, consistent with at least 3ºC of warming by 2100. Results for Australia are likely sensitive to these transition risk assumptions.

3.4.15 Schroders forecast that the markets that will suffer most from climate change over the next 30 years are those in the warmest countries. Australia is one of worst affected countries. Australia's relatively high current temperatures mean is it more at risk from climate change than, for example, the UK. In cold but developed markets, like the UK, the results show a warmer climate could improve productivity, boosting returns over the next 30 years. The paper notes that while some benefits are projected for cool climate countries over the next 30 years, the consequences of not acting on rising temperatures could be devastating across all countries this century.

Summary of the possible future impacts of climate change on Australian economic growth and investment returns on individuals currently under 18 years of age

3.4.16 It should be noted that there is no agreement in the academic literature on, or accepted framework for modelling, the economic and financial impacts of climate change. All analyses such as Mercers (2015, 2019), DAE (2020) and Schroders (2020) need to make simplifying assumptions, many not all, of which are open to challenge. Long-term asset return forecasts can

[21] Source: https://www.schroders.com/en/bm/asset-management/insights/equities/the-uncomfortable-truth-about-climate-change-and-investment-returns/

[22] Burke and Tanutama (2019) allow for the non-linear impact that higher temperatures could have on economic output; they find that once average temperatures exceed 20 degrees, it becomes much more difficult to adapt to further temperature increases without reducing output growth; e.g. constant air conditioning would increase the cost of production.

vary materially depending on the models used and assumptions made. Nevertheless, consistent themes emerge in the studies mentioned previously:

- The higher risk exposure of the Australian economy and financial markets relative to other developed economies due to the warmer current climate of Australia and higher exposure to the physical risks of climate change (e.g. bushfires, floods)
- The relatively large share of the economy and financial markets that are emissions-intensive compared to some other developed economies.

3.4.17 Over the short to medium term, some portion of physical and/or transition risks is likely to be diversifiable (CISL, 2015). For example, at certain global temperature increases, geographic diversification of physical risk may be possible, e.g. by increasing exposures in cool-climates while reducing exposure to assets in warm or hot climates. By investing selectively across asset markets, countries, sectors and industries, Mercer believes it is possible that a 2°C scenario would not harm diversified returns to 2050 (Mercer, 2019). But under extreme climate change scenarios, e.g. beyond 2°C of global warming, a larger portion of climate risks will become non-diversifiable. This is because under more extreme climate change scenarios the scale and breadth of the physical risks are more likely to impact all asset markets, countries, sectors and industries - meaning the risks cannot be diversified away and are likely to harm investment returns.

3.4.18 Based on the evidence presented above it is my opinion that the drivers described in paragraphs 15.1 to 15.3 of the Concise Statement will cause some level of reduction in Australian GDP in future, as well as to Australian equity and fixed income returns. Some individuals may benefit economically from climate change; however, it is my opinion that due to a material proportion of climate risk being non-diversifiable, on average individuals aged under 18 will earn lower long-term investment returns as a result of climate change. Reduced accumulated retirement savings, as illustrated via scenarios in Table 3, is one type of economic loss that could be felt at the individual level as a result of reduced investment returns.

3.4.19 The scenarios in Table 3 illustrate the impact on the accumulated superannuation balance of an ‘average’ Australian individual, who starts working at age 20 in 2020, works full-time earning adult average weekly ordinary time earnings (AWE) ($1,713.90 per week or $89,123 p.a.[23]) until age 67, and accumulates mandated superannuation. These reflect current assumptions regarding inflation, fees within superannuation, tax on investment earnings and default investment returns based on those provided by the Australian Securities and Investments Commission (ASIC) Moneysmart calculator as at 3 December 2020.

Table 3 – Illustration of the impact of reduced investment returns on accumulated superannuation balance

Reduction in returns (on base)	Investment Return	Superannuation accumulation at age 67	% change from base
Base	7.5%	$720,743	
0.5% p.a.	7.0%	$639,599	-11%
1.0% p.a.	6.5%	$569,316	-21%
2.0% p.a.	5.5%	$455,359	-37%
3.0% p.a.	4.5%	$368,995	-49%

Note: Expected accumulated superannuation balances are in current wage terms for an individual who starts working at age 20 in 2020, works full-time earning AWE until age 67 and accumulates mandated superannuation. Assumptions of inflation (2.5%p.a. Rise in cost of living + 1.5% p.a. Rise in living standards), Admin fees ($74 p.a.), Investment fees (0.85% p.a.), tax on investment earnings (7.0% p.a.) and default returns (7.5% p.a.) are taken from the Moneysmart calculator here: https://moneysmart.gov.au/how-super-works/superannuation-calculator

[23] https://www.abs.gov.au/statistics/labour/earnings-and-work-hours/average-weekly-earnings-australia/may-2020#key-statistics

3.4.20 Based on the evidence presented above it is my opinion that the drivers described in paragraphs 15.1 to 15.3 will cause some level of reduction in Australian GDP in future, as well as to Australian equity and fixed interest returns. Reduced accumulated retirement savings, as illustrated via scenarios in Table 3, are one type of economic loss that would be felt at the individual level by individuals currently under 18 years of age if investment returns were lower compared to a baseline without climate change.

4 Question 4: If the drivers in paragraphs 15.1 to 15.3 of the Concise Statement become more severe and/or more frequent, how would this affect your analysis under question 3 above?

4.1 Impacts of more severe and/or more frequent heatwaves on mortality

4.1.1 Despite the absence of a universal definition of a heatwave, research shows that higher intensity and longer duration of heatwaves increase the mortality impact (Xu et al. 2016). Therefore, if heatwaves became more intense, more frequent or longer it is my opinion, all else being equal, that this would result in more heat-related deaths.

4.2 Impacts of more severe daily temperatures on mortality

4.2.1 As discussed in *Section 3.3*, if daily temperatures get hotter in future, I would expected this to result in more heat-related deaths and an overall net increase in mortality risk in Australia. To the extent that average temperature increases are more severe, I would expect this to further increase mortality risk (because heat-related mortality is an increasing function of temperature).

4.3 Impacts of more severe and/or more frequent drivers in paragraphs 15.1 to 15.3 of the Concise Statement on investment returns

4.3.1 If the drivers in paragraphs 15.1 to 15.3 of the Concise Statement become more severe and/or more frequent, it is my opinion that this would lead to lower future expected investment returns versus milder climate change scenarios, and therefore worse outcomes for the average investor. I think this because, among other impacts:

- More severe climate change scenarios increase the physical risks of climate change, leading to an increase in the expected future costs of damage to physical assets
- More severe climate change scenarios lead to an increase in the expected future loss of labour productivity.

4.3.2 If future investment returns are lower, it follows that the expected future accumulated retirement savings of individuals currently under 18 years of age (illustrated in Table 3) will also be lower compared to a baseline with less severe climate change.

4.4 Systemic risk and interaction of shocks

4.4.1 Finally, my answers to *Questions 3 and 4* do not consider the compounding effect that multiple shocks (of the type outlined in paragraphs 15.1 to 15.3 of the Concise Statement) may have on human health and mortality, economic growth and/or financial systems. When two or more shocks interact, their potential collective effect can be greater than the sum of the individual effects of isolated shocks. For example, the combined effects of the "Black Summer" bushfires of 2019-20 and COVID-19 on the Australian economy and the health of affected communities is, in my opinion, greater than if two events had hypothetically occurred years apart from one another. If the drivers in paragraphs 15.1 to 15.3 of the Concise Statement become more severe and/or more frequent, then the likelihood of compounding events would increase. In my opinion this would further increase the negative impacts on mortality and investment returns outlined in 4.1 to 4.3.

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Appendix A Copy of letter of engagement and follow up email

Figure A.1 – Follow up email

Re: Letter of instruction – Anjali Sharma & Ors v Minister for the Environment, Federal Court of Australia [illegible]

[illegible]

Kind regards

David

[illegible]
Principal Lawyer
Equity Generation Lawyers
[illegible]

[illegible]

16 November 2020

Dr. Ramona Meyricke
Director, Taylor Fry

By email only: Ramona.Meyricke@taylorfry.com.au

Dear Dr Meyricke

Anjali Sharma v Minister for the Environment
Federal Court of Australia | VID 607/2020

Introduction

1. Equity Generation Lawyers represents Anjali Sharma and seven other individuals aged between 13 and 17 (**Applicants**) in a Federal Court of Australia proceeding (**proceeding**) against the Respondent, the Commonwealth Minister for the Environment (**Minister**).

2. The proceeding was filed on 8 September 2020 by the Applicants' litigation representative, Sister Marie Brigid Arthur. The proceeding is brought on the Applicants' own behalf and as a representative proceeding (or 'class action') on behalf of persons under the age of 18 (**children**) who were born before the date this proceeding was filed, and who ordinarily reside:

   (a) in Australia (**the Australian Represented Children**); or

   (b) elsewhere;

   (together, the **Represented Children**).

3. The proceeding relates to a project involving expansion of a 'greenfield' coal mine in Northwest New South Wales (**Project**), for which approval has been sought by Whitehaven Coal Ltd (**Whitehaven**) from the Respondent under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**Act**).

4. In the proceeding, the Applicants seek the following final relief:

(a) a declaration that the Minister owes the Applicants a duty to take reasonable care not to cause them harm while exercising her powers (**the statutory powers**) under ss 130 and 133 of the Act in respect of the Project; and

(b) an injunction to restrain the Minister from exercising the statutory powers in respect of the Project in a manner likely to cause them harm in breach of the alleged duty.

5. The Applicants argue that approval of the Project would be likely to cause harm to the Applicants and the Represented Children, as the result of the extraction and combustion of the coal, which will increase the concentration of carbon dioxide (**CO_2**) in the atmosphere. The effect of increasing CO_2 concentration, and consequent harms, are outlined in the two affidavits of David Barnden filed in this proceeding (and the exhibits to those affidavits), both of which are included in your brief of materials.

6. The injunction sought by the Applicants may have the effect of restraining the Minister from approving the Project.

7. On behalf of the Applicants, we seek to engage you as an expert witness in the proceeding, to provide an expert report in respect of certain actuarial and economic questions that arise in respect of the Applicant's claim, regarding the observed and expected impacts of increased CO_2 concentration in the atmosphere.

8. Your report is due to be filed by early December 2020. It is proposed that your expert report will be relied upon at the trial of this proceeding, which is presently set down for a five-day hearing commencing on 2 March 2021 for four days (with an additional day listed for 12 March 2021 if required). You may also be required to attend Court to give evidence at the trial of the proceeding. We will confirm this with you in due course. In the meantime, we would be grateful if you could confirm your availability for the duration of the trial as presently scheduled for March 2021.

Preparation of your report

9. The role of an independent expert witness is to provide relevant and impartial evidence in their area of expertise.

10. An independent expert witness has duties to the Court as set out in the Federal Court of Australia Practice Note entitled "Expert Evidence Practice Note GPN-EXPT" (**Practice Note**). Importantly, an expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

11. A copy of the Practice Note, which includes the Harmonised Expert Witness Code of Conduct at Annexure A to that document (**Code**), is included in your brief of materials in this matter. You are required to read, understand and comply with the entire Practice Note, including the Code, when preparing your report (in particular, you ought to ensure that your report complies with Part 5.2 of the Practice Note and Part 3 of the Code, both of which expressly relate to the contents of expert reports). If you have any questions about the application or meaning of any aspect of the Practice Note or the Code, please contact us.

12. This letter sets out a number of factual matters in the section below entitled 'Assumptions' which, so far as they have relevance for your work in this matter, you are instructed to assume are accurate. To the extent that you rely on any additional assumptions of fact in preparing your report, you should clearly identify such assumptions (and the basis for those assumptions) in your report.

13. Further, accompanying this letter are a number of documents that may be relevant to the questions on which you are asked to express your opinion. Those documents are listed in the index that is provided at the end of this letter. In preparing your report, you may have regard to those documents to the extent and in the manner that you see fit. Where you rely upon a document in your report (whether one of those documents accompanying this letter, or otherwise), you should clearly identify this in your report.

Assumptions

<u>The Project</u>

14. The Project is an extension of a greenfield coal mine in NSW (**Mine**) for which Whitehaven originally received development consent in 2014.[1]

15. Under the Mine's original approval, Whitehaven was permitted to extract 135 million tonnes (**Mt**) of coal over a 30-year period, at a rate of up to 4.5 million tonnes of run-of-mine (**ROM**) coal a year (**Mtpa**), with coal hauled by trucks on public roads to Whitehaven's existing coal handling and preparation plant (**CHPP**) near Gunnedah, for processing and transport by rail to the Port of Newcastle.[2]

16. The Project proposes:[3]

    (a) an increase in total coal extraction by 33 Mt, from 135 to 168 Mt;

[1] Concise statement at [3]; first affidavit of David Barnden at [8]-[9]; exhibit DLB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at p iii; second affidavit of David Barnden at [9].

[2] Exhibit DLB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at p iii;

[3] First affidavit of David Barnden at [16]-[17]; exhibit DB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at pp iv and 6.

(b) an increase in the peak annual extraction rate from 4.5 up to 10 Mtpa of coal; and

(c) to increase the disturbance area of the Mine by an additional 776 hectares;

(d) to develop a new CHPP and train load out facility at the Mine (both of which would process coal from other nearby mines), such that the proposed CHPP and load out facility would:

(i) stockpile and process a total of 13 Mtpa of ROM coal from the project and other Whitehaven mining operations;

(ii) produce up to 11.5 Mtpa of metallurgical and thermal coal products; and

(iii) transport up to 11.5 Mtpa of product coal from the rail load facility, the rail spur line and via the public rail network to Newcastle for export markets;

(e) to develop a new rail spur to connect the load out facility to the main Werris Creek to Mungindi Railway line;

(f) to construct a water supply borefield and associated infrastructure;

(g) to change the final landform in certain specified ways relating to the overburden emplacement areas and pit lake voids.

17. If approved, the Project would generate approximately:[4]

(a) 3.1 Mt CO_2-e of Scope 1 emissions. These are direct emissions from owned or controlled sources of an organisation / development.

(b) 0.8 Mt CO_2-e of Scope 2 emissions. These are indirect emissions from the generation of purchased energy electricity, heat and steam used by an organisation / development.

(c) 366 Mt CO_2-e Scope 3 emissions. These are all other upstream and downstream emissions related to an organisation / development.

18. The coal that is the subject of the Project (and which Whitehaven proposes to extract if the Project is approved) presently lies underground, storing carbon.[5] It cannot be extracted without the Minister exercising her statutory powers to grant approval under the Act.[6]

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[4] First affidavit of David Barnden at [18]; exhibit DLB-17, NSW Independent Planning Commission Statement of Reasons dated August 2020 at pp 42, 47.

[5] Concise statement at [5].

[6] Concise statement at [5].

19. If the project is approved, coal at the Project site will be extracted, exported, and burned, emitting the carbon it contains as CO_2 into the atmosphere.[7]

CO_2 emissions and fossil fuels

20. CO_2 is one of a number of greenhouse gases present in the Earth's atmosphere.[8] Since the Industrial Revolution, a sustained, accelerating and extraordinary increase in both CO_2 concentration and surface temperature has been recorded.[9]

21. When burned to produce energy, each of coal, oil and natural gas produces CO_2.[10] Of those three substances, coal produces the most CO_2 per energy unit.[11] When CO_2 is emitted, it can persist in the Earth's atmosphere for more than 1,000 years.[12]

22. About 1/3 of present global CO_2 emissions are caused by burning coal.[13] Of all human activities, the burning of coal is responsible for the greatest proportion of the extraordinary rates of increase observed in CO_2 concentration and surface temperature.

23. Unless the extracting and burning of fossil fuels (in particular, coal) is constrained, the extraordinary rates of increase in CO_2 concentration and surface temperature will continue.

Relevant impacts

24. By emitting CO_2 into the atmosphere in the manner described above, humans have changed (and will continue to change) the Earth's systems.[14]

25. Generally, these changes include:[15]

    (a) the heating of Earth's surface and oceans;

    (b) the acidification of oceans;

    (c) changing precipitation patterns;

    (d) rising sea levels;

    (e) increasing incidence and intensity of heatwaves, droughts, bushfires, violent storms, storm-surge flooding and other extreme weather events;

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[7] Concise statement at [5].
[8] Concise statement at [6].
[9] Concise statement at [7], [9], [11]-[12].
[10] Concise statement at [8].
[11] Concise statement at [8].
[12] Concise statement at [8].
[13] Concise statement at [8].
[14] Concise statement at [15.1].
[15] Concise statement at [15.2].

(f) erosion;

(g) melting ice (on both land and sea) and permafrost;

(h) harm to and destruction of non-human ecosystems, species and beings; and

(i) the increasing risk of triggering 'tipping points', such as the Amazon tipping point, the Boreal tipping point, thawing of global permafrost, reduction in Arctic and East Antarctic sea ice, disintegration of the West Antarctic and Greenland ice sheets, and large-scale coral reef die offs, that will cause massive additional increases in CO2 concentration, sudden major shifts in Earth's natural systems, or both.[16]

26. Specifically in Australia, these changes have already included:[17]

(a) increased mean surface temperature;

(b) unprecedented temperatures and heatwaves;

(c) increased regularity and intensity of heatwaves, extreme fire weather days, bushfires, floods, droughts, extreme storms and rain events, and other extreme climatic and weather events;

(d) reduced cool-season rainfall in southeast and southwest Australia, increased wet-season rainfall in northern Australia, and increased proportion of total rainfall in Australia caused by heavy rainfall; and

(e) rising sea levels.

Alleged harm

27. The harm suffered or likely to be suffered by humans is relevantly alleged by the Applicants, in paragraph 16 of the concise statement, to include economic loss, from:

(a) more, longer and more intense:

(i) bushfires, storm surges, coastal flooding, inland flooding, cyclones and other extreme weather events;

(ii) periods of extreme heat;

(iii) periods of drought;

(b) sea-level rise;

(c) increasing loss of non-human species and ecosystems, on land and in oceans;

[16] Concise statement at [15.4].
[17] Concise statement at [15.3].

(d) systemic breakdowns and overwhelming of infrastructure networks and critical services, including electricity, water supply, internet, health care, and emergency services;

(e) food insecurity and breakdown of food systems;

(f) adverse impacts on:

(i) national and global economies;

(ii) financial markets;

(iii) industries, businesses and professions;

(iv) the number and quality of employment opportunities;

(v) standard of living; and

(vi) living costs;

(g) increasing smoke, heat, and disease;

(h) loss of clean water, clean air and nutriment (**essentials**);

(i) social and political unrest, violence and scarcity as essentials are depleted, and humans try to move in search of essentials, habitable land, or both; and

(j) mental harm caused by solastalgia, and the experience and anticipation of the above.

28. The Applicants also allege that:

(a) Unless the rate of increase in CO_2 concentration reaches zero (namely, flattens) and then decreases, then humans will be very likely to experience the harm set out in the preceding paragraph (**the relevant harm**).

(b) The greater the level of CO_2 concentration when the rate of increase flattens, the higher the risk that humans will suffer (a) the relevant harm; (b) more of, and more severe forms of, the relevant harm.[18]

(c) The less coal that is burned on Earth from today, the lower will be the level of CO_2 concentration when its rate of increase flattens.[19]

(d) They, and the other Represented Children, are more likely to suffer (a) the relevant harm, (b) more of, and more severe forms of, the relevant harm, if the Project is approved.[20]

[18] Concise statement at [17].
[19] Concise statement at [17].
[20] Concise statement at [18].

Questions

You have been asked to respond to the following questions.

In doing so, please limit your responses to matters derived from or appropriately connected to your training, study or experience. To the extent that there are matters on which you do not feel you are able to comment, please expressly note this in your response/s.

1. Please describe your academic qualifications, professional background and experience in the fields of actuarial and economic analysis, and any other training, study or experience that is relevant to this brief (you may wish to do so by reference to a current curriculum vitae).
2. Please describe:
    a. the function of an actuary;
    b. the role of an actuary with respect to the assessment or quantification of future impacts of climate change, if any;
    c. your experience and research as an actuary with respect to climate change.
3. Can you assess possible future impacts of the type/s referred to in paragraph 16 of the Concise Statement of any one or more of the drivers described in paragraph 15.1 to 15.3 of the Concise Statement? If so, what is your analysis of the effect of such impact/s on individuals currently under 18 years of age? Please explain any assumptions and refer to any material upon which you rely to reach your answer.
4. If the impacts in paragraph 16 of the Concise Statement become more severe and/or more frequent, how would this affect your analysis under question 3 above?

Other matters

29. You will observe that point 3 of the Code requires your report to include a declaration that you have made all the inquiries which you believe are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which you regards as relevant have, to your knowledge, been withheld from the Court. Accordingly, if, in the course of preparing your report, you identify further information or materials that you consider are relevant to your task, please contact us to discuss this further.

Yours sincerely

s. 47F(1)

David Barnden
Principal Lawyer

Encl.

Index of documents contained in brief to expert witness

Annexure #	Document Title
1	Originating Application dated 8 September 2020.
2	Concise Statement dated 8 September 2020.
3	Response to the Concise Statement dated 29 September 2020.
4	Affidavit of David Barnden dated 8 September 2020 with exhibits: ○ **Exhibit "DLB-1"**, Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2014: Synthesis Report" (Assessment Report 5)"; ○ **Exhibit "DLB-2"**, Whitehaven Coal, March 2020 Quarterly Report; ○ **Exhibit "DLB-3"**, Professor Will Steffen, Expert Report to Independent Planning Commission (IPC), 2020; ○ **Exhibit "DLB-4"**, United Nations Production Gap Report, 2019; ○ **Exhibit "DLB-5"**, Climate Analytics, "Evaluating the significance of Australia's global fossil fuel carbon footprint", 2019; ○ **Exhibit "DLB-6"**, Climate Council, "Dangerous Summer: Escalating Bushfire, Heath and Drought risk", 2019; ○ **Exhibit "DLB-7"**, Watts et al, "The 2019 report of The Lancet Countdown on health and climate change", 2019; ○ **Exhibit "DLB-8"**, NSW Government Assessment Report, Vickery Extension Project, 2020; ○ **Exhibit "DLB-9"**, Doctors for the Environment, "Children and climate change", 2018; ○ **Exhibit "DLB-10"**, Climate Council, "Lethal Consequences: Climate Change Impacts on the Great Barrier Reef", 2018; ○ **Exhibit "DLB-11"**, Doctors for the Environment, "Climate Change and Health in Australia - Fact Sheet", 2016; ○ **Exhibit "DLB-12"**, American Psychological Association, "Mental Health and Our Changing Climate", 2017; ○ **Exhibit "DLB-13"**, Department of the Environment, "The Intergovernmental Panel on Climate Change" (IPCC Fact Sheet), 2014; ○ **Exhibit "DLB-14"**, IPCC "Special Report on 1.5C", 2018; ○ **Exhibit "DLB-15"**, Actuaries Institute of Australia,"The impact of climate change on mortality and retirement incomes in Australia", 2019; ○ **Exhibit "DLB-16"**, EPBC Notice, "Notification of Referral Decision EPBC 2012/6263"; ○ **Exhibit "DLB-17"**, Independent Planning Commission NSW, "Statement of Reasons for Decision, Vickery Extension Project SSD 7480".
5	Affidavit of David Barnden dated 8 October 2020 with exhibits: ○ **Exhibit "DLB2-18"**, EPBC Notice, "EPBC 2016/7649 Decision whether action needs approval/Approval Required", 14 April 2016; ○ **Exhibit "DLB2-19"**, EPBC Notice, "EPBC 2016/7649 Statement of Reasons: Decision under section 75", 2 June 2016; ○ **Exhibit "DLB2-20"**, EPBC Notice "EPBC 2016/7649 Notification of Change of Designation of Proponent", 17 July 2018; ○ **Exhibit "DLB2-21"**, EPBC Notice "EPBC 2016/7649 Notification of

	Extension of Time" 29 September 2020; ○ **Exhibit "DLB2-22"**, Independent Planning Commission NSW (IPC) Vickery Extension Project SSD 7480: Issues Report, 30 April 2019; ○ **Exhibit "DLB2-23"**, Bilateral Agreement between Commonwealth and New South Wales; ○ **Exhibit "DLB2-24"**, IPC, Development Consent for Vickery Extension Project, 12 August 2020; ○ **Exhibit "DLB2-25"**, Letter from Equity Generation Lawyers to Australian Government Solicitors 1 October 2020; ○ **Exhibit "DLB2-26"**, Guardian Newspaper, "Environment Minister Rejects Queensland Wind Farm Project to Save Old Growth Forest", 8 June 2020; ○ **Exhibit "DLB2-27"**, Guardian Newspaper, "Australia has denied Environmental Approval to Just 18 Projects Since 2000", 12 August 2015; ○ **Exhibit "DLB2-28"**, EPBC Decisions Spreadsheet; ○ **Exhibit "DLB2-29"**, Resource related EPBC decisions Spreadsheet; ○ **Exhibit "DLB2-30"**, Letter from Australian Government Solicitor to Equity Generation Lawyers, 30 September 2020; ○ **Exhibit "DLB2-31"**, RBA Bulletin: The Changing Global Market for Australian Coal, September 2019; ○ **Exhibit "DLB2-32"**, Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM), "State of the Climate Report", 2018; ○ **Exhibit "DLB2-33"**, CSIRO, Response to Notice to Give Information to the Royal Commission (RCNDA HTG-HB1-002), 21 April 2020; ○ **Exhibit "DLB2-34"**, CSIRO "Climate and Disaster Resilience" report, 30 June 2020; ○ **Exhibit "DLB2-35"**, Commonwealth Department of the Environment RCP Fact Sheet; ○ **Exhibit "DLB2-36"**, CSIRO "Climate Compass: A climate risk management framework for Commonwealth agencies", August 2018; ○ **Exhibit "DLB2-37"**, Westerhold et al, "An astronomically dated record of Earth's climate and its predictability over the last 66 million years" *Science* 369, 1383-1387, 11 September 2020; ○ **Exhibit "DLB2-38"**, Westerhold et al, "Supplementary Materials: An astronomically dated record of Earth's climate", *Science* 369, 1383, 11 September 2020; ○ **Exhibit "DLB2-39"**, Live Science, "Earth barreling towards 'Hothouse' state not seen in 50 million years, epic new climate record shows", 2020; ○ **Exhibit "DLB2-40"**, Letter from Australian Government Solicitor to Equity Generation Lawyers, 7 October 2020; ○ **Exhibit "DLB2-41"**, "Letter to Commonwealth Government - Vickery Extension Project Referral Redacted", 14 August 2020.

6	Orders made by the Court on 24 September 2020
7	Orders made by the Court on 25 September 2020
8	Orders made by the Court on 5 October 2020
9	Orders made by the Court on 30 October 2020
10	Orders made by the Court on 10 November 2020
11	Federal Court of Australia Expert Evidence Practice Note (including Annexure A, Harmonised Code of Conduct)

Appendix B CV

Qualifications

- Bachelor Science (Hons 1) and University Medal in Statistics, Australian National University, 2003
- Fellow of the Institute of Actuaries Australia, 2007
- PhD, University of Cambridge, Department of Land Economy, 2013

Professional background

I qualified as a Fellow of the Institute of Actuaries (FIAA) in 2007. Since qualifying as a FIAA I have worked as an actuary across two main practice areas:

- Superannuation and Retirement Incomes (Five and a half years),
- Life Insurance (Six and a half years).

My current role involves actuarial and analytical consulting across a range of fields including Health, Worker's Compensation and Compulsory Third-Party insurance (2019-present).

I have been an active member of the Institute of Actuaries Climate Change Working Group since 2018 and during this time have made contributions to a wide range of projects including:

- Peer review of the Australian Actuaries Climate Index[24], 2018
- Paper titled "The Impact of Climate Change on Mortality and Retirement Incomes in Australia"[25], September 2019
- Actuaries Summit 2020 presentation "The health impacts and costs of bushfire smoke"[26], August 2020
- Peer reviewer "Climate Change - Information note for Appointed Actuaries"[27], November 2020.

Academic experience

Additional academic experience and research that is relevant to the opinions I will provide is below.

- From October 2008 to December 2011, I was a PhD Candidate within the Cambridge Centre for Climate Change Mitigation Research at the University of Cambridge, Department of Land Economy. My PhD research focussed on understanding financial contagion along supply chains and other inter-sectoral linkages. It sought to understand whether the contagion effects seen in financial markets also occur in non-financial industries and asset prices. Thesis titled "Theoretical and empirical evidence of the influence of economic linkages on stock returns" was awarded from the University of Cambridge in July 2013. *The areas of economic inter-linkages and portfolio analysis are relevant to understanding how economic growth and financial asset prices might respond to shocks driven by the physical or transition risks linked with climate change.*
- Following my PhD, I completed a post-doctoral fellowship at the Centre of Excellence in Population Ageing Research. My research over this time covered:
  - Methodologies for long-term forecasting of mortality rates and longevity risk
  - Understanding the interacting role of individual-level risk factors and systematic risk factors in mortality risk

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[24] https://www.actuaries.asn.au/microsites/climate-index
[25] https://actuaries.asn.au/Library/Opinion/2019/TheDialogue10ClimateWEBLres.pdf
[26] https://www.pacificlifere.com/content/dam/paclife_corp/pre/public/publications/Summit2020%20Air%20Pollution%20Slides_10%20August.pdf
[27] https://actuaries.asn.au/Library/Standards/MultiPractice/2020/INCCFinal121120.pdf

- Financial and longevity risk management for pension plans, life insurers and governments.

This is relevant because my answer to Questions 3 and 4 below will discuss the potential future impact of climate change on mortality rates.

Selection of relevant research

- Xu M., Meyricke R. and Sherris M. (2019): Systematic Mortality Improvement Trends and Mortality Heterogeneity: Insights from Individual Level HRS Data. North American Actuarial Journal, DOI: 10.1080/10920277.2018.1513369
- Asher A., Meyricke R., Thorp S. and Wu S. (2017): Age pensioner decumulation: Responses to incentives, uncertainty and family need. Australian Journal of Management, Vol. 42 Iss. 4
- Meyricke R. and Sherris M. (2014): Longevity Risk, cost of capital and hedging for life insurers under Solvency II. Insurance: Mathematics and Economics, Vol. 55, Iss. 1
- Meyricke R. and Sherris M. (2013): The determinants of mortality heterogeneity and implications for pricing annuities, Insurance: Mathematics and Economics, Vol. 53, Iss. 2
- Meyricke, R. (2011): Diversification vs. Contagion in Inter-Linked Portfolios, 24th Australasian Finance and Banking Conference 2011 Paper
- Meyricke R. (2010): Institutional Investment and Financial Regulation: An International Comparison, In Arestis P., Sobreira R., Oreiro J., Eds. An Assessment of the Global Impact of the Financial Crisis, Vol 2, Chapter 8, Palgrave Macmillan: London, in press
- Meyricke R. (2010). Sustainable Claims Management, Cambridge Programme for Sustainability Leadership report, University of Cambridge

Appendix C Actuaries Institute Dialogue report

The Dialogue

Leading the conversation

The impact of climate change on mortality and retirement incomes in Australia

Ramona Meyricke and Rafal Chomik

Actuaries Institute

The Dialogue is a series of papers written by actuaries and published by the Actuaries Institute. The papers aim to stimulate discussion on important, emerging issues.

Opinions expressed in this publication do not necessarily represent those of either the Institute of Actuaries of Australia (the 'Institute'), its members, directors, officers, employees, agents, or that of the employers of the authors. The Institute and the employers of the authors accept no responsibility, nor liability, for any action taken in respect of such opinions.

Published September 2019

About the authors

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Dr Ramona Meyricke is a Senior Actuary at TAL, and an Associate Investigator at the UNSW Centre of Excellence in Population Ageing Research (CEPAR). She has over ten years' corporate experience in superannuation consulting and the life insurance sector. Her work focuses on financial and enterprise risk management for life insurers, superannuation funds and pension providers. Ramona has also completed a PhD in Financial Economics at the University of Cambridge, and worked as a Post-Doctoral Fellow at CEPAR, specialising in longevity risk management for individuals, companies and governments. She is an active member of the Institute's Climate Change Working Group.

Rafal Chomik

Rafal Chomik is a Senior Research Fellow at the Centre of Excellence in Population Ageing Research (CEPAR), located in the UNSW Business School, where he leads the centre's research translation effort. He has experience in economic and business consulting in the private sector, as an economic advisor in the British Government, and as a pensions economist at the OECD in Paris. He specialises in population ageing, social policy design, tax-benefit modelling, and poverty and income measurement.

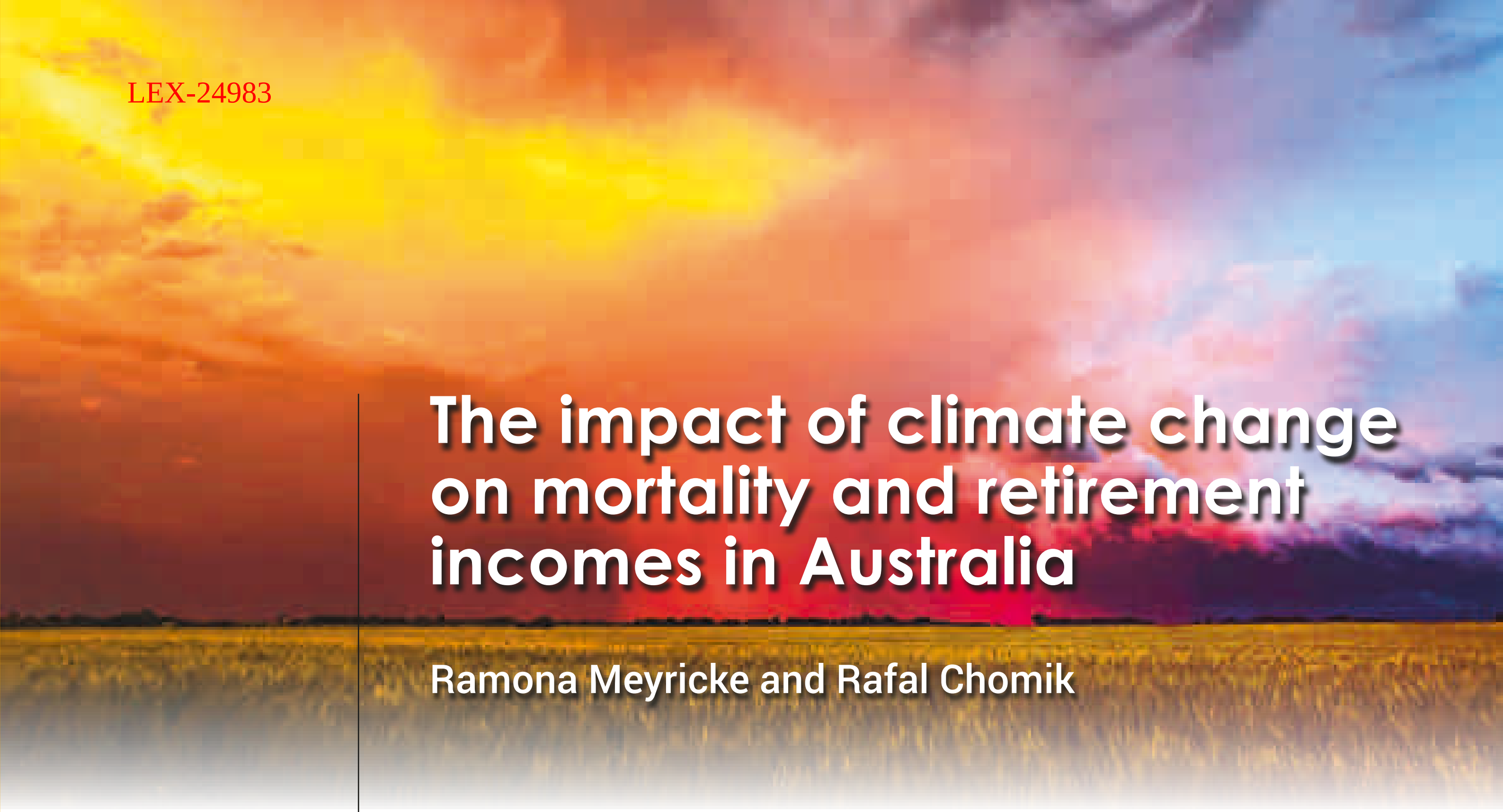
We gratefully acknowledge Cris Townley for research support during early development of the project, and Sharanjit Paddam and Stephanie Wong for their review and comments.

Actuaries Institute

About the Actuaries Institute

The Actuaries Institute is the sole professional body for Actuaries in Australia. The Institute provides expert comment on public policy issues where there is uncertainty of future financial outcomes.

Actuaries have a reputation for a high level of technical financial expertise and integrity. They apply their risk management expertise to allocate capital efficiently, identify and mitigate emerging risks and to help maintain system integrity across multiple segments of the financial and other sectors. This unrivalled expertise enables the profession to comment on a wide range of issues including life insurance, health insurance, general insurance, climate change, retirement income policy, enterprise risk and prudential regulation, finance and investment and health financing.



The impact of climate change on mortality and retirement incomes in Australia

Ramona Meyricke and Rafal Chomik

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Executive summary

Australians' health and finances are at risk in coming decades, as a result of climate change. The wide-ranging implications of climate change include higher mortality, lower superannuation balances and lower retirement incomes.

- In Australia, the main risk to human life from climate change arises from heatwaves. Historically heatwaves have killed more Australians than any other natural hazard. The January 2009 heatwave in Victoria alone is estimated to have caused 374 deaths.

- The frequency and duration of heatwaves will increase significantly over the 21st century, with greater increases in the north than south of Australia. Increases in heatwaves will drive a significant increase in the number of heat-related deaths in Australia. Many factors will affect the number of deaths from heatwaves in the future including public awareness, how we work and other factors.

- Older people are most vulnerable to heatwaves so, all else being equal, ageing of the population will amplify the absolute mortality impacts of climate change.

- Life and health insurers are increasingly focussed on customer wellbeing and on helping their customers reduce risks to their health. This could be extended to increasing customer awareness of how to avoid the risks posed by extreme heat.

- From a financial perspective:

  - **For life insurers and annuity providers,** the impact of climate change on mortality needs to be considered alongside the impact it may have on investment returns. Climate change could have negative long-term return implications for investors who are not diversified at a total portfolio level to climate change.

  - **For individuals,** exposure to the negative long-term return implications of climate change could be expected to lower the accumulated superannuation balance (at age 67) and retirement income (including Age Pension) of a worker on median earnings by 18% and 5% respectively. Reduced capacity to contribute to superannuation due to income shocks driven by the physical or transition risks (linked with climate change) could further erode balances and retirement income.

  - **For government,** while higher levels of mortality translate into lower fiscal expenditures on the Age Pension, lower investment returns on superannuation savings could translate into higher fiscal expenditures on the Age Pension. The present value of extra Age Pension expenditure on the median earner, if investment returns were 1% p.a. lower over that person's life, is estimated to be around $30,000, all else being equal.

- In terms of public policy, the wide-ranging consequences of climate change on mortality, public health and the economy mean that system-wide policy responses (across the health system, aged care services, emergency services, and other social services) are necessary to mitigate the risks posed and their interaction with population ageing.

1. Background

As global warming takes place, how might climate change affect mortality in Australia, and what are the consequences for life insurers, pension providers and public policy? Furthermore, what are the interactions with one of the other megatrends that will define the 21st century: population ageing?

The evidence base relating to climate science is strong (IPCC, 2014). But as Australia braces for higher temperatures and more extreme weather events such as fires, floods, and tropical cyclones (CSIRO and BoM, 2015), less thought has gone into interrogating the potential magnitude and distribution of effects on human health and life. Evidence suggests that the extent and timing of such effects are subject to a great deal of variability (IAA, 2017), and the impacts are likely to differ at a regional level, requiring place-specific responses.

The segment of the Australian population most vulnerable to the mortality impacts of climate change is the elderly. Older people are identified in health assessments as more vulnerable than younger people to a range of health outcomes associated with climate change, including injury and illness resulting from weather extremes such as heatwaves, storms, and floods (WHO, 2003). As such, the effects and management of the risks of climate change on mortality in Australia are related to demographic change.

In this Dialogue we first explore how climate change may affect mortality in Australia and how population trends could exacerbate the effects. We then discuss the potential impacts of climate change on economic growth and investment, life insurance and retirement incomes. We conclude by discussing several implications for policy-makers.

2. Climate change and mortality

Over recent decades, the world has grown accustomed to increases in life expectancies. In high-income countries life expectancy at birth has increased by about 15 years since 1950 to reach over 80 years of age. World-wide, life expectancy improvements have been even more dramatic, increasing over the same period by about 25 years to reach over 70 years of age (UN, 2017). But further increases are not guaranteed, with some countries witnessing a recent slow-down in mortality improvements (e.g., UK and US). To what extent could climate change affect these trends in the future?

2.1 Global overview

At the global level, there is strong evidence of several health impacts of climate change (WHO, 2015). Globally, climatic changes impact health and mortality via three main channels:

1. severe weather-related events (floods, droughts, and bushfires);
2. heat-related mortality or morbidity; and
3. infectious illness and vector-borne diseases (IPCC, 2014; WHO, 2015; Zhang and Beggs, 2018).

Severe weather-related events (floods, droughts, bushfires) induced by a changing climate, expose communities to the threat of unusually high incidence of mortality or morbidity, including both physical and mental health disorders. A warming climate can also result in heat-related mortality or morbidity and drives an increasing incidence of infectious illness and vector-borne diseases. In some parts of the world, climate change is also expected to increase the risk of under-nutrition resulting from diminished food production in poor regions and lack of drinking water (IPCC, 2014; WHO, 2015; Zhang and Beggs, 2018).

There is weaker evidence of positive effects from climate change, including modest improvements in cold-related mortality and morbidity. Expert advice is that, on balance, there is high confidence that negative health effects will outweigh positive effects at the global level (IPCC, 2014; WHO, 2015).

The relative importance of these channels is influenced by geography and the level of resilience of the human systems in a given location. For example, many Asian cities, such as Dhaka, are situated in low-lying delta areas, which puts millions of people at risk from impacts of climate change such as flooding (World Bank, 2014). Rapid urbanisation, large populations, poverty and low levels of economic development mean there are very low levels of resilience to flooding, and therefore it is a major risk to life in such cities.

2.2 Climate change and mortality in Australia

In Australia, there is strong evidence that climate change will have a wide range of negative impacts on health and mortality. For example;

- Climate change is likely to drive longer, harsher and more frequent droughts in parts of Australia (Herold et al., 2018). The negative impacts of drought on mental health of those living in remote and regional communities is widely evidenced (Austin et al., 2018).
- Climate change is likely to exacerbate the health and mortality impacts of air pollution. In Sydney, for example, the influence of climate change on ozone concentrations alone is expected to cause an additional 55-65 deaths per year in 2051-2060[1] (Physick et al.,

2014). In addition, the issue of more heavy smoke days due to more bushfires, could be expected to contribute to more deaths.

- While Australia experiences relatively low incidences of vector borne disease, it has been shown that expected cases of the Ross River virus, for example, will increase as certain regions get warmer (Herold et al., 2018).

Life insurers operating in Australia tend to have significant amounts of both morbidity and mortality risk on their books. Data on how morbidity products (Income Protection, Total Permanent Disability and Trauma insurance) could be affected by climate change, however, is virtually non-existent. For example, for a heart attack occurring during a heatwave the primary cause of claim would likely be recorded as 'heart attack' with few, if any, details of climate related drivers recorded. That is, life insurers commonly record the clinical diagnosis behind a claim, and not the climate related factors linked to an event. This makes it difficult to quantify how climate change might affect morbidity products[2]. For this reason, this paper focusses on the impact of climate change on mortality.

Heatwaves have killed more Australians than any other natural hazard and have caused more deaths since 1890 than bushfires, cyclones, earthquakes, floods and severe storms combined.

The main impact of climate change on mortality arises from heat-related mortality. Heatwaves have killed more Australians than any other natural hazard and have caused more deaths since 1890 than bushfires, cyclones, earthquakes, floods and severe storms combined (Climate Council, 2016). The Victorian 2009 heatwave is estimated to have caused 374 more deaths than what would otherwise have been expected (Victorian DHS, 2009). In comparison to heatwaves, other natural disasters are expected to result in low numbers of deaths. For example, bushfires were the most common natural disaster in NSW between 2004-2014, followed by storms and floods (Sewell et al., 2016). Due to relatively high building standards and emergency response capabilities, among other factors, these fires, storms and floods resulted in a far lower number of deaths than the Victorian 2009 heatwave (Victorian DHS, 2009).

Heatwaves are also responsible for a range of other adverse impacts such as: increased demand for social and health services, ambulance services, GP attendances, Emergency Department presentations, and additional strain on infrastructure such as electricity supply (Victorian DHS, 2009). Hotter overnight temperatures also adversely affect sleep and can lead to a range of other adverse impacts, for example workers may become fatigued which increases the risk of accidents (Safe Work Australia, 2017).

2.3 Defining a heatwave

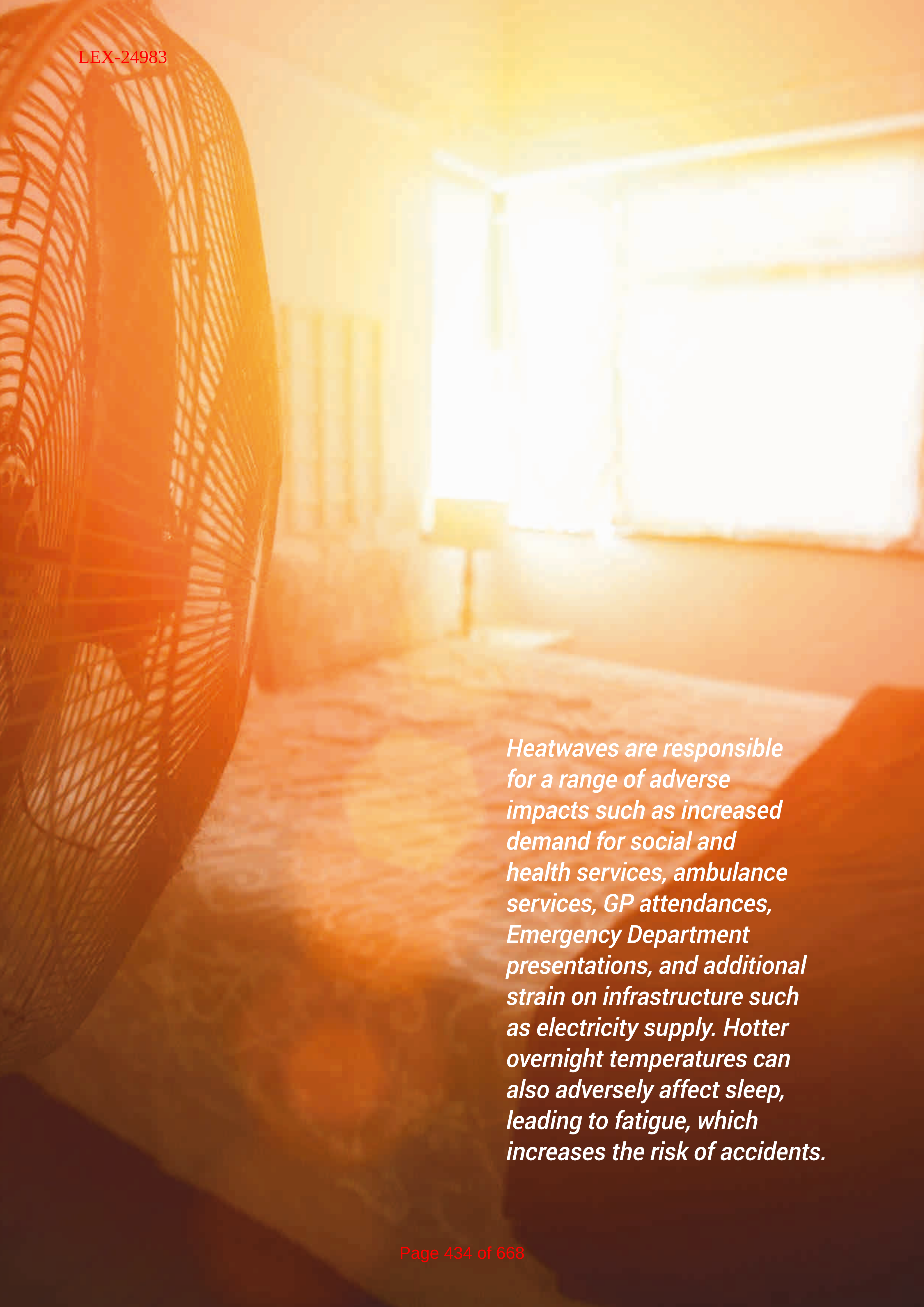
Heatwave effects on mortality are significant, especially in the context of climate change. But there is no universally consistent definition of a heatwave, and the estimated magnitude of the effect that heatwaves have on mortality varies under different heatwave definitions. A systematic review and meta-analysis were conducted to assess the heatwave definitions used in the literature published up to 1 April 2015; it showed that mortality risk during heatwaves was 3% to 16% higher than on non-heatwaves days:

- 3% when "mean temperatures ≥95th percentile for ≥2days"
- 4% when "mean temperatures ≥ 98th percentile for ≥ 2 days"
- 7% when "mean temperatures ≥ 99th percentile for ≥ 2 days" and
- 16% when "mean temperatures ≥ 97th percentile for ≥ 5 days" (Xu et al., 2016).

Despite the absence of a universal definition of a heatwave, it is agreed that the intensity and duration of heatwaves consistently influence the mortality impact (Xu et al., 2016).

1 Estimated impact on ozone-related mortality in Sydney due to climate change, ignoring changes in population size or structure, or baseline emissions, and under an A2 emission scenario, compared to a baseline of 1996-2005.

2 The consequences of climate change on morbidity risk are potentially severe for some market segments, and insurers could improve monitoring of these risks and think about them in their product terms and conditions.



Heatwaves are responsible for a range of adverse impacts such as increased demand for social and health services, ambulance services, GP attendances, Emergency Department presentations, and additional strain on infrastructure such as electricity supply. Hotter overnight temperatures can also adversely affect sleep, leading to fatigue, which increases the risk of accidents.

2.4 Projecting excess mortality of heatwaves in Australia

Many factors will affect the number of deaths from heatwaves in Australia in the future including: changes in demographics, air pollution, adaptation to climate change including increased use of air-conditioning and better building standards, how we work, and other environmental factors. Population ageing would increase absolute excess mortality (the number of deaths above that expected in non-heatwave conditions), though factors such as acclimatisation and the increased availability of air-conditioning, for example, would likely decrease absolute excess mortality. There are, however, physiological and behavioural limits (e.g. 100% penetration of air-conditioning) to adaptation to climate change (Sherwood and Huber, 2010).

The following results (taken from Herold et al., 2018) illustrate the best estimate of the impact of future climates in Sydney and Brisbane on excess mortality, should they occur in the present demographic structure and environmental conditions. For the future periods, the simulations assume emissions follow the Special Report on Emission Scenarios (SRES) A2 scenario. Current global emissions data suggests global emissions are following a trajectory slightly higher than SRES A2 (Peters et al., 2013), thus the projections presented below, as they relate to temperature extremes, may be conservative.

Climates vary significantly across Australian capital cities, meaning that the impacts of climate change need to be investigated at a regional level, rather than at a national level. Sydney and Brisbane, however, have similar current and projected mean daily maximum temperatures. As detailed in Table 1, the studies of excess mortality were conducted at all-ages in Sydney and over 65s in Brisbane. Comparing the results between Sydney and Brisbane, therefore, illustrates the difference in the estimated impact of future climates on excess mortality across different age groups.

Table 1: Projected average summer daily maximum temperatures in Sydney and Brisbane and related excess mortality expected (all-age for Sydney, over age 65 for Brisbane)

City	Relationship	Units	Recent past	2020-2040	2060-2080
Sydney	Increase in excess mortality for **all-ages** of 0.9% per °C in monthly **mean summer daily max temp**	mean daily max temp	29°C	30°C **1% excess mortality increase for all-ages**	31°C **2% excess mortality increase for all-ages**
Brisbane	Increase in excess mortality for **for ages > 65** of 7% per °C in monthly **mean summer daily max temp**	mean daily max temp	29.3°C	29.8°C **4% excess mortality increase for over age 65**	31°C **12% excess mortality increase for over age 65**

Source: Herold et al., 2018

Table 1 shows that excess mortality in over 65s is approximately *four to six times* higher than excess all-ages mortality caused by similar heatwaves. Excess mortality expected in 2020-2040 is 1% for all ages (Sydney), but 4% in over 65s (Brisbane). Over the period 2060-2080, excess mortality from heat is projected to be 2% at all ages, but 12% in over 65s. It is likely that among the oldest in the population, the mortality rates would be higher still.

Many States and Territories have already implemented heatwave response plans, early warning systems and/or conducted awareness campaigns to educate people about the health risks of heatwaves. With ongoing improvement in public awareness and risk mitigation, the amount of excess mortality from climate change should be below the projected levels in Table 1. In addition, life and health insurers are increasingly focussed on customer wellbeing and helping their customers reduce risks to their health. This could be extended to increasing customer awareness of the risks posed by extreme heat in order to reduce the mortality impacts of climate change.

Notwithstanding this, the results suggest that ageing of the population will amplify the mortality impacts of climate change. This is critical because the population over age 65 is projected to increase significantly. Australian Bureau of Statistics (2018) projections suggest that by 2050, the populations aged 65+ and 85+ are expected to nearly double and triple, respectively.

2.5 Vulnerability of older people

Older Australians are especially vulnerable to the health risks posed by climate change due to factors such as the physiological changes of old age, impaired functional responses to heat stress and the higher prevalence of chronic diseases.

Older Australians are especially vulnerable to the health risks posed by climate change (Horton et al., 2010; Tong et al., 2014; Victorian DHS, 2009). Understanding the reasons why the elderly are at risk is essential to inform policy that could reduce the mortality impact of future heatwaves. The primary driver of this relates to the physiological changes in the human body from ageing, which are particularly acute for older women. The increased vulnerability relates to a combination of an impaired physiological response to heat (reduced thirst response and diminished ability to sweat) and the higher prevalence of chronic diseases among the elderly (Kovats and Hajat, 2008).

Older people also tend to have lower cardiovascular fitness, which is essential for thermoregulation. Chronic under-hydration may also be observed among the frail and elderly, increasing their vulnerability to environmental and physiological stressors. Finally, common characteristics among older people, such as impaired mobility, cognitive decline, and waning social connectedness and support, all further reduce the capacity of the elderly to adequately protect themselves from the effects of extreme heat (Victorian DHS, 2009).

The vulnerability of older disadvantaged people may be even greater. For example, Toloo et al. (2014), studied heat-related emergency department visits in Brisbane between 2000-2008, breaking down the data by age and area-based measures of disadvantage. They found that for younger people, the increase in visits during heat waves was similar whether they lived in a poor or an affluent area. But among those aged 65-74, those from poor areas had a substantially elevated level of visits.

2.6 Indirect impacts of climate change

Additional indirect impacts on mortality and morbidity related to climate change include impacts caused by a sustained surge in demand beyond the capacity of a healthcare system to cope effectively (IAA, 2017). For example, in 2005 when Hurricane Katrina hit the United States, it caused massive displacement of people and an overload of healthcare services, which did not have enough spare capacity to cope (IAA, 2017). In the 2009 Victorian heatwave, emergency services, ambulances, hospitals and morgues were overwhelmed by a surge in demand (Victorian DHS, 2009). While these indirect effects and impacts are important, we do not explore them further in this paper.

In summary, as global warming raises the frequency, severity and duration of heatwaves in Australia, the population is expected to experience greater excess mortality, particularly among people aged over 65. Population ageing will amplify the burden of heat-related mortality and health risks in a warming climate; an interaction that policymakers and insurers have not yet fully taken into account.

3. Impact on life insurance and retirement incomes

Two material cost drivers for life insurance and pensions (annuities) are mortality and investment returns. Climate change is expected to impact on both, driving changes in the cost of these products.

Two material cost drivers for life insurance and pensions (annuities) are mortality and investment returns. Climate change is expected to impact on both.

3.1 Impact on life insurance

The CRO Forum (2019) reviewed the exposure of life insurers to climate change and concluded that climate change has the potential to lead to: adverse claims experience, deterioration of macroeconomic conditions and lower new business sales of life insurance. An additional risk is that customers lapse their cover following a natural disaster due to financial difficulties. Some Australian life insurers have recognised and responded to this risk. For example, TAL waived premium payments for up to two months to help customers affected by the 2019 Queensland floods and Tasmania bushfires (Insurance News, 2019).

Section 2 showed that climate change is expected to increase mortality in Australia, particularly among the older population, because of more frequent and intense heatwaves. The projected mortality impacts have the potential to impact the cost of life insurance and annuities. Higher levels of mortality, in isolation, would increase the cost of life insurance, and reduce the cost of annuities. The impact on life insurers of increased mortality should be kerbed by their lower exposure beyond age 65, however, as the impact of climate change on mortality under age 65 is expected to be limited.

It is misleading to look at the impacts of heatwaves in isolation because climate change will have wide-ranging direct and indirect physical impacts, as well as socio-economic implications, that will affect life insurers. This range of impacts on life insurance is illustrated in Figure 1. The risk that climate change presents to investment returns is discussed further in the next section.

Figure 1: How life insurers are exposed to climate change

Physical impacts		Socio-economic impacts		Impacts on life insurance
Direct	**Indirect**	**Social**	**Economic**	
• Heatwaves • Storms • Floods • Bushfires • Droughts	• Air pollution • Water and food supply • Diseases	• Health infrastructure • Emergency services • Social services	• GDP growth • Investment returns • Employment • Tax increases (e.g. infrastructure repair)	• Claims experience • Premiums • Lapse rates / Retention • Investment returns • Insurability • New business

Source: Authors' compilation

3.2 Impact on economic growth and investment returns

Climate-change poses a risk to economic growth and investment returns. Economic impacts occur through two main channels: physical damage arising from more frequent and intense natural disasters and higher temperatures ('physical risk'), and the risks associated with transition of the economy from dependence on fossil fuels to a low-carbon economy ('transition risk').

3.2.1 Physical risk

The extent to which natural disasters have an adverse effect on the economy has been subject to debate. The empirical literature shows mixed results, but recent meta-analyses suggest that the effect of natural disasters on GDP has been negative and increasing (Klomp and Valckx, 2014). On the one hand, natural disasters can destroy productive capital, causing a negative deviation from the economy's long-term growth path. On the other hand, such shocks can stimulate the economy and lead to higher long-term growth if the event accelerates capital stock upgrades. Past events show that in the short term, disasters have a negative impact on output, income, and employment, but subsequent recovery spending may lead to higher output and employment (Bally, 2011). While the 'recovery spending' effect means that moderate disasters can have a growth effect in some sectors, research shows that severe disasters do not lead to higher long-term growth (Loayza et al., 2012). As natural disasters become more frequent and more intense some economies may struggle to rebound.

Deloitte Access Economics (2013) estimated the tangible cost of natural disasters in Australia was $9 billion in 2015 (or 0.6% of GDP) and expected to rise to $23 billion a year by 2050, in 2011 prices, even without factoring in any increase in frequency or intensity of natural disaster events from climate change. The increase is driven by continued population growth, concentrated infrastructure density, and migration to particularly vulnerable regions. Any increase in frequency or intensity of natural disaster events from climate change would increase this cost. Wade and Jennings (2016), from Schroders, suggest that the impact of climate change on global economies could be a 1 percentage point reduction in GDP growth per year. They argue that lower growth will be caused by the combination of greater damage to property and infrastructure, lost productivity, mass migration and security threats.

Studies looking at the effect of historic temperature variations also suggest that a warming climate could negatively affect GDP growth (IMF, 2017; Carleton & Hsiang, 2016; Dell et al., 2014). Temperature shocks appear to affect growth via various channels, including lower agricultural and industrial output, higher energy demand and lower labour productivity. However, the relationships are complex, and most studies emphasise the greater impact on developing countries.

3.2.2 Transition risk

Results of investment modelling by Mercer (2015, 2019) demonstrate climate change will inevitably have an impact on investment returns under scenarios of global temperature rises this century of 2°C, 3°C and 4°C above pre-industrial levels. Mercer (2015, 2019) identify four channels by which climate change will impact investment returns:

1. **Progress and investment in technology to support a low-carbon economy**
2. **Physical impacts on investments of natural disasters**
3. **Resource availability**
4. **Policy**

In a 2°C scenario, average sector-level return impacts to 2050 are all negative except for renewables, infrastructure, and minor positives for materials, telecoms and consumer staples (Mercer 2019). In 3°C and 4°C scenarios, all sectors, apart from renewables, have negative return impacts to 2030, 2050 and 2100, with return impacts varying between -0.1% p.a. and -7.7% p.a. (Mercer 2019). Across all scenarios the sectors expected to be most negatively impacted by climate change are: Coal, Oil and Gas (Mercer, 2019). Weighting the sector-level returns to 2050 under a 2°C scenario (Mercer, 2019 p.47-48) by the ASX 200 market capitalisation by sector at 1 July 2019 gives a weighted average expected reduction in annual returns of around 0.7% p.a.

It is important to note that these results are only expected average sector-level returns. Individual stocks within a sector will move differently. In addition, variations in results between asset classes and across regions, as well as sustainable opportunities such as renewables, mean that climate change may have positive impacts for some investors.

Under almost all future scenarios, climate change has negative long-term return implications for investors who are not diversified at a total portfolio level to climate change.

The report also highlights that sovereigns such as Australia and New Zealand are expected to be more sensitive to the impact of physical damages and resource scarcity (Mercer, 2019); an added dimension that investors in Australian government debt should note.

Under almost all future scenarios, climate change has negative long-term return implications for investors who are not diversified at a total portfolio level to climate change (Mercer 2015, 2019). The fact that many institutional investors are rebalancing their portfolios to address climate change risk lends support to this finding.

3.3 Impact on retirement incomes

There are several consequences of climate change that may impact on individuals' accumulated superannuation balances at retirement:

- **Income risks:** The economic transition required to combat climate change is likely to lead to the loss of jobs in carbon-intensive industries. The transition is also forecast to create millions of new job opportunities that will offset losses in traditional industries (ILO, 2018). In cases where individuals lose a job and need to retrain, however, this may mean a period of lost income and superannuation contributions.

  In addition, natural disasters can result in financial losses for individuals. Insurance can ease the financial burden, but there are challenges involved in ensuring both the affordability and sufficient coverage against disaster risks in a changing climate (OECD, 2015). Under-insurance may lead to the erosion of savings and/or gaps in superannuation contributions following a natural disaster if either (a) households' savings are diverted into repairing personal property or (b) business disruption leads to a drop in employment income[3].

- **Return risks:** The negative long-term return implications of climate change for investment returns, outlined in the previous section, have the potential to negatively impact retirement incomes. A greater number or severity of such shocks can compound and reduce individuals' accumulated superannuation savings.

Post-retirement, in Australia, a typical individual's total retirement income is the sum of any Age Pension income they receive plus the draw-down of their accumulated superannuation balance. The Age Pension is means tested, so any losses that push an individual's accumulated superannuation balance or superannuation income in retirement below certain asset or income test thresholds[4] will increase an individual's entitlement to the Age Pension (Age Pension income).

3 Following the Brisbane floods in 2011 there was a fall in the labour force participation rate equivalent to an extra 18,000 people out of work each month (Queensland Treasury, 2011). Many of those that continued to work saw reduced hours. In one survey, 17% of adults in Queensland reported experiencing lower income in the aftermath of the flooding (Clemens et al., 2013). Reduced employment income or draw-down of savings impacts retirement funding.

4 For example, based on thresholds in place in March 2019, a single non-homeowner, could receive a full Age Pension if their assessable assets were below $465,500; a part Age Pension, which reduces as assets increase between $465,500 and $771,000; and no pension if they had assets beyond $771,000. Similarly, a single person could receive a full pension with an annualised assessable income below about $4,500; a part pension, which gradually reduces as income increases to about $52,000; and no pension with income beyond. The actual level of pension received depends on the lower of the asset and income tests.

To gain an insight about the potential impact of climate change on individuals' retirement incomes we estimate a baseline scenario of superannuation and Age Pension income, for each percentile of the full-time earnings distribution, and compare this with two 'what if' scenarios designed to illustrate the potential impacts of climate change on retirement incomes:

- **Scenario 1** is designed to illustrate the income risks of climate change (economic transition risks and natural disaster risks). It models the effect of a periodic loss of employer contributions into an individual's superannuation account one year in every 10 (Figure 2), equivalent to approximately a 10% reduction in lifetime employer super contributions[5].

- **Scenario 2** models the effect of lower investment returns on superannuation, which are assumed to decline by 1 percentage point[6] from a nominal return of 4.8% p.a. (ASIC's default return assumption for a Balanced portfolio) to 3.8% p.a. (Figure 3).

The results of Scenario 1 show that with a loss of employer contributions once every 10 years, accumulated superannuation balances and average retirement income are expected to drop by about 11% (Table 2) and 2% (Figure 2) respectively, though this varies across the earnings distribution. Retirement income would decline by just over $900 per year for a median earner, in today's wage terms. The lower reduction in retirement income compared to accumulated superannuation savings (2% vs 11%) occurs because the government funded Age Pension hedges an individual's retirement income against lower investment returns.

The impact of Scenario 2, 1 percentage point lower investment returns, is greater than Scenario 1. That is, a 1 percentage point drop in investment returns could be expected to lower accumulated superannuation balances and retirement income of a worker on median earnings by 18% (Table 2) and 5% (Figure 3) respectively. In dollar terms, this equates to a decrease in retirement income of about $2,000 per year for the median earner. The decrease in retirement income is lower than the decrease in superannuation balances and superannuation income (as shown in Figure 3) because, again, the Age Pension offsets superannuation losses, providing a safety net for individuals.

Table 2: Effect on accumulated superannuation savings of climate-risk related scenarios at the median of the full-time earnings distribution

	Annual income	Investment return	Superannuation accumulation at age 67 (% change from base)
Baseline	$75,000	4.80% p.a.	$382,000
Scenario 1	$75,000 but $0 p.a. once every ten years	4.80% p.a.	$341,000 (-11%)
Scenario 2	$75,000	3.80% p.a.	$313,000 (-18%)

Note: Table 2 shows expected accumulated superannuation balances in current wage terms (rounded) for an individual who starts working at age 20 in 2018, works full-time at a given point in the earnings distribution until age 67, and accumulates mandated superannuation. The median full-time worker is assumed to earn $75,000 p.a. Assumptions of real wage inflation (1.2% p.a.), price inflation (2%p.a.), fees ($50 p.a. + 1.1%p.a.), tax on investment earnings (6.5% p.a.) and returns (4.8% p.a.) are based on those provided by the Australian Securities and Investments Commission. Income is based on the median weekly earnings of all Australians as at August 2018 (ABS, 6333.0 - Characteristics of Employment, Australia, August 2018).

5 The choice of 1 in 10 years is illustrative, it is not based on climate forecasts and damage functions because these are not available at present. The last ten years of Australian economic transition and natural disaster experience broadly support the feasibility of this scenario. Within the last ten years: (a) there have been widespread job losses in South Australia and Victoria linked to closure of car manufacturers and coal-fired power stations (b) Queensland has experienced two large scale flooding events, the 2011 Brisbane floods and the 2019 Townsville floods, damages from Cyclone Debbie in 2017, and flash flooding in 2013. Looking to the future, extreme rainfall events are projected, with high confidence, to increase in intensity (CSIRO and BoM, 2015; Rafter and Abbs, 2009) and other natural disasters such as bushfires, tropical cyclones and storms are projected to increase in frequency and/or intensity (Reisinger et al., 2014).

6 The choice of a 1% reduction in investment returns is illustrative but plausible based on the projections in Mercer (2019) and Wade and Jennings (2016). Actual investment returns could be higher or lower and highly sensitive to portfolio construction.

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Figure 2: Effect on average retirement income of climate-related losses of employment income – Scenario 1, across the full-time earnings distribution

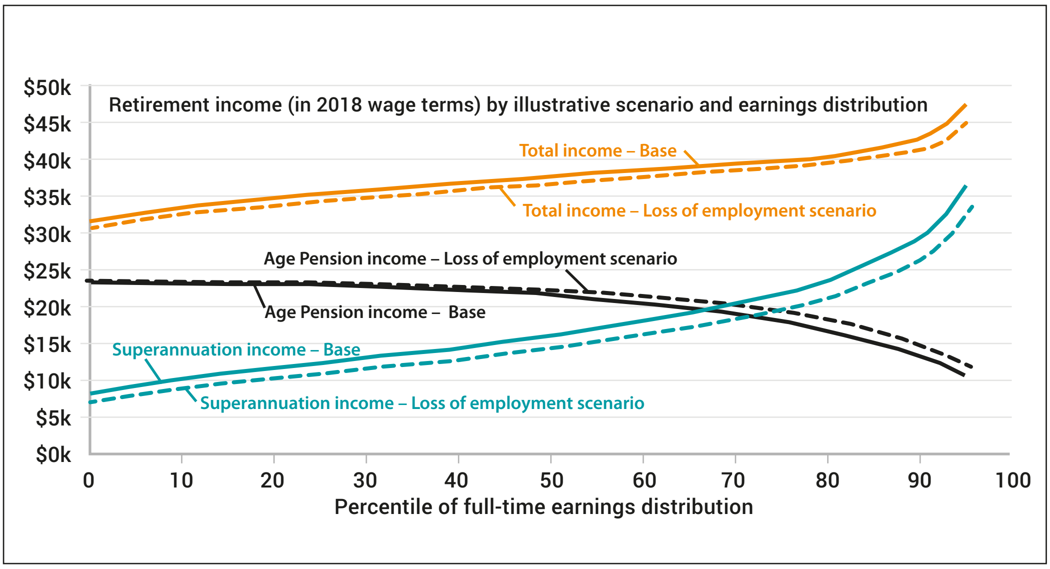
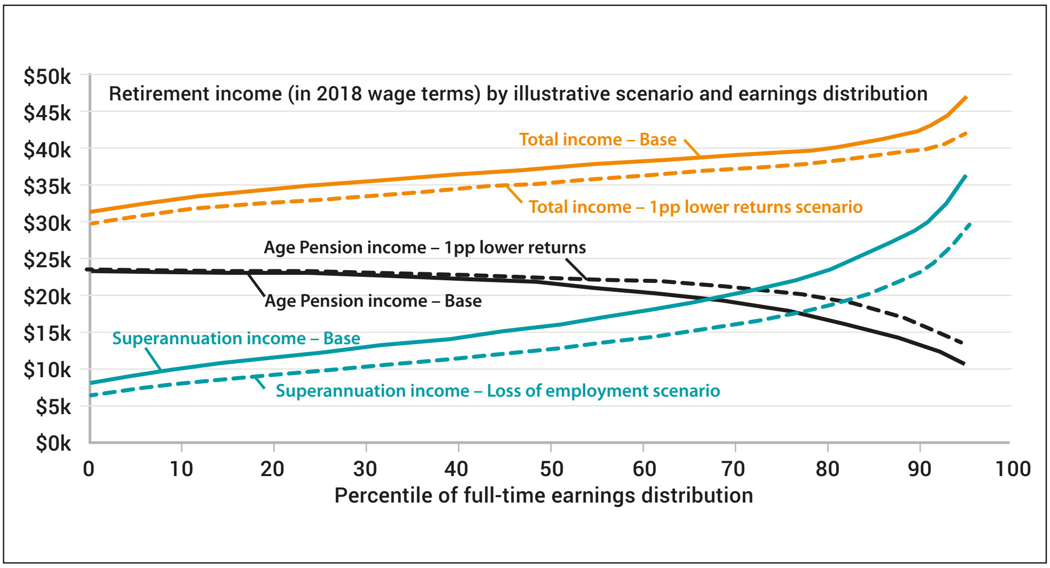


Figure 3: Effect on average retirement income of climate-related losses of investment returns – Scenario 2, across the full-time earnings distribution



Note: Figures 2 and 3 show average retirement income in current wage terms for an individual who starts working at age 20 in 2018, works full-time at a given point in the earnings distribution until age 67, accumulates mandated superannuation, runs this down by age 92 and then receives the Age Pension (as a homeowner) according to a wage-indexed, future means test in line with 2018 parameters. Assumptions of real wage inflation (1.2% p.a.), price inflation (2% p.a.), fees (1.1% p.a.), and returns (4.8% p.a. before fees) are based on those provided by the Australian Securities and Investments Commission. Post-retirement, the assumed nominal return after retirement is 2.9% p.a. after fees. See Chomik and Piggott (2016) for further details.

The declines in an individual's total income vary across the earnings distribution because of the Age Pension means testing rules. The Age Pension hedges those at the bottom of the earnings distribution against shocks to superannuation savings but provides no protection for individuals with assets and income above the means test limit. At the bottom of the earnings distribution, those who already receive the maximum Age Pension are not compensated for lower superannuation income, those in the middle see a greater amount of Age Pension replacing superannuation losses, while self-funded retirees will not receive any Age Pension until their assessable assets fall below the assets test limit. (The average Age Pension income in Figures 2 and 3 is above zero for the highest earners because it is assumed that individuals spend down their superannuation over time, so even the very rich become entitled to a partial Age Pension in their last few years.)

3.4 Impact on costs to government

For the government, lower accumulated superannuation savings at the point of retirement (driven by lower investment returns pre-retirement) mean higher eligibility for, and therefore higher fiscal expenditures on, the Age Pension. In Scenario 1 and Scenario 2 the present value[7] of extra Age Pension expenditure on the median earner is estimated to be $20,000 to $30,000 respectively, assuming current levels of population mortality.

The change in the long-term cost of the Age Pension is a function of both investment returns and population mortality rates.

The change in the long-term cost of the Age Pension is a function of both investment returns and population mortality rates. Higher mortality post-retirement, a potential consequence of climate change, would mean the Age Pension would be paid for fewer years on average and fiscal expenditures on the Age Pension would reduce. Lower investment returns pre-retirement will increase Age Pension eligibility for individuals whose accumulated superannuation savings fall below the means test limits (as shown in Figure 3). In addition, for a given level of Age Pension eligibility, lower long-term government bond yields (risk-free rates) increase the present value of government liabilities in respect of the Age Pension.

Table 3 shows how the present value of government liabilities in respect of the Age Pension (used here as a proxy for the cost to government of the Age Pension) changes as the risk-free rate and mortality rates change. The results show that with a 1 percentage point drop in the risk-free rate the annuity cost goes up, unless mortality rates increase by 1 percentage point or more. Vice versa, with a 1 percentage point increase in excess mortality the annuity cost goes down, unless the risk-free rate decreases by 1 percentage point or more.

Table 3: Present value of a lifetime annuity of $1 paid from age 67, shown for a range of discount and mortality rates

Excess mortality	**Risk-free discount rate p.a.**		Lower discount rates (long-term Aus. Govt bond rates) increase the present value of government liabilities in respect of the Age Pension			
	1%	2%	3%	4%	5%	Higher pensioner mortality rates (ages 67+) decrease cost to government of Age Pension
0% (ALT 2010-12 Males)	$16.3	$14.8	$13.4	$12.3	$11.3	
1% (ALT 2010-12 Males + 1%)	$14.8	$13.4	$12.3	$11.3	$10.4	
2% (ALT 2010-12 Males + 2%)	$13.5	$12.3	$11.3	$10.4	$9.6	
3% (ALT 2010-12 Males + 3%)	$12.3	$11.3	$10.4	$9.7	$9.0	
4% (ALT 2010-12 Males + 4%)	$11.3	$10.5	$9.7	$9.0	$8.4	

Note: The annuity is not indexed. Mortality is ALT2010-12 Male rates, plus the excess mortality indicated in the first column. The yellow cell, with value $14.8, is the present value of a lifetime annuity of $1 paid from age 67, using mortality rates (ALT2010-12 Males) and the 10-year Australian Government bond rate current as at writing, in March 2019.

7 Present value is the lifetime cost in today's wage terms.

With ongoing improvement in public awareness and risk mitigation, the amount of excess mortality from climate change should be limited. Climate change, however, could have negative long-term return implications for investors and governments, and it is more complicated to mitigate this risk. In addition, a drop in long-term returns would have a compounding impact on government finances, increasing both Age Pension eligibility in the population and the present value of future Age Pension expenditures for a given level of eligibility. Conversely, higher long-term government borrowing rates would decrease the present value of Age Pension expenditure. It is possible that climate change could drive higher government borrowing costs if the government must borrow more to repair or rebuild infrastructure damaged by natural disasters or invest heavily in climate change adaptation (such as building levees in flood prone areas).

Failure to address climate change has been identified as one of the largest socio-economic risks to modern society and lack of action on climate change is no longer just a reputation risk; it is a core business issue being discussed in terms of physical risks, liability risks and transition risks.

4. The role of Actuaries, the financial sector and public policy

Failure to address climate change has been identified as one of the largest socio-economic risks to modern society (World Economic Forum, 2016; Lloyd's of London, 2017). Lack of action on climate change is no longer just a reputation risk; it is a core business issue being discussed in terms of physical risks, liability risks and transition risks (The Geneva Association, 2018). The insurance industry plays a critical role in building socio-economic resilience and enabling entrepreneurial pathways for achieving climate change mitigation and adaptation (The Geneva Association, 2018). Internationally, the insurance industry is building this resilience by, for example, providing risk pricing expertise and offering innovative risk transfer products and services.

Due to the long-term nature of life insurance, superannuation and retirement incomes, actuaries will have to come to grips with the future effects of climate change and start efforts to limit the adverse effects of climate change on their organisations. In addition, there is mounting pressure on all financial institutions from investors and regulators to improve transparency and the disclosure of climate-related risk.

- In 2017, the Taskforce on Climate-related Financial Disclosures (TCFD) recommended a single international cross-industry standard for disclosing climate risk in the mainstream financial reporting of companies designed to assist financial markets to allocate capital more efficiently, and create more resilient economies (Paddam and Wong, 2017). While these disclosures are voluntary at present, several Australian financial institutions, such as VicSuper and UniSuper, have already released Climate Change Reports in accordance with the TCFD recommendations.

- In Australia both ASIC and APRA have made it very clear that they are increasing their scrutiny of how companies manage and disclose the risks that climate change poses (climate risks) to listed companies and regulated entities. APRA will be increasing the intensity of its supervisory activity to assess the effectiveness of entities' climate risk identification, measurement and mitigation strategies (Paddam and Meyricke, 2019).

In light of these developments, insurers, superannuation funds and institutional investors should embed climate change as a core business issue and continue to build their financial resilience to climate change, thereby protecting individuals.

In terms of public policy, the wide-ranging consequences of climate change on mortality, public health and the economy mean that system-wide policy responses (across the health system, aged care services, emergency services and other social services) are necessary to mitigate the risks posed. In relation to the risks posed by more frequent and intense heatwaves, a number of health related bodies have begun to respond to climate change in Australia; current responses include measures to prepare the public for heatwaves and natural disasters and building infrastructure for a hotter climate (O'Shea, 2017).

Climate change and population ageing are the perfect storm. It is now time to act.

Climate change and population ageing are the perfect storm. Without proper risk management these megatrends have the potential to overwhelm individuals, private companies and government balance sheets over the course of this century. Enough forewarning has been given, it is now time to act.

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Appendix D Main assumptions underlying modelling of the economic and investment return impacts of climate change

Model	Climate change scenarios modelled	Physical risk assumption	Transition risk assumptions
Mercer (2019)	Temperature increase scenarios of 2ºC, 3ºC and 4ºC by 2100	Physical risk allowed for via a "bottom-up" damage function for: – Agriculture (wheat, maize, soy, rice) – Coastal flood – Wildfires	**2ºC scenario**: Aggressive climate action: – Emissions peak in 2020 then fall to 16 $GtCO_2$ by 2050 – Net-zero emissions are reached by 2080–2100. **3ºC scenario**: Some climate action but not transformative, and we fail to achieve a 2ºC outcome: – Global emissions are essentially flat to – 2050 and rise slighter after. – Emissions reach 41 $GtCO_2$ in 2050. **3ºC scenario**: Business as usual pathway: – Global annual emissions increase by 49% by 2050 relative to 2015. – Emissions reach 91 $GtCO_2$ by 2100.
Deloitte Access Economics (2020)	RCP 8.5 and RCP 6.0 are modelled.	For a given RCP (and projected change in temperature pathway) physical risk allowed for via a damage function[28] for six regionalised damages to Australia: 1. Heat stress damages on labour productivity	To model a pathway towards net zero emissions, a representative emissions profile is adopted, implying a technology and policy pathway for the acceleration and deployment of mature and demonstrated technologies. This representative pathway largely reflects that described in the

[28] Developed by DAE in consultation with climate science experts and translated to regionalised economic impacts.

Model	Climate change scenarios modelled	Physical risk assumption	Transition risk assumptions
		2. Human health damages to labour productivity 3. Sea level rise damages to land and capital stock 4. Capital damages 5. Agricultural damages from changes in crop yields 6. Tourism damages to net inflow of foreign currency.	Decarbonisation Futures Report, published by Climate Works Australia.
Schroders (2020)	The temperature profiles of different climate change scenarios begin to diverge only after 2050. I.e. it is assumed the physical cost of climate change on our 30-year horizon will be the same in RCP 2.6 as in RCP 8.5. It is assumed temperatures rise by 0.04ºC p.a. throughout the 30-year forecast period.	Costs of physical risk are calculated using a non-linear relationship between temperatures and productivity, as measured by aggregate output (GDP) at country level, as outlined in Burke and Tanutama (2019). A five-year lag is modelled for the impact of temperature changes on productivity. No explicit allowance for the effects of severe weather events or natural disasters (beyond the impact of temperatures on GDP).	It is assumed the world adopts carbon pricing in the form of a carbon tax in the year 2030, imposing a price of $50 per ton of carbon emitted; the revenues from this tax are assumed to be used to make lump sum payments to the electorate and maintain political support, weighing on efficiency further. In addition it is assumed that 60% of oil and gas reserves, and 80% of coal reserves are left in the ground resulting in a $4 trillion reduction in global market cap; in keep with less ambitious mitigation efforts, it is assumed a larger quantity, consistent with at least three degrees of warming by 2100, are consumed.

NOTICE OF FILING

This document was lodged electronically in the FEDERAL COURT OF AUSTRALIA (FCA) on 7/12/2020 4:36:38 PM AEDT and has been accepted for filing under the Court's Rules. Details of filing follow and important additional information about these are set out below.

Details of Filing

Document Lodged:	Expert Report
File Number:	VID607/2020
File Title:	ANJALI SHARMA & ORS (BY THEIR LITIGATION REPRESENTATIVE SISTER MARIE BRIGID ARTHUR) v MINISTER FOR THE ENVIRONMENT (COMMONWEALTH)
Registry:	VICTORIA REGISTRY - FEDERAL COURT OF AUSTRALIA

SEAL OF THE FEDERAL COURT OF AUSTRALIA

Dated: 7/12/2020 4:36:46 PM AEDT

Registrar

Important Information

As required by the Court's Rules, this Notice has been inserted as the first page of the document which has been accepted for electronic filing. It is now taken to be part of that document for the purposes of the proceeding in the Court and contains important information for all parties to that proceeding. It must be included in the document served on each of those parties.

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MONASH University

MONASH SUSTAINABLE DEVELOPMENT INSTITUTE

6 December 2020

Mr D Barnden
Principal Lawyer
Equity Generation Lawyers
L40, 140 William Street
Melbourne VIC 3000

Dear Mr Barnden,

Anjali Sharma v Minister for the Environment
Federal Court of Australia | VID 607/2020

I refer to your letter dated 13 October 2020 requesting expert evidence in relation to the Federal Court of Australia proceeding detailed above.

Thank you for the opportunity to provide expert evidence in response to the five questions on pages 8 and 9 of that letter.

The evidence report is appended below. Please let me know if you would like any further information (s. 47F(1)).

Yours sincerely,

s. 47F(1)

Professor Anthony Capon MBBS PhD FAFPHM
Director and Professor of Planetary Health

Monash Sustainable Development Institute
8 Scenic Boulevard, Clayton Campus
Monash University VIC 3800
Telephone 03 9905 0124
ABN 12 377 614 012

1. In providing this expert report, I declare that I have read and complied with the Federal Court of Australia's Expert Evidence Practice Note (GPN-EXPT) and agree to be bound by it.

2. I declare that I have made all the inquiries I believe are desirable and appropriate, and that no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Court.

3. I declare that my expert opinions are based wholly or substantially on specialised knowledge arising from my training, study or experience.

4. I declare that I am not, and never have been, a member of a political party.

5. I declare that I am a member of the Expert Advisory Committee for the Climate and Health Alliance (CAHA), and have been a member of this committee since CAHA's establishment in 2010.

6. I declare that I have no other potential competing interests in providing this report to the Court.

Question 1: Please describe your academic qualifications, professional background and experience in the fields of public and planetary health, and any other training, study or experience that is relevant to this brief.

7. I am an Australian-trained public health physician and internationally recognised authority in environmental health and health promotion. With more than 30 years of professional experience, my career has spanned progressively more senior positions in policy, practice, education and research in Australia and internationally.

8. In 1983, I graduated with Bachelor of Medicine and Bachelor of Surgery (MBBS) from the University of Queensland. Subsequently, I undertook research training at the Queensland Institute of Medical Research, earning a Doctorate of Philosophy (PhD) in Child Health from the University of Queensland in 1989. In 1991, I was awarded Foundation Fellowship of the Australasian Faculty of Public Health Medicine (FAFPHM) in the Royal Australasian College of Physicians.

9. During 1991-2006, I was the inaugural Director of the Public Health Unit and Medical Officer of Health (MOH) in the Western Sydney Area Health Service. This MOH role was a statutory appointment under the New South Wales Public Health Act *1991*.

10. In 2008, I joined Professor Tony McMichael's research group in the National Centre for Epidemiology and Population Health at Australian National University. The late Tony McMichael (1942-2014) was an eminent Australian environmental epidemiologist, among the first researchers in the world to study relationships between climate change and human health.

11. In 2009, Tony McMichael and I won funding from the CSIRO Flagship Collaboration Fund to establish a national research cluster on urbanism, climate adaptation and health, and we also won funding from the National Climate Change Adaptation Research Facility

to establish a climate change adaptation research network for human health that brought together colleagues from universities and research institutes across Australia.

12. In 2013, I moved to Kuala Lumpur, Malaysia as the first internationally-recruited Director of the International Institute for Global Health at United Nations University. The following year, I was invited to join the Rockefeller Foundation—*Lancet* Commission on Planetary Health, and in 2015 we published the landmark report "Safeguarding human health in the Anthropocene epoch" in *The Lancet*.

13. In 2016, I returned to Australia as the world's first professor of planetary health in the School of Public Health at the University of Sydney. In 2017, I won a public tender from the NSW Office of Environment and Heritage to establish the human health and social impacts of climate change knowledge node within the NSW Adaptation Hub.

14. In 2018, I convened colleagues across Australia to establish the *MJA—Lancet* Countdown on health and climate change to track Australian progress on health and climate change. This was a world-first initiative to downscale the global *Lancet* Countdown on health and climate change to a national level.

15. In 2020, I was invited to join the Technical Advisory Group on Climate Change and Environment for the World Health Organization's Western Pacific Region.

16. During my career, I have been chief investigator on competitive research grants with a total value of more than $10 million from funding sources including the National Health and Medical Research Council (NHMRC), Wellcome Trust and Rockefeller Foundation. I have published more than 100 peer-reviewed papers which, according to Google Scholar, have been cited more than 4000 times, with an h-index of 32 and i10-index of 67.

17. I have held fellowships from the NHMRC and the World Health Organization. I have also been invited to give numerous keynote addresses and named lectures, including the 2020 Redfern Oration for the Royal Australasian College of Physicians.

18. My current paid appointment is Director of the Monash Sustainable Development Institute and Professor of Planetary Health in the School of Public Health and Preventive Medicine at Monash University.

19. My current honorary appointments include membership of the Climate Change and Health Planning Group, US National Academy of Medicine; the Climate Change Working Group, Association of Academies and Societies of Sciences in Asia (AASSA)—as the nominee of the Australian Academy of Science; the International Advisory Board for *The Lancet Planetary Health*; and the Editorial Advisory Group for *The Medical Journal of Australia* (2017-present); and co-chair of the Future Earth Health—Knowledge Action Network Steering Committee.

20. A copy of my curriculum vitae, including a list of publications, is attached to this report.

Question 2: Please refer to paragraph 15.3 of the concise statement.

a. **To date, have there been observed public health consequences of the phenomena referred to in that paragraph (or any of them) for human beings of any age in Australia?**

   Please include both direct and indirect public health consequences in your answer, and please describe any such consequences by reference to available relevant evidence, where possible.

b. **Are there any other phenomena associated with increased or increasing CO2 emissions that are not referred to in paragraph 15.3 of the concise statement, but which you consider have resulted in public health consequences for human beings of any age in Australia to date?**

   If so, please specify what you consider those phenomena to be and their public health consequences (whether direct or indirect), by reference to available relevant evidence, where possible.

21. The 2019-20 bushfires in Australia are a compelling example of public health consequences of the phenomena referred to in paragraph 15.3 of the concise statement. A robust attribution study of the 2019-20 bushfires demonstrates the role of climate change in these fires, highlighting the importance of rising temperature extremes and persistent drought.[1]

22. Tragically, 33 people lost their lives during that bushfire season, including 9 firefighters.[2] Epidemiologists have since estimated that the smoke from those bushfires was associated with 429 premature deaths, 3230 hospitalisations for cardiovascular and respiratory problems, and 1523 emergency department presentations for asthma.[3] Other health impacts of fires include the long-term health sequelae of burns, impacts on eye health, substance use, and domestic and family violence.[4] The mental health toll from the 2019-20 bushfires, including from loss of property and livelihoods, is yet to be fully calculated.

23. The 2019-20 bushfires brought public health impacts of climate change into sharp focus for all Australians. Indeed, the global media coverage of those bushfires made health impacts of climate change clear to people all around the world.

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[1] van Oldenborgh GJ, Krikken F, Lewis S, et al. Attribution of the Australian bushfire risk to anthropogenic climate change [preprint]. Nat Hazards Earth Syst Sci Discuss; 11 Mar 2020. https://doi.org/10.5194/nhess-2020-69

[2] Parliament of Australia 2020. 2019–20 bushfires—frequently asked questions: a quick guide. Canberra: Parliament of Australia. https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1920/Quick_Guides/AustralianBushfires

[3] Johnston, F.H., Borchers-Arriagada, N., Morgan, G.G. et al. Unprecedented health costs of smoke-related PM2.5 from the 2019–20 Australian megafires. Nat Sustain (2020). https://doi.org/10.1038/s41893-020-00610-5

[4] Australian Institute of Health and Welfare. *Australian bushfires 2019–20: Exploring the short-term health impacts.* Cat. no. PHE 276. Canberra: AIHW; 2020.

24. The 2020 special report of the *MJA—Lancet* Countdown on health and climate change found that Australia has already experienced one of the greatest increases in fire risk globally, with an annual average increase of 30.6 days of high to extreme Fire Danger Index in 2016-2019 compared with 2001-2004.[5]

25. More generally, climate change is a public health issue because climate change affects health in myriad ways. Indeed, climate change threatens the very foundations of human life on Earth including deleterious impacts on air and water quality, and food security. According to the *The Lancet*, one of the world's leading medical journals, climate change is the biggest global health threat of the 21st century.[6]

26. There are 3 broad categories of health impacts from climate change.[7,8,9] First, direct health impacts which include injuries and deaths from extreme weather events such as heatwaves, bushfires, storms and floods. Heatwaves are the most deadly natural hazard in Australia.[10] Climate change is increasing the frequency and intensity of these extreme weather events and, in future, we can expect the risks to health to increase.

27. The second category of health impacts from climate change are indirect (also called secondary or system-mediated) health impacts. These can be further sub-categorised into (1) changes to physical systems, (2) changes to biological systems, and (3) changes to ecosystem structure and function.

28. An example of the first sub-category of these system-mediated health impacts—changes to physical systems—is urban air pollution. In Australia, urban air pollution comes from a variety of sources including transport, energy production and manufacturing industry. However, the level of air pollution to which Australian people are exposed is also affected by weather conditions. For example, hot weather conditions can lead to higher levels of ozone formation at ground level and, therefore, increased risks to health (e.g. exacerbating childhood asthma).

29. An example of the second sub-category of system-medicated health impacts—changes to biological systems—is the changing abundance and distribution of mosquitoes and other vectors for infectious diseases. In Australia, important endemic vector-borne viruses

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[5] Zhang Y, Beggs PJ, McGushin A, Bambrick H, Trueck S, Hanigan IC, Morgan GG, Berry HL, Linnenluecke MK, Johnston FH, Capon AG, Watts N. The 2020 special report of the MJA–Lancet Countdown on health and climate change: lessons learnt from Australia's "Black Summer". *Med J Aust* 2020. https://doi.org/10.5694/mja2.50869

[6] Costello A, Abbas M, Allen A, et al. Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission. *Lancet* 2009; 373:1693–733.

[7] Capon AG, Hanna EG. Climate change: an emerging health issue. *NSW Public Health Bulletin* 2009; 20:1-4.

[8] Butler CD. *Climate change and global health*. Wallingford, UK: CABI Publishing, 2014.

[9] Watts N, Adger WN, Agnolucci P, Blackstock J, Byass P, Cai W, et al. Health and climate change: policy responses to protect public health. *Lancet* 2015; 386:1861–914.

[10] Coates L, Haynes K, O'Brien J et al. Exploring 167 years of vulnerability: an examination of extreme heat events in Australia 1844–2010. *Environ Sci Policy* 2014; 42: 33-44

include Ross River and Barmah Forest. Although dengue is not currently endemic in Australia, outbreaks are associated with imported cases.

30. An example of the third sub-category of system-mediated health impacts—changes to ecosystem structure and function—is the impact of climate change on the habitat of wild animals which can lead to new opportunities for spill-over of pathogens to domestic animals and humans.

31. The final category of health impacts from climate change are flow-on health impacts. These have also been called tertiary health impacts, and are perhaps the most profound impacts. They are mediated via social, economic and demographic disruption.

32. One important example of these flow-on impacts in Australia are the effects of prolonged drought which lead to reduced levels of soil moisture, declines in agricultural productivity, and declines in rural incomes. This affects the wellbeing of rural communities and the mental health of farmers. Psychiatrists are concerned about rising levels of depression from prolonged drought in Australia.[11]

33. Another important example of these flow-on health impacts is displacement from inundation in low-lying island communities with attendant risks to community wellbeing and mental health.

34. Remote settlements are vulnerable to health impacts of climate change due to isolated location, quality of infrastructure, economic resources, limited transport and existing health vulnerabilities. Remote Indigenous communities are particularly vulnerable.[12]

35. The conclusion of the inaugural *MJA—Lancet* Countdown on health and climate change report in 2018 was that Australian policy inaction is threatening lives. Climate change is already affecting the health of Australians and unless there is urgent policy action—including a rapid transition to renewable energy generation—climate change will have an escalating toll on the health of Australians, and people around the world.

Question 3: Please refer to paragraphs 15 and 16 of the concise statement.

a. Do you consider that occurrence of one or more kinds of the phenomena described in paragraphs 15 and/or 16 are likely, in the future, to result in one or more of the public health harms described in paragraph 16 being suffered by human beings who are children (namely, less than 18 years of age) at the date of your report, in (i) Australia, and/or (ii) other parts of the world?

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[11] Austin EK, Handley T, Kiem AS, Rich JL, Lewin TJ, Askland HH, Askarimarnani SS, Perkins DA, Kelly BJ. Drought-related stress among farmers: findings from the Australian Rural Mental Health Study. *Med J Aust* 2018; 209: 159-165. https://doi.org/10.5694/mja17.01200

[12] Hall NL, Crosby L. (2020): Climate Change Impacts on Health in Remote Indigenous Communities in Australia. *International Journal of Environmental Health Research* 2020; https://doi.org/10.1080/09603123.2020.1777948

If so, please state the basis for your opinion in respect of each such phenomenon and corresponding public health harm/s (whether direct or indirect), by reference to available relevant evidence, where possible.

b. Are there any other public health consequences (either direct or indirect) that are not referred to in paragraph 16 of the concise statement, but which you consider are likely to be suffered in the future by human beings who are children (namely, less than 18 years of age) at the date of your report, in (a) Australia, and/or (b) other parts of the world, as a result of the occurrence of one or more kinds of the phenomena described in paragraph 15?

If so, please specify what you consider those public health consequences might be, by reference to available relevant evidence, where possible.

36. Yes, I do consider that the occurrence of one or more kinds of the phenomena described in paragraphs 15 and 16 are likely, in the future, to result in one or more of the public health harms described in paragraph 16 being suffered by people currently under the age of 18 years of age in Australia and around the world.

37. The evidence for the statement in paragraph 36 comes from "The 2019 report of The *Lancet* Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate."[13] This report concludes that a business-as-usual trajectory will result in a fundamentally altered world, with the lives of today's children profoundly affected by climate change. The report argues that without urgent intervention to reduce the burning of coal and other sources of greenhouse gas emissions, this new era will come to define the health of people at every stage of their lives, including through:

   a. direct health impacts of hot weather and heatwaves;
   b. food insecurity and undernutrition;
   c. diarrhoeal disease such as *Vibrio*, and vectorborne diseases such as dengue fever;
   d. health impacts of air pollution which include damage to the heart, lungs and other vital organs;
   e. exposure to bushfires;
   f. economic losses from extreme weather events and their flow on health consequences;
   g. the impacts of hot weather and heatwaves on worker productivity;
   h. downstream risks of climate change, including migration, poverty exacerbation, violent conflict and mental illness.

38. In addition to the public health harms referred to in paragraph 16, there is concern that climate change could increase the geographic extent of risk of spillover of novel pathogens from animals to humans, such as Hendra virus.[14]

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[13] Watts N, Amann M, Arnell N, et al. The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. *Lancet* 2019; 394: 1836–78.

[14] Martin G, Yanez-Arenas C, Chen C, Plowright RK, Webb RJ, Skerratt LF. Climate Change Could Increase the Geographic Extent of Hendra Virus Spillover Risk. *Ecohealth*. 2018; 15: 509-525.

Question 4: If the risk of the occurrence of one or more kinds of the phenomena described in paragraphs 15 and/or 16 increases in future, in your view, does that increase the risk of the public health harms (or any of them) you have identified in your responses to questions 2 and 3 above? Please explain the basis for your response.

39. Yes. It is entirely reasonable to anticipate that if the environmental, social and economic phenomena described in paragraphs 15 and/or 16 are more likely to occur in future, then the public health harms that I have described above are similarly more likely to occur in future.

40. The best evidence to support this conclusion comes from "The 1.5 Health Report" published by the World Health Organization in 2018[15] which provides a synthesis of the health content of the IPCC special report on global warming of 1.5ºC.[16] This synthesis makes clear that the greater the warming, the greater the risks to health overall. The IPCC special report acknowledges that there are local variations, and is frank about the uncertainties in attempting to give precise estimates of the health impacts under each scenario, particularly in specific locations. However, that is not an excuse for inaction. The report is clear that some of the consequences of global warming, such as the sea level rise that threatens population health, and eventually the existence of small island states and low-lying communities, increase inexorably with temperature. Higher air temperatures eventually pass the thresholds above which it is safe to work or play outside. Increasing energy in the atmosphere, leading to elevated air and water temperatures, increase the potential for extreme weather events and the transmission of certain infectious disease. Uncertainty about the precise magnitude and pattern of these changes should be an argument for caution, not complacency. There is a strong public health case for limiting warming to the greatest extent possible. The findings of this report include:

    a. any increase in global warming, even an increase by half a degree, could affect human health. Warming of 1.5°C is not considered 'safe' for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems;

    b. risks to human health and food production systems are projected to be lower at 1.5°C than at 2°C. Risks are projected to be lower at 1.5°C than at 2°C for heat-related morbidity and mortality, ozone-related mortality, and undernutrition;

    c. the impacts of 1.5°C could disproportionately affect disadvantaged and vulnerable populations through food and water insecurity, higher food prices, income losses, lost livelihood opportunities, adverse health impacts, and population displacements;

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[15] Ebi K, Campbell-Lendrum D, Wyns A. *The 1.5 Health report: synthesis on health & climate science in the IPCC SR1.5*. Geneva: World Health Organization; 2018.

[16] Masson-Delmotte V, Zhai P, H.-O. Pörtner H-O, et al, eds. Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Cambridge, UK: Cambridge University Press, 2018.

d. climate change is projected to be a poverty multiplier. The health risks that come with global warming are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development;

e. there is robust evidence that climate change is affecting the frequency, intensity, and duration of heatwaves and that exposure to high ambient temperatures is associated with excess morbidity and mortality;

f. the magnitude of projected heat-related mortality and hazardous heat conditions at +2°C is greater than at +1.5°C, and each additional unit of warming is projected to increase heat related mortality;

g. the extent to which mortality increases with rising temperatures varies by region, presumably because of acclimatisation, population vulnerability, the built environment, access to air conditioning, and other factors. Populations at highest risk include older adults, children, women, those with chronic diseases, and people taking certain medications;

h. previous IPCC reports[17] confirmed that increased storm surges, coastal flooding, and sea level rise due to global warming is projected to exacerbate the risk of death, injury, ill-health, and the disruption of livelihoods in low-lying coastal zones and small island developing states and other small islands;

i. coastal communities especially will suffer from reduced health, reduced income, livelihoods, cultural identity and reduced coastal protection;

j. the risks of 1.5°C vs 2°C of global average warming for Small Island Developing States (SIDS) are expected to be severe;

k. there is strong evidence that changing weather patterns associated with climate change are shifting the geographic range, seasonality, and intensity of transmission of selected climate-sensitive infectious diseases, with increases and decreases projected with additional warming;

l. projections suggest that climate change will further expand the geographic range of these diseases, with increases and decreases projected depending on the disease (e.g. malaria, dengue, West Nile virus, and Lyme disease), the region, and the degree of temperature change;

m. the magnitude and pattern of future impacts is expected to depend on the extent and effectiveness of additional adaptation and vulnerability reduction, and on mitigation for risks past mid-century;

n. many scientific studies suggested the negative health impact of malaria could increase with climate change due to a greater geographic range for the*Anopheles* vector, a longer season, and/or an increase in the number of people at risk, with

[17] IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

larger negative health impacts occurring in relation to greater amounts of warming, and complex regional patterns;

o. some regions are projected to become too hot and/or dry for the *Anopheles* mosquito, such as in northern China and parts of south and southeast Asia. Vector populations are projected to shift with climate change, with expansions and reductions depending on the degree of local warming, the ecology of the mosquito vector, and other factors;

p. the mosquitos *Aedes aegypti* and *Aedes albopictus* - the principal vectors for Dengue Fever, Chikungunya, Yellow fever, and Zika virus - are projected to increase in number, with a larger geographic range by the 2030s than at present, which could put more individuals at risk of the diseases they carry, with regional differences;

q. warmer global average temperatures are expected to expand the range of the West Nile Virus in North America and Europe, particularly along the current edges of its transmission areas, and are expected to extend the transmission season, with the magnitude and pattern of changes varying by location and degree of warming;

r. climate change is expected to expand the geographic range and seasonality of Lyme disease and other tick-borne diseases in parts of North America and Europe. These changes are larger with greater degrees of warming. Climate change is already worsening the adverse health outcomes associated with Lyme disease in Canada;

s. climate change could increase or decrease future negative health impacts of leishmaniasis, Chagas disease, and other vector-borne and zoonotic diseases, with generally greater negative health impacts at higher degrees of warming;

t. because ozone formation is temperature dependent, projections focusing only on temperature increase generally conclude that ozone-related mortality could increase with additional warming, with the risks higher at +2°C than at 1.5°C;

u. changes in projected Particulate Matter-related mortality could increase or decrease, depending on climate projections and emissions assumptions;

v. climate change exacerbates the risk of food insecurity and the breakdown of food systems, particularly for poorer populations in both urban and rural settings. For example, the interaction of climate change with food security can exacerbate undernutrition, increasing the vulnerability of individuals to a range of diseases;

w. health risks associated with food insecurity are higher and the globally undernourished population larger at 2°C compared to 1.5°C of warming;

x. climate change-related changes in dietary and weight-related risk factors are projected to increase mortality due to global reductions in food availability;

y. there is increasing evidence that high ambient levels of CO_2 concentrations could affect human health by increasing the production and allergenicity of pollen and allergenic compounds and by decreasing the nutritional quality of important food crops;

z. in experiments, artificially elevated CO2 and 1.5°C of warming caused an increase in the yield of maize and potato crops. However, observations of actual crop yield trends indicate that reductions as a result of climate change remain more common than crop yield increases, despite increased atmospheric CO2 concentration;

aa. the rise in tropospheric ozone has already reduced yields of wheat, rice, maize, and soybean ranging from a 3% to a 16% reduction globally;

bb. while climate change is very likely to decrease agricultural yield, the consequences could be reduced substantially at 1.5°C with appropriate investment and adaptation;

cc. elevated CO2 concentration lead to faster growth rates and lower protein values in several important cereal grains (C3-type) although perhaps not always for drought resistant grains such as sorghum (C4-type);

dd. elevated CO2 concentrations of 568–590 ppm alone (corresponding to a warming of 2.3 – 3.3°C) would reduce the protein, micronutrient, and B vitamin content of the 18 rice cultivars grown most widely grown in southeast Asia, where it is a staple food source, by an amount sufficient to create nutritional-related health risks for 600 million people;

ee. furthermore, climate-change induced species redistribution could be far reaching and extensive, even if anthropogenic greenhouse gas emissions stopped today. This is projected to have global consequences for food security and human health: key insect crop pollinators will see their range shrink with increasing temperatures, and certain pest and disease species will move into areas which become newly climatically suitable, causing them to become invasive or harmful in certain agricultural areas;

ff. climate change will negatively affect childhood undernutrition, particularly stunting, through reduced food availability, and will negatively affect undernutrition-related childhood mortality and disability-adjusted lives lost, with the largest risks in Asia and Africa. Climate change is projected to hinder increasing food security, stunting the prevention of childhood deaths;

gg. the projected health risks for undernutrition are greater at 2° vs 1.5°C warming. The projected global undernourished population is 530 to 550 million at 1.5°C and 540 to 590 million at 2oC. Furthermore, climate change is reducing the protein and micronutrient content of major cereal crops, which is expected to further affect food security. Socioeconomic conditions are the primary driver of vulnerability;

hh. climate change can alter the availability of water and threaten water security. 80% of the world's population already suffers from serious threats to its water security as measured by indicators including water availability, water demand, and pollution;

ii. limiting global warming to 1.5°C is expected to substantially reduce the probability of drought and risks associated with water availability (i.e. water stress) in some regions. In particular, risks associated with increases in drought frequency and magnitude are substantially larger at 2°C than at 1.5°C in the Mediterranean region and Southern Africa. Higher warming levels may induce strong levels of vulnerability exacerbated by large changes in demography;

jj. poverty and disadvantage increased with recent warming (about 1°C) and are projected to increase in many populations as average global temperatures increase from 1°C to 1.5°C and beyond;

kk. by the mid to late of 21st century, climate change is projected to be a poverty multiplier that makes poor people poorer and increases the total number of people in poverty;

ll. climate change could force more than 100 million people into extreme poverty, with the numbers attributed to climate change alone between 3 million and 16 million, mostly through impacts on agriculture and food prices;

mm. unmitigated warming could reshape the global economy later in the century by reducing average global incomes and widening global income inequality. Most severe impacts are projected for urban areas and some rural regions in sub-Saharan Africa and Southeast Asia;

nn. health risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development. Risks are currently moderate due to regionally differentiated climate-change impacts on crop production in particular. Based on projected decreases in regional crop yields and water availability, risks of unevenly distributed health impacts are high for additional warming above 2°C;

oo. the potential impacts of climate change on migration and displacement are an emerging risk. The social, economic and environmental factors underlying migration are complex and varied, however, and our understanding of the linkages of 1.5oC and 2oC of global warming on human migration are limited and represent an important knowledge gap;

pp. temperature had a statistically significant effect on outmigration over recent decades in 163 countries, but only for agricultural-dependent countries. A 1°C increase in temperature was associated with a 1.9% increase in bilateral migration flows from 142 sending countries and 19 receiving countries;

qq. internal and international migration have always been important for small islands, with numerous factors playing a role;

rr. at 2°C warming, there is a potential for significant population displacement concentrated in the tropics. Tropical populations may have to move at distances greater than 1000 km if global mean temperature rises by 2 °C from the period of 2011–2030 to the end of the century;

ss. drought significantly increases the likelihood of sustained conflict for particularly vulnerable nations or groups due to their livelihood dependence on agriculture. If the world warms by 2°C–4°C by 2050, then rates of human conflict could increase;

tt. additional climate change is projected to increasingly compromise safe work activity and worker productivity during the hottest months of the year. Higher ambient temperatures and humidity levels place additional stress on individuals engaging in physical activity;

uu. global warming of +1.5°C is projected to reduce working hours worldwide by 6% due to heat stress. Environmental heat stress in 2050 is projected to reduce worldwide labour capacity by 20% in hot months from a 10% reduction today, assuming no change in worker behaviour or workplace conditions;

vv. it is unclear whether tipping points, defined as thresholds for abrupt and irreversible change, exist for human health impacts from climate change. Increases in temperature are often modelled using a linear relationship with hospitalisations and deaths, making it hard to identify a tipping point for heat-related deaths. It is plausible that coping strategies will not be in place for many regions, that could result in potentially significant impacts on communities with low adaptive capacity, effectively representing the occurrence of local or regional tipping points;

ww. warming of 2°C poses greater risks to human health than warming of 1.5°C, often with complex regional patterns, with a few exceptions. A warming of 1.5°C compared to 2°C would lower: (1) the risk of temperature related morbidity and smaller mosquito geographic ranges; (2) the exposure of 3546 to 4508 million people to heatwaves; (3) the exposure of 496 million people exposed and vulnerable to water stress; (4) 110 to 190 million fewer premature deaths. If climate change continues as projected, major changes in ill health could include: (1) greater risks of injuries, diseases, and death due to more intense heatwaves and fires; (2) increased risk of undernutrition resulting from diminished food production and reduced nutritional quality of some cereal crops in poor regions; (3) lost work capacity and reduced labour productivity and (4) increased risks of food-, water-, vector borne diseases. If climate change continues as projected, potentially limited positive health effects could include: (1) the reduction of cold-related morbidity and mortality in some areas due to fewer cold extremes; (2) geographic shifts in food production; (3) reduced capacity of disease-carrying vectors due to exceedance of thermal thresholds. However, these positive effects are projected to be increasingly outweighed, worldwide, by the magnitude and severity of the negative health effects of climate change.

Question 5: If the intensity or severity of occurrence of one or more kinds of the phenomena described in paragraphs 15 and/or 16 increases in future, in your view, does that increase the likely intensity or severity of the public health harms (or any of them)

you have identified in your responses to questions 2 and 3 above? Please explain the basis for your response.

41. Yes. Likewise, it is entirely reasonable to anticipate that if the environmental, social and economic phenomena described in paragraphs 15 and/or 16 are more intense or severe in future, then the public health harms that I have described above are likely to be greater in future.

42. The best evidence to support this conclusion comes from 'The 1.5 Health Report' published by the World Health Organization in 2018 and has been detailed in paragraph 40 above.

Personal data

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DATE OF BIRTH	s. 47F(1)
NATIONALITIES	Australia and New Zealand
MAORI IWI	Ngai Tahu
GENDER	Male

Education

FAFPHM	Royal Australasian College of Physicians	1991
PhD	University of Queensland	1989
MBBS	University of Queensland	1983
BMedSci	University of Queensland	1981

Summary of professional expertise and experience

An internationally recognized authority in health and environmental change, Tony Capon has 30 years of leadership and management experience spanning research, education, policy and practice. His research focuses on urbanisation, sustainable development and human health. A former director of the global health institute at United Nations University (UNU-IIGH), Tony has consulted in many countries and for a wide variety of organisations. His current appointment is Professor of Planetary Health in the School of Public Health and Preventive Medicine at Monash University, where he also directs the Monash Sustainable Development Institute.

Summary of work experience

CURRENT APPOINTMENT

Director, Monash Sustainable Development Institute
Professor of Planetary Health, School of Public Health and Preventive Medicine
Monash University
Melbourne
2019 to present

PREVIOUS APPOINTMENTS

Professor of Planetary Health, Sydney School of Public Health, and Director, Planetary Health Platform, University of Sydney, 2016-2019

Director, International Institute for Global Health, United Nations University (UNU–IIGH), Kuala Lumpur, 2013-2016

Foundation Professor of Public Health and Head, Discipline of Public Health, University of Canberra, 2011-2013

Professor of Population Health, National Centre for Epidemiology and Population Health, Australian National University, 2008-2011

Medical Member (part-time), Social Security Appeals Tribunal, Darwin and Sydney, 1990-2010

Adjunct Professor (honorary), Department of Human Geography, Macquarie University, 2003-2009

Consultant in Urban Health Policy (part-time), Australian Health Policy Institute, The University of Sydney, 2007-2008

Research Associate (part-time), CSIRO Sustainable Ecosystems, 2007-2008

Medical Director, The Travel Doctor TMVC, Sydney, 2006

Director of Public Health and Medical Officer of Health, Western Sydney Area Health Service, 1991-2006

Clinical Senior Lecturer, School of Public Health, The University of Sydney, 1991-2006

Deputy Head, Public Health and Epidemiology Unit, Menzies School of Health Research, Darwin, 1990-1991

Senior Clinical Research Officer, Menzies School of Health Research, 1989-1990

Resident Medical Officer, Nambour General Hospital, Queensland, 1988

NHMRC Research Scholar, Queensland Institute of Medical Research, 1985-1987

Medical Intern, Princess Alexandra Hospital, Queensland, 1984

ACADEMIC AWARDS AND DISTINCTIONS

Redfern Oration, Royal Australasian College of Physicians, 2020

Fellow, Frank Fenner Foundation, 2017-present

Fulbright Specialist Award, University of Canberra, 2013

Fenner Conference on the Environment, with Professor Janette Lindesay, *Healthy climate, planet and people: co-benefits for health of action on climate change*, Australian Academy of Science, 2010

Fenner Conference on the Environment, with Professor Tony McMichael, *Urbanism, Environment and Health*, Australian Academy of Science, 2006

World Health Organization Fellowship, Western Pacific Region, 1993

Australian Applied Health Sciences Fellowship, National Health and Medical Research Council, 1989-1991

Medical Postgraduate Research Scholarship, National Health and Medical Research Council, 1985-1987

Dr Magdalene Brodie Memorial Prize in Child Health, University of Queensland, 1983

Dux of the School, Kenmore State High School, 1976

BOARD AND COMMITTEE SERVICE

Co-Chair, Health Knowledge Action Network Development Team, Future Earth 2018-present

Member, National Sustainable Development Council, Australia, 2017-present

Member, International Advisory Board, The Lancet Planetary Health, Elsevier, 2017-present

Member, Editorial Advisory Committee, The Medical Journal of Australia, Australasian Medical Publishing Company, 2017-present

Member, Editorial Board, Cities & Health, Routledge, Tayor & Francis Group, 2016-present

Member, Advisory Committee, Planetary Health Alliance, Harvard University, 2016-present

Member, Editorial Board, Journal of Urban Health, Springer, 2017-2019

Member, Health Knowledge Action Network Development Team, Future Earth, 2016-2018

Member, Scientific Advisory Panel, Global Environment Outlook 6 (GEO–6), United Nations Environment Programme, 2015-2017

Member, Rockefeller Foundation–*Lancet* Commission on Planetary Health, 2014-2016

Member-at-Large, Executive Board, International Society for Urban Health, 2014-2017

Board Member, Frank Fenner Foundation 2013-2017.

Member, Scientific Committee, Health and Wellbeing in the Changing Urban Environment Program, International Council for Science, 2012-2016.

Member, International Board, Sustainable Places Research Institute, Cardiff University, 2011-present

Member, International Advisory Board, NZ Centre for Sustainable Cities, University of Otago, 2010-present

Chair and Lead Fellow, Climate Change Working Group, Royal Australasian College of Physicians, 2010-2011

Member, Global Science Planning Group on Urban Health, International Council for Science, 2008-2010

Member, Environmental Health External Advisory Committee, College of Health and Science, University of Western Sydney, 2003-2009

Member-at-Large, Executive Board, International Society for Urban Heath, 2007-2009

Chair, Nature and Society Forum Board, 2007-2009

Member, Editorial Advisory Committee, NSW Public Health Bulletin, 1999-2005

Chair, Greater Western Sydney Health and Urban Development Group, Western Sydney Area Health Service, 2000-2004

Member, Meningococcal Guidelines Working Party, Communicable Disease Network of Australia and New Zealand, 1999-2002

Chair, NSW Public Health Network, 1999-2000

Member, Tuberculosis Advisory Committee, NSW Health Department, 1997-2000

Member, Advisory Board, Australian Centre of Immunisation Research, Westmead Children's Hospital, 1996-1999

Member, Health Outcomes Council, Western Sydney Area Health Service, 1994-1998

Member, Standing Committee of College Chairmen, NSW Health Department, 1993-1996

Chair, Regional Committee for New South Wales, Australasian Faculty of Public Health Medicine, Royal Australasian College of Physicians, 1993-1996

Member, Public Health Officer Training Program Advisory Committee, NSW Health Department, 1992-1996

Member, Policy Committee, Penrith Food Project, Penrith City Council, 1991-1995

Member of Advisory Committee, Centre for Health Economics Research and Evaluation, University of Sydney, 1991-1993

Chair, Regional Committee for the Northern Territory, Australasian Faculty of Public Health Medicine, Royal Australasian College of Physicians, 1990-1991

Secretary, Institutional Ethics Committee, Royal Darwin Hospital & Menzies School of Health Research, 1990-1991

Member, Postgraduate Studies Committee, Menzies School of Health Research, 1989-1991

COMPETITIVE RESEARCH FUNDING

1. *NSW Office of Environment & Heritage and NSW Ministry of Health.* (2019-2020). AUD 300,000. Human Health and Social Impacts of Climate Change Knowledge Node: Phase II. **Capon A** et al**.**
2. *National Health and Medical Research Council.* (2019-2021). AUD 659,056. An evidence-based extreme heat policy for child and youth sport. Jay O, **Capon A**, et al.
3. *Wellcome Trust.* (2018-2022). GBP 5,000,000. Complex Urban Systems for Sustainability and Health. Davies M, Wilkinson P, **Capon A**, et al.
4. *National Health and Medical Research Council*. (2018-2022). AUD 1,100,237. Identifying optimal sustainable cooling strategies for the most vulnerable during heatwaves. Jay O, **Capon A**, et al.
5. *UrbanGrowth NSW.* (2017-2019). AUD 458,600. Translating evidence to support planning strategies for higher density living. Prior J, Kent J, **Capon A**, Rissel C, Thompson S, Adams J, Thomas L.
6. *NSW Office of Environment & Heritage and NSW Ministry of Health.* (2017-2019). AUD 500,000. Human Health and Social Impacts of Climate Change Knowledge Node. **Capon A** et al**.**
7. *The University of Sydney*. (2017-2018). AUD 150,000. Strategic Research Excellence Initiative: Climate, Environment and Health. **Capon A** et al**.**
8. *British Council, Newton–Ungku Omar Fund.* (2016-2017). USD 218,300. Systems Thinking and Place-based Methods for Healthier Malaysian Cities. Marsden T, **Capon A.**
9. *Wellcome Trust*. (2016-2017). USD 61,000. Historical Perspectives on the Interplay between Public Health and Urban Planning in Penang, Malaysia. Proust K, **Capon A.**
10. *Rockefeller Foundation*. (2016). USD 30,000. Planetary Health: Integrating Environmental Sustainability and Health in the Anthropocene Epoch. **Capon A.**
11. *Australian Research Council Linkage Grant.* (2012-2015). AUD 382,219. The development and application of an evaluation framework to assess transport, health and economic impacts of new urban cycling infrastructure. Rissel C, Greaves S, Wen LM, **Capon AG.**

12. *NSW Department of Health.* (2009-2014). AUD 1,500,000. The New South Wales Healthy Built Environments Program. Thompson SM, **Capon AG**.

13. *Commonwealth Scientific and Industrial Research Organisation.* (2010-2013). AUD 3,150,000. Flagship Collaboration Cluster on Urbanism, Climate Adaptation and Health**.** **Capon AG**, McMichael AJ et al.

14. *National Climate Change Adaptation Research Facility.* (2008-2012). AUD 960,000. Australian Climate Change Adaptation Research Network for Human Health. **Capon AG**, McMichael AJ.

15. *National Health and Medical Research Council.* (1996-1997). AUD 97,000. Evaluation of Daruk community based maternity service. **Capon AG**, Conaty SJ, Brodie P.

16. *NSW Environment Protection Authority.* (1993-1995). AUD 118,000. The health effects of the Castlereagh Liquid Waste Depot. Jalaludin B, **Capon AG**.

17. *Westmead Hospital Charitable Trust.* (1994). AUD 45,000. Development and validation of surgical wound infection surveillance techniques for Australian hospitals. Gilbert L, Sorrell T, **Capon AG**, Mitchell D, Bell J

18. *NHMRC Public Health Research and Development Committee.* (1992-1994). AUD 121,000. Ambient air pollution and asthma morbidity in Western Sydney. Jalaludin B, Leeder SR, **Capon AG**.

19. *NSW Health Department Legionella Fund.* (1993). AUD 47,000. Seroprevalence of antibodies to *Legionella pneumophila* in an elderly population. Jorm LR, **Capon A**.

20. *Westmead Hospital Charitable Trust*.. (1993). AUD 15,000. Prospective study of diarrhoeal outbreaks in long day care centres in western Sydney. Ferguson JK, Jorm LR, **Capon AG**, Gilbert GL.

21. *NSW Health Department Legionella Fund*. (1993). AUD 17,000. Cross-sectional study of exposure to *Legionella pneumophila* in people who attended a retirement seminar. Bell J, Jorm LR, **Capon A**.

22. *NSW Environment Protection Authority*. (1992-1993). AUD 110,000. Air quality and health in Western Sydney. Jalaludin B, **Capon AG,** Smith W.

23. *Federal Office of Road Safety*. (1992). AUD 20,000. Western Sydney traffic injury risk factor study. Close G, **Capon AG**.

24. *National Injury Surveillance Unit, Australian Institute of Health and Welfare*. (1992). AUD 19,500. Development of an injury surveillance system utilising a minimum data set. **Capon AG**.

25. *NHMRC Public Health Research and Development Committee.* (1991). AUD 8,000. Strategies for evaluation of Aboriginal health promotion. Fejo L, Chuah J, **Capon AG**.

OPINION PIECES ON WEB PLATFORMS AND IN MAJOR NEWSPAPERS

1. **Capon AG**, Malik A, Pencheon D, Weisz H, Lenzen M. Health care has a huge environmental footprint, which then harms health. This is a matter of ethics. *The Conversation* July 16, 2020.
2. Armstrong F, **Capon AG**, McFarlane R. Coronavirus is a wake-up call: our war with the environment is leading to pandemics. *The Conversation* March 31, 2020.
3. **Capon AG**. 222 scientists say cascading crises are the biggest threat to the well-being of future generations. *The Conversation* February 12, 2020.
4. Norman B, **Capon A**, Kubiszewski I, Costanza B, Steffen W. Times demand a Sustainable Development Commission to replace the Productivity Commission. *The Conversation* March 26, 2016.
5. **Capon A**, Hamid ZA. Tackling overweight, obesity epidemic. *New Straits Times* June 14, 2014.
6. **Capon A**, Hamid ZA. Obesity: An urgent global epidemic and local challenge. *Our World* June 14, 2014.
7. Haque SE, Tsutsumi A, **Capon A**. Sick cities: A scenario for Dhaka city. *Our World* June 10, 2014.
8. **Capon A**. Putting health at the heart of sustainability policy. *The Conversation* July 4, 2012.
9. **Capon A**. Rio+20: Human health, wellbeing and survival depend on the future of cities. *The Conversation* June 24, 2012.
10. **Capon A**. How full is full? Planning Sydney to be big, sustainable and healthy. *The Conversation* March 29, 2012.
11. **Capon A**. And another thing. *Sunday Life* (The Sun-Herald and Sunday Age Magazine) August 24, 2008.
12. Keleher H, **Capon A**. Forsaking expert input unhealthy for democracy. *The Canberra Times* August 18, 2008.
13. **Capon A**. Let's support Gehl's vision to regain the city's heart. *Sydney Morning Herald* December 5, 2007.
14. **Capon A**. Finding a cure for our sick cities. *Sydney Morning Herald* August 14, 2006.
15. **Capon A**. As Sydney's waistline expands, health workers should talk the walk. *Sydney Morning Herald* November 21, 2003.

PUBLICATIONS

1. Capon, A. (2020) Understanding planetary health. *The Lancet*, **396**(10259): 1325-1326.
2. Capon, A., Madden, D. L. & Truskett, P. G. (2020) Environmentally sustainable health care: now is the time for action. *The Medical Journal of Australia*, **213**(10): 479-479. e1.
3. Hospers, L., Smallcombe, J. W., Morris, N. B., Capon, A. & Jay, O. (2020) Electric fans: A potential stay-at-home cooling strategy during the COVID-19 pandemic this summer? *Science of the Total Environment*, **747**: 141180.
4. Jenkins, A., Jupiter, S. D., Capon, A., Horwitz, P. & Negin, J. (2020) Nested ecology and emergence in pandemics. *The Lancet Planetary Health*, **4**(8): e302.
5. Lenzen, M., Malik, A., Li, M., Fry, J., Weisz, H., Pichler, P.-P., Chaves, L. S. M., Capon, A. & Pencheon, D. (2020) The environmental footprint of health care: a global assessment. *The Lancet Planetary Health*, **4**(7): e271-e279.
6. Lo, S. N., Skarbek, A. & Capon, A. (2020) Recovery from the pandemic: Evidence-based public policy to safeguard Australian health. *The Medical Journal of Australia*: 1.
7. Madden, D. L., Capon, A. & Truskett, P. G. (2020) Environmentally sustainable health care: now is the time for action. *The Medical Journal of Australia*, **212**(8): 361-362.
8. Aginam, O., Alders, R., Arabena, K., Ashleigh, C., Bagnol, B., Black, K., Braaten, Y., Coogan, S., Dawson, A. & Degeling, C. (2019) *One Planet, One Health.* Sydney*:* Sydney University Press.
9. Beggs, P. J., Zhang, Y., Bambrick, H., Berry, H. L., Linnenluecke, M. K., Trueck, S., Bi, P., Boylan, S. M., Green, D. & Guo, Y. (2019) The 2019 report of the MJA–Lancet Countdown on health and climate change: a turbulent year with mixed progress. *Medical Journal of Australia*, **211**(11): 490-491. e21.
10. Capon, A., Jay, O., Ebi, K. & Lo, S. (2019) Heat and health: a forthcoming Lancet Series. *Lancet (London, England)*, **394**(10198): 551.
11. Connon, I. L., Prior, J., Kent, J. L., Thomas, L., McIntyre, E., Adams, J., Capon, A., Rissel, C. & Thompson, S. M. (2019) Conceptualising health for understanding healthy higher density living: A systematic narrative literature review. Sydney: University of Technology, Sydney.
12. Dunk, J. H., Jones, D. S., Capon, A. & Anderson, W. H. (2019) Human health on an ailing planet—historical perspectives on our future. *N Engl J Med*, **381**: 778-82.
13. FitzGerald, G. J., Capon, A. & Aitken, P. (2019) Resilient health systems: preparing for climate disasters and other emergencies. *Med J Aust*, **210**(7): 304-05.

14. Hill-Cawthorne, G., Negin, J., Capon, T., Gilbert, G. L., Nind, L., Nunn, M., Ridgway, P., Schipp, M., Firman, J. & Sorrell, T. C. (2019) Advancing Planetary Health in Australia: focus on emerging infections and antimicrobial resistance. *BMJ global health*, **4**(2): e001283.

15. Jay, O., Hoelzl, R., Weets, J., Morris, N., English, T., Nybo, L., Niu, J., de Dear, R. & Capon, A. (2019) Fanning as an alternative to air conditioning–A sustainable solution for reducing indoor occupational heat stress. *Energy and Buildings*, **193**: 92-98.

16. McFarlane, R. A., Horwitz, P., Arabena, K., Capon, A., Jenkins, A., Jupiter, S., Negin, J., Parkes, M. W. & Saketa, S. (2019) Ecosystem services for human health in Oceania. *Ecosystem Services*, **39**(C).

17. Morris, N. B., English, T., Hospers, L., Capon, A. & Jay, O. (2019) The effects of electric fan use under differing resting heat index conditions: a clinical trial. *Annals of Internal Medicine*, **171**(9): 675-677.

18. Morris, N. B., Gruss, F., Lempert, S., English, T., Hospers, L., Capon, A. & Jay, O. (2019) A preliminary study of the effect of dousing and foot immersion on cardiovascular and thermal responses to extreme heat. *Jama*, **322**(14): 1411-1413.

19. Patrick, R., Armstrong, F., Hancock, T., Capon, A. & Smith, J. A. (2019) Climate change and health promotion in Australia: Navigating political, policy, advocacy and research challenges. *Health promotion journal of Australia: official journal of Australian Association of Health Promotion Professionals*, **30**(3): 295.

20. Sainsbury, P., Charlesworth, K., Madden, L., Capon, A., Stewart, G. & Pencheon, D. (2019) Climate change is a health issue: what can doctors do? *Internal Medicine Journal*, **49**(8): 1044-1048.

21. Zhu, Y.-G., Zhao, Y., Zhu, D., Gillings, M., Penuelas, J., Ok, Y. S., Capon, A. & Banwart, S. (2019) Soil biota, antimicrobial resistance and planetary health. *Environment international*, **131**: 105059.

22. Zhang Y, Beggs PJ, Bambrick H, Berry HL, Linnenluecke MK, Trueck S, Alders R, Bi P, Boylan SM, Green D, Guo Y, Hanigan IC, Hanna EG, Malik A, Morgan GG, Stevenson M, Tong S, Watts N, **Capon AG**. The *MJA–Lancet* Countdown on health and climate change: Australian policy inaction threatens lives. *Med J Aust* 2018; **209** (11): 1.e1- 1.e21. doi: 10.5694/mja18.00789.

23. **Capon A**, Corvalan C. Climate change and health: global issue, local responses. *Public Health Res Pract* 2018; **28** (4):e2841823. https://doi. org/10.17061/phrp2841823

24. Boylan S, Beyer K, Schlosberg D, Mortimer A, Hime N, Scalley B, Alders R, Corvalan C, **Capon A**. A conceptual framework for climate change, health and wellbeing in NSW, Australia. *Public Health Res Pract* 2018; **28** (4):e2841826. https://doi. org/10.17061/phrp2841826

25. Prior JH, Connon ILC, McIntyre E, Adams J, **Capon A**, Kent J, Rissel C, Thomas LE, Thompson SM, Westcott H. Built environment interventions for human and planetary health: integrating health in climate change adaptation and mitigation. *Public Health Res Pract* 2018; **28** (4):e2841831. https://doi.org/10.17061/phrp2841831

26. Arabena K, Armstrong F, Berry H, Brooks P, **Capon T**, Crabb B, Demaio A, Doherty P, Lewin S, Lo S, Lopez A, McMichael C, McPake B, Moodie R, Nolan T, Ruff T, Sainsbury P, Selvey L, Shearman D, Stanley F, Talley NJ, Watts N. Australian health professionals' statement on climate change and health. *The Lancet* 2018; **392**: 2169-2170.

27. Jenkins A, **Capon A**, Negin J, Marais B, Sorrell T, Parkes M, Horwitz P. Watersheds in planetary health research and action. *The Lancet Planetary Health* 2018; 2: e510-e511.

28. **Capon AG**, Talley NJ, Horton RC. Planetary health: what is it and what should doctors do? *Med J Aust* 2018; **208**: 296-7.

29. Brown H, Proust K, Newell B, Spickett J, **Capon A**, Bartholomew L. Cool Communities: Urban Density, Trees and Health. *Int J Environ Res Public Health* 2018; **15**: 1547.

30. **Capon A**. Biosensitivity: An integrative approach to the health of people and planetary systems. In: *The Sage Handbook of Nature*. Marsden T (ed). London: Sage, 2018.

31. Jay O, **Capon A**. Use of physiological evidence for heatwave public policy. *The Lancet Planetary Health* 2018; **2**: e10.

32. Siri JG, **Capon AG**. Public Health. In: *Defining the Urban: Interdisciplinary and professional perspectives*. Oxford: Routledge, 2018.

33. Howden-Chapman P, Siri J, Chisholm E, Chapman R, Doll CNH, **Capon A**. SDG 3 Ensure healthy lives and promote well-being for all at all ages. In: *A Guide to SDG Interactions: from Science to Implementation*. Griggs DJ, Nilsson M, Stevance A, McCollum D (eds). Paris: International Council for Science, 2017.

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35. Gatzweiler FW, Zhu Y-G, Diez Roux AV, **Capon A**, Donnelly C, Salem G, Ayad HM, Speizer I, Nath I, Boufford JI, Hanaki K, Rietveld LC, Ritchie P, Jayasinghe S, Parnell S, Zhang Y. *Advancing Health and Wellbeing in the Changing Urban Environment: Implementing a Systems Approach.* Singapore: Springer, 2017.

36. Grant M, Brown C, Caiaffa WT, **Capon A**, Corburn J, Coutts C, Crespo CJ, Ellis G, Ferguson G, Fudge C, Hancock T, Lawrence RJ, Nieuwenhuijsen MJ, Oni T, Thompson S, Wagenaar C, Ward Thompson C. Cities and health: an evolving global conversation. *Cities & Health* 2017: **1**: 1-9.

37. Lawrence R, **Capon A**, Siri J. Lessons from Hippocrates for Contemporary Urban Health Challenges *Cities & Health* 2017; **1**: 72-82.

38. Hill-Cawthorne GA, **Capon AG**, Sorrell TC, Marais BJ. A planetary health approach to emerging infections in Australia. *The Lancet* 2017; **389**: 1293.

39. Puppim de Oliveira JA, Doll CNH, Siri J, Dreyfus M, Farzaneh H, **Capon A**. A systems approach for health/environment/climate co-benefits in cities. In: Doll CNH, Puppim de Oliveira JA, editors. *Urbanization and Climate Co-Benefits.* Oxford: Routledge, 2017.

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43. Hancock T, Capon AG, Dietrich U, Patrick RA. Governance for health in the Anthropocene. *International Journal of Health Governance* 2016; 21: 245-262.

44. Chapman R, Howden-Chapman P, **Capon A**. Understanding the systemic nature of cities to improve health and climate change mitigation. *Environ Int* 2016; 94: 380-7.

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INVITED ADDRESSES AND CONFERENCE KEYNOTES

Forthcoming

2 Dec 2020	Royal Society of NSW, Hunter Branch, Newcastle (Zoom)
30 Nov 2020	Healthy City Design International Conference, London (Zoom)

Selected from the last 12 months

10 Jul 2020	RACP William Redfern Oration, Melbourne (Zoom)
25 May 2020	7th Rural & Remote Health Scientific Symposium (Zoom)
13 Feb 2020	Parliamentary Friends of Rural Health, Canberra
9-11 Dec 2019	One Health Aotearoa Conference, Wellington, New Zealand
4-6 Nov 2020	International Conference on Urban Health, Xiamen, China
21-23 Oct 2020	NT Chronic Disease Network Conference, Alice Springs

Equity Generation Lawyers

13 October 2020

Professor Tony Capon
Chair in Planetary Health / School of Public Health and Preventative Medicine
Director Monash Sustainable Development Institute
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By email only: Tony.Capon@monash.edu

Dear Professor Capon

Anjali Sharma v Minister for the Environment
Federal Court of Australia | VID 607/2020

Introduction

1. Equity Generation Lawyers represents Anjali Sharma and seven other individuals aged between 13 and 17 (**Applicants**) in a Federal Court of Australia proceeding (**proceeding**) against the Respondent, the Commonwealth Minister for the Environment (**Minister**).
2. The proceeding was filed on 8 September 2020 by the Applicants' litigation representative, Sister Marie Brigid Arthur. The proceeding is brought on the Applicants' own behalf and as a representative proceeding (or 'class action') on behalf of persons under the age of 18 (**children**) who were born before the date this proceeding was filed, and who ordinarily reside:

   (a) in Australia (**the Australian Represented Children**); or

   (b) elsewhere;

   (together, the **Represented Children**).
3. The proceeding relates to a project involving expansion of a 'greenfield' coal mine in Northwest New South Wales (**Project**), for which approval has been sought by

Whitehaven Coal Ltd (**Whitehaven**) from the Respondent under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**Act**).

4. In the proceeding, the Applicants seek the following final relief:

   (a) a declaration that the Minister owes the Applicants a duty to take reasonable care not to cause them harm while exercising her powers (**the statutory powers**) under ss 130 and 133 of the Act in respect of the Project; and

   (b) an injunction to restrain the Minister from exercising the statutory powers in respect of the Project in a manner likely to cause them harm in breach of the alleged duty.

5. The Applicants argue that approval of the Project would be likely to cause harm to the Applicants and the Represented Children, as the result of the extraction and combustion of the coal, which will increase the concentration of carbon dioxide (**CO_2**) in the atmosphere. The effect of increasing CO_2 concentration, and consequent harms, are outlined in the two affidavits of David Barnden filed in this proceeding (and the exhibits to those affidavits), both of which are included in your brief of materials.

6. The injunction sought by the Applicants would have the effect of restraining the Minister from approving the Project.

7. On behalf of the Applicants, we seek to engage you as an expert witness in the proceeding, to provide an expert report in respect of certain questions regarding the observed and expected public health impacts of increased CO_2 concentration in the atmosphere. Your report is due to be filed by early December 2020.

8. It is proposed that your expert report will be relied upon at the trial of this proceeding, which is presently set down for a five-day hearing commencing on 2 March 2021 for four days (with an additional day listed for 12 March 2021 if required). You may also be required to attend Court to give evidence at the trial of the proceeding. We will confirm this with you in due course. In the meantime, we would be grateful if you could confirm your availability for the duration of the trial as presently scheduled for March 2021.

Preparation of your report

9. The role of an independent expert witness is to provide relevant and impartial evidence in their area of expertise.

10. An independent expert witness has duties to the Court as set out in the Federal Court of Australia Practice Note entitled “Expert Evidence Practice Note GPN-EXPT” (**Practice Note**). Importantly, an expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person

retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

11. A copy of the Practice Note, which includes the Harmonised Expert Witness Code of Conduct at Annexure A to that document (**Code**), is included in your brief of materials in this matter. You are required to read, understand and comply with the entire Practice Note, including the Code, when preparing your report (in particular, you ought to ensure that your report complies with Part 5.2 of the Practice Note and Part 3 of the Code, both of which expressly relate to the contents of expert reports). If you have any questions about the application or meaning of any aspect of the Practice Note or the Code, please contact us.

12. This letter sets out a number of factual matters in the section below entitled 'Assumptions' which, so far as they have relevance for your work in this matter, you are instructed to assume are accurate. To the extent that you rely on any assumptions of fact in preparing your report (whether those set out in this letter, or otherwise), you should clearly identify such assumptions (and the basis for those assumptions) in your report.

13. Further, accompanying this letter are a number of documents that may be relevant to the questions on which you are asked to express your opinion. Those documents are listed in the index that is provided at the end of this letter. In preparing your report, you may have regard to those documents to the extent and in the manner that you see fit. Where you rely upon a document in your report (whether one of those documents accompanying this letter, or otherwise), you should clearly identify this in your report.

Assumptions

<u>The Project</u>

14. The Project is an extension of a greenfield coal mine in NSW (**Mine**) for which Whitehaven originally received development consent in 2014.[1]

15. Under the Mine's original approval, Whitehaven was permitted to extract 135 million tonnes (**Mt**) of coal over a 30-year period, at a rate of up to 4.5 million tonnes of run-of-mine (**ROM**) coal a year (**Mtpa**), with coal hauled by trucks on public roads to Whitehaven's existing coal handling and preparation plant (**CHPP**) near Gunnedah, for processing and transport by rail to the Port of Newcastle.[2]

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[1] Concise statement at [3]; first affidavit of David Barnden at [8]-[9]; exhibit DLB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at p iii; second affidavit of David Barnden at [9].

[2] Exhibit DLB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at p iii;

16. The Project proposes:[3]

(a) an increase in total coal extraction by 33 Mt, from 135 to 168 Mt;

(b) an increase in the peak annual extraction rate from 4.5 up to 10 Mtpa of coal; and

(c) to increase the disturbance area of the Mine by an additional 776 hectares;

(d) to develop a new CHPP and train load out facility at the Mine (both of which would process coal from other nearby mines), such that the proposed CHPP and load out facility would:

(i) stockpile and process a total of 13 Mtpa of ROM coal from the project and other Whitehaven mining operations;

(ii) produce up to 11.5 Mtpa of metallurgical and thermal coal products; and

(iii) transport up to 11.5 Mtpa of product coal from the rail load facility, the rail spur line and via the public rail network to Newcastle for export markets;

(e) to develop a new rail spur to connect the load out facility to the main Werris Creek to Mungindi Railway line;

(f) to construct a water supply borefield and associated infrastructure;

(g) to change the final landform in certain specified ways relating to the overburden emplacement areas and pit lake voids.

17. If approved, the Project would generate approximately:[4]

(a) 3.1 Mt CO_2-e of Scope 1 emissions. These are direct emissions from owned or controlled sources of an organisation / development.

(b) 0.8 Mt CO_2-e of Scope 2 emissions. These are indirect emissions from the generation of purchased energy electricity, heat and steam used by an organisation / development.

(c) 366 Mt CO_2-e Scope 3 emissions. These are all other upstream and downstream emissions related to an organisation / development.

18. The coal that is the subject of the Project (and which Whitehaven proposes to extract if the Project is approved) presently lies underground, storing carbon.[5] It cannot be

[3] First affidavit of David Barnden at [16]-[17]; exhibit DB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at pp iv and 6.
[4] First affidavit of David Barnden at [18]; exhibit DLB-17, NSW Independent Planning Commission Statement of Reasons dated August 2020 at pp 42, 47.
[5] Concise statement at [5].

extracted without the Minister exercising her statutory powers to grant approval under the Act.[6]

19. If the project is approved, coal at the Project site will be extracted, exported, and burned, emitting the carbon it contains as CO_2 into the atmosphere.[7]

CO_2 emissions and fossil fuels

20. CO_2 is one of a number of greenhouse gases present in the Earth's atmosphere.[8] Since the Industrial Revolution, a sustained, accelerating and extraordinary increase in both CO_2 concentration and surface temperature has been recorded.[9]

21. When burned to produce energy, each of coal, oil and natural gas produces CO_2.[10] Of those three substances, coal produces the most CO_2 per energy unit.[11] When CO_2 is emitted, it can persist in the Earth's atmosphere for more than 1,000 years.[12]

22. About 1/3 of present global CO_2 emissions are caused by burning coal.[13] Of all human activities, the burning of coal is responsible for the greatest proportion of the extraordinary rates of increase observed in CO_2 concentration and surface temperature.

23. Unless the extracting and burning of fossil fuels (in particular, coal) is constrained, the extraordinary rates of increase in CO_2 concentration and surface temperature will continue.

Relevant impacts

24. By emitting CO_2 into the atmosphere in the manner described above, humans have changed (and will continue to change) the Earth's systems.[14]

25. Generally, these changes include:[15]

(a) the heating of Earth's surface and oceans;

(b) the acidification of oceans;

(c) changing precipitation patterns;

(d) rising sea levels;

(e) increasing incidence and intensity of heatwaves, droughts, bushfires, violent storms, storm-surge flooding and other extreme weather events;

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[6] Concise statement at [5].
[7] Concise statement at [5].
[8] Concise statement at [6].
[9] Concise statement at [7], [9], [11]-[12].
[10] Concise statement at [8].
[11] Concise statement at [8].
[12] Concise statement at [8].
[13] Concise statement at [8].
[14] Concise statement at [15.1].
[15] Concise statement at [15.2].

(f) erosion;

(g) melting ice (on both land and sea) and permafrost;

(h) harm to and destruction of non-human ecosystems, species and beings; and

(i) the increasing risk of triggering 'tipping points', such as the Amazon tipping point, the Boreal tipping point, thawing of global permafrost, reduction in Arctic and East Antarctic sea ice, disintegration of the West Antarctic and Greenland ice sheets, and large-scale coral reef die offs, that will cause massive additional increases in CO2 concentration, sudden major shifts in Earth's natural systems, or both.[16]

26. Specifically in Australia, these changes have already included:[17]

(a) increased mean surface temperature;

(b) unprecedented temperatures and heatwaves;

(c) increased regularity and intensity of heatwaves, extreme fire weather days, bushfires, floods, droughts, extreme storms and rain events, and other extreme climatic and weather events;

(d) reduced cool-season rainfall in southeast and southwest Australia, increased wet-season rainfall in northern Australia, and increased proportion of total rainfall in Australia caused by heavy rainfall; and

(e) rising sea levels.

Alleged harm

27. Harm suffered or likely to be suffered by humans is alleged by the Applicants, in paragraph 16 of the concise statement, to include mental or physical injury, including ill-health or death, or economic loss, from:

(a) more, longer and more intense:

(i) bushfires, storm surges, coastal flooding, inland flooding, cyclones and other extreme weather events;

(ii) periods of extreme heat;

(iii) periods of drought;

(b) sea-level rise;

(c) increasing loss of non-human species and ecosystems, on land and in oceans;

[16] Concise statement at [15.4].
[17] Concise statement at [15.3].

(d) systemic breakdowns and overwhelming of infrastructure networks and critical services, including electricity, water supply, internet, health care, and emergency services;

(e) food insecurity and breakdown of food systems;

(f) adverse impacts on:

(i) national and global economies;

(ii) financial markets;

(iii) industries, businesses and professions;

(iv) the number and quality of employment opportunities;

(v) standard of living; and

(vi) living costs;

(g) increasing smoke, heat, and disease;

(h) loss of clean water, clean air and nutriment (essentials);

(i) social and political unrest, violence and scarcity as essentials are depleted, and humans try to move in search of essentials, habitable land, or both; and

(j) mental harm caused by solastalgia, and the experience and anticipation of the above.

28. The applicants allege that:

(a) Unless the rate of increase in CO_2 concentration reaches zero (namely, flattens) and then decreases, then humans will be very likely to experience the harm set out in the preceding paragraph (**the relevant harm**). The greater the level of CO_2 concentration when the rate of increase flattens, the higher the risk that humans will suffer (a) the relevant harm; (b) more of, and more severe forms of, the relevant harm.[18]

(b) The less coal that is burned on Earth from today, the lower will be the level of CO_2 concentration when its rate of increase flattens.[19]

(c) They, and the other Represented Children, are more likely to suffer (a) the relevant harm, (b) more of, and more severe forms of, the relevant harm, if the Project is approved.[20]

[18] Concise statement at [17].
[19] Concise statement at [17].
[20] Concise statement at [18].

Questions

You have been asked to respond to the following questions. In doing so, please limit your responses to matters derived from or appropriately connected to your training, study or experience. To the extent that there are matters on which you do not feel you are able to comment, please expressly note this in your response/s.

1. Please describe your academic qualifications, professional background and experience in the fields of public and planetary health, and any other training, study or experience that is relevant to this brief (you may wish to do so by reference to a current curriculum vitae).

2. Please refer to paragraph 15.3 of the concise statement.

    a. To date, have there been observed public health consequences of the phenomena referred to in that paragraph (or any of them) for human beings of any age in Australia?

       Please include both direct and indirect public health consequences in your answer, and please describe any such consequences by reference to available relevant evidence, where possible.

    b. Are there any other phenomena associated with increased or increasing CO2 emissions that are not referred to in paragraph 15.3 of the concise statement, but which you consider have resulted in public health consequences for human beings of any age in Australia to date?

       If so, please specify what you consider those phenomena to be and their public health consequences (whether direct or indirect), by reference to available relevant evidence, where possible.

3. Please refer to paragraphs 15 and 16 of the concise statement.

    a. Do you consider that occurrence of one or more kinds of the phenomena described in paragraphs 15 and/or 16 are likely, in the future, to result in one or more of the public health harms described in paragraph 16 being suffered by human beings who are children (namely, less than 18 years of age) at the date of your report, in (i) Australia, and/or (ii) other parts of the world?

       If so, please state the basis for your opinion in respect of each such phenomenon and corresponding public health harm/s (whether direct or indirect), by reference to available relevant evidence, where possible.

    b. Are there any other public health consequences (either direct or indirect) that are <u>not</u> referred to in paragraph 16 of the concise statement, but which you consider are likely to be suffered in the future by human beings who are children (namely, less than 18 years of age) at the date of your report, in (a) Australia, and/or (b) other parts of the world, as a result of the occurrence of one or more kinds of the phenomena described in paragraph 15?

If so, please specify what you consider those public health consequences might be, by reference to available relevant evidence, where possible.

4. If the risk of the occurrence of one or more kinds of the phenomena described in paragraphs 15 and/or 16 increases in future, in your view, does that increase the risk of the public health harms (or any of them) you have identified in your responses to questions 2 and 3 above? Please explain the basis for your response.
5. If the intensity or severity of occurrence of one or more kinds of the phenomena described in paragraphs 15 and/or 16 increases in future, in your view, does that increase the likely intensity or severity of the public health harms (or any of them) you have identified in your responses to questions 2 and 3 above? Please explain the basis for your response.

Other matters

29. You will observe that point 3 of the Code requires your report to include a declaration that you have made all the inquiries which you believe are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which you regards as relevant have, to your knowledge, been withheld from the Court. Accordingly, if, in the course of preparing your report, you identify further information or materials that you consider are relevant to your task, please contact us to discuss this further.

Yours sincerely

s. 47F(1)

David Barnden
Principal Lawyer

Encl.

Index of documents contained in brief to expert witness

Annexure #	Document Title
1	Originating Application dated 8 September 2020.
2	Concise Statement dated 8 September 2020.
3	Affidavit of David Barnden dated 8 September 2020 with exhibits: ○ **Exhibit "DLB-1"**, Intergovernmental Panel on Climate Change (IPCC), "Climate Change 2014: Synthesis Report" (Assessment Report 5)"; ○ **Exhibit "DLB-2"**, Whitehaven Coal, March 2020 Quarterly Report; ○ **Exhibit "DLB-3"**, Professor Will Steffen, Expert Report to Independent Planning Commission (IPC), 2020; ○ **Exhibit "DLB-4"**, United Nations Production Gap Report, 2019; ○ **Exhibit "DLB-5"**, Climate Analytics, "Evaluating the significance of Australia's global fossil fuel carbon footprint", 2019; ○ **Exhibit "DLB-6"**, Climate Council, "Dangerous Summer: Escalating Bushfire, Heath and Drought risk", 2019; ○ **Exhibit "DLB-7"**, Watts et al, "The 2019 report of The Lancet Countdown on health and climate change", 2019; ○ **Exhibit "DLB-8"**, NSW Government Assessment Report, Vickery Extension Project, 2020; ○ **Exhibit "DLB-9"**, Doctors for the Environment, "Children and climate change", 2018; ○ **Exhibit "DLB-10"**, Climate Council, "Lethal Consequences: Climate Change Impacts on the Great Barrier Reef", 2018; ○ **Exhibit "DLB-11"**, Doctors for the Environment, "Climate Change and Health in Australia - Fact Sheet", 2016; ○ **Exhibit "DLB-12"**, American Psychological Association, "Mental Health and Our Changing Climate", 2017; ○ **Exhibit "DLB-13"**, Department of the Environment, "The Intergovernmental Panel on Climate Change" (IPCC Fact Sheet), 2014; ○ **Exhibit "DLB-14"**, IPCC "Special Report on 1.5C", 2018; ○ **Exhibit "DLB-15"**, Actuaries Institute of Australia,"The impact of climate change on mortality and retirement incomes in Australia", 2019; ○ **Exhibit "DLB-16"**, EPBC Notice, "Notification of Referral Decision EPBC 2012/6263"; ○ **Exhibit "DLB-17"**, Independent Planning Commission NSW, "Statement of Reasons for Decision, Vickery Extension Project SSD 7480".
4	Affidavit of David Barnden dated 8 October 2020 with exhibits: ○ **Exhibit "DLB2-18"**, EPBC Notice, "EPBC 2016/7649 Decision whether action needs approval/Approval Required", 14 April 2016; ○ **Exhibit "DLB2-19"**, EPBC Notice, "EPBC 2016/7649 Statement of Reasons: Decision under section 75", 2 June 2016; ○ **Exhibit "DLB2-20"**, EPBC Notice "EPBC 2016/7649 Notification of Change of Designation of Proponent", 17 July 2018; ○ **Exhibit "DLB2-21"**, EPBC Notice "EPBC 2016/7649 Notification of Extension of Time" 29 September 2020;

	○ **Exhibit "DLB2-22"**, Independent Planning Commission NSW (IPC) Vickery Extension Project SSD 7480: Issues Report, 30 April 2019; ○ **Exhibit "DLB2-23"**, Bilateral Agreement between Commonwealth and New South Wales; ○ **Exhibit "DLB2-24"**, IPC, Development Consent for Vickery Extension Project, 12 August 2020; ○ **Exhibit "DLB2-25"**, Letter from Equity Generation Lawyers to Australian Government Solicitors 1 October 2020; ○ **Exhibit "DLB2-26"**, Guardian Newspaper, "Environment Minister Rejects Queensland Wind Farm Project to Save Old Growth Forest", 8 June 2020; ○ **Exhibit "DLB2-27"**, Guardian Newspaper, "Australia has denied Environmental Approval to Just 18 Projects Since 2000", 12 August 2015; ○ **Exhibit "DLB2-28"**, EPBC Decisions Spreadsheet; ○ **Exhibit "DLB2-29"**, Resource related EPBC decisions Spreadsheet; ○ **Exhibit "DLB2-30"**, Letter from Australian Government Solicitor to Equity Generation Lawyers, 30 September 2020; ○ **Exhibit "DLB2-31"**, RBA Bulletin: The Changing Global Market for Australian Coal, September 2019; ○ **Exhibit "DLB2-32"**, Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM), "State of the Climate Report", 2018; ○ **Exhibit "DLB2-33"**, CSIRO, Response to Notice to Give Information to the Royal Commission (RCNDA HTG-HB1-002), 21 April 2020; ○ **Exhibit "DLB2-34"**, CSIRO "Climate and Disaster Resilience" report, 30 June 2020; ○ **Exhibit "DLB2-35"**, Commonwealth Department of the Environment RCP Fact Sheet; ○ **Exhibit "DLB2-36"**, CSIRO "Climate Compass: A climate risk management framework for Commonwealth agencies", August 2018; ○ **Exhibit "DLB2-37"**, Westerhold et al, "An astronomically dated record of Earth's climate and its predictability over the last 66 million years" *Science* 369, 1383-1387, 11 September 2020; ○ **Exhibit "DLB2-38"**, Westerhold et al, "Supplementary Materials: An astronomically dated record of Earth's climate", *Science* 369, 1383, 11 September 2020; ○ **Exhibit "DLB2-39"**, Live Science, "Earth barreling towards 'Hothouse' state not seen in 50 million years, epic new climate record shows", 2020; ○ **Exhibit "DLB2-40"**, Letter from Australian Government Solicitor to Equity Generation Lawyers, 7 October 2020; ○ **Exhibit "DLB2-41"**, "Letter to Commonwealth Government - Vickery Extension Project Referral Redacted", 14 August 2020.
5	Orders made by the Court on 24 September 2020

6	Orders made by the Court on 5 October 2020
7	Federal Court of Australia Expert Evidence Practice Note (including Annexure A, Harmonised Code of Conduct)

NOTICE OF FILING

This document was lodged electronically in the FEDERAL COURT OF AUSTRALIA (FCA) on 7/12/2020 4:36:38 PM AEDT and has been accepted for filing under the Court's Rules. Details of filing follow and important additional information about these are set out below.

Details of Filing

Document Lodged:	Expert Report
File Number:	VID607/2020
File Title:	ANJALI SHARMA & ORS (BY THEIR LITIGATION REPRESENTATIVE SISTER MARIE BRIGID ARTHUR) v MINISTER FOR THE ENVIRONMENT (COMMONWEALTH)
Registry:	VICTORIA REGISTRY - FEDERAL COURT OF AUSTRALIA

Sia Lagos

Dated: 7/12/2020 4:36:47 PM AEDT

Registrar

Important Information

As required by the Court's Rules, this Notice has been inserted as the first page of the document which has been accepted for electronic filing. It is now taken to be part of that document for the purposes of the proceeding in the Court and contains important information for all parties to that proceeding. It must be included in the document served on each of those parties.

The date and time of lodgment also shown above are the date and time that the document was received by the Court. Under the Court's Rules the date of filing of the document is the day it was lodged (if that is a business day for the Registry which accepts it and the document was received by 4.30 pm local time at that Registry) or otherwise the next working day for that Registry.

Report for Equity Generation Lawyers on:

Anjali Sharma v Minister for the Environment
Federal Court of Australia | VID 607/2020

Federal Court of Australia

7 December 2020

Professor Will Steffen
Emeritus Professor, The Australian National University
Senior Fellow, Stockholm Resilience Centre

At the outset of this report, I acknowledge that I have read Expert Evidence Practice Note (GPN-EXPT), and, in particular, acknowledge the following:

- I have read and complied with the Practice Note and agree to be bound by it, and that my opinions are based wholly or substantially on specialised knowledge arising from my training, study and experience as an expert for well over 30 years;

- I have signed this report at the end, and have appended the original letter of instruction and a follow-up email, as well as the Westerhold et al. (2020) paper, which I was asked to consider;

- As is standard practice for the presentation of scientific information, I have included references to literature that I have quoted for specific elements of knowledge or information that I have drawn upon. In addition, I have synthesized a vast body of scientific literature in developing and presenting my views on various aspects of climate change science and its relevance for this Project.

- I declare that I have made all of the inquiries and investigations that I believe are desirable and appropriate to this report. I have not withheld any matters of significance from the Court.

Executive Summary

1. Anthropogenic climate change is real and poses serious risks for the wellbeing of humans and our societies. Many impacts of climate change are already being experienced. The risk of further impacts will continue to rise rapidly and nonlinearly with the rise in global average surface temperature, as described in the three scenarios outlined in this report.

2. The primary cause of climate change is the human emissions of carbon dioxide (CO_2) to the atmosphere, originating primarily from the burning of coal, oil and gas. Carbon dioxide is a greenhouse gas that traps heat near the Earth's surface, raising the global average temperature and driving many other changes to the climate system.

3. To meet a 2°C temperature target (the upper target of the Paris climate accord), a very rapid phase-out of all fossil fuel usage by 2050 at the latest, or preferably earlier, is required.

4. This means that the majority of the world's existing fossil fuel reserves (coal, oil, gas) must be left in the ground, unburned. Furthermore, no new fossil fuel developments, or extensions to existing fossil fuel mines or wells, can be allowed.

5. Continuing to develop new coal reserves, or extending existing coal facilities, will condemn our children and the generations that follow them to live on a planet with much harsher, dangerous, and damaging climatic conditions than those we are already experiencing today.

Note: In the body of my report below, the questions put to me are laid out in *italics*, followed by my answers in regular font.

Basis of expertise

1. *Please describe your academic qualifications, professional background and experience in the field of climate change science, and any other training, study or experience that is relevant to this brief (you may wish to do so by reference to a current curriculum vitae).*

I am a climate and Earth System scientist, with over 30 years of experience in research and teaching, as well as a strong background in working across the science-policy interface and in communicating the science of climate change. I have appended (i) my detailed Curriculum Vitae and (ii) a more concise account of my expertise, research background and publication record.

Carbon dioxide (CO_2) emissions, CO_2 concentration and temperature rise

2. *What was/is the concentration of CO_2 in the Earth's atmosphere (CO_2 concentration) as at:*

   a. the reference date (defined below);

   b. the present day?

The commonly used reference date for climate change-related parameters, as defined by the International Panel on Climate Change (IPCC), is the 1850-1900 average, or where data are available for individual years, 1876 (IPCC 2013). This is often referred to as 'pre-industrial'.

   a. The pre-industrial (ca. 1750) atmospheric concentration of CO_2 is usually taken as 280 ppm (parts per million). The CO_2 concentration in 1875 (consistent with the 1850-1900 average used as the temperature baseline by the IPCC) was 289 ppm.

   b. The CO_2 concentration in 2019 was 410 ppm and is currently rising at about 2.5 ppm per year (Friedlingstein et al. 2019).

3. *What is the difference between the average global surface temperature at a specific point in time and the average global surface temperature before the industrial revolution (temperature difference), where the specific point in time is the present date?*

The temperature difference between any given year and pre-industrial is taken as the observed annual average over ocean and land for the given year compared to the pre-industrial, defined as the 1850-1900 average temperature.

4. *Please state the date you have used as a reference point for "before the industrial revolution", for the purpose of identifying temperature difference (the reference date), and explain the basis for using this reference date.*
As noted in 3, the 1850-1900 average is usually taken as the 'baseline temperature' against which increases in global average surface temperature are referenced.

5. *Describe the causal relationship between:*
   a. emissions from the Earth's surface of CO_2; and
   b. CO_2 concentration; and
   c. temperature difference.

Emissions of CO_2 from the Earth's surface increase the concentration of CO_2 in the atmosphere. Increasing atmospheric CO_2 concentration increases the global average surface temperature of Earth because CO_2 is a so-called 'greenhouse gas'. That is, CO_2 absorbs some of the outgoing long wavelength radiation (heat) from the Earth's surface, re-radiating it in all directions, thus increasing the heat content of the Earth's lower atmosphere and increasing the surface temperature of the Earth.

6. *How has human industrial activity affected the level of CO_2 concentration and temperature difference from the reference date up until the present date?*
Emissions of CO_2 from industrial sources (the dominant source, currently about 90%) and land-use change (the secondary source, currently about 10%) have raised the atmospheric concentration of CO_2 to 410 ppm (2019) and raised the global average surface temperature by 1.1°C compared to the 1850-1900 average (Friedlingstein et al .2019; WMO 2020).

7. *How has the combustion by human beings of coal for industrial activity affected the level of CO2 concentration and temperature difference from the reference date up until the present date?*

The cumulative emissions of coal from pre-industrial to the present are estimated to be around 1,000 Gt (billion tonnes) of CO_2. This would contribute about 0.5°C to the observed temperature rise of 1.1C compared to pre-industrial (GCP 2020).

8. *In a comparator world, in 2020, where human industrial activity had not produced any emissions of CO_2:*

a. what would be the likely CO_2 concentration as at the present date?

b. would there be any temperature difference as at the present date, and if so, what would it likely be?

In the comparator world with no industrial emissions of CO_2:

a. the atmospheric CO_2 concentration would still be higher than the 1850-1900 average because of land-use change, but it would be far less than the current value of 410 ppm. My estimate is that CO_2 concentration would be about 310 ppm based on land-use change alone (GCP 2020).

b. the global average surface temperature would now be about 0.1 or 0.2°C above pre-industrial.

9. *Describe the rate of increase in CO_2 concentration and temperature difference from the reference date up to the present date.*

The rates of increase in atmospheric CO_2 concentration is itself increasing. The current rate is about 2.5 ppm/year (Friedlingstein et al. 2019). The rate of temperature increase is also increasing. The current rate is 0.24°C per 5-year period or nearly 0.5°C per decade (Canadell and Jackson 2020). If this rate were to continue through the rest of this century, by 2100 the global average surface temperature would reach about 5°C above the pre-industrial level.

10. *To what extent has the combustion of coal contributed to the rate of increase in CO_2 concentration and temperature difference from the reference date up to the present date?*

The combustion of coal has contributed about 1,000 Gt of the total 2,180 Gt CO_2 emitted to the atmosphere by human activities (GCP 2020). This is about 46% of the total emission of CO_2. Thus, coal has contributed about 0.5°C out of the total of 1.1°C temperature rise from the reference date up to the present date.

Present CO_2 emissions

11. *Based on data from an appropriate recent period, what is the present rate of emissions of CO_2 into the atmosphere?*

Emissions of CO_2 from human activity were about 43 Gt for 2019, which is the pre-COVID rate of emissions. Emissions rose steadily over the 2015-2019 period from about 39 to 43 Gt CO_2 per annum (Friedlingstein et al. 2019). Emissions for 2020 are estimated to be 4-7% lower than for 2019 due to the reduced economic activity caused by the COVID pandemic (Le Quere et al. 2020).

12. *What proportion of those emissions is likely to be the result of the combustion of coal by human beings?*

Emissions of CO_2 from the combustion of coal in 2019 were 14.5 Gt, comprising 34% of the total human emissions of CO_2 in 2019 (GCP 2020).

Future CO_2 emissions and flattening the curve

13. *At some point in time in the future, will the rate of increase in:*

  a. CO_2 concentration;

  b. temperature difference;

reach zero (flatten)?

(That is, will they reach a level where they no longer increase?)

At some point of time in the future, the trajectories of increasing atmospheric CO_2 concentration and increasing global average surface temperature will likely slow and then stabilise for a multi-decadal period. However, the level at which this stabilisation occurs depends not only on human emissions of CO_2 but also on feedbacks within the Earth System that strengthen or weaken the trajectories of CO_2 and temperature.

14. *If the answer to question 13(a) or (b) is "yes":*

  a. if both the rate of increase in CO_2 concentration and the rate of increase in temperature difference will flatten:

i. is there a relationship between the level of CO_2 concentration when it stops increasing and the level of temperature difference when it stops increasing? If so, what is the relationship?

ii. Will the rate of increase in CO_2 concentration flatten at the same time as the rate of increase in temperature difference? If not, which will flatten first, and why?

b. what would need to happen for the rate of increase of temperature difference or rate of increase of CO_2 concentration, or both, to flatten?

c. what are the key causal factors that will determine the level of temperature difference or CO_2 concentration, or both, when the rates of increase flatten?

d. what is the relationship between:

i. the amount of further emissions of CO_2 from human industrial activity, including the combustion of coal; and

ii. the level of temperature difference or CO_2 concentration, or both, when they flatten?

a(i) There will be a lag between the time that CO_2 concentration is stabilised and the time that the global average surface temperature is stabilised; the lag time would be a minimum of multi-decadal (at least three decades) up to a century or longer. Model experiments have been carried with a hypothetical stabilisation of CO_2 at the level of the year 2000 (about 370 ppm), with a slow temperature rise through the following century reaching 0.6°C in 2100, relative to the 2000 level (Collins et al. 2013).

a(ii). As per the point above, stabilisation of temperature lags the stabilisation of CO_2 concentration for several decades at least, or possibly up to a century. The reason for the lag is the time needed for the heat content of the major Earth System components - land, ocean, ice, atmosphere - to equilibrate, with a net transfer of heat from the ocean to the atmosphere following the stabilisation of atmospheric CO_2 concentration.

b. Human emissions of CO_2 must reach net zero, and be held at net zero indefinitely, for the atmospheric CO_2 concentration to stabilise. This is a pre-requisite for the global average surface temperature to stabilise, but this stabilisation process would take several decades or a century (Collins et al. 2013).

c. The maintenance of CO_2 concentration at a stabilised level depends on several factors: (i) achieving net-zero emissions of CO_2 from human sources; (b) feedbacks within the Earth System that could release additional CO_2 to the atmosphere (e.g., melting permafrost, Amazon forest fires and dieback, etc.), and (c) natural processes that absorb CO_2 from the atmosphere, such as dissolution of CO_2 in ocean water and the uptake of CO_2 by growing forests. In addition to CO_2 concentration, the other factors that influence global average surface temperature are (i) the concentrations of other greenhouse gases such as methane (CH_4) and nitrous oxide (ii) the atmospheric concentration of aerosols (small particles such as soot (black carbon) and dust), (iii) melting of ice (e.g., Arctic sea ice) that influences the reflectivity of the Earth's surface, and (iv) geophysical feedbacks within the Earth System such as cloud types and dynamics.

d. The further emissions of CO_2 from human activities (combustion of fossil fuels and land use) will increase the global average surface temperature at a rate of about 1°C for every 1,800 Gt CO_2 emitted (Collins et al. 2013). As noted above the final temperature increase depends on the cumulative CO_2 emissions from the beginning of the industrial revolution (and on other factors as noted in point 14c above), and there will be a lag of at least several decades and up to a century between the time that the CO_2 concentration is stabilised and the time that the global average surface temperature is stabilised.

C. The Earth System

15. *What is the Earth system?*

The Earth System is defined as "…the suite of interlinked physical, chemical, biological and human processes that cycle (transport and transform) materials and energy in complex, dynamic ways within the system." (Steffen et al. 2004; Steffen et al. 2020).

16. *What is the role of CO_2 in the Earth system?*
Atmospheric CO_2 acts as the 'thermal regulator' of the Earth System. It is an integral component of the planet's carbon cycle (Life on Earth is carbon-based). That is, plants absorb CO_2 from the atmosphere to power their growth and emit CO_2 back to the atmosphere as part of their metabolism. Geophysical processes, such as the dissolution and release of CO_2 to and from the ocean also plays a crucial role in the planetary metabolism.

17. *Is there a relationship between the level of CO_2 concentration and the Earth system?*
The level of CO_2 in the atmosphere is a fundamental controller of the temperature of the planet as measured at the planet's surface and in the lower atmosphere.

18. *If the answer to question 17 is "yes":*

a. describe that relationship.

b. what is the effect on the Earth system of increases in the level of CO_2 concentration?

a. CO_2 is a so-called 'greenhouse gas' because it plays a crucial role in the planet's energy balance. The planet's surface absorbs energy from the sun (visible and ultra-violet radiation), but to avoid overheating and eventually burning up, the planet must also discharge energy back into space (the planetary energy balance). The Earth does this by emitting longer wavelength infrared radiation (heat) from the surface back through the atmosphere and into space. CO_2 absorbs a significant fraction of this outgoing infrared radiation (it "excites" the C-O double bonds), and when the "excited" CO_2 molecules relax again, they emit infrared radiation in all directions. Some of the infrared radiation is thus re-radiated back into the lower atmosphere and to the Earth's surface, thus warming the surface and the lower atmosphere. This is the greenhouse effect.

b. Increasing the concentration of CO_2 in the atmosphere enhances the greenhouse effect. That is, more outgoing infrared radiation is trapped and re-radiated by CO_2 molecules, thus warming Earth's surface and the lower atmosphere even more.

19. *What is the relationship between the Earth system and subsidiary systems or natural phenomena occurring in particular parts of the Earth?*

The relationship between the Earth System as a whole (it is a single, self-regulating complex system) and its subsystems, and the natural phenomena that emerge from these relationships, is dynamic, two-way and complex. It is best addressed through a conceptual systems dynamics model of the Earth System (Steffen et al. 2020):

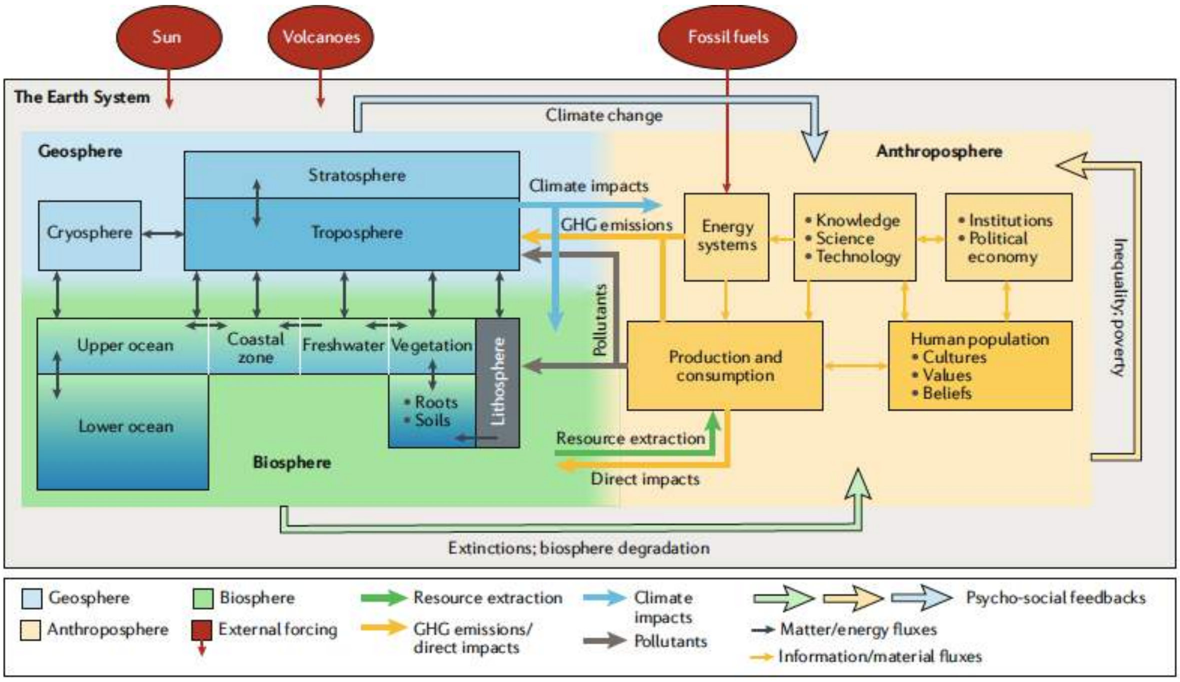

Fig 1. A detailed systems diagram of the Earth System, with humans (the anthroposphere) as a fully integrative, interacting sphere. The internal dynamics of the anthroposphere are depicted as a production/consumption core driven by energy systems and modulated by human societies, as influenced by their cultures, values, institutions, and knowledge. Interactions between the Anthropocene and the rest of the Earth System are two-way, with human greenhouse gas emissions, resource extraction and pollutants driving impacts that reverberate through the geosphere-biosphere system. Feedbacks to the anthroposphere are also important, including direct impacts of climate change and biosphere degradation but also psycho-social feedbacks from the rest of the Earth System and within the anthroposphere. Source: Steffen et al. (2020).

Here are just a few examples of the roles that subsystems play in the overall functioning of the Earth System:

- The stratosphere filters most of the damaging ultraviolet radiation from the sun, allowing life to flourish on the surface of the Earth.
- The troposphere (lower atmosphere) carries freshwater (via evaporation, cloud formation and rainfall) around the planet in complex ways, ultimately carrying water

derived from the ocean and then dropping it over land, allowing ecosystems to flourish.

- Vegetation absorbs CO_2 from the atmosphere (it uses the carbon from CO_2 as the building blocks of life), thus regulating the Earth's energy balance.

The list could go on and on, but the point is that the Earth is a single complex system at the planetary level - our 'life support system' - in which the biosphere, and increasingly human activities, playing a vital role in the stable functioning of the planet as a whole.

20. *Is there a relationship between the level of CO_2 concentration and subsidiary systems or natural phenomena occurring in particular parts of the Earth?*

Yes

21. *If the answer to question 20 is "yes":*

    a. describe that relationship.

    b. what is the effect on those subsidiary systems or natural phenomena of increases in the level of CO2 concentration?

The best way to describe the relationship between CO_2, the carbon cycle and the rest of the Earth System is via a 'system dynamics diagram':

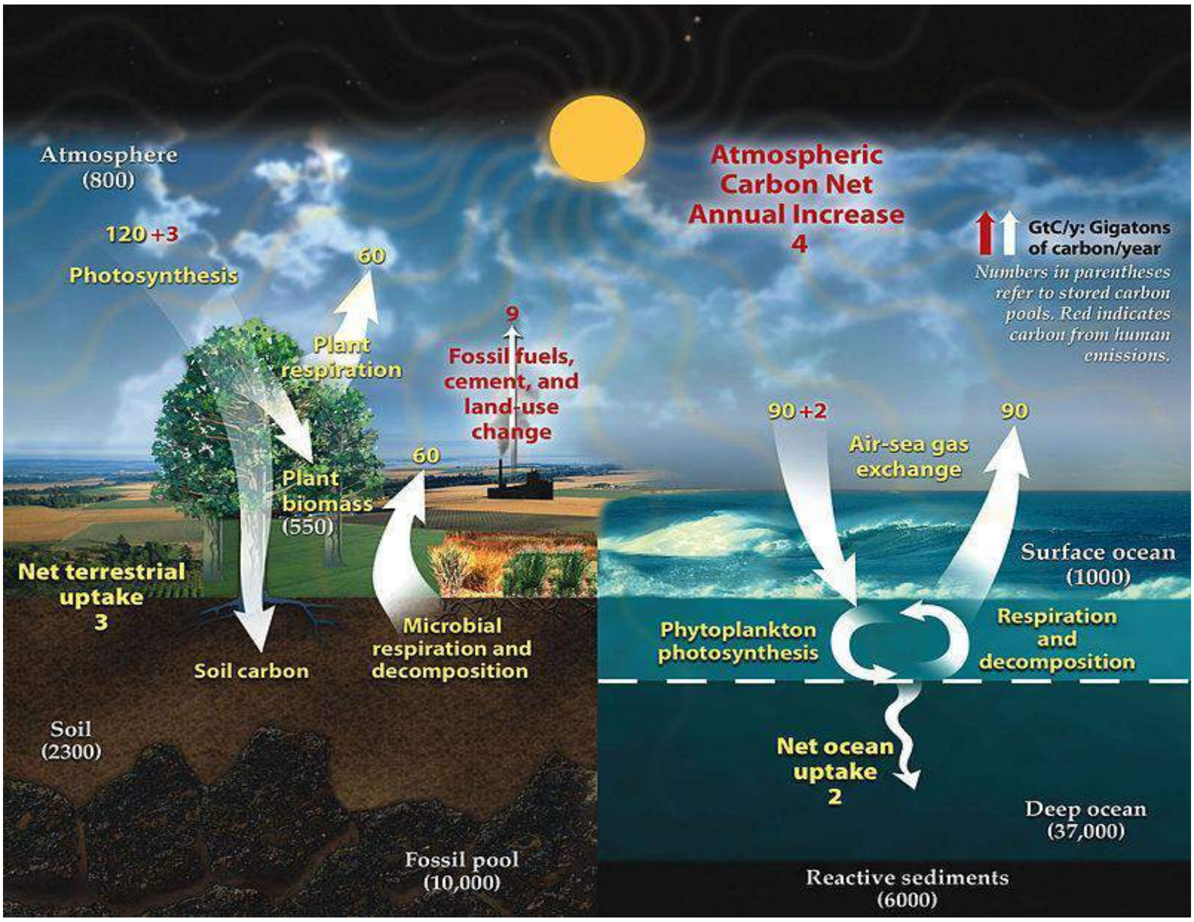

Fig 2: The global carbon cycle showing the movement of carbon between land, atmosphere and oceans in billions of tons (gigatonnes - Gt) of carbon per year. Yellow numbers are natural fluxes, red are human-driven fluxes, and white are stored carbon. Source: Riebeek (2011).

Note the change in fluxes in the natural carbon cycle due to the additional CO_2 emitted to the atmosphere because of human activities, primarily the combustion of fossil fuels (coal, oil, gas). The take-home message from this systems analysis is that about 55% of the human emissions of CO_2 are absorbed by the land and ocean (slightly more by land) and the remaining 45% that accumulates in the atmosphere is the primary driver of the increasing global average surface temperature. Thus, natural 'sinks' of carbon fall far short of absorbing enough of human emissions of CO_2 to prevent a serious destabilisation of the climate system.

Another method to understand the global carbon cycle is shown in Figure 3 below, which shows human emissions of CO_2 from 1850 through 2018, and the partitioning of this additional CO_2 in the Earth System among the atmosphere, the land (vegetation and soils) and the ocean (Friedlingstein et al. 2019).

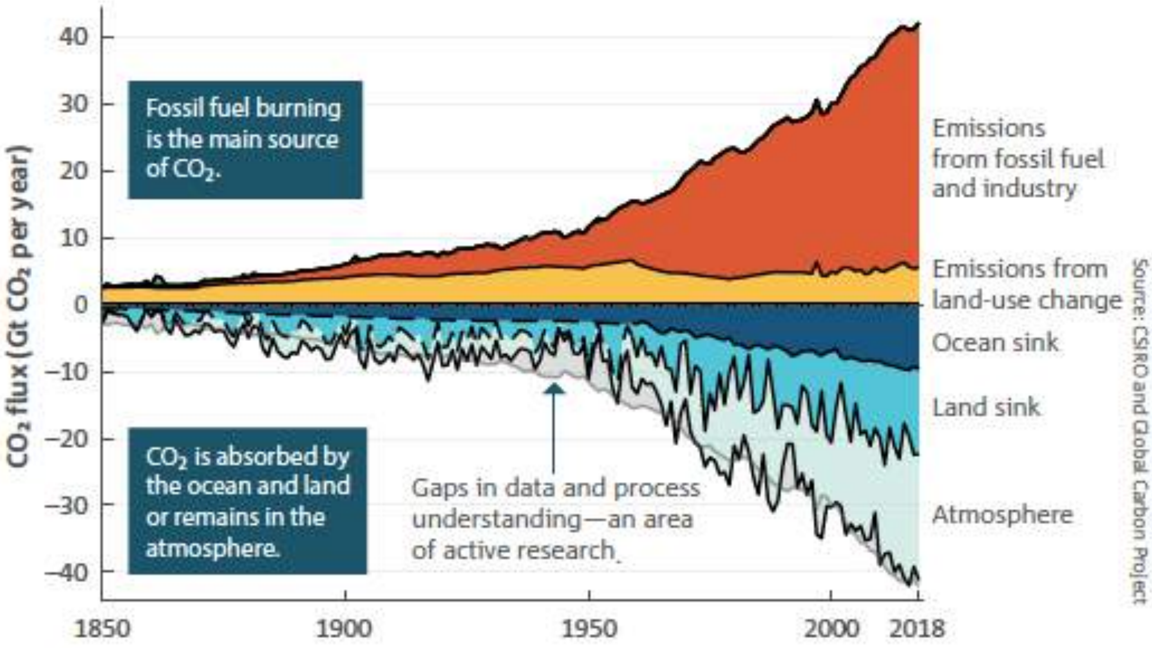

Fig 3: The human emissions of CO_2, primarily from the combustion of fossil fuels, are partitioned among the atmosphere and carbon sinks on land and in the ocean. The "imbalance" between total emissions and total sinks reflects imprecisions in our measurements and understanding, primarily of the land and ocean sinks. Source: Friedlingstein et al. (2019) and CSIRO and BoM (2020).

Again, it is clear that the magnitude of human emissions of CO_2 is overwhelming the capability of the ocean and land sinks to absorb this accelerating burden of additional CO_2 in the atmosphere. Thus, the amount of CO_2 that remains in the atmosphere (bottom light blue wedge) has grown at an increasing rate since the mid-20th century.

D. Effects to date

22. *To date, what have been the effects of emissions of CO_2 from human industrial activity on the Earth system, and subsidiary systems or natural phenomena:*

a. in Australia?

b. globally?

The human emissions of CO_2 (and other greenhouse gases, although CO_2 is the most important) have already changed Earth's climate in very many significant ways. As an overview, the planet's atmosphere and ocean are heating at an increasing rate, polar ice is melting, extreme weather events are becoming more extreme, sea levels are rising, and ecosystems and species are being lost or degraded.

a. The most important impacts of climate change to date on Australia include the following (CSIRO and BoM 2020):

- Australia's climate has warmed on average by 1.44 ± 0.24°C since national records began in 1910, leading to an increase in the frequency of extreme heat events. Summer extreme temperatures are increasingly breaching 35°C and even 40°C in most of our capital cities and many regional centres.
- There has been a decline of around 16 per cent in April to October rainfall in the southwest of Australia since 1970. Across the same region, May–July rainfall has seen the largest decrease, by around 20 per cent since 1970.
- In the southeast of Australia there has been a decline of around 12 per cent in April to October rainfall since the late 1990s.
- There has been a decrease in streamflow at the majority of streamflow gauges across southern Australia since 1975.
- Rainfall and streamflow have increased across parts of northern Australia since the 1970s.
- There has been an increase in extreme fire weather, and in the length of the fire season, across large parts of the country since the 1950s, especially in southern Australia.
- There has been a decrease in the number of tropical cyclones observed in the Australian region since 1982.
- Oceans around Australia are acidifying and have warmed by around 1°C since 1910, contributing to longer and more frequent marine heatwaves.
- Sea levels are rising around Australia, including more frequent extremes, that are increasing the risk of inundation and damage to coastal infrastructure and communities.

(b) The effects of climate change are clear and unequivocal around the planet - on every continent and in every ocean basin. The most important impacts of climate change to date globally include the following (IPCC 2013):

- Warmer and/or fewer cold days and nights over most land areas.
- Warmer and/or more frequent hot days and nights over most land areas.
- Increases in the frequency and/or duration of heat waves in many regions.
- Increase in the frequency, intensity and/or amount of heavy precipitation (more land areas with increases than with decreases).
- Increases in intensity and/or duration of drought in many regions since 1970.
- Increases in intense tropical cyclone activity in the North Atlantic since 1970.

- Increased incidence and/or magnitude of extreme high sea levels.

Global observational evidence published since the IPCC Fifth Assessment Report in 2013 reinforce these trends. For example:

- Measurements from satellite altimeters show a climate-change driven acceleration of mean global sea level over the past 25 years (Nerem et al. 2018). Averaged globally over the past 27 years, sea level has been rising at 3.2mm/year. But for the past five years, the rate was 4.8mm/year, and for the 5-year period before that the rate was 4.1mm year (Canadell and Jackson 2020, based on data from the European Space Agency and Copernicus Marine Service).
- Climate change is rapidly increasing the thermal stress for coral reefs as measured at 100 coral reef locations around the world. The level of thermal stress during the 2015-2016 El Niño was unprecedented over the period 1871-2017 (Lough et al. 2018).
- Intense tropical cyclone activity has increased from 1980 to 2016. Storms of 200 km/hr have doubled in number, and storms of 250 km/hr have tripled in number (Rahmstorf et al. 2018).

E. Future Effects

23. *What will be the future effects on the Earth system, and subsidiary systems or natural phenomena, if emissions of CO2 from human industrial activity continue in the future?*

Future climate change will be driven in the near-term (several decades into the future) by the further amount of greenhouse gas emissions emitted by human activities, and in the longer term (centuries) by both human emissions and feedbacks in the climate system (e.g., melting of permafrost, collapse of the Amazon rainforest) that could emit significant additional amounts of greenhouse gases to the atmosphere. Climate scientists use a number of approaches to project how the climate system might change in the future and what impacts might occur because of these changes. The most common approach to explore future climate changes is quantitative projections by Earth System models, which are based on mathematical descriptions of the major features of the Earth System and their interactions. The models are driven by projected human emissions of greenhouse gases and land-use change, as well as natural drivers of change such as changes in solar radiation. Model outputs provide detailed insights into the risks that humanity faces at various levels of climate change, often characterised by changes in global average surface temperature. Evidence from past changes in the Earth System, such as melting of ice caps during previous warm periods, provide important supplemental information that give insights into how the Earth System might change in the future.

The projections for future changes in Australia's climate include (CSIRO and BoM 2020):

a. Continued warming, with more extremely hot days and fewer extremely cool days.

b. A decrease in cool season rainfall across many regions of the south and east, likely leading to more time spent in drought.

c. A longer fire season for the south and east and an increase in the number of dangerous fire weather days.

d. More intense short-duration heavy rainfall events throughout the country.

e. Fewer tropical cyclones, but a greater proportion projected to be of high intensity, with ongoing large variations from year to year.

f. Fewer east coast lows particularly during the cooler months of the year. For events that do occur, sea level rise will increase the severity of some coastal impacts.

e. More frequent, extensive, intense and longer-lasting marine heatwaves leading to increased risk of more frequent and severe bleaching events for coral reefs, including the Great Barrier and Ningaloo reefs.

f. Continued warming and acidification of its surrounding oceans.

g. Ongoing sea level rise. Recent research on potential ice loss from the Antarctic ice sheet suggests that the upper end of projected global mean sea level rise could be higher than previously assessed (as high as 0.61 to 1.10 m global average by the end of the century for a high emissions pathway, although these changes vary by location).

h. More frequent extreme sea levels. For most of the Australian coast, extreme sea levels that had a probability of occurring once in a hundred years are projected to become an annual event by the end of this century with lower emissions, and by mid-century for higher emissions.

24. *In making predictions about those future effects:*

a. can the level of temperature difference be used as a proxy for levels of CO2 concentration? If so, why; if not, why not?

b. is there a linear correlation between:

i. increase in CO_2 emissions from human industrial activity;

ii. increase in CO_2 concentration and temperature difference; and

iii. increase in effects on the Earth system and subsidiary systems or natural phenomena?

c. If not, are there particular levels or rates of increase in CO_2 emissions, or CO_2 concentration and temperature difference, that will produce non-linear rates of change, cascades or cycles in the effect on the Earth system? If so, why?

a. The increase in global average surface temperature is never used as a proxy for the atmospheric CO_2 concentration. Both are measured directly.

b) (i) and (ii) There is an approximately linear relationship between human emissions of CO_2 from all sources and the increase in global average surface temperature (but see description of nonlinear impacts in c) below). The pre-industrial levels are used as a baseline for both observations.

b) (iii) Global average surface temperature is used as an indicator for the increasing heating of the Earth System - atmosphere, ocean, land, cryosphere (ice). Some of the impacts of this heating are approximately linear but many are not.

c) In terms of nonlinear impacts, some of these produce feedbacks that accelerate warming of the Earth System. Examples include (i) melting of Arctic sea ice, which uncovers darker seawater, which absorbs more sunlight (in the northern hemisphere summer) and accelerates warming; (ii) increasing drought in the Amazon basin, which increases fire frequency, leading to an increase in the emissions of CO_2, and (iii) melting of the permafrost, which releases both CO_2 and methane to the atmosphere, accelerating the warming. As the global average surface temperature rises towards 2°C and beyond, the risk of such feedbacks being activated increases. Given that many of these feedback processes are linked (see Lenton et al. 2019 for details on tipping cascades), a global tipping cascade could form that takes the trajectory of the Earth System out of human control or influence and leads to a much hotter Earth. This scenario is often called the 'Hothouse Earth' scenario (Steffen et al. 2018).

25. *For the purpose of answering question 25, please choose several indicative points (by reference to the level of temperature difference at the point in time when the increase in temperature difference flattens) on the spectrum of possible future worlds. Please start with the lowest level of temperature difference when it flattens that is, at the present date, a real possibility. Please end with the highest level of temperature difference when it flattens that is, at the present date, a real possibility. Please explain why you have selected these particular indicative points of temperature difference.*
For each indicative possible future world:

> *a. what would be the level of temperature difference at the point in time when it flattened?*
>
> *b. in broad terms, what would need to occur for temperature difference to flatten at that level?*
>
> *c. when would temperature difference be most likely to flatten at that level?*
>
> *d. what is the approximate total amount of future emissions of CO_2 that could be emitted (assessed from the present day onwards) for temperature difference to flatten at that level?*
>
> *e. what is the likelihood of temperature difference flattening at that level?*
>
> *f. what is the effect on the likelihood of temperature difference flattening at that level of any non-linear effects identified in response to question 24.c above?*
>
> *g. would it be possible for temperature difference to flatten at that level if the coal presently available and permitted to be mined everywhere on Earth were extracted and combusted? If so, what would be the effect of that occurring on the likelihood of temperature difference flattening at that level?*
>
> *h. would it be possible for temperature to flatten at that level if the coal presently permitted to be mined were extracted and combusted, and coal were also extracted and combusted from extant deposits for which permission has not presently yet been granted? If so, what would be the effect of that occurring on the likelihood of temperature difference flattening at that level?*

i. what would be the likely effects on the Earth system, subsidiary systems and/or natural phenomena, up to and including the point in time at which the level of temperature difference would flatten?

I propose three possible climate futures:

Scenario 1: Stabilisation of global average surface temperature at, or very close to, 2°C above pre-industrial. This is the best possible outcome that we can envisage today, and is equivalent to the IPCC RCP4.5 scenario. RCP stands for "Representative Concentration Pathway" and the number following it (4.5 in this case) refers to the radiative forcing in the year 2100, as measured in watts per square metre (W/m^2), that results from different levels of greenhouse gases emitted to the atmosphere. The RCPs include (from lowest to highest) 2.6, 4.5, 6.0 and 8.5. The lowest RCP (2.6) would result in global average temperature rise of below 2°C by 2100, while the highest RCP (8.5) would lead to a temperature rise of 4°C or more by 2100 (Collins et al. 2013).

The Paris accord of 2015 agreed to limit temperature increase to well below 2°C above pre-industrial levels (similar to RCP2.6), with the ambition to limit it to 1.5°C. The lower Paris target of 1.5°C is now very likely to be inaccessible without significant 'overshoot' (temperature rising to beyond 1.5°C above pre-industrial, as per scenario 1), followed by 'drawdown' of CO_2 from the atmosphere, by natural means (e.g., reforestation), by industrial means (e.g. carbon capture-and-storage), or both. In summary, scenario 1 would lead to a global average surface temperature in 2100 that would be approximately equivalent to, or slightly higher than, the upper Paris accord target of "well below 2°C".

Scenario 2: Stabilisation of global average surface temperature at, or very close to, 3°C above pre-industrial. This corresponds to the outcome if the present national policy settings guide future emissions trajectories (CAT 2020). It is approximately equivalent to the upper end of the IPCC RCP6.0 envelope of temperature scenarios.

Scenario 3: No stabilisation of global average surface temperature this century, with the 4°C above pre-industrial level breached late in the century with temperature continuing to rise into the 22nd century. This corresponds to the IPCC RCP8.5 scenario, with its extremely high and very damaging impacts (see below). In essence, this is the worst possible outcome, but could eventuate if global cooperation on climate change breaks down and many nations continue on a pathway of high usage of fossil fuels (coal, oil, gas). RCP8.5 appears to be increasingly unlikely as renewable energies become less costly and begin to replace fossil fuels at large scales. However, there is a risk that an RCP8.5 scenario could, in effect, eventuate if the climate is driven onto the Hothouse Earth trajectory noted above (Steffen et al. 2018), The difference between RCP8.5 and Hothouse Earth is that, in the IPCC RCP8.5 scenario, human emissions of greenhouse gases are the dominant driver of the temperature rise, while in the Hothouse Earth scenario, feedbacks within the Earth System, which add significant amounts of greenhouse gases to the atmosphere, play an important role in the ultimate temperature rise. See detailed description of the scenarios below.

Although these are described as three possible scenarios, there is a significant risk that Scenario 2 is not accessible; that is, it may not be possible to stabilise the Earth System at a 3°C level above pre-industrial. The reason is that many feedback processes will be activated by a 3°C (or even lower) temperature rise, with a consequent significant risk that a tipping cascade will be activated, taking the global average surface temperature beyond 3°C and onto a Hothouse Earth trajectory. This feedback processes include climate change-driven degradation of large biomes (e.g., Amazon rainforest; boreal forests in Canada and Siberia) and subsequent release of CO_2; melting of polar ice such as the Arctic sea ice over the north pole, and changes in ocean and atmospheric circulation, such as a weakening of the Atlantic Ocean thermohaline circulation (Lenton et al. 2019). There is, in addition, also a risk that a 2°C temperature rise could trigger a Hothouse Earth trajectory, but the probability of such a scenario is much lower for a 2°C temperature rise than for a 3°C temperature rise.

The characteristics and consequences of each of the scenarios are:

<u>Scenario 1:</u>

a. The temperature at stabilisation is approximately 2°C above the pre-industrial level.

b. Cumulative emissions (the remaining 'carbon budget') from 2021 onwards would need to be restricted to about 855 Gt CO_2 (assuming a 67% probability of meeting a 2°C target, and accounting for non-CO_2 greenhouse gases and carbon cycle feedbacks). This equates to about 20 years of emissions at 2019 rates.

c. Stabilisation would occur in the second half of this century.

d. See point b.

e. Stabilisation around 2°C would require a significant increase in national emission reduction targets and the corresponding policy, legislative and technological changes required to meet these targets. Achieving net-zero emissions by 2050 by all major emitting countries would be required to have a reasonable probability of stabilising the climate at a 2°C temperature level above pre-industrial.

f. Feedbacks (e.g., permafrost, forest dieback etc as described above) have been estimated for a 2°C forcing and included in emission reduction requirements described in point b) above. More specifically, the combined emissions from permafrost thaw, Amazon forest dieback, boreal forest dieback, and ocean bacterial respiration is about 240 Gt CO_2. My assessment of tipping point behaviour is that there is a small (but non-zero) probability of initiating a tipping cascade at a 2°C temperature rise.

g.& h. The carbon budget framework has significant implications for fossil fuel reserves and resources, particularly for coal. Here we adopt the definitions of "reserves" and "resources" used by McGlade and Ekins (2015) in their analysis of the relationship between fossil fuel usage and the rise in global average surface temperature:

> "Reserves" are defined as a subset of "resources" that are recoverable under current economic conditions and have a specific probability of being produced. "Resources" are the remaining ultimately recoverable deposits of fossil fuels that are recoverable over all time with both current and future technologies, irrespective of economic conditions. Thus, "resources" are all of the fossil fuels that are known to exist, and "reserves" are the subset of resources that are economically and technologically viable to exploit now."

McGlade and Ekins use the global carbon budget framework to assess the amount of fossil fuel reserves that can be exploited without transgressing a particular temperature target. For example, based on a 50% probability of meeting the 2°C temperature target, they estimated the global carbon budget for the 2011-2050 period to be 1,100 Gt CO_2, somewhat higher than the budget of 855 Gt CO_2 as in point 25b above for the 2021-2050 period. The McGlade and Ekins study showed that if all of the world's existing fossil fuel reserves were burned, about 2,860 Gt CO_2 would be emitted (and about 2,000 Gt of these emissions would come from the combustion of coal). This level of emissions is about 2.5 times greater than the allowable budget for the 2°C temperature target. Globally, 62% of the world's ***existing*** fossil fuel reserves need to be left in the ground, unburned, to remain within the carbon budget. Meeting the 2°C carbon budget therefore means that not only must currently operating mines and gas wells be closed before their economic lifetime is completed, but also that no approved (but not yet operating) and no proposed fossil fuel projects or extensions of existing fossil fuel projects, based on existing reserves, can be implemented. It should be noted that the McGlade and Ekins analysis used only a 50% probability of meeting the 2°C temperature target. If a higher probability were adopted, say 67%, the remaining carbon budget would be much less than 1,100 Gt CO_2, and even less coal and other fossil fuels reserves could be exploited.

McGlade and Ekins (2015) also applied an economic analysis individually to the three types of fossil fuels – coal, oil and gas – and also to the various regions of the world that are major producers of fossil fuels. Again, the overall goal was to meet the 2°C temperature target. Based on their analysis, 88% of global coal reserves are unburnable for any purpose (it is the CO_2 emissions that matter for the carbon budget approach, not the purpose for which the fossil fuel is burnt). The regional analysis yielded even more stringent conditions for Australia's fossil fuel industry. Over 90% of Australia's ***existing*** coal reserves cannot be burned to be consistent with a 2°C target, and certainly no new coal resources can be developed. Furthermore, many existing coal extraction facilities would need to be closed before the end of their economic lifetimes.

i. The obvious conclusion from the carbon budget analysis above is that currently operating coal mines must be phased out as soon as possible (preferably no later than 2030), and that no new coal mines, or extensions to existing coal mines, can be allowed. The likely effects of stabilisation of the global average surface temperature at 2°C above the pre-industrial level are described in Section F (Future harm) below.

<u>Scenario 2:</u> (this scenario may not be accessible - see note above)

a. The temperature at stabilisation is approximately 3°C above the pre-industrial level.

b. Implementation of current national climate policies around the world would lead to stabilisation around 3°C.

c. Stabilisation would be achieved, at the earliest, late in this century but more likely early in the 22nd century.

d. The future emissions of CO_2 consistent with a 3°C temperature are about 2,600 Gt, from 2021 until net zero emissions are achieved. I note that this is a very generous carbon budget, as I have linearly scaled the carbon cycle feedbacks that were estimated for a 2°C forcing. These feedbacks are almost surely nonlinear, but as yet there has not been an estimate of feedback strength explicitly for a 3°C forcing.

e. This estimate for a 50% probability of limiting the temperature rise to 3°C above the pre-industrial level.

f. As noted in d. above, there is a very significant risk that strongly nonlinear feedbacks will be activated by a 3°C warming, leading to my assessment above that the 3°C stabilisation scenario may not be possible. As support for this assessment, the IPCC (2018) has estimated that there is a 'moderate' risk of triggering these feedbacks already at a 2°C temperature rise, and this risk will undoubtedly rise with a 3°C temperature forcing on the Earth System.

g. & h. According to the McGlade and Ekins (2015) analysis described above, 2,860 Gt CO_2 would be emitted if all of the world's fossil fuel reserves (this includes oil and gas in addition to coal) were consumed. This value is already higher than the 2,600 Gt CO_2 for a 3°C carbon budget. In theory, it would be possible to stabilise global average surface temperature at 3°C even if all of existing coal reserves were combusted, but this would require (i) fewer oil and gas reserves to be exploited, and (ii) carbon cycle feedbacks to behave in a linear fashion as temperature forcing is increased up to 3°C. This is a highly unlikely scenario.

i. The likely effects of stabilisation of the global average surface temperature at 3°C above the pre-industrial level are described in Section F (Future harm) below.

<u>Scenario 3:</u>

a. The global average surface temperature continues to rise throughout the 21st century with no stabilisation until sometime in the 22nd century and at a temperature of at least 4°C above pre-industrial and probably higher.

b. Stabilisation would be dictated by Earth System processes and not by human actions. There are currently no climate system models that can simulate a Hothouse Earth trajectory (that is, the Earth System feedback processes that would drive a Hothouse Earth trajectory are not included in the model architecture) so it is not possible to suggest what may be 'required' to stabilise at that level.

c. The time of stabilisation is difficult to predict but would occur sometime in the 22nd century or beyond.

d. Human CO_2 emissions are less relevant for this scenario (stabilisation at Hothouse Earth conditions), as once a tipping cascade is initiated, the internal dynamics of the Earth System comprise the controlling factor, with CO_2 emissions from feedbacks such as permafrost melt and forest dieback becoming an important source of CO_2.
e. Once a tipping cascade is initiated, there is a very high probability that the Earth System will be stabilised at much hotter conditions (4°C or higher) compared to pre-industrial. Based on a complex systems framework (see Fig. 4 below), a Hothouse Earth state could be stable for hundreds of thousands or perhaps a few million years. An appropriate analogue is the mid-Miocene period, about 15 to 17 million years ago, when atmospheric CO_2 concentrations were in the 300-500 ppm range (current atmospheric CO_2 concentration is 410 ppm) and global average surface temperature was 4 to 5°C higher than pre-industrial (Greenop et al. 2014; Kominz et al. 2008).
f. Feedbacks are the key feature of Scenario 3. The risk is that a set of interacting Earth System feedbacks could drive a cascade that would drive the Earth System to a much hotter state. To summarise again, the feedbacks are of three basic types: (i) melting ice, such as the melting of Arctic sea ice and the loss of ice from the Greenland and Antarctic ice sheets; (ii) forest dieback through drought, heat and fire; the Amazon and boreal forests are appropriate examples; and (iii) changes in Earth System circulation patterns, such as the Atlantic Ocean circulation of the northern hemisphere jet stream circulation. The risk of triggering a tipping cascade increases with the rise in global average surface temperature. As noted above, a cascade of these tipping elements could be initiated at a rise in global average surface temperature of around 2°C (Scenario 1). In fact, recent observations show that at the current rise in global average surface temperature (~1.1°C), several of these tipping points are already being activated (Figure 5; Lenton et al. 2019).
g. & h. The combustion of all global reserves of coal (both hard coal and lignite) would release about 2,000 Gt CO_2 to the atmosphere (McGlade and Ekins 2015). This easily exceeds the remaining carbon budget for the 2°C temperature target (Scenario 1 above) and would thus significantly increase the risk of triggering a tipping cascade (see Figures 4 and 5 below).

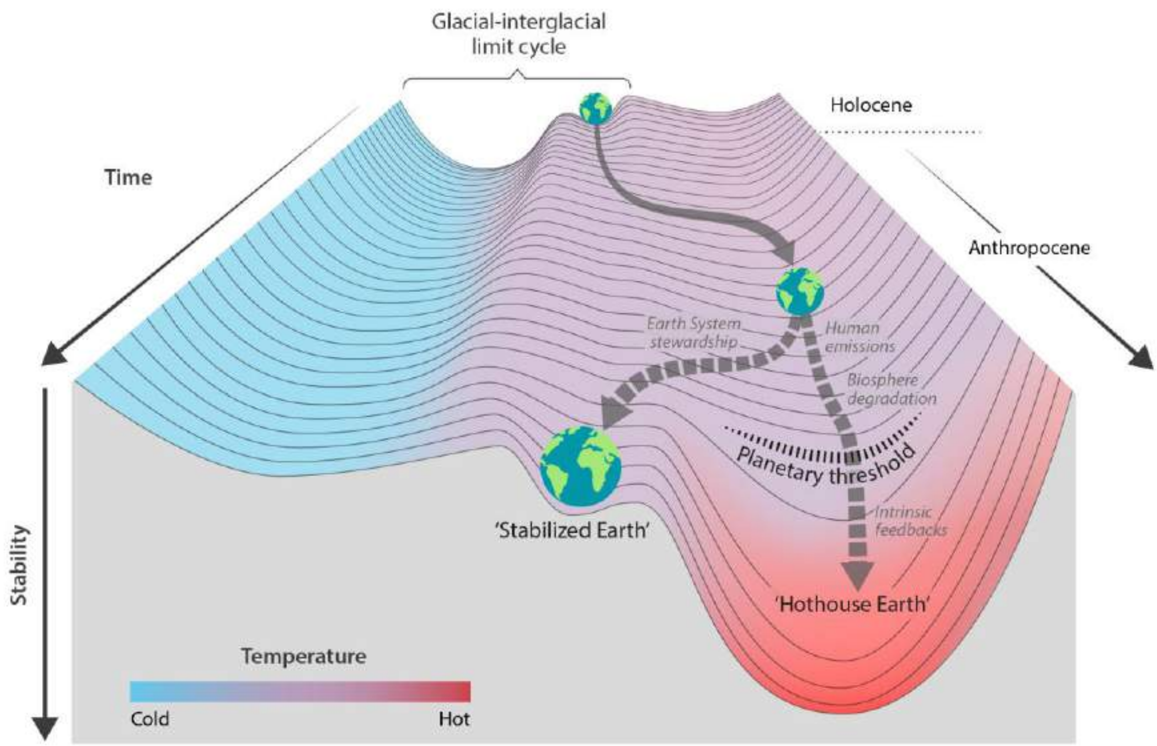

Fig. 4: Stability landscape showing the pathway of the Earth System out of the Holocene to its present position in the hotter Anthropocene. The "fork in the road" is shown here as the two divergent pathways of the Earth System in the future (broken arrows). Currently the Earth System is on a 'Hothouse Earth' pathway, driven by human emissions of greenhouse gases and biosphere degradation towards a potential planetary threshold at ~2°C (horizontal broken line at 2°C in Figure 1), beyond which the system follows an essentially irreversible pathway driven by intrinsic biogeophysical feedbacks (Scenario 3). The other pathway leads to 'Stabilized Earth', a pathway of Earth System stewardship guided by human-created feedbacks to a quasi-stable, human-maintained basin of attraction (Scenario 1). Note that the fork in the road (planetary threshold) eliminates the possibility of Scenario 2. (Steffen et al. 2018).

i. The impacts of this scenario on the Earth System are shown in Figure. The system would be irreversibly (on any timescale of relevance for humans) driven into Hothouse Earth conditions, with global average surface temperature about 4-5°C above the pre-industrial level. These conditions were described in the Steffen et al. (2018) paper as:

"Hothouse Earth is likely to be uncontrollable and dangerous to many, particularly if we transition into it in only a century or two, and it poses severe risks for health, economies, political stability, and, ultimately, the habitability of the planet for humans".

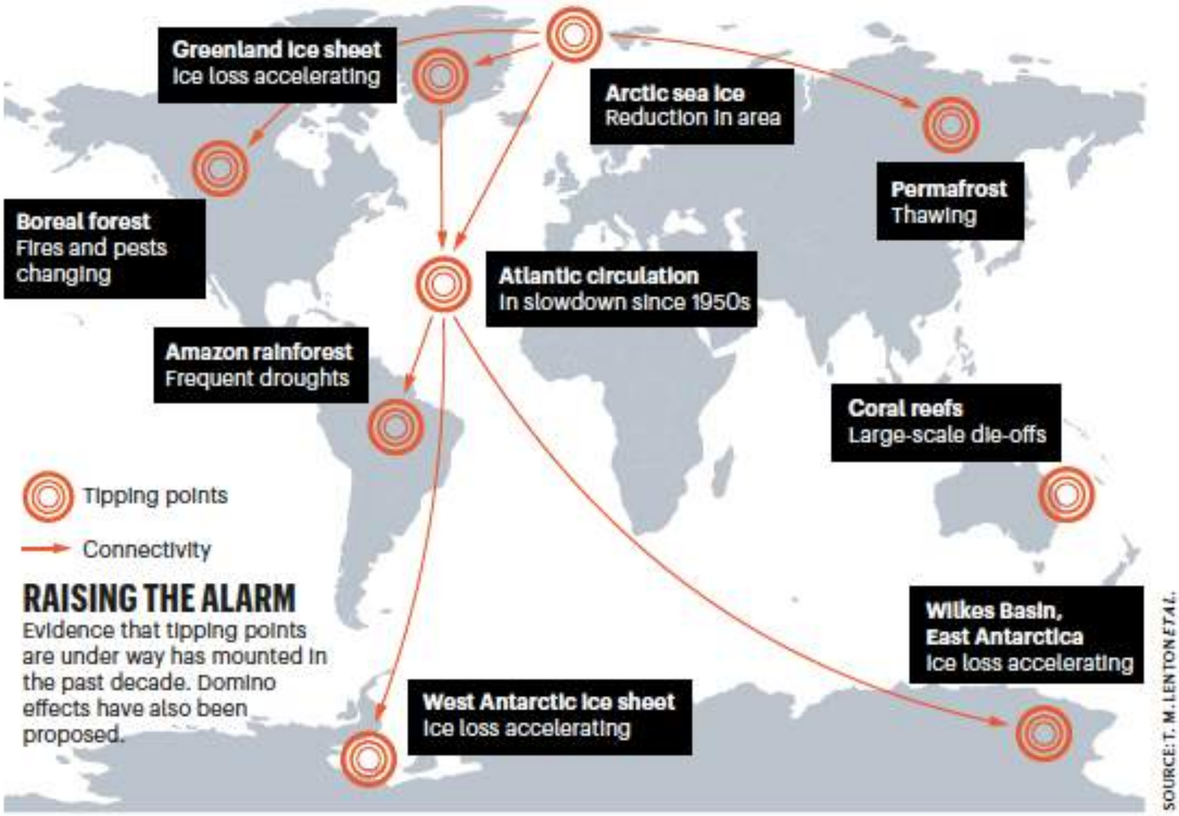

Fig. 5: Observational evidence shows that several tipping elements in the Earth System are already being activated. (Lenton et al. 2019).

F. Future Harm

26. *For each indicative possible future world adopted by you for the purpose of answering question 25 above, what is the likelihood that the harms referred to in paragraph 15 and 16 (or any of them) of the concise statement will be suffered by members of the current generation of children, in the course of their future lives:*

a. in Australia?

b. globally?

Below I first describe projected global impacts (harms) for each of the three scenarios above (part b of the question), followed by a description of impacts in Australia (part a). The timeframe for these risks and impacts is linked to the stabilisation of the global average surface temperature for each of the three scenarios. This stabilisation will take multiple decades at a minimum and therefore the risks and impacts described below are relevant to the current generation of children and to the following generation or two.

<u>Scenario 1</u>: Stabilisation at a rise in global average surface temperature of about 2°C above the pre-industrial level (IPCC 2018).

- 37% of the global population will be exposed to extreme heat at least once every five years. This will have severe impacts on human health and wellbeing, as well as on worker productivity.
- Sea-level will rise by 0.46 m by 2100, leading to large increases in coastal flooding, saltwater intrusion in low-lying areas, and more damaging storm surges. The most vulnerable countries include small island states, Bangladesh, low-lying Southeast Asian cities and settlements, and many regions along the African coast.
- 99% of coral reefs will be dead from severe bleaching; this means that the Great Barrier Reef will cease to exist as we know it today, as well as other coral reefs around the world.
- A decline of 3 million tonnes in marine fisheries, with the most severe impacts on developing countries that rely on marine fish for a large fraction of protein in their diets.
- Ecosystems will shift to a new biome on 13% of Earth's land, leading to large rates of extinctions as well as a surge in invasive species as individual organisms migrate in response to a changing climate.
- 6.6 million square kilometres of Arctic permafrost will thaw, releasing large amounts of CO_2 and methane to the atmosphere, accelerating the warming trend.
- 7% reduction in maize harvests in the tropics, with the poorest countries suffering the most damaging impacts.
- 16% of plant species will lose at least half of their current range, leading to significant within-ecosystem changes as well as an increase in extinction rates.

For Australia, scenario 1 would significantly increase the likelihood in any given year of extreme weather events (King et al. 2017): (i) 77% likelihood of severe heatwaves, power blackouts and bushfires; and 74% likelihood of severe droughts, water restrictions and reduced crop yields. More generally, CSIRO and BoM 2020, have used simulations from the latest generation of climate models to project changes to Australia's climate over the next few decades. These projections would thus be relevant for a 1.5-2°C world, and thus provide useful insights for Scenario 1:

- Continued warming, with more extremely hot days and fewer extremely cool days.

- A decrease in cool season rainfall across many regions of the south and east, likely leading to more time spent in drought.
- A longer fire season for the south and east and an increase in the number of dangerous fire weather days.
- More intense short-duration heavy rainfall events throughout the country.
- Fewer tropical cyclones, but a greater proportion projected to be of high intensity, with ongoing large variations from year to year.
- Fewer east coast lows particularly during the cooler months of the year. For events that do occur, sea level rise will increase the severity of some coastal impacts.
- More frequent, extensive, intense and longer-lasting marine heatwaves leading to increased risk of more frequent and severe bleaching events for coral reefs, including the Great Barrier and Ningaloo reefs.
- Continued warming and acidification of its surrounding oceans.
- Ongoing sea level rise. Recent research on potential ice loss from the Antarctic ice sheet suggests that the upper end of projected global mean sea level rise could be higher than previously assessed (as high as 0.61 to 1.10 m global average by the end of the century for a high emissions pathway, although these changes vary by location).
- More frequent extreme sea levels. For most of the Australian coast, extreme sea levels that had a probability of occurring once in a hundred years are projected to become an annual event by the end of this century with lower emissions, and by mid-century for higher emissions.

<u>Scenario 2</u>: Stabilisation at a rise in global average surface temperature of about 3°C above the pre-industrial level. Here I focus on projected impacts on Australia of this scenario, based on a recent assessment by the Australian Academy of Sciences (Hoegh-Guldberg et al. 2020, and references therein):

- Many of Australia's ecological systems, such as coral reefs and forests, would be unrecognisable, accelerating the decline or Australia's natural resources through the loss or change in the distribution of thousands of species and ecological processes. (As noted for scenario 1, the Great Barrier Reef will no longer exist at temperature rises of 2°C or more).

- Much larger climate change-driven changes to water resources are likely, leading to increasingly contested supplies for natural flows, irrigated agriculture and other uses.
- At 3°C, living in many Australian cities and towns would be extremely challenging due to more frequent and severe extreme weather events, including much higher temperatures and more severe water shortages.
- Sea levels will rise by 0.4 to 0.8 metres by 2100 and by many metres over subsequent centuries. These changes will cost hundreds of billions of dollars over coming decades as coastal inundation and storm surge increasingly impact Australia's coastal communities, infrastructure and businesses. Between 160,000 and 250,000 properties are at risk of flooding when sea levels rise to 1 metre above pre-industrial.
- The probability of large-scale extreme events, such as large storms, floods, droughts, hail storms, tropical cyclones, heatwaves and other climate-related phenomena will increase rapidly.
- High fire danger weather will increase significantly, leading to more catastrophic fire seasons such as the 2019/2020 Black Summer fires.
- Grain, fruit and vegetable crops will suffer more severe reductions in yields in a 3°C world, and rising heat stress will negatively affect extensive and intensive livestock systems.
- Rural communities will face increasingly harsh living conditions due to increasing debt from diminishing crop yields, insurance losses from worsening extreme weather events, and more challenging working conditions due to increasing extreme heat.
- Australia at 3°C will be hotter, drier and more water stressed with impacts on water security, availability, quality, economies, human health and ecosystems. Many locations in Australia in a 3°C world would be very difficult to inhabit due to projected water shortages.
- Multiple impacts of a 3°C world would damage the health and wellbeing of Australians. These include escalating heat stress, more frequent and intense bushfires, reduced access to food and water, increasing risk of infectious disease, and deteriorating mental health and general wellbeing.

Scenario 3: The Hothouse Earth scenario, with stabilisation in the 22nd century at a global average surface temperature level at least 4°C, and probably higher, above the pre-industrial level. There has been much less research on the impacts of a 4-5°C temperature rise in global average surface temperature. However, a few of the potential impacts that could arise from such a high level of warming were summarised in Steffen et al. (2018: Supplementary Information). These include:

- Multiple impacts on agricultural regions, including depletion of soil fertility, changes in water availability and loss of coastal agricultural lands, with the risk of widespread starvation in the most vulnerable regions and/or large migrations out of those regions, increasing the risk of conflict elsewhere.
- Destruction of coral reefs from ocean warming and acidification, and consequent loss of livelihoods for those communities and societies dependent on reefs.
- Amazon rainforest at risk of conversion to savanna from both climate and land-use change. This would lead to large releases of CO_2 to the atmosphere as well as large increases in extinction rates of species that depend on the rainforest.
- Tropical drylands at risk of becoming too hot and dry for agriculture, and too hot for human habitation. This has very large implications for many regions in Africa in particular, but also parts of Asia and much of Australia (see below).
- Very large risks from coastal flooding to transport, infrastructure and coastal ecosystems. Economic damages could trigger regional or global economic collapse as major coastal cities on all continents become uninhabitable.
- Reliability of South Asian (Indian) Monsoon vulnerable to high aerosol loading and to the warming of the Indian Ocean and adjacent land. Well over 1 billion people in south Asia depend on a reliable monsoon system. Failure of the monsoon would very likely lead to large-scale starvation, migration and conflict.
- Mountain glaciers melting at rapid rates, changing amount and timing of run-off. Freshwater resources of over 1 billion people at risk.
- Large changes to riparian and wetlands, with loss of water of some places and increased flooding in others.

For Australia, the corresponding impacts (harms) of Scenario 3 are:

- Much of Australia's inland areas (savanna and semi-arid zones) will become uninhabitable for humans, except for artificial enclosed environments.
- The southeast and southwest agricultural zones will become largely unviable, due to extreme heat and a reduction in cool season rainfall. This would lead to a large depopulation of regional Australia.
- Australia's large coastal cities (Brisbane, Sydney, Melbourne, Adelaide, Perth) will suffer increasing inundation and flooding from storm surges as sea level rises to

metres above its pre-industrial level over the coming centuries. This will drive severe economic challenges, both because of direct damage from flooding and the large costs of adaptation.

- The Great Barrier Reef will no longer exist.
- Most of the eastern broadleafed (eucalypt forests) will no longer exist due to repeated, severe bushfires.

27. *Further to your response to question 26 above, please identify any other harms that are likely to occur in Australia or globally in the indicative possible future worlds adopted by you for the purpose of answering question 25 above.*

I have included the potential harms to Australia from the three scenarios in my response to question 26 above.

G. Materiality of the Project

28. *As stated above in paragraphs 16 and 17 of this letter of instruction, you are instructed to assume that, if approved, the Project would in the future cause, by the extraction, transportation and combustion of the coal from the Project:*

a. 3.1 Mt CO2-e of Scope 1 emissions;

b. 0.8 Mt CO2-e of Scope 2 emissions; and

c. 366 Mt CO2-e Scope 3 emissions.

As stated in the letter of instruction, I have assumed that the Project, if approved, would cause the emission of greenhouse gases to the atmosphere through the extraction, transportation, processing and combustion of coal as follows:

a. 3.1 Mt CO_2-e of Scope 1 emissions

b. 0.8 Mt CO_2-e of Scope 2 emissions

c. 366 Mt CO_2-e of Scope 3 emissions.

29. *In your opinion, would the contribution of those CO_2-e emissions materially contribute to increasing the level at which CO_2 concentration will flatten in all possible worlds in which those emissions occur?*

Based on my knowledge and understanding of the climate system, these CO_2-e emissions would increase the level at which atmospheric CO_2 concentration is eventually stabilised, and thus would increase the level at which the global average surface temperature is eventually stabilised.

H. Other research.

30. *Regarding the paper by Westerhold et al. entitled "An astronomically dated record of Earth's climate and its predictability over the last 66 million years" and associated materials:*

a. *What does that research show?*

b. *Do you agree with the findings of that paper?*

c. *How, if at all, does that research inform the findings, interpretations and opinions stated in my report?*

a. The research shows that, over the past 66 million years, the Earth System has existed in four relatively well-defined states. It also shows that in the more recent past (the "Coolhouse" and "Icehouse" states), the dynamics of the Earth System are strongly influenced by the large ice sheets at the poles as well as the CO_2 concentration in the atmosphere.

b. Yes, the findings support the hypothesis that the Earth System can exist in well-defined states and can undergo transitions between them if the forcing on the system is sufficiently strong. At the current time, this forcing would consist of the human emissions of CO_2 and other greenhouse gases, as well as biosphere degradation, which also emits CO_2 to the atmosphere.

c. The Westerhold et al. (2020) paper shows that the Hothouse trajectory proposed in Figure 4 above is plausible given sufficient levels of human forcing. In fact, the Steffen et al. (2018) is cited near the end of the Westerhold et al. paper in the content of a potential future trajectory of the Earth System.

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Will Steffen
7 December 2020

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CURRICULUM VITAE
WILL STEFFEN

PERSONAL DATA

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BUSINESS ADDRESS:

TELEPHONE S.

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DATE OF BIRTH:
PLACE OF BIRTH:
CITIZENSHIP:
MARITAL STATUS: 47F(1)

EDUCATION AND DEGREES:

PhD (Honoris causa)	University of Canberra, Australia (April 2015)
PhD (Honoris causa):	Stockholm University, Sweden (September 2010)
PhD (Chemistry):	University of Florida, USA (August 1975)
MS (Chemistry):	University of Florida, USA (August 1972)
BS (Chemical Engineering):	University of Missouri, USA (May 1970)

ACADEMIC AFFILIATIONS
Emeritus Professor, The Australian National University, Canberra
Senior Fellow, Stockholm Resilience Centre, Stockholm University, Sweden
Adjunct Professor, The University of Canberra, Australia
Fellow, Beijer Institute of Ecological Economics, Stockholm
Senior Associate, University of Cambridge Institute for Sustainability Leadership, UK

POSITIONS HELD

Sept 2013-present	Climate Councillor (with the independent, publicly funded Climate Council of Australia)
Nov 2011-June 2019	Member, ACT Climate Change Council

Feb 2011-Sept 2013	Climate Commissioner (with Australian Government Climate Commission)
Jul 2008-June 2012	Executive Director, ANU Climate Change Institute, The Australian National University (ANU), Canberra
Aug 2004-Jan 2011	Science Adviser (part-time), Department of Climate Change and Energy Efficiency (earlier Australian Greenhouse Office), Australian Government, Canberra
Mar 2007-Jul 2008	Director, Fenner School of Environment and Society, and Director, ANU Institute of Environment, The Australian National University (ANU), Canberra
Oct 2006-Feb 2007	Pro Vice-Chancellor (Research), The Australian National University, Canberra
Oct 2005-Oct 2006	Director, Centre for Resource and Environmental Studies, and Director, ANU Institute of Environment, The Australian National University (ANU), Canberra
Jul 2004 –Jun 2006	Chief Scientist, International Geosphere-Biosphere Programme (IGBP), Stockholm
Aug 2004-Sept 2005	Visiting Fellow, Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry, Australian Government, Canberra
Mar 1998 - Jun 2004	Executive Director, International Geosphere-Biosphere Programme (IGBP), Stockholm, Sweden
Dec 1990 - Feb 1998:	Executive Officer, Global Change and Terrestrial Ecosystems (GCTE) Core Project, International Geosphere-Biosphere Programme (IGBP), based at CSIRO, Canberra
April 1981 - Nov 1990:	Editor and Information Officer, CSIRO Centre for Environmental Mechanics, Canberra
Aug 1977 - July 1980:	Research Fellow, Research School of Chemistry, The Australian National University, Canberra
Sept 1975 - June 1977:	Postdoctoral Fellow, Department of Chemistry, Cornell University, New York, USA

PROFESSIONAL EXPERIENCE

Research Interests and Expertise:

- Earth System/climate science, with a focus on integration and synthesis towards understanding planetary dynamics involving coupling of biogeochemical cycles and physical climate; dynamics of abrupt and irreversible changes; integration of natural and human dimensions of Earth System and climate science, particularly around the concept of the Anthropocene; global carbon cycle.

- Sustainability science, with an emphasis on ecosystem services as a unifying concept; global aspects of sustainability; integration of humanities scholarship into sustainability research; participatory research approaches.

- Global change and terrestrial ecosystems, with a focus on regional and global scales; terrestrial carbon cycle; incorporation of ecosystem dynamics in global vegetation models; functional type approach to modelling vegetation dynamics under global change; transect-based analysis of regional vegetation change.

Science Leadership and Management:

- Creation of the ANU Climate Change Institute (Australian National University) in 2008, and its first Executive Director. Development of transdisciplinary climate change research projects involving natural science, social science, economics and humanities scholars at the ANU.

- Creation of the Fenner School of Environment and Society at the ANU in 2007, and its inaugural Director. Development of the School (60 academic staff and 120 PhD students) as Australia's leading transdisciplinary research and teaching unit on environment and society.

- Leadership as Executive Director of the International-Geosphere Biosphere Programme (IGBP), a multi-disciplinary international research programme on global change involving about 10,000 scientists in 80 countries around the world. Duties included: coordination of research effort involving 10 projects, support to the IGBP Chairman and to the Scientific Committee of the IGBP, management of the IGBP Secretariat (Stockholm) with a staff of 10 and an annual budget of USD 2.5M, publication of overview and synthesis papers on global change and Earth System science, promotion of global change science at international meetings and conferences around the world; numerous presentations at a wide range of fora in ca. 35 countries, liaison with policy communities on the application of IGBP science, and raising funds for IGBP activities.

- Management of the day-to-day operation of the Global Change and Terrestrial Ecosystems (GCTE) Core Project, an international research effort under the auspices of the IGBP, from 1990 to 1998. Duties included overall coordination of GCTE's international Core Research Programme (41 countries, 700 scientists and technicians, USD 33M per annum; establishment and overall direction of GCTE Impacts Centre, Bogor, Indonesia; and raising funds for GCTE activities.

- Leadership role in planning and carrying out a large number of international conferences and policy events, including three in the prestigious Dahlem Conference Series in Germany, Royal Colloquia in Sweden, two IGBP Congresses and the Challenges of a Changing Earth global change conference in Amsterdam in 2001.

Science-Policy Interface:

- Independent expert adviser to the Multi-Party Climate Change Committee. Australian Government. The role of the MPCCC, chaired by the Prime Minister Hon Julia Gillard, was to develop a long-term policy to reduce Australia's greenhouse gas emissions. The MPCCC built the Clean Energy Futures package, the centrepiece of which is an emissions trading scheme but with complementary programs for land carbon sequestration and biodiversity conservation.

- Advice to the Department of Climate Change and Energy Efficiency (previously Australian Greenhouse Office), Australian Government, on the link between science and climate change policy, with an emphasis on the scientific research needed to support policy development. Specific projects include carbon cycle research in support of carbon accounting and reporting; generic climate adaptation strategies across a broad range of sectors; definition of "dangerous climate change" with respect to Article 2 of the UN Framework Convention on Climate Change; and a review of the Australian Climate Change Science Program, towards developing a national framework for climate change research.

- General briefings and inputs at the international level to the development of policy on climate change and other aspects of global environmental change. The work included interaction with the European Union Commission for the Environment; advice to the Swedish Government Departments of Environment and Education and the Stockholm City Government, primarily on application of carbon cycle research; and contributions to the work of the Intergovernmental Panel for Climate Change (IPCC), primarily on implications of carbon cycle dynamics for carbon sinks policy.

- Contributions to development of climate risk management strategy for Australian agricultural sector, Bureau of Rural Sciences (BRS), Australian Government. The project involved consultation with industry/producers through workshop series, and production of decision support tools for climate risk management.

Teaching:

- Contribution to course development at the ANU, focusing on climate change courses at the post-graduate level and professional courses for public servants.

- Lectures on global change and the Earth System at the ANU and at Stockholm University, Sweden.

- Lectures, tutorials, and demonstrations in chemistry at the tertiary level at the ANU and the University of Florida, USA.

Communication and Outreach:

- Member of the independent Climate Commission, formed by the Australian Government in February 2011. Role of the Commission is to engage the Australian public, private sector and community groups on climate science, the economics of climate change mitigation, and international action on climate change. Activities in public forums around the country, business roundtables, site visits, community group engagement, production of reports and communication via the media. With the closure of the Commission in September 2014, became a Councillor with the publicly funded Climate Council of Australia, formed to replace the Commission.

- Numerous presentations on climate change, the Earth System and the Anthropocene to a very wide range of audiences, including governments at high levels, business and industry, non-governmental organisations (NGOs), professional organisations and the general public.

- Participation in a large number of conferences, summits, future think tanks and other events involving participants from all walks of life. Participation in the 2020 Summit in Canberra in April 2008.

- Much experience with the media, both print and electronic, on complex and contentious issues like climate change and sustainability.

- Provision of background support to and appearances in the Swedish documentary film “The Planet”, and contributions to several films on the Anthropocene.

- Operation of the editorial, communication, and information services at the CSIRO Centre for Environmental Mechanics 1981-1990.

ADVISORY/HONORARY POSITIONS AND REVIEW PANELS

Apr 2016 – present	Member, International Advisory Board, Centre for Collective Action Research, Gothenburg University, Sweden
Jan 2011 – present	Member, Volvo Environment Prize jury, Sweden (Chair of Jury from May 2013)
Jul 2004 – Dec 2015	Member, National Committee for Earth System Science (NCESS), Australian Academy of Science
Oct 2010 – July 2011	Member, Multi-Party Climate Change Committee, Australian Government
Oct 2009- Dec 2014	Chair, Antarctic Science Advisory Committee, Australian Government
Aug 2009 – May 2011	Member, Science Advisory Committee, APEC Climate Center, Busan, Korea
Jan 2005 – May 2010	Chair, International Advisory Board, QUEST (Quantifying and Understanding the Earth System) programme, UK
Oct 2005 – Nov 2008	Chair, Advisory Panel, Earth and Sun System Laboratory, National Center for Atmospheric Research, Boulder, CO, USA
Jan 2006-Dec 2008	Member, Advisory Board, Australian Bureau of Meteorology
May 2007	Review of the Australian Climate Change Science Program. Australian Government. Carried out with Dr Susan Solomon, NOAA, USA and Convening Lead Author, Working Group 1, IPCC Fourth Assessment Report
Apr 2007	Member of review panel, Potsdam Institute for Climate Impact Research, Germany
Aug 2006 – Dec 2006	Member, PMSEIC (Prime Minister's Science, Engineering and Innovation Council) working group on Australia's S&T Priorities for Global Engagement
Feb 2005	Member of review panel for du Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Paris, France
Apr 2004	Member of review panel for the Tyndall Centre, UK (Climate Adaptation Research)

PUBLICATIONS LIST

WILL STEFFEN

2020

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Palenik, G.J., Mathew, M., **Steffen, W.L.,** and Beran, G. (1975). Steric versus electronic effects in palladium-thiocyanate complexes: The crystal and molecular structures of dithiocyanato-[bis(diphenylphosphino) methane] palladium(II), Isothiocyanatothiocyanato[1,2-bis-(diphenylphosphino) ethane]palladium(II) and diisothiocyanato[1,3-bis-(diphenylphosphino)propane]palladium(II). *J. Am. Chem. Soc.* 97: 1059-66.

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Palenik, G.J., **Steffen, W.L**., and Mathew, M. (1974). Steric control of thiocyanate coordination in palladium (II)-diphosphine complexes. *Inorg. Nucl. Chem. Letters* 10: 125-8.

Biography (October 2020) - Will Steffen

Will Steffen is an Earth System scientist. His research interests span a broad range within climate and Earth System science, with an emphasis on system-level understanding of climate change, incorporation of human processes in Earth System modelling and analysis; and on sustainability and climate change. In addition, Steffen has been active on the climate change science-policy interface for three decades, and has played a leading role in the development of Earth System science internationally.

Education and Degrees:

PhD (Honoris causa)	University of Canberra, Australia (April 2015)
PhD (Honoris causa):	Stockholm University, Sweden (September 2010)
PhD (Chemistry):	University of Florida, USA (August 1975)
MS (Chemistry):	University of Florida, USA (August 1972)
BS (Chemical Engineering):	University of Missouri, USA (May 1970)

Current positions:

- Emeritus Professor, Fenner School of Environment and Society, The Australian National University (ANU), Canberra
- Councillor, Climate Council of Australia
- Senior Fellow, Stockholm Resilience Centre, Stockholm University, Sweden
- Fellow, Beijer Institute of Ecological Economics, Stockholm
- Senior Associate, University of Cambridge Institute for Sustainability Leadership, UK

Leadership roles in climate-related research

- ANU - inaugural director of ANU Climate Change Institute, 2008-2012
- Creation of the Fenner School of Environment and Society, ANU, from its constituent bodies, 2007
- International Geosphere-Biosphere Programme (IGBP) Executive Director (1998-2004) - guided IGBP synthesis project, and lead author of synthesis book. Chief Scientist of IGBP (2004-2006) (IGBP was an international research programme (1986-2015) on global change involving about 10,000 scientists from over 50 countries
- Global Change and Terrestrial Ecosystems (GCTE) Executive Officer (1990-1998), leading international research body on terrestrial carbon cycle.

Major climate change-related achievements:

Numerous contributions to the development of climate policy in Australia:

- Science adviser to the Australian Government on climate change: 2007-2013
- Independent Expert Adviser to the Multi-Party Climate Change Committee, chaired by Prime Minister Hon. Julia Gillard, 2011
- Commissioner on the Australian Government's Climate Commission, 2011-2013

- Many briefings on climate change to Commonwealth Government departments: Industry and Resources, Treasury, Environment, Primary Industries and Water Resources
- Member of the Australian Capital Territory (Canberra) Government Climate Change Committee, 2011-2019

Contributions as author and reviewer to five IPCC (Intergovernmental Panel on Climate Change) assessments and special reports between 2000 and 2018:

- Major contributions to the IPCC Fourth Assessment Report (2007) Working Group I: Couplings between Changes in the Climate System and Biogeochemistry. Lead author on the terrestrial carbon cycle section
- IPCC Special Report on Land Use, Land-Use Change and Forestry (2000). This report was instrumental in establishing accounting rules for land-based carbon uptake and emissions in the context of national reporting to the UNFCCC (United Nations Framework Convention on Climate Change).
- Contribution to IPCC Special Report on Global Warming of 1.5°C: Chapter 1: Framing and Context
- Reviews of Australian impacts sections on two IPCC Assessment reports (Working Group II).

Major contributions to Earth System and climate system research:

- Key role in the development of the field of Earth System science
- Integration and synthesis of primary research towards understanding planetary dynamics as a whole
- Coupling of biogeochemical cycles (mainly carbon) and physical climate;
- Dynamics of abrupt and irreversible changes; tipping points in the climate system
- Global carbon cycle, including interaction between biosphere and physical climate system
- integration of natural and human dimensions of Earth System and climate science
- Lead author on paper in Nature Reviews describing the origins and evolution of Earth System science as a new field of study

Leading role in the development of the Anthropocene concept

- Close collaboration with Paul Crutzen on the origins and early development of the concept from an Earth System perspective
- Originator of the 'Great Acceleration' graphs and data analysis, which for the scientific basis for a mid-20th century start date for the Anthropocene
- Member of the Anthropocene Working Group (AWG), which has recommended formal recognition of the Anthropocene as a new epoch in the Geologic Time Scale.
- Co-author on numerous peer-reviewed AWG publications that have developed the concept from both Earth System and stratigraphic perspectives.

Communication activities:

- Numerous presentations on climate change, the Earth System and the Anthropocene to a very wide range of audiences, including governments at high levels, business and industry, non-governmental organisations (NGOs), professional organisations and the general public.

- Participation in a large number of conferences, summits, future think tanks and other events involving participants from all walks of life.
- Much experience with the media, both print and electronic, on complex and contentious issues like climate change and sustainability.
- Provision of background support to and appearances in several full-length films such as the Swedish documentary film “Planeten” (“The Planet”), an upcoming Australian film “Carbon. An Unauthorized Biography”, and a Danish documentary on Earth System science. Also, contributions to several films on the Anthropocene.

Advisory and other roles

- Apr 2016 – present — Member, International Advisory Board, Centre for Collective Action Research, Gothenburg University, Sweden
- Jan 2011 – present — Member, Volvo Environment Prize jury, Sweden (Chair of Jury from May 2013)
- Jul 2004 – Dec 2015 — Member, National Committee for Earth System Science (NCESS), Australian Academy of Science
- Oct 2010 – July 2011 — Member, Multi-Party Climate Change Committee, Australian Government
- Oct 2009- Dec 2014 — Chair, Antarctic Science Advisory Committee, Australian Government
- Aug 2009 – May 2011 — Member, Science Advisory Committee, APEC Climate Center, Busan, Korea
- Jan 2005 – May 2010 — Chair, International Advisory Board, QUEST (Quantifying and Understanding the Earth System) programme, UK
- Oct 2005 – Nov 2008 — Chair, Advisory Panel, Earth and Sun System Laboratory, National Center for Atmospheric Research, Boulder, CO, USA
- Jan 2006-Dec 2008 — Member, Advisory Board, Australian Bureau of Meteorology
- May 2007 — Review of the Australian Climate Change Science Program. Australian Government. Carried out with Dr Susan Solomon, NOAA, USA and Convening Lead Author, Working Group 1, IPCC Fourth Assessment Report
- Apr 2007 — Member of review panel, Potsdam Institute for Climate Impact Research, Germany
- Aug 2006 – Dec 2006 — Member, PMSEIC (Prime Minister’s Science, Engineering and Innovation Council) working group on Australia’s S&T Priorities for Global Engagement
- Feb 2005 — Member of review panel for du Laboratoire des Sciences du Climat et de l’Environnement (LSCE), Paris, France

- Apr 2004 Member of review panel for the Tyndall Centre, UK (Climate Adaptation Research)

Publications:

Over 150 publications spanning Earth System science, climate change, and sustainability, including lead-authored publications in most prestigious journals - *Science*, *Proceedings of the National Academy of Sciences (USA)*, and the *Nature* journal group.

Below are the top 15 publications in terms of scientific advances, influence on scientific research, and science-policy links:

Steffen, W., Rockström, J., Richardson,, K., Lenton, T.M., Folke, C., Liverman, D., Summerhayes, C.P., Barnosky, A.D, Cornell, S.E., Crucifix, M., Donges, J.F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R., and Schellnhuber, H.J. (2018) Trajectories of the Earth System in the Anthropocene. *Proceedings of the National Academy of Sciences (USA)*, doi:10.1073/pnas.1810141115.

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Steffen, W., Leinfelder, R., Zalasiewicz, J., Waters, C.N., Williams, M., Summerhayes, C., Barnosky, A.D., Cearreta, A., Crutzen, P., Edgeworth, M., Ellis, E.C., Fairchild, I.J., Gałuszka, A., Grinevald, J., Haywood, A., Ivar do Sul, J., Jeandel, C., McNeill, J.R., Odada, E., Oreskes, N., Revkin, A., Richter, D. deB, Syvitski, J., Vidas, D., Wagreich, M., Wing S.L., Wolfe, A.P., Schellnhuber, H.J. (2016) Stratigraphic and Earth System approaches to defining the Anthropocene. *Earth's Future* **4**: doi:eft2/2016EF000379

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Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O. and Ludwig, C. (2015) The trajectory of the Anthropocene: The Great Acceleration. *The Anthropocene Review* DOI: 10.1177/2053019614564785

Zalasiewicz, J., Waters, C.N., Williams, M. Barnosky, A.D., Cearreta, A., Crutzen, P., Ellis, E., Ellis, M.A., Fairchild, I.J., Grinevald, J., Haff, P.K., Hajdas, I., Leinfelder, R., McNeill, J., Odada,

E.O., Poirier, C., Richter, D., **Steffen, W**., Summerhayes, C., Syvitski, J.P.M., Vidas, D., Wagreich, M., Wing, S.L., Wolfe, A.P. and Zhisheng, A. (2015) When did the Anthropocene begin? A mid-twentieth century boundary level is stratigraphically optimal. *Quaternary International* **383**: 196-203. doi:10.1016/j.quaint.2014.11.045

Steffen, W. and Griggs, D. (2013) Compounding crises: Climate change in a complex world. In: Christoff, P. (ed.) *Four Degrees of Warming: Australia in a Hot World*. Routledge/Earthscan: London, pp. 118-134.

Mackey, B., Prentice, I.C., **Steffen, W.**, Lindenmayer, D., Keith, H., Berry, S. and House, J. (2013) Untangling the confusion around land carbon science and climate change mitigation policy. *Nature Climate Change* 3: 552-557.

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Steffen, W., Grinevald, J., Crutzen, P. and McNeill, J. (2011). The Anthropocene: Conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A* **369**: 842-867.

Richardson, K., **Steffen, W.**, Liverman, D., Barker, T., Jotzo, F., Kammen, D., Leemans, R., Lenton, T., Munasinghe, M., Osman-Elasha, B., Schellnhuber, J., Stern, N., Vogel, C., and Waever, O. (2011) Climate Change: Global Risks, Challenges and Decisions. Cambridge: Cambridge University Press, 502 pp.

Steffen, W., Crutzen, P.J. and McNeill, J.R. (2007). The Anthropocene: Are humans now overwhelming the great forces of Nature? *Ambio* 36: 614-621.

Steffen, W., Love, G. and Whetton, P. (2006) Approaches to defining dangerous climate change: a southern hemisphere perspective. In: Schellnhuber, H.J., Cramer, W., Nakicenovic, N., Wigley, T. and Yohe, G. (eds*) Avoiding Dangerous Climate Change.* Cambridge University Press, pp. 219-225.

Steffen, W., Sanderson, A., Tyson, P.D., Jäger, J., Matson, P., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.-J., Turner II, B.L. and Wasson, R.J. (2004). Global Change and the Earth System: A Planet Under Pressure. The IGBP Book Series, Springer-Verlag, Berlin, Heidelberg, New York, 336 pp.

Equity Generation Lawyers

27 October 2020

Professor Will Steffen
Emeritus Professor, Fenner School of Environment & Society
Australian National University

By email only: s. 47F(1)

Dear Professor Steffen

Anjali Sharma v Minister for the Environment
Federal Court of Australia | VID 607/2020

Introduction

1. Equity Generation Lawyers represents Anjali Sharma and seven other individuals aged between 13 and 17 (**Applicants**) in a Federal Court of Australia proceeding (**proceeding**) against the Respondent, the Commonwealth Minister for the Environment (**Minister**).
2. The proceeding was filed on 8 September 2020 by the Applicants' litigation representative, Sister Marie Brigid Arthur. The proceeding is brought on the Applicants' own behalf <u>and</u> as a representative proceeding (or 'class action') on behalf of persons under the age of 18 (**children**) who were born before the date this proceeding was filed, and who ordinarily reside:

   (a) in Australia (**the Australian Represented Children**); or

   (b) elsewhere;

   (together, the **Represented Children**).
3. The proceeding relates to a project involving expansion of a 'greenfield' coal mine in Northwest New South Wales (**Project**), for which approval has been sought by Whitehaven Coal Ltd (**Whitehaven**) from the Respondent under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**Act**).

4. In the proceeding, the Applicants seek the following final relief:

   (a) a declaration that the Minister owes the Applicants a duty to take reasonable care not to cause them harm while exercising her powers (**the statutory powers**) under ss 130 and 133 of the Act in respect of the Project; and

   (b) an injunction to restrain the Minister from exercising the statutory powers in respect of the Project in a manner likely to cause them harm in breach of the alleged duty.

5. The Applicants argue that approval of the Project would be likely to cause harm to the Applicants and the Represented Children, as the result of the extraction and combustion of the coal, which will materially contribute to an increase in the concentration of carbon dioxide (**CO_2**) in the atmosphere.

6. The injunction sought by the Applicants would have the effect of restraining the Minister from approving the Project in a manner that would result in a material contribution to an increase in CO_2 concentration in the atmosphere.

7. On behalf of the Applicants, we seek to engage you as an expert witness in the proceeding, to provide an expert report in respect of certain questions regarding the climate science relevant to the proceeding. Your report is due to be filed by **early December 2020**.

8. It is proposed that your expert report will be relied upon at the trial of this proceeding, which is presently set down for a five-day hearing commencing on **2 March 2021** for four days (with an additional day listed for 12 March 2021 if required). You may also be required to attend Court to give evidence at the trial of the proceeding. We will confirm this with you in due course. In the meantime, we would be grateful if you could confirm your availability for the duration of the trial as presently scheduled for March 2021 (although we do not anticipate that you will be required for the entire period of the trial).

Preparation of your report

9. The role of an independent expert witness is to provide relevant and impartial evidence in their area of expertise.

10. An independent expert witness has duties to the Court as set out in the Federal Court of Australia Practice Note entitled "Expert Evidence Practice Note GPN-EXPT" (**Practice Note**). Importantly, an expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

11. A copy of the Practice Note, which includes the Harmonised Expert Witness Code of Conduct at Annexure A to that document (**Code**), is included in your brief of materials in

this matter. You are required to read, understand and comply with the entire Practice Note, including the Code, when preparing your report (in particular, you ought to ensure that your report complies with Part 5.2 of the Practice Note and Part 3 of the Code, both of which expressly relate to the contents of expert reports). If you have any questions about the application or meaning of any aspect of the Practice Note or the Code, please contact us.

12. This letter sets out a number of factual matters in the section below entitled 'Assumptions' which, so far as they have relevance for your work in this matter, you are instructed to assume are accurate. To the extent that you rely on any assumptions of fact in preparing your report (whether those set out in this letter, or otherwise), you should clearly identify such assumptions (and the basis for those assumptions) in your report.

13. Further, accompanying this letter are a number of documents that may be relevant to the questions on which you are asked to express your opinion. Those documents are listed in the index that is provided at the end of this letter. In preparing your report, you may have regard to those documents to the extent and in the manner that you see fit. Where you rely upon a document in your report (whether one of those documents accompanying this letter, or otherwise), you should clearly identify this in your report.

Assumptions

<u>The Project</u>

14. The Project is an extension of a greenfield coal mine in NSW (**Mine**) for which Whitehaven originally received development consent in 2014.[1]

15. Under the Mine's original approval, Whitehaven was permitted to extract 135 million tonnes (**Mt**) of coal over a 30-year period, at a rate of up to 4.5 million tonnes of run-of-mine (**ROM**) coal a year (**Mtpa**), with coal hauled by trucks on public roads to Whitehaven's existing coal handling and preparation plant (**CHPP**) near Gunnedah, for processing and transport by rail to the Port of Newcastle.[2]

16. The Project proposes:[3]

    (a) an increase in total coal extraction by 33 Mt, from 135 to 168 Mt;

[1] Concise statement at [3]; first affidavit of David Barnden at [8]-[9]; exhibit DLB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at p iii; second affidavit of David Barnden at [9].

[2] Exhibit DLB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at p iii;

[3] First affidavit of David Barnden at [16]-[17]; exhibit DB-8 (NSW Government 'Vickery Extension Project State Significant Development Assessment SSD 7480' report at pp iv and 6.

(b) an increase in the peak annual extraction rate from 4.5 up to 10 Mtpa of coal; and

(c) to increase the disturbance area of the Mine by an additional 776 hectares;

(d) to develop a new CHPP and train load out facility at the Mine (both of which would process coal from other nearby mines), such that the proposed CHPP and load out facility would:

(i) stockpile and process a total of 13 Mtpa of ROM coal from the project and other Whitehaven mining operations;

(ii) produce up to 11.5 Mtpa of metallurgical and thermal coal products; and

(iii) transport up to 11.5 Mtpa of product coal from the rail load facility, the rail spur line and via the public rail network to Newcastle for export markets;

(e) to develop a new rail spur to connect the load out facility to the main Werris Creek to Mungindi Railway line;

(f) to construct a water supply borefield and associated infrastructure;

(g) to change the final landform in certain specified ways relating to the overburden emplacement areas and pit lake voids.

17. If approved, the Project would generate approximately:[4]

(a) 3.1 Mt CO_2-e of Scope 1 emissions. These are direct emissions from owned or controlled sources of an organisation / development.

(b) 0.8 Mt CO_2-e of Scope 2 emissions. These are indirect emissions from the generation of purchased energy electricity, heat and steam used by an organisation / development.

(c) 366 Mt CO_2-e Scope 3 emissions. These are all other upstream and downstream emissions related to an organisation / development.

18. The coal that is the subject of the Project (and which Whitehaven proposes to extract if the Project is approved) presently lies underground, storing carbon.[5] It cannot be extracted without the Minister exercising her statutory powers to grant approval under the Act.[6]

[4] First affidavit of David Barnden at [18]; exhibit DLB-17, NSW Independent Planning Commission Statement of Reasons dated August 2020 at pp 42, 47.

[5] Concise statement at [5].

[6] Concise statement at [5].

Questions

You have been asked to respond to the following questions. In doing so, please limit your responses to matters derived from or appropriately connected to your training, study or experience. To the extent that there are matters on which you do not feel you are able to comment, please expressly note this in your response/s. Where possible, please include references to available evidence in your responses.

A. Basis of expertise

1. Please describe your academic qualifications, professional background and experience in the field of climate change science, and any other training, study or experience that is relevant to this brief (you may wish to do so by reference to a current curriculum vitae).

B. CO_2 emissions, CO_2 concentration and temperature rise

<u>CO_2 concentration and temperature difference</u>

2. What was/is the concentration of CO_2 in the Earth's atmosphere (**CO_2 concentration**) as at:

   a. the reference date (defined below);

   b. the present day?

3. What is the difference between the average global surface temperature at a specific point in time and the average global surface temperature before the industrial revolution (**temperature difference**), where the specific point in time is the present date?

4. Please state the date you have used as a reference point for "before the industrial revolution", for the purpose of identifying temperature difference (the **reference date**), and explain the basis for using this reference date.

5. Describe the causal relationship between:

   a. emissions from the Earth's surface of CO_2; and

   b. CO_2 concentration; and

   c. temperature difference.

6. How has human industrial activity affected the level of CO_2 concentration and temperature difference from the reference date up until the present date?

7. How has the combustion by human beings of coal for industrial activity affected the level of CO_2 concentration and temperature difference from the reference date up until the present date?

8. In a comparator world, in 2020, where human industrial activity had not produced any emissions of CO_2:

   a. what would be the likely CO_2 concentration as at the present date?

   b. would there be any temperature difference as at the present date, and if so, what would it likely be?

9. Describe the rate of increase in CO_2 concentration and temperature difference from the reference date up to the present date.

10. To what extent has the combustion of coal contributed to the rate of increase in CO_2 concentration and temperature difference from the reference date up to the present date?

Present CO_2 emissions

11. Based on data from an appropriate recent period, what is the present rate of emissions of CO_2 into the atmosphere?

12. What proportion of those emissions is likely to be the result of the combustion of coal by human beings?

Future CO_2 emissions and flattening the curves

13. At some point in time in the future, will the rate of increase in:

   a. CO_2 concentration;

   b. temperature difference;

   reach zero (**flatten**)?

   (That is, will they reach a level where they no longer increase?)

14. If the answer to question 13(a) or (b) is "yes":

   a. if both the rate of increase in CO_2 concentration and the rate of increase in temperature difference will flatten:

      i. is there a relationship between the level of CO_2 concentration when it stops increasing and the level of temperature difference when it stops increasing? If so, what is the relationship?

ii. Will the rate of increase in CO_2 concentration flatten at the same time as the rate of increase in temperature difference? If not, which will flatten first, and why?

b. what would need to happen for the rate of increase of temperature difference or rate of increase of CO_2 concentration, or both, to flatten?

c. what are the key causal factors that will determine the level of temperature difference or CO_2 concentration, or both, when the rates of increase flatten?

d. what is the relationship between:

i. the amount of further emissions of CO_2 from human industrial activity, including the combustion of coal; and

ii. the level of temperature difference or CO_2 concentration, or both, when they flatten?

C. The Earth system

15. What is the Earth system?

16. What is the role of CO_2 in the Earth system?

17. Is there a relationship between the level of CO_2 concentration and the Earth system?

18. If the answer to question 17 is "yes":

a. describe that relationship.

b. what is the effect on the Earth system of increases in the level of CO_2 concentration?

19. What is the relationship between the Earth system and subsidiary systems or natural phenomena occurring in particular parts of the Earth?

20. Is there a relationship between the level of CO_2 concentration and subsidiary systems or natural phenomena occurring in particular parts of the Earth?

21. If the answer to question 20 is "yes":

a. describe that relationship.

b. what is the effect on those subsidiary systems or natural phenomena of increases in the level of CO_2 concentration?

D. Effects to date

22. To date, what have been the effects of emissions of CO_2 from human industrial activity on the Earth system, and subsidiary systems or natural phenomena:

a. in Australia?

b. globally?

E. Future effects

23. What will be the future effects on the Earth system, and subsidiary systems or natural phenomena, if emissions of CO_2 from human industrial activity continue in the future?

24. In making predictions about those future effects:

a. can the level of temperature difference be used as a proxy for levels of CO_2 concentration? If so, why; if not, why not?

b. is there a linear correlation between:

i. increase in CO_2 emissions from human industrial activity;

ii. increase in CO_2 concentration and temperature difference; and

iii. increase in effects on the Earth system and subsidiary systems or natural phenomena?

c. If not, are there particular levels or rates of increase in CO_2 emissions, or CO_2 concentration and temperature difference, that will produce non-linear rates of change, cascades or cycles in the effect on the Earth system? If so, why?

For the purpose of answering question 25, please choose several indicative points (by reference to the level of temperature difference at the point in time when the increase in temperature difference flattens) on the spectrum of possible future worlds. Please start with the lowest level of temperature difference when it flattens that is, at the present date, a real possibility. Please end with the highest level of temperature difference when it flattens that is, at the present date, a real possibility. Please explain why you have selected these particular indicative points of temperature difference.

25. For each indicative possible future world:

a. what would be the level of temperature difference at the point in time when it flattened?

b. in broad terms, what would need to occur for temperature difference to flatten at that level?

c. when would temperature difference be most likely to flatten at that level?

d. what is the approximate total amount of future emissions of CO_2 that could be emitted (assessed from the present day onwards) for temperature difference to flatten at that level?

e. what is the likelihood of temperature difference flattening at that level?

f. what is the effect on the likelihood of temperature difference flattening at that level of any non-linear effects identified in response to question 24.c above?

g. would it be possible for temperature difference to flatten at that level if the coal presently available and permitted to be mined everywhere on Earth were extracted and combusted? If so, what would be the effect of that occurring on the likelihood of temperature difference flattening at that level?

h. would it be possible for temperature to flatten at that level if the coal presently permitted to be mined were extracted and combusted, and coal were also extracted and combusted from extant deposits for which permission has not presently yet been granted? If so, what would be the effect of that occurring on the likelihood of temperature difference flattening at that level?

i. what would be the likely effects on the Earth system, subsidiary systems and/or natural phenomena, up to and including the point in time at which the level of temperature difference would flatten?

F. Future harm

26. For each indicative possible future world adopted by you for the purpose of answering question 25 above, what is the likelihood that the harms referred to in paragraph 15 and 16 (or any of them) of the concise statement will be suffered by members of the current generation of children, in the course of their future lives:

a. in Australia?

b. globally?

27. Further to your response to question 26 above, please identify any other harms that are likely to occur in Australia or globally in the indicative possible future worlds adopted by you for the purpose of answering question 25 above.

G. Materiality of the Project

28. As stated above in paragraphs 16 and 17 of this letter of instruction, you are instructed to assume that, if approved, the Project would in the future cause, by the extraction, transportation and combustion of the coal from the Project:

    a. 3.1 Mt CO_2-e of Scope 1 emissions;

    b. 0.8 Mt CO_2-e of Scope 2 emissions; and

    c. 366 Mt CO_2-e Scope 3 emissions.

29. In your opinion, would the contribution of those CO_2-e emissions materially contribute to increasing the level at which CO_2 concentration will flatten in all possible worlds in which those emissions occur?

H. Other research

30. We refer you to the attached paper by Westerhold et al, titled “An astronomically dated record of Earth’s climate and its predictability over the last 66 million years”, and associated materials.

    a. What does that research show?

    b. Do you agree with the opinions expressed in that paper?

    c. How, if at all, does that research inform the opinions stated by you in your report?

Other matters

31. You will observe that point 3 of the Code requires your report to include a declaration that you have made all the inquiries which you believe are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which you regards as relevant have, to your knowledge, been withheld from the Court. Accordingly, if, in the course of preparing your report, you identify further information or materials that you consider are relevant to your task, please contact us to discuss this further.

Yours sincerely

s. 47F(1)

David Barnden
Principal Lawyer

Encl.

Index of documents contained in brief to expert witness

Attachment No.	Document Title
1	Originating Application: Sharma v Minister for the Environment VID607/2020 dated 8 September 2020.
2	Concise Statement: Sharma v Minister for the Environment VID607/2020 dated 8 September 2020.
3	Affidavit of David Barnden dated 8 September 2020 plus exhibits: ○ **Exhibit "DLB-1"**, being a copy of pages of the report "Climate Change 2014: Synthesis Report"; ○ **Exhibit "DLB-2"**, Whitehaven's March 2020 Quarterly Report; ○ **Exhibit "DLB-3"**, Expert Report of Professor Will Steffen, 2020; ○ **Exhibit "DLB-4"**, United Nations Production Gap report, 2019; ○ **Exhibit "DLB-5"**, Climate Analytics report "Evaluating the significance of Australia's global fossil fuel carbon footprint", 2019; ○ **Exhibit "DLB-6"**, Climate Council report "Dangerous Summer: Escalating Bushfire, Heath and Drought risk", 2019; ○ **Exhibit "DLB-7"**, "The 2019 report of The Lancet Countdown on health and climate change", 2019; ○ **Exhibit "DLB-8"**, extracts from NSW Government Assessment Report, 2020; ○ **Exhibit "DLB-9"**, Doctors for the Environment report "Children and climate change", 2018; ○ **Exhibit "DLB-10"**, Climate Council report "Lethal Consequences: Climate Change Impacts on the Great Barrier Reef", 2018; ○ **Exhibit "DLB-11"**, Doctors for the Environment fact sheet "Climate Change and Health in Australia", 2016; ○ **Exhibit "DLB-12"**, American Psychological Association publication "Mental Health and Our Changing Climate", 2017; ○ **Exhibit "DLB-13"**, Department of Environment "The Intergovernmental Panel on Climate Change (IPCC Fact Sheet", 2014); ○ **Exhibit "DLB-14"**, IPCC "Special Report on 1.5C", 2018; ○ **Exhibit "DLB-15"**, Actuaries Institute of Australia publication "The impact of climate change on mortality and retirement incomes in Australia", 2019; ○ **Exhibit "DLB-16"**, Notification of Referral Decision EPBC 2012/6263; ○ **Exhibit "DLB-17"**, Independent Planning Commission NSW, Statement of Reasons for Decision, Vickery Extension Project SSD 7480.
4	Supplementary Affidavit of David Barnden dated 8 October 2020 plus exhibits: ○ **Exhibit "DLB2-18"**, EPBC 2016/7649 Decision whether action needs approval/Approval Required; ○ **Exhibit "DLB2-19"**, EPBC 2016/7649 Statement of Reasons: Decision under section 75; ○ **Exhibit "DLB2-20"**, EPBC 2016/7649 Notification of Change of

	Designation of Proponent; ○ **Exhibit "DLB2-21"**, EPBC 2016/7649 Notification of Extension of Time; ○ **Exhibit "DLB2-22"**, Vickery Extension Project SSD 7480: Issues Report; ○ **Exhibit "DLB2-23"**, Bilateral Agreement between Commonwealth and New South Wales; ○ **Exhibit "DLB2-24"**, IPC Development Consent for Vickery Extension Project; ○ **Exhibit "DLB2-25"**, Letter from Equity Generation Lawyers to Australian Government Solicitors; ○ **Exhibit "DLB2-26"**, Guardian Newspaper Article dated 8 June 2020; ○ **Exhibit "DLB2-27"**, Guardian Newspaper Article dated 12 August 2015; ○ **Exhibit "DLB2-28"**, EPBC Decisions Spreadsheet; ○ **Exhibit "DLB2-29"**, Resource related EPBC decisions Spreadsheet; ○ **Exhibit "DLB2-30"**, Letter from Australian Government Solicitor to Equity Generation Lawyers; ○ **Exhibit "DLB2-31"**, RBA Bulletin: The Changing Global Market for Australian Coal; ○ **Exhibit "DLB2-32"**, CSIRO and BoM State of the Climate 2018; ○ **Exhibit "DLB2-33"**, CSIRO, Response to Notice to Give Information to the Royal Commission (RCNDA HTG-HB1-002); ○ **Exhibit "DLB2-34"**, CSIRO "Climate and Disaster Resilience" report; ○ **Exhibit "DLB2-35"**, Commonwealth Department of the Environment RCP Fact Sheet; ○ **Exhibit "DLB2-36"**, CSIRO "Climate Compass: A climate risk management framework for Commonwealth agencies"; ○ **Exhibit "DLB2-37"**, Westerhold et al, "An astronomically dated record of Earth's climate"; ○ **Exhibit "DLB2-38"**, Westerhold et al, "Supplementary Materials: An astronomically dated record of Earth's climate"; ○ **Exhibit "DLB2-39"**, Live Science Article; ○ **Exhibit "DLB2-40"**, Letter from Australian Government Solicitor to Equity Generation Lawyers (7 October 2020); ○ **Exhibit "DLB2-41"**, "Letter to Commonwealth Government - Vickery Extension Project Referral Redacted".
5	Westerhold et al, "An astronomically dated record of Earth's climate and its predictability over the last 66 million years", Science 369:6509 (2020), pp. 1383-1387
6	Westerhold et al, "Supplementary Materials for: an astronomically dated record of Earth's climate and its predictability over the last 66 million years", Science 369:6509 (2020), p. 1383
7	Orders made by the Court on 24 September 2020

8	Orders made by the Court on 25 September 2020
9	Orders made by the Court on 5 October 2020
10	Federal Court of Australia Expert Evidence Practice Note (including Annexure A, Harmonised Code of Conduct)

GLOBAL CLIMATE

An astronomically dated record of Earth's climate and its predictability over the last 66 million years

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Much of our understanding of Earth's past climate comes from the measurement of oxygen and carbon isotope variations in deep-sea benthic foraminifera. Yet, long intervals in existing records lack the temporal resolution and age control needed to thoroughly categorize climate states of the Cenozoic era and to study their dynamics. Here, we present a new, highly resolved, astronomically dated, continuous composite of benthic foraminifer isotope records developed in our laboratories. Four climate states—Hothouse, Warmhouse, Coolhouse, Icehouse—are identified on the basis of their distinctive response to astronomical forcing depending on greenhouse gas concentrations and polar ice sheet volume. Statistical analysis of the nonlinear behavior encoded in our record reveals the key role that polar ice volume plays in the predictability of Cenozoic climate dynamics.

Global changes in Earth's climate during the Cenozoic era, the last 66 million years, have long been inferred from stable-isotope data in carbonate shells of benthic foraminifera, which are single-celled amoeboid organisms that live on the seafloor. Stable carbon and oxygen isotope records from deep-sea benthic foraminifera are a proven, invaluable archive of long-term changes in Earth's carbon cycle, deep-sea temperature, and seawater composition driven by changes in ice volume (*1*, *2*). In 1975, Shackleton and Kennett (*3*) produced one of the first deep-sea benthic foraminifer stable isotope records of the Cenozoic. Despite being of low temporal resolution, it revealed that Earth's climate had transitioned from a warm state 60 to 40 million years ago (Ma) to a cool state 10 to 5 Ma. Over the last 45 years, many deep-sea benthic foraminifer stable-isotope records of variable length and quality have been developed, resulting in a more detailed record of Cenozoic climate change. Compilations of these deep-sea isotope records provide a compelling chronicle of past trends, cyclic variations, and transient events in the climate system from the Late Cretaceous to today (*1*, *4*–*10*). However, even the most recent benthic isotope compilations cannot accurately document the full range and detailed characteristics of Cenozoic climate variability on time scales of 10 thousand to 1 million years. Age models and temporal resolution of Cenozoic benthic isotope compilations are too coarse and/or include gaps, particularly before 34 Ma. These weaknesses hamper progress in determining the dynamics of the Cenozoic climate system (*4*, *9*, *11*), for example, because they prohibit application of advanced techniques of nonlinear time series analysis at the required (astronomical) time scales. The lack of highly resolved, continuous, and accurately dated records constitutes a key limitation in our ability to identify and understand the characteristics of Earth's evolving climate during the Cenozoic.

Here, we present a new astronomically tuned deep-sea benthic foraminifer carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotope reference record uniformly covering the entire Cenozoic, developed in our laboratories by using sediment archives retrieved by the International Ocean Discovery Program and its predecessor programs (Fig. 1). To produce this composite record, we selected 14 ocean drilling records, checked and revised their composite splices if necessary, and preferentially selected records using the genera *Cibicidoides* and *Nuttallides* to minimize systematic interspecies isotopic offsets (*1*, *4*, *12*, *13*). We additionally generated new benthic stable-isotope data spanning the late Miocene and middle to late Eocene to fill intervals inadequately covered by existing records. We collated existing astrochronologies for all records, recalibrated them to the La2010b orbital solution (*14*) if required, and developed an astrochronology for the middle to late Eocene (*13*). We estimate our chronology to be accurate to ±100 thousand years (kyr) for the Paleocene and Eocene, ±50 kyr for the Oligocene to middle Miocene, and ±10 kyr for the late Miocene to Pleistocene. The composite record is affected by some spatial biases arising from the uneven distribution of deep-sea stable isotope data that mainly derive from low to mid-latitudes (*13*). Nevertheless, the resulting Cenozoic Global Reference benthic foraminifer carbon and oxygen Isotope Dataset (CENOGRID) provides a refined record with higher signal-to-noise ratio than any previous compilations (*13*) (supplementary text S1) and better coverage of the Paleocene, Eocene, and late Miocene intervals (fig. S32). The CENOGRID serves as an astronomically tuned, high-definition stratigraphic reference of global climate evolution for the past 66 million years.

On time scales of 10 thousand to 1 million years, global climate is a complex, dynamical system responding nonlinearly to quasi-periodic astronomical forcing. By combining the latest high-resolution generation of Cenozoic deep-sea isotope records on a highly accurate time scale, CENOGRID enables the definition of Earth's fundamental climates and investigation of the predictability of their dynamics. We used recurrence analysis (RA) of the CENOGRID record (*13*, *15*) to identify fundamental climate states that internally share characteristic and statistically distinctive dynamics. Recurrence is a major property of dynamical systems, and RA provides information about nonlinear dynamics, dynamical transitions, and even nonlinear interrelationships (*15*) and facilitates evaluation of underlying dynamical processes—e.g., whether they are stochastic, regular, or chaotic. We present recurrence plots and their quantification of the benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ records to recognize different climate states and apply the RA measure of "determinism" (DET) to quantify the predictability of Cenozoic climate dynamics.

Four distinctive climate states emerge as separate blocks from our recurrence plots of the $\delta^{18}O$ CENOGRID record, which we designate as

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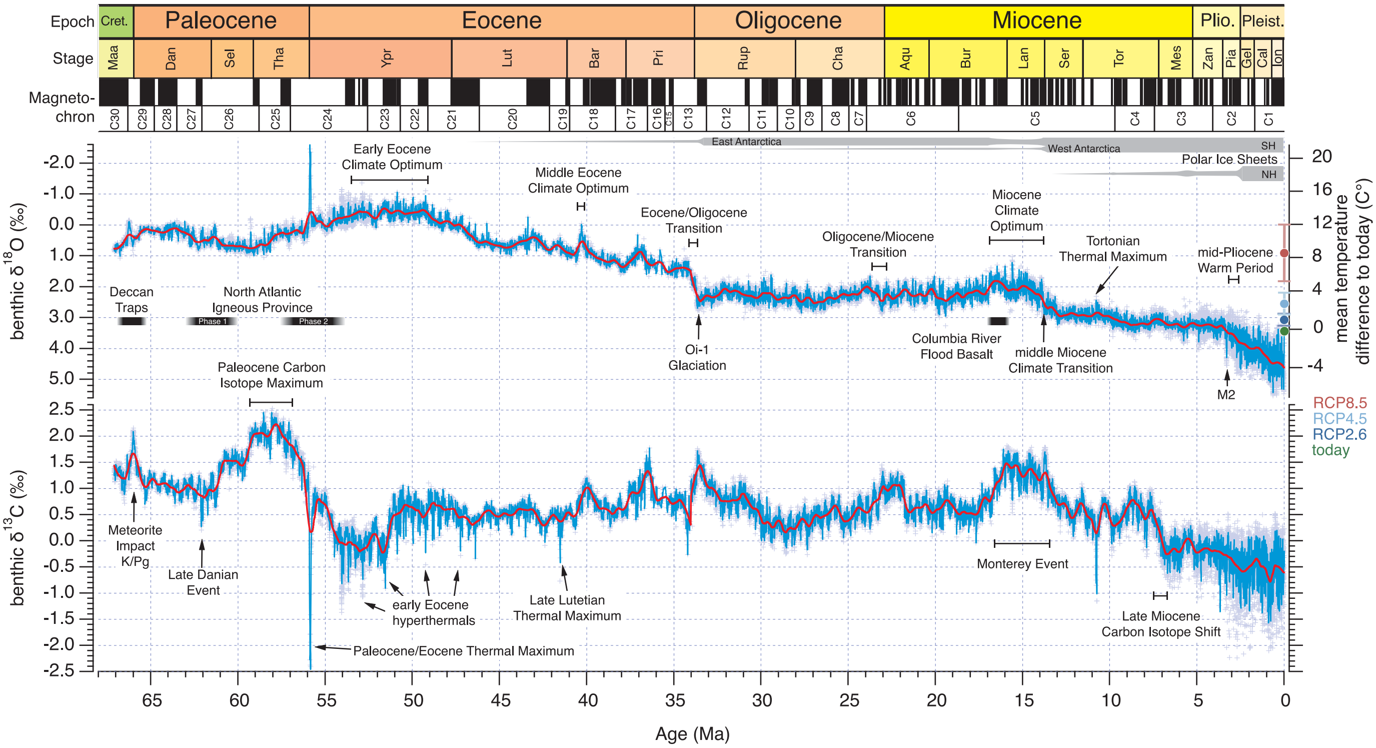

Fig. 1. Cenozoic Global Reference benthic foraminifer carbon and oxygen Isotope Dataset (CENOGRID) from ocean drilling core sites spanning the past 66 million years. Data are mostly generated by using benthic foraminifera tests of the taxa *Cibicidoides* and *Nuttallides* extracted from carbonate-rich deep-sea sediments drilled during Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP) expeditions. Genus-specific corrections were applied and oxygen isotope data adjusted by +0.64‰ and +0.4‰, respectively (*12*), with the green dot indicating the average oxygen isotope composition of the last 10 kyr. Average resolution for the interval from 0 to 34 Ma is one sample every 2 ky; for the interval from 34 to 67 Ma, it is one sample every 4.4 kyr. After binning, data were resampled and smoothed by a locally weighted function over 20 kyr (blue curve) and 1 Myr (red curve) to accentuate the different rhythms and trends in Earth's carbon cycle and temperature operating on various time scales. Oxygen isotope data have been converted to average temperature differences with respect to today (*13*). Future projections for global temperature (*44*) in the year 2300 are shown by plotting three representative concentration pathways (RCP) scenarios (light blue, dark blue, and red dots). Gray horizontal bars mark rough estimates of ice volume in each hemisphere. Absolute ages for epochs and stages of the Cenozoic (GTS2012) and geomagnetic field reversals (this study) are provided for reference. The oxygen isotope data axis is reversed to reflect warmer temperatures at times of lower $\delta^{18}O$ values. Aqu, Aquitanian; Bur, Burdigalian; Cal, Calabrian; Cha, Chattian; Cret., Cretaceous; Dan, Danian; Gel, Gelasian; Ion, Ionian; K/Pg, Cretaceous/Paleogene boundary; Lan, Langhian; Lut, Lutetian; M2, first major glacial event in the NH; Maa, Maastrichtian; Mes, Messinian; NH, Northern Hemisphere; Oi-1, the first major glacial period in the Oligocene; Pia, Piacenzian; Pleist., Pleistocene; Plio., Pliocene; Pri, Priabonian; Rup, Rupelian; Sel, Selandian; Ser, Serravallian; SH, Southern Hemisphere; Tha, Thanetian; Tor, Tortonian; Ypr, Ypresian; Zan, Zanclean.

the Hothouse, Warmhouse, Coolhouse, and Icehouse states (Fig. 2). Blocklike structures in the recurrence plots identify epochs where the dynamical system is "trapped" in a particular state. This interpretation of Cenozoic climate history is broadly consistent with previous interpretations, but our recurrence plot analysis of the highly resolved CENOGRID data provides a more statistically robust and objective exposition of events.

Characteristic features of the four climate states can be inferred from the isotope profiles (Fig. 1) and scatterplots of the CENOGRID $\delta^{13}C$ and $\delta^{18}O$ data and from atmospheric CO_2 concentration estimates (Fig. 2) (*13*). Warmhouse and Hothouse states prevailed from the Cretaceous/Paleogene boundary (K/Pg, 66 Ma) to the Eocene-Oligocene Transition (EOT, 34 Ma). During the Warmhouse, global temperatures were more than 5°C warmer than they are today (*13*), and benthic $\delta^{13}C$ and $\delta^{18}O$ show a persistent positive correlation with one another. The Hothouse operated between the Paleocene-Eocene Thermal Maximum at 56 Ma and the end of the Early Eocene Climate Optimum (EECO) at 47 Ma (*16*), when temperatures were more than 10°C warmer than they are today and displayed greater amplitude variability. Transient warming events (hyperthermals) are an intrinsic feature of the Hothouse, wherein paired negative excursions in $\delta^{13}C$ and $\delta^{18}O$ reflect warming globally through rapid addition of carbon to the ocean-atmosphere system. The two Warmhouse phases from 66 to 56 Ma (Paleocene) and 47 to 34 Ma (middle-late Eocene) share a similar temperature range but have distinct background $\delta^{13}C$ isotope values and atmospheric CO_2 concentrations (Fig. 2 and fig. S35). At the EOT, the Warmhouse transitioned into the Coolhouse state, marked by a stepwise, massive drop in temperature and a major increase in continental ice volume with large ice sheets appearing on Antarctica (*17*) to establish a unipolar glacial state (*18*). The recurrence plots mark out the EOT as the most prominent transition of the whole Cenozoic, which highlights the important role of ice sheets in modulating Earth's climate state (fig. S33) (*13*).

The Coolhouse state spans ~34 Ma (EOT) to 3.3 Ma (mid-Pliocene M2 glacial) and is divided into two phases by the marked shift in $\delta^{18}O$ increase at 13.9 Ma related to the expansion of Antarctic ice sheets during the middle Miocene Climate Transition (mMCT) (*19*). Warmer conditions culminating in the Miocene Climatic Optimum (MCO; ~17 to 14 Ma) (*20*) characterize the first phase, followed by cooling and increasing $\delta^{18}O$ during the second phase (Fig. 2). RA of carbon isotope data documents an additional major transition in the carbon cycle around 7 Ma related to the

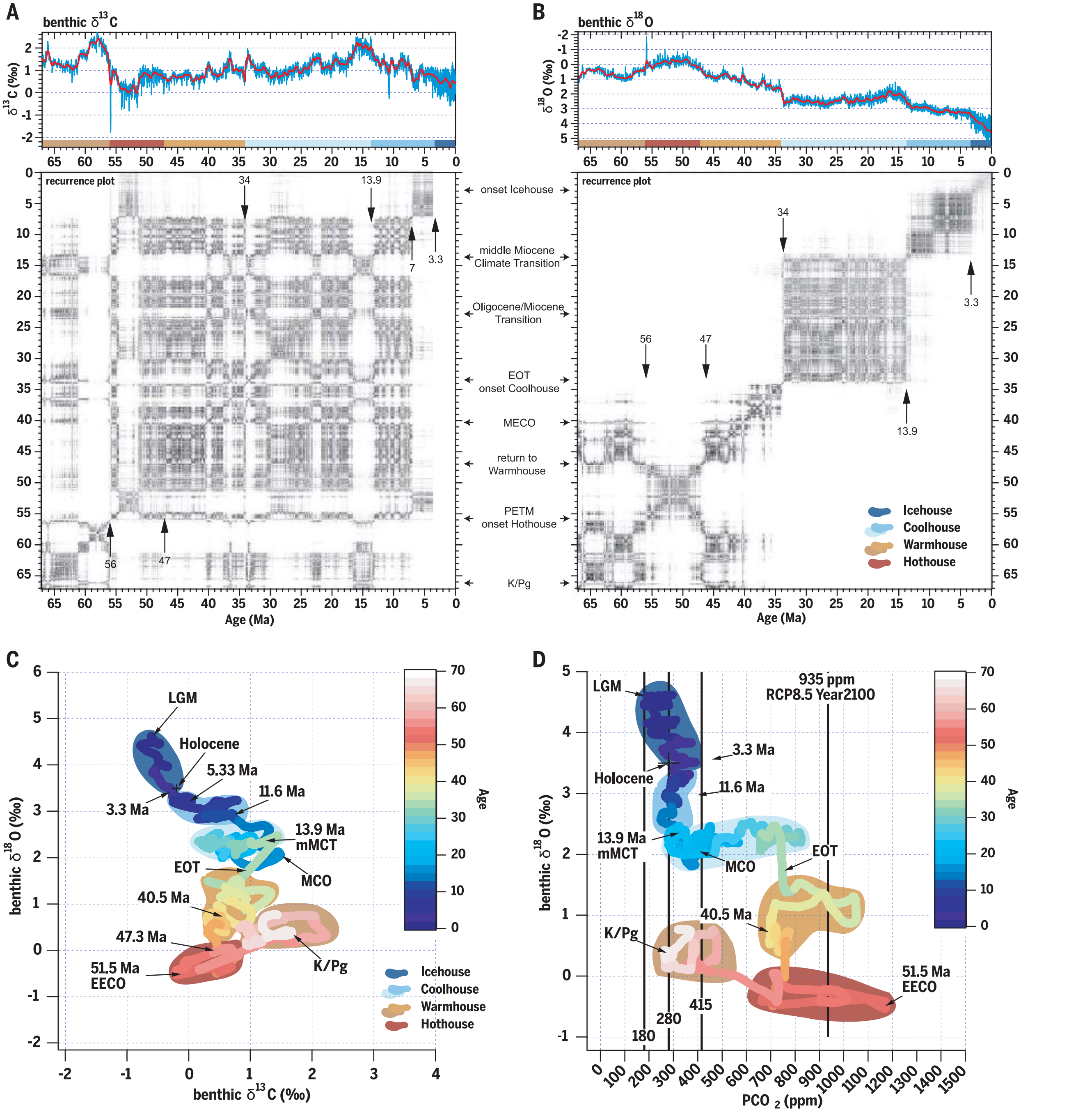

Fig. 2. Climate states of the Cenozoic. Deep-sea benthic foraminifer high-resolution carbon (**A**) and oxygen (**B**) isotope records and the respective recurrence plots as well as scatterplots of long-term benthic foraminifer carbon versus oxygen values (**C**) and oxygen values versus atmospheric CO_2 concentrations (**D**). Recurrence analysis compares climate change patterns occurring in a specific interval to the entire record. If climate dynamics have similar patterns, they will show up as darker areas in the plot; if they have no common dynamics, the plot will remain white. Four distinct climate states can be identified as Hothouse, Warmhouse, Coolhouse, and Icehouse with distinct transitions among them. The relation of oxygen isotopes, representative for average global temperature trends, to atmospheric CO_2 concentrations suggests that the present climate system as of today [415 parts per million (ppm) CO_2] is comparable to the Miocene Coolhouse close to the MCO. If CO_2 emissions continue unmitigated until 2100, as assumed for the RCP8.5 scenario, Earth's climate system will be moved abruptly from the Icehouse into the Warmhouse or even Hothouse climate state. LGM, Last Glacial Maximum; MECO, Middle Eocene Climate Optimum; PETM, Paleocene/Eocene Thermal Maximum.

end of the late Miocene carbon isotope shift (*11*, *21*, *22*). A major change in the correlation between benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ occurs during the Pliocene epoch (*23*). The Icehouse climate state (Fig. 2), driven by the appearance of waxing and waning ice sheets in the Northern Hemisphere, was fully established by the Pliocene-Pleistocene transition (*24*) (Figs. 1 and 2) with Marine Isotope Stage M2 at 3.3 Ma being a possible harbinger. The recurrence plots are less pronounced and more transparent from 3.3 Ma to today (Fig. 2 and fig. S34), suggesting that Earth's climate cryosphere dynamics entered a state not comparable to anything seen in the preceding 60 or more million years.

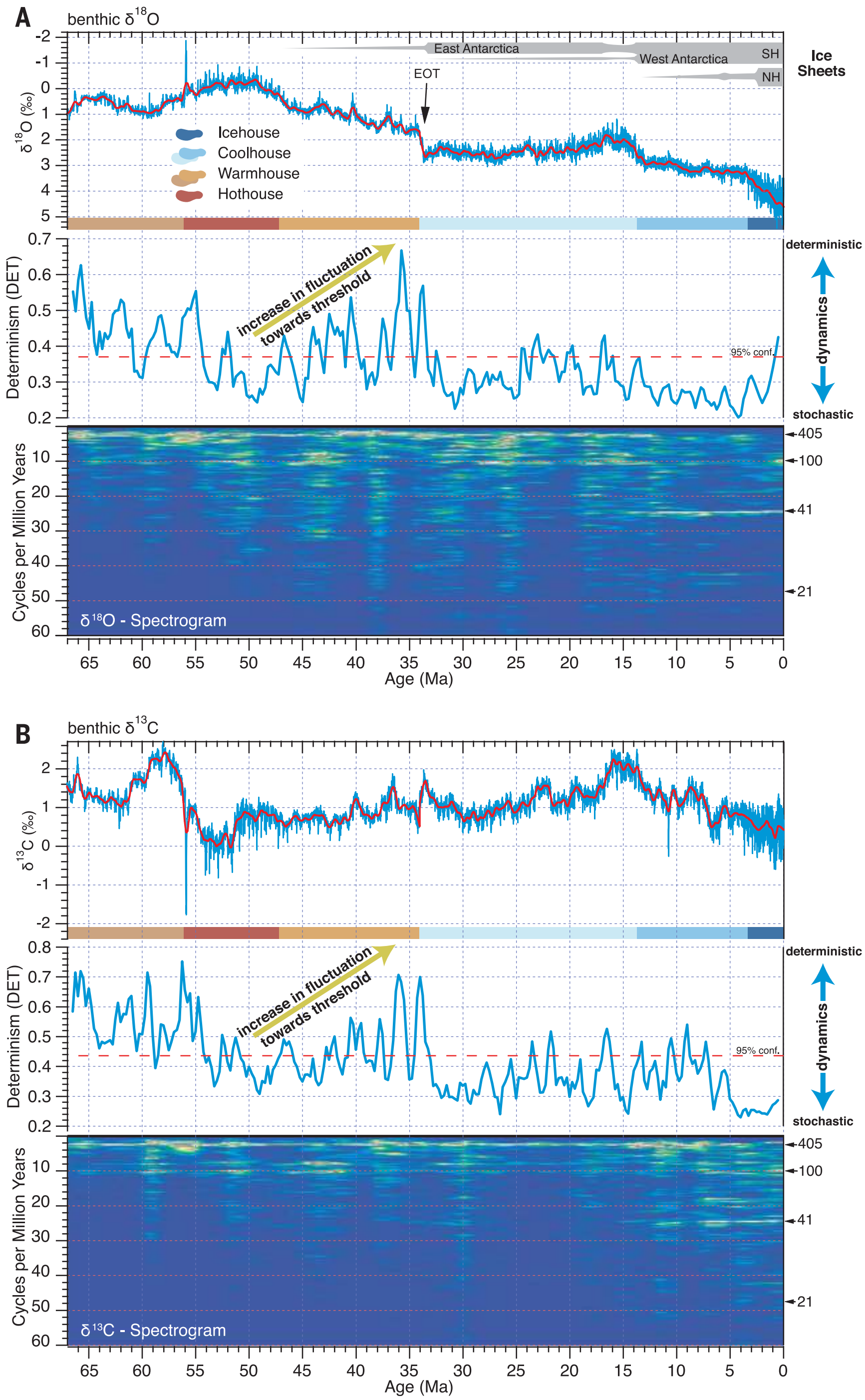

Fig. 3. Quasi-periodic changes and determinism in the global reference carbon cycle and oxygen isotope record. Evolutionary fast Fourier transform (FFT) spectrogram, recurrence determinism analysis, and benthic foraminifer oxygen (**A**) and carbon (**B**) isotope data plotted on age with the four climate states. Frequencies between 2 and 60 cycles per million years are related to changes in Earth's orbital parameters, known as Milankovitch cycles. The FFT spectrograms were computed with a 5-Myr window on the detrended records of benthic carbon and oxygen isotope data. From 67 to 13.9 Ma, cyclic variations in global climate are dominated by the eccentricity cycles of 405 and 100 kyr. Thereafter, in particular in the oxygen isotope record, the influence of obliquity increased, dominating the rhythm of climate in the record younger than ~7.7 Ma. Recurrence analysis of determinism (DET) shows that climate in the Warmhouse state is more deterministic (predictable) than in the Hothouse, Coolhouse, and Icehouse. From 47 Ma toward the EOT at 34 Ma, climate dynamic changes are rising in amplitude, approaching a threshold in the climate system. If DET tends to low values, the dynamics are stochastic, whereas high values represent deterministic dynamics.

The CENOGRID allows us to scrutinize the state dependency of climate system response to CO_2 and astronomical forcing on time scales of 10 thousand to 1 million years (*13*). Astronomical forcing throughout the Cenozoic is consistently uniform, but the RA indicates that the nonlinear response in climate variability to this forcing is strongly influenced by the fundamental state of climate. Evolutionary spectrograms characterize the dominant climatic response to astronomical forcing during the Cenozoic (Fig. 3). We find that the prevailing climate state, as characterized by atmospheric CO_2 concentration and polar ice sheets, orchestrates the response of climate processes to astronomical forcing. Modeled insolation-driven global temperature variability on astronomical time scales suggests that different temperature-response regimes exist: Eccentricity dominates temperature responses in low latitudes, precession in mid-latitudes, and obliquity in high latitudes (*25*). Thus, pronounced astronomical cyclicity in the CENOGRID could reflect climate state–dependent amplifications of latitude-specific climate processes.

In the Hothouse and Warmhouse, as well as the first Coolhouse phase, eccentricity-related cycles dominate the CENOGRID records, indicating a strong influence of low-latitude processes on climate variations. Obliquity-related cycles are sparse in these intervals but have been documented in other geochemical records (*26*, *27*), exhibiting perhaps local lithological responses. Weak response in the obliquity band during the Hothouse and Warmhouse intervals might be related to the absence of a high-latitude ice sheet that could have amplified climate response to obliquity forcing. The driving mechanism for the prevailing eccentricity cyclicity in the benthic $\delta^{13}C$ and $\delta^{18}O$ records is still unknown, but modeling suggests that low- and mid-latitude processes in the climate system respond in a nonlinear way to insolation forcing (*25*, *28*–*30*). In this regard, a key feedback likely involves the hydrological cycle with highly seasonal precipitation patterns during intervals of strong monsoon response to precession-induced insolation change, which could play a major role in the global distribution of moisture and energy (*31*–*34*). The expression of precession is apparently weak in the CENOGRID composite record, despite the dominant eccentricity forcing, likely owing to the long residence time of carbon in the oceans enhancing longer forcing periods (*30*, *35*), as well as our strategy to avoid "overtuning" the record. After the increasing influence of high-latitude cooling and ice growth during the second Coolhouse phase, the obliquity-band response steadily increases after the mMCT before dominating climate dynamics by the late Miocene–early Pliocene (*11*, *22*, *36*). In the Icehouse state, the progressive decrease in atmospheric CO_2 and major growth of polar ice sheets, which enhanced variability in $\delta^{18}O$, steadily amplified the influence of complex high-latitude feedbacks until they essentially dominated climate dynamics.

To better understand the complexity of climate dynamics recorded in the CENOGRID, we computed the RA measure of DET (*13*). This parameter quantifies the predictability of dynamics in a system's state. Predictability estimates the stochastic (unpredictable) versus the deterministic (predictable) nature of climate dynamics recorded in CENOGRID (*13*). DET values near zero correspond to unpredictable dynamics, whereas large values indicate predictable dynamics, which are especially interesting to examine on the approach to tipping points. Changes in DET can thus reveal transitions between fundamentally different climate regimes.

Our RA suggests that climate dynamics during the Warmhouse and Hothouse Cenozoic states are more predictable or more regular than those of the Coolhouse and Icehouse states (Fig. 3). The growth of polar ice sheets at the EOT enhanced the effect of obliquity pacing of high-latitude climate that interacted with eccentricity-modulated precession forcing at lower latitudes from that point in time. This led to increased nonlinear interactions among astronomically paced climate processes and, thus, more complex, stochastic climate dynamics. The development of a large Antarctic ice volume at the inception of the Coolhouse is associated with a fundamental regime change toward less predictable climate variability (lower DET values calculated from benthic $\delta^{18}O$) (Fig. 3). From 25 to 13.9 Ma DET is elevated again, related to a reduction in ice volume in relatively warmer times of the Coolhouse, culminating in the MCO. Despite the growing influence of ice sheets in the Coolhouse, until ~6 to 7 Ma, carbon-cycle dynamics remain more deterministic than temperature because $\delta^{13}C$ variations are predominantly driven by low-latitude processes and less strongly influenced by the complex interaction with polar ice-sheet fluctuations. After ~6 Ma DET drops, likely because of a stronger cryosphere imprint on the carbon cycle. Upon initiation of the Icehouse at 3.3 Ma, $\delta^{18}O$ recorded climate dynamics become slightly more deterministic (*37*) and carbon-cycle dynamics unpredictable, likely resulting from the complex response to the waxing and waning of polar ice caps (*38*).

The CENOGRID spectrogram displays a broader frequency range during several intervals with low DET values (e.g., Coolhouse), whereas high DET values (e.g., Warmhouse) occur when single frequencies dominate (Fig. 3). This could be signaling a more direct response to astronomical forcing in the Warmhouse compared with that in the Coolhouse. Our RA suggests that the Hothouse is more stochastic (less predictable) than the Warmhouse, presumably induced by the occurrence of extreme hyperthermal events and their strong nonlinear and much-amplified climate response to astronomical forcing (*39*, *40*). The evolving pattern in the DET from the onset of cooling after the EECO to the EOT is pronounced (Fig. 3). The amplitude in fluctuations between stochastic and deterministic dynamics intensifies from 49 Ma to 34 Ma, consistent with how Earth's climate system is suggested to behave (*41*, *42*) as it moves toward a major tipping point. Once that tipping point is reached at the EOT, a rapid shift toward more permanently stochastic dynamics marks the inception of a new climate state (*43*). Thus, not only is polar ice volume critical to defining Earth's fundamental climate state, it also seems to play a crucial role in determining the predictability of its climatological response to astronomical forcing.

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SUPPLEMENTARY MATERIALS

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Materials and Methods
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An astronomically dated record of Earth's climate and its predictability over the last 66 million years

Thomas Westerhold, Norbert Marwan, Anna Joy Drury, Diederik Liebrand, Claudia Agnini, Eleni Anagnostou, James S. K. Barnet, Steven M. Bohaty, David De Vleeschouwer, Fabio Florindo, Thomas Frederichs, David A. Hodell, Ann E. Holbourn, Dick Kroon, Vittoria Lauretano, Kate Littler, Lucas J. Lourens, Mitchell Lyle, Heiko Pälike, Ursula Röhl, Jun Tian, Roy H. Wilkens, Paul A. Wilson and James C. Zachos

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The states of past climate

Deep-sea benthic foraminifera preserve an essential record of Earth's past climate in their oxygen- and carbon-isotope compositions. However, this record lacks sufficient temporal resolution and/or age control in some places to determine which climate forcing and feedback mechanisms were most important. Westerhold *et al.* present a highly resolved and well-dated record of benthic carbon and oxygen isotopes for the past 66 million years. Their reconstruction and analysis show that Earth's climate can be grouped into discrete states separated by transitions related to changing greenhouse gas levels and the growth of polar ice sheets. Each climate state is paced by orbital cycles but responds to variations in radiative forcing in a state-dependent manner.

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Supplementary Materials for

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This PDF file includes:

Materials and Methods
Supplementary Text S1 to S4
Figs. S1 to S35
Tables S1 to S7
Captions for Tables S8 to S34
References

Other Supplementary Material for this manuscript includes the following:
(available at science.sciencemag.org/content/369/6509/1383/suppl/DC1)

Tables S8 to S34 (.xlsx)

Materials and Methods

1. New Stable Carbon and Oxygen Isotope Data

New high-resolution stable carbon and oxygen isotope data were generated on bulk carbonate and deep-sea benthic foraminifer carbonate from key intervals to assure full coverage of the Cenozoic. Here we describe the methods used to collect new data from biogenic carbonates at Sites 1263, 1264, and 1265. Ocean Drilling Program (ODP) Leg 208 Sites 1263 (28°32'S, 2°47'E), 1264 (28°32'S, 2°51'E), and 1265 (28°50'S, 2°38'E) drilled during Ocean Drilling Program (ODP) Leg 208 are located on the Walvis Ridge in the SE Atlantic (*46*) in 2,717 m, 2,505 m, and 3,059 m water depth (Fig. S1).

Bulk carbonate $\delta^{13}C$ and $\delta^{18}O$ analyses on 2000 freeze-dried and pulverized sediment samples from Site 1263 (80.69 to 156.40 rmcd depth) spanning the period from 32 to 41.7 Ma were undertaken at MARUM, University Bremen to validate and improve the benthic record. The bulk stable carbon and oxygen isotope data from the MARUM lab are reported relative to the Vienna Pee Dee Belemnite (VPDB) international standard, determined via adjustment to calibrated in-house standards and NBS-19. Bulk carbonate analyses at MARUM were carried out on Finnigan MAT 251 mass spectrometers equipped with automated carbonate preparation lines (Kiel I or III). Carbonate was reacted with orthophosphoric acid at 75 °C. Analytical precision based on replicate analyses of in-house standard (Solnhofen Limestone) is 0.03‰ (1σ) for $\delta^{13}C$ and 0.05 - 0.07‰ (1σ) for $\delta^{18}O$.

Benthic foraminifer tests carbonate $\delta^{13}C$ and $\delta^{18}O$ were measured on 2934 samples at MARUM and University of Cambridge. At the MARUM lab, good to moderately preserved specimen of benthic foraminifera *Nuttallides truempyi*, *Cibicidoides praemundulus, Oridorsalis umbonatus* (Eocene) from the >150µm fraction, as well as *Cibicidoides mundulus (C. kullenbergi)* and *Cibicidoides wuellerstorfi* (Miocene-Pliocene) picked from the 250-500µm fraction were measured on samples from ODP Sites 1263 (1998 samples), 1264 (85 samples), and 1265 (217 samples). Each measurement was made using a single species. Analysis at MARUM were performed on Finnigan MAT 251 with Kiel III, Finnigan MAT 252 with Kiel III, or ThermoFisher Scientific 253plus with Kiel IV automated carbonate preparation line. Samples were reacted with orthophosphoric acid at 75 °C. Analytical precision based on replicate analyses of in-house standard (Solnhofener Limestone) averages 0.02 - 0.04‰ and 0.05 - 0.07‰ (1σ) for $\delta^{13}C$ and $\delta^{18}O$, respectively. Data are reported relative to the Vienna Pee Dee Belemnite international standard, determined via adjustment to calibrated in-house standards and NBS-19.

At the University of Cambridge lab 634 20-cc samples taken every 2-3 cm from the composite section of ODP Site 1264 between 58 and 75 rmcd were processed. Oxygen and carbon isotope ratios were measured on the benthic foraminifer *Cibicidoides wuellerstorfi* and *Cibicidoides mundulus* from the >150 µm size fraction. Benthic foraminifer tests were cleaned in an ultrasonic bath to remove fine-grained particles and soaked in 15% H_2O_2 to remove surface organic contaminants prior to analysis. The number of specimens of *C. wuellerstorfi*/*C. mundulus* varied from 1 to 4. Each measurement was made using a single species. Benthic tests were crushed and between 20 and 60 µg of calcite were used for each analysis. The foraminifer calcite was reacted in orthophosphoric acid at 70°C using a Finnigan-MAT Kiel III carbonate preparation device. Evolved CO_2 gas was measured online with a Finnigan-MAT 252 mass spectrometer at the University of Florida. All isotope results are reported in standard delta notation relative to Vienna Pee Dee Belemnite (*47*). Analytical precision for both $\delta^{18}O$ and $\delta^{13}C$ was better than ±0.1‰.

All new stable carbon and oxygen isotope data are reported in the other supplementary materials Tab. S8 (Site 1263), Tab. S9 (Site 1264), Tab. S10 (Site 1265), Tab. S11 (Site 1263 bulk), and plotted against drilled depth in Fig. S2.

Our new bulk stable isotope data from ODP Site 1263 combined with the previously published data (*48*) compose to a 150-meter-long record with 3-5 kyr resolution covering the entire middle to late Eocene from 32 to 49 Ma (Fig. S2). The new benthic foraminifer data presented here span the period from 35.6 to 48.2 Ma. Together with the published data of the Late Lutetian Thermal Maximum (LLTM, (*49*)), latest Eocene (*50*) and the EOT (*51),* the Site 1263 benthic foraminifer record has an unprecedented average resolution of 5-7 kyr over the entire middle to late Eocene.

New benthic foraminifer stable isotope data were generated with samples from ODP Site 1264 (Fig. S2) to fill gaps in the record after revision of the late Miocene-Pliocene shipboard composite splice (52) and extend the published 0 to 5.25 Ma record (*53*) back to 6.1 Ma. At ODP Site 1265 new benthic foraminifer data (Fig. S2) were generated between 38.0 and 39.4 Ma to test the revised composite record for Site 1263 (see below) as well as between 48.0 and 49.8 Ma to cover an interval of coring disturbance in Site 1263 (*54*).

2. Splice revision Site 1263

Deep-sea drilling techniques and methods have evolved and now allow to retrieve complete nearly undisturbed and successive 9.6-meter-long cores from the upper 200 to 400 meters of the soft sediment pile. Between the consecutively taken drill cores a recovery gap always exists, mostly due to ship motion (*55*). Common practice is to drill several offset, parallel holes at the same site, to then correlate all cores using physical properties data and core images (*56*) to generate a complete record from spliced intervals out of the parallel cores that represents the full sedimentary package targeted by drilling. The splicing of cores towards a composite heavily relies on the core and data quality used for correlation. The shipboard composite record of Site 1263 was already revised using shipboard magnetic susceptibility data and high-resolution digital line scan core images (W15 splice; (*48*)). Due to slight coring disturbance this revision revealed a difficult to splice interval around 125 rmcd between cores 1263B-6H, 1263B-7H, and 1263C-2H, which required a reevaluation by additional parameters, in this case stable isotope data.

Therefore, we generated high-resolution stable isotope data at on benthic foraminifer tests extracted from Cores 1263C-2H and 1263B-7H (Fig. S3) that reveal a mismatch in the overlapping interval between cores at 126 rmcd in the W15 splice (*48*). By moving Core 1263C-2H up by 50 cm, a reasonable match was found. To validate this correlation, we generated a benthic foraminifer stable isotope data on the complementary interval in ODP Site 1265 that supports the new correlation. Revised offsets (Tab. S12), revised composite (Tab. S13), and revised mapping pairs (Tab. S14) as well as corrected site-to-site correlation ties are given in the other supplementary materials (Tab. S15, S16, S17).

3. Paleomagnetic data Site 1263

To contribute towards the compilation of an updated Cenozoic geomagnetic polarity time scale (GPTS; see Section 4), we generated a new astronomically-tuned magnetostratigraphy at ODP Site 1263 spanning Chron C12r to C19n, as this interval was poorly calibrated elsewhere.

The geocentric axial dipole field at the geographic latitude of Site 1263, assuming that the site location did not change significantly its position within the last 40 Myr, has an inclination of ca. ±47°, which makes it feasible to reconstruct paleomagnetic polarity using only inclinations. During ODP Leg 208, the bulk of the remanence measurements was made using a pass-through cryogenic magnetometer (model 760R) (*46*). The Natural Remanent Magnetization (NRM) was routinely measured before and after alternating field (AF) demagnetization at 5-cm increments, with 10-cm-long headers and trailers, on all archive-half core sections from Holes 1263A, 1263B, 1263C. Time constraints permitted analysis with only 2 or 3 AF demagnetization steps at 10 and 15 mT peak values for most of the core sections. Only Section 1263B-2H3 was demagnetized up to 25 mT. The low-maximum-peak AFs ensured that the archive halves remained useful for shore-based palaeomagnetic studies.

Natural remanent magnetization (NRM) was measured on 586 discrete cube samples (dimensions 2 cm x 2 cm x 2 cm) to document magnetic polarity Chrons C12r (earliest Oligocene) to C19r at ODP Site 1263. In total, 43 discrete samples were analyzed at the Faculty of Geosciences, University of Bremen, spanning Chrons C18n to C19r, and 543 discrete samples at Istituto Nazionale di Geofisica e Vulcanologia (INGV, Rome) covering Chrons C12r to C18r.

At the Faculty of Geosciences, University of Bremen, paleomagnetic directions and magnetization intensities were determined using a cryogenic magnetometer (2G Enterprises model 755 HR). NRM was measured on each sample before being subjected to a systematic alternating field demagnetization treatment involving steps of 7.5, 10, 15, 20, 25, 30, 40, and 60 mT. Intensities of orthogonal magnetic components of the remanent magnetization were measured after each step. A detailed vector analysis (*57*) was applied to the results in order to determine the characteristic remanent magnetization (ChRM) without anchoring to the origin of the orthogonal projections by choosing an individual demagnetization interval for each sample.

All samples but one showed a reversed, mostly steep, probably drilling induced, magnetic overprint of relative high intensity, which was easily removed at a demagnetization level of 7.5 mT (Fig. S4, S5). NRM intensities range from 3.1 to 33.4 x10^{-3} Am^{-1} with a mean of 9.9 x 10^{-3} A m^{-1}. The maximum peak demagnetization field (60 mT) reduced the NRM to about 3% in average of the NRM intensity prior to AF demagnetization, indicating a dominant low-coercive magnetization and no clear evidence for high-coercive NRM carriers. Declinations shown here were not corrected for core orientation in the horizontal plane because our reversal stratigraphy is based on inclination data only.

The majority of the samples (> 95%) provide very stable ChRM results with maximum angular deviations (MAD), a measure of the determination of the ChRM direction, lower than 5° (mean ~3.4°). The mean normal (reversed) inclination is -32° (39°), which is slightly shallower than -47° to be expected for a geocentric axial dipole assuming that the site location had not significantly moved within the last 40 Myr.

For analysis at the INGV ODP Holes 1263A, 1263B, 1263C were sampled between August 2007 and April 2008 using standard 8 cm^3 plastic cubes at the Integrated Ocean Drilling Program (IODP) Bremen Core Repository, where the core is curated. 543 samples were taken from 1263B-2H-3,3 to 1263A-15H-7,29, between depths of 58.52 (67.53 rmcd) and 134.78 mbsf (158.65 rmcd) and oriented with respect to vertical. To minimize sample dehydration and alteration, samples were packed in sealed bags and were stored in a refrigerated room until they were processed at the INGV. NRMs were analyzed within a Lodestar Magnetics shielded room (internal field < 200 nT) using a 2-G Enterprises automated cryogenic magnetometer (model

755R) with an internal diameter of 4.2 cm and equipped with three DC SQUID sensors (noise level 3 x 10^{-9} Am^2/kg).

Before performing routine demagnetization of all samples a pilot study on 32 samples was conducted to determine the most appropriate demagnetization technique. Fourteen samples were subjected to AF demagnetization at successive peak fields of 5, 10, 15, 20, 25, 30, 35, 40, 50, 60, 70, 80, 90 and 100 mT. The remainder 18 samples were carefully removed from the plastic cubes and subjected to progressive thermal demagnetization from room temperature up to 650°C at the following steps: 100, 200, 300, 330, 360, 400, 500, 550, 600, 650°C.

In most cases, the pilot study at INGV demonstrated that thermal and AF demagnetization were both effective in removing secondary remanence components and in isolating the ChRM. AF demagnetization, up to peak fields of 80-100 mT, was adopted for routine treatment of samples because it was less time-consuming and because it avoided the possibility of thermal alteration during demagnetization, which would hinder future analysis of the magnetic mineralogy content. Most of the samples from ODP site 1263 are affected by a steep reversed polarity overprint which appears to be drilling induced (Fig. S6 and S7). This magnetic overprint was successfully removed at peak fields of 10-15 mT.

For a few samples, AF demagnetization above 40 mT was obscured by the simultaneous acquisition of a gyroremanent magnetization (GRM) (e.g., (*58, 59*) suggesting the presence of a single-domain material (Fig. S7d). The ChRM was generally isolated at fields below 40 mT and consequently the GRM acquisition did not hamper the polarity interpretation for these samples. NRM stability was assessed using vector component diagrams (*60*). Principal component analysis (*56*) was used to calculate characteristic remanent magnetization (ChRM) directions, with linear best fits calculated from a minimum of three demagnetization steps using the PuffinPlot paleomagnetic analysis application (*61*). The maximum angular deviation (MAD) was calculated to provide an estimate of the precision for each best-fit line. Samples were only included in this study if MAD values were less than 10°.

Five hundred twenty-nine samples (ca. 97%) are characterized by stable ChRMs which allows construction of a detailed magnetic polarity zonation for the studied interval. NRM intensities range between 2.65 x 10^{-5} A m^{-1} and 1.55 x 10^{-2} A m^{-1} with a mean of 5.52 x 10^{-3} A m^{-1}. The normal and reversed polarity ChRM inclinations are grouped in two nearly antipodal clusters, as expected for reliable ChRM directions, with the mean normal and reverse inclinations of -30° and 32°, respectively. In conjunction with evidence from vector component diagrams this indicates that secondary overprints were successfully removed by stepwise AF demagnetization.

Applying calcareous nannofossil events documented in Site 1263 (*46, 54*; Tab. 18) to the inclination record (Tab. S19), we establish a paleomagnetic polarity interpretation (Fig. S8, Tab. S20). The resulting new Site 1263 magnetostratigraphy spanning Chron C12r to C19n is given in Table S21.

4. Cenozoic Magnetostratigraphy

The complete Cenozoic geomagnetic polarity time scale (GPTS) is given in the *Geomagnetic Polarity Time Scale (62),* the *The Neogene Period* (*63*) and *The Paleogene Period* (*64*) chapters of the Geological Time Scale 2012. Since the publication of the GPTS in 2012 several new-high resolution magnetostratigraphic records have been produced mainly refining the Paleogene Period. Here we have compiled additional recent magnetostratigraphic interpretations from base of Chron C6n to the top of C30n (Tab. S22) and applied the new astrochronology (see below) to form a new GPTS from 19.727 to 66.393 Ma (Tab. S23) consistent with the new tuned benthic foraminifer stable isotope reference record. The differences to the GPTS 2012 in this interval are less than 400 kyr (one 405 kyr eccentricity cycle) except for Chron C21n and C22n (Fig. S9). Two independent studies have refined the early to middle Eocene magnetostratigraphy for Chron 21 to 24 using deep-sea records (*54*) and a pelagic/hemipelagic succession of the western Tethys Possagno section (Southern Alps, northeastern Italy;(*65*)). Consistently they reach similar ages and durations for Chrons C21n, C21r and C22n. In the GPTS2012, the age calibration within this interval was difficult due to relatively large uncertainty in the radioisotopic ages of the Montanari ash, located in Chron C21n and used to calibrate the GPTS (*66, 67*). For the interval younger than the base of Chron C6n (19.727 Ma), we applied the GPTS2012 because no major changes are apparent so far. Only the interval between top Chron C3An.1n (6.023 Ma) and top Chron C4r.1n (8.236 Ma) was replaced by the recent refinement from IODP U1337 (*22*), where for the first time an astronomically tuned benthic foraminifer stable isotope stratigraphy (1.5 kyr resolution) and magnetostratigraphy from a single deep-sea location was combined for this time interval.

5. Astrochronology

Dating of geological archives by astrochronology provides accurate age models at a resolution not achieved by any other dating method for the Cenozoic (*68*). The breakthrough of our study is to present an unprecedently high resolution, astronomically tuned benthic foraminifer stable isotope record spanning over the entire Cenozoic. In this section, we describe the development of the astronomically tuned age model for the deep-sea sediment successions.

Quasiperiodic cycles with periods in the order of 10^4 and 10^5 years are found in many geological records and are known as Milankovitch cycles. The distribution and quantity of the incoming solar radiation vary due to subtle variations of the Earth's orbit around the Sun caused by the gravitational interaction of larger bodies in the Solar System. Over the timeframe of tens- to hundreds of thousands of years, climatic patterns on the Earth respond to the quasiperiodic orbital forcing recorded as rhythmic variations in numerous paleoclimate proxy records. Milankovitch cycles show characteristic rhythms of 21 kyr (precession), 41 kyr (tilt or obliquity), 100 and 405 kyr (both eccentricity). Cyclostratigraphic age models evolve out of the recognition of these cycles in geological data using the quasi-regular Milankovitch beats as a natural metronome to measure elapsed time. Matching Milankovitch cycles containing records to long-term numerical solutions for the insolation quantities of the Earth results in highly accurate astrochronologies (*68*).

By combining the numerical solutions of precession, obliquity and eccentricity one can form target curves to which to correlate geological data to. Correlation of the geological data to the astronomical target results in astrochronologies that are of much higher resolution and in effect more precise and accurate than any other geological dating technique over the Cenozoic. All of the published benthic foraminifer isotope records used in CENOGRID have an astrochronology, either as provided in the respective publication or refined if needed (see Tab. S1, S24 to S32). From 0 to 20 Ma, the integrated records are tuned to an astronomical target that is a appropriate combination of eccentricity, obliquity and/or precession (*20, 22, 56, 69-71*). For records older than 20 Ma, only eccentricity was used as a target curve due to (a) the less evolved expression of precession and obliquity in the geological records and (b) the uncertainty in precession and obliquity in the astronomical solutions itself. Details about the splice reference record for each record are given in Section 6 below.

The most prominent and stable astronomical cycle is the 405-kyr eccentricity cycle, which is driven by the planetary perturbations caused by Venus and Jupiter (*71*). Cenozoic deep-sea foraminifer stable carbon isotope records are predominantly imprinted by this cycle (*72*) suggesting a tight link between orbital forcing and the climate system, likely due to intricate feedback mechanisms in the carbon cycle (*30, 73*). Most of the orbital cycles experience marked changes in their periodicity and phasing due to the dissipative effect of the Earth-Moon system, friction, dynamic changes in the distribution of masses in the Earth and on Earths' surface, as well as chaotic diffusion of the Solar System (*14, 68, 71, 74*). Therefore, numerical solutions for precession and obliquity can only provide accurate targets back to about 10 to 20 Ma (*75, 76*), and usable targets back to 40 Ma (*71*). As said before, for intervals older than 20 Ma, eccentricity-related cycles provides the only accurate tuning target.

Major components of Earths' orbital eccentricity have a period of ~95 kyr (Mars – Jupiter), ~124 kyr (Mars – Venus), ~405 kyr (Venus – Jupiter), and ~2.4 Myr (Earth – Mars) (*71*). Accurate tuning to numerical solutions of eccentricity are limited by the chaotic behavior of the inner Solar System planets and the largest bodies in the asteroid belt (*14, 71*). Recent orbital solutions (*14, 77*) are valid from 0 to ~54 Ma for all eccentricity components, whereas only the 405-kyr eccentricity cycle is stable and can be used for astronomical tuning back to 200 Ma (*14, 68, 78*). However, comparison to geological data from the Eocene (*54*) and Paleocene (*79*) suggests that the La2010b solution (*14*) best matches to the observed eccentricity related cycle modulations imprinted in the records older than 50 Ma. Therefore, we used the La2010b orbital eccentricity solution to establish a consistent astrochronology for the Eocene and Paleocene. Tuning more negative carbon isotope values to short eccentricity maxima in the La2010b solution (*30, 35, 80, 81*) avoids distortion effects in the $\delta^{13}C$ 405-kyr component due to the residence time of carbon in the ocean-atmosphere system and to the enhanced carbon isotope excursions of hyperthermal events (*54, 82*). We do not use the recently published ZB18a orbital solution because it is almost identical with the La2010b up to 58 Ma, and beyond 58 Ma it is unconstrained due to chaotic behavior (*77*). Furthermore, in the ZB18a solution some parameters have been varied beyond physically realistic values (pers.comm Jacques Laskar) and, thus, need to be tested first before being applied. For the same reason, we do not apply the recently proposed age (*77*) for the Paleocene/Eocene boundary or onset of the PETM.

All age models applied to the individual records used for the CENOGRID are given in Tab. S24 to S32. For the new benthic foraminifer stable isotope data generated from Site 1263 (middle to late Eocene) and Site 1264 (early Pliocene to late Miocene) samples we ascertained astrochronologies where necessary. Benthic carbon isotope data from the earliest Oligocene to late Eocene interval at Site 1263 exhibit a distinct eccentricity-related cyclicity (Fig. S10), which was used to tune the record from 32.7 to 42 Ma (Fig. S11). The astrochronology for Site 1264 from 0 Ma to 6.1 Ma is from (52). It is based on tuning of the high-resolution $\%CaCO_3$ record was tuned to a normalized eccentricity, tilt and precession (E+T-P) target, guided by benthic $\delta^{18}O$ where available, using a similar approach ($\%CaCO_3$ maxima/benthic $\delta^{18}O$ minima tuned to E+T-P maxima) as in (*22*).

6. Cenozoic global reference benthic foraminifer carbon and oxygen isotope dataset (CENOGRID)

To compose the new high-fidelity Cenozoic benthic foraminifer stable carbon and oxygen isotope reference record, we selected the temporally best resolved deep-sea records from the Atlantic and Pacific Oceans featuring published astrochronologies. Additionally, we filled gaps, expanded these existing records, and generated new data for the early Pliocene to late Miocene (Site 1264) and middle to late Eocene (Site 1263) intervals. We included records from 14 ODP and IODP sites (Fig. S1) from the Atlantic: ODP Leg 154 Ceara Rise Sites 925, 926, 927, 928, and 929; ODP Leg 207 Demerara Rise Site 1258; ODP Leg 208 Walvis Ridge Sites 1262, 1263, 1264, and 1265; and the Pacific: ODP Leg 184 South China Sea Site 1146; ODP Leg 199 East Equatorial Pacific Site 1218; IODP Exp. 320/321 East Equatorial Pacific Sites U1337 and U1338. These sites are also ideal as it is possible to correlate between sites and compare coeval datasets, thereby highlighting the optimum, expanded intervals to use at each location in order to best target a consistent global signal. To avoid systematic interspecies isotopic offsets in isotope data (*12, 83*), whenever possible we only used species of the genus *Cibicidoides* and *Nuttallides*, as suggested by (*4*). The isotopic correction factors applied are given in Tab. S2 and Fig. S12. To obtain the best estimates of oxygen isotopic equilibrium and carbon isotopic composition of ocean deep-water dissolved CO_2, adjustment factors were applied (Tab. S3) and documented for each isotope value.

After compiling, generating, testing and refining astrochronologies for all the records as well as correcting interspecies offsets, we calculated a 10-point LOESS smooth and plotted the smooth along with the data (Fig. S13). Then we ascertained the optimal position to switch from one record to the next and determined the isotopic offsets between records from different ocean basins. The later step is necessary to produce a single high-fidelity reference record that documents the overall global carbon and oxygen isotope evolution in the Cenozoic. The Pacific Ocean is the largest ocean and probably best resembles a global mean, therefore all data were offset with respect to the equatorial Pacific values (Sits 1218, U1337, U1338; Fig. S14). One has to realize that single, continuous, individual high-resolution records for each of the different ocean basins and spanning the entire Cenozoic are unrealistic due to local sedimentation effects (gaps and condensed intervals) in available deep-sea sections. Comparing the evolution of ocean basin geochemistry is tempting having the new reference record at hand, but beyond the scope of this manuscript. It also involves an order of magnitude more effort to revise the published composite records from all three major ocean basins and their age models.

Ten switch points were defined where we switched from one record to the next (Fig. S15 to S24) to build a continuous high-fidelity record utilizing the specifies given in Tab. S5. We defined optimal points to switch between records to ensure the maximum resolution possible and from locations, where the isotope signals between records are highly consistent. In the latest Eocene interval the time resolution of available records is lower (Fig. S22 and S23), therefore we used the bulk isotope records to ensure that the age models are well synchronized. Due to severe dissolution across the 34.025 to 34.308 Ma interval of Site 1218, the Eocene-Oligocene Transition (EOT) (Fig. S22), we had to switch from Site 1218 to Site 1263. Low data coverage at 35.5 Ma forced us to introduce an uncertain switch (Fig. S23), which may need a refinement when additional benthic isotope records become available. However, this would require new ocean drilling campaigns, because currently no high-resolution sedimentary section provides a continuous benthic foraminifer isotope record at a single location and at the same time unaffected by dissolution.

After the data for the reference record were merged (Fig. S25, Tab. 33), the average sample resolution was determined. Average sample resolution from 0 to 34.025 Ma is 2 kyr and from 34.025 to 67.100 Ma is 4.4 kyr (Tab. S6). The lower sample resolution for the Eocene and Paleocene is due to lower sedimentation rates and lower sample resolution of the available records. Based on this observation, we divided the reference record in two intervals for subsequent binning and smoothing of data. We binned the data into equally spaced bins of respectively 2 kyr and 5 kyr bins for the younger and older intervals. The bin sizes were determined based on the average sample resolution. Binning was done by dividing a weighted histogram of the data by a frequency histogram of the data in IGOR Pro 8 (Wavemetrics). Where empty bins occurred, the bin was filled with interpolated data based on surrounding bins, to provide a continuous and equally spaced dataset for smoothing. To minimize the effects of outliers the records were then smoothed in IGOR Pro 8 using a nonparametric LOESS quadratic regression smooth with a tricube locally-weighted function equivalent to a 20-kyr smooth window. This equated to a 10-point smooth for the 0 to 34.025 Ma interval and 5-point smooth for the 34.025 to 67.100 Ma interval. To generate a long-term trend curve equivalent to a 1-Myr smooth window, the reference record was LOESS smoothed over 500 points for the 0 to 34.025 Ma interval and 250 points for the 34.025 to 67.100 Ma interval (Fig. S26). The binning and smoothing avoid biases due to intervals with higher sample resolution and data density and provide a balanced view for the entire Cenozoic at higher resolution than before (Fig. S27). The benthic deep-sea foraminifer carbon and oxygen isotope reference record and LOESS smoothed data are provided in Tab. S33 and S34.

Sampling Biases - Cenozoic deep-sea benthic foraminifer oxygen isotope data essentially track mean deep-sea temperature and ice sheet evolution (see *1, 4, 84*). The temperature component of the oxygen isotope record essentially tracks mean deep-sea temperature which is set by surface conditions at sites of water mass formation. It has been suggested that the low latitudes may have contributed to sites of water mass formation under past warm climate states but the balance of evidence suggests that that the main explanation for the very warm intermediate and deep waters evidenced in the oxygen isotope record during the warm climate states are warm surface water conditions at high latitude sites of water mass formation during the season of deep convection (winter) with southern hemisphere sources dominant (e.g., *85-88*). Biases in benthic foraminifer records have been discussed in detail by (*1, 4*). Another issue is the bias due to the uneven distribution of deep-sea stable isotope data in both space and in time, particularly in the early Cenozoic with few high-resolution records. Splicing records from different regions can create artificial steps in the global record. Compared to previous records, the CENOGRID significantly reduces the temporal limitations (sampling density), but not the regional distribution issues (*4*). The regional distribution and water depth bias can only be solved by getting access to multiple new records from low to high latitudes over a range of water depth, a major endeavor for future scientific ocean drilling. However, the global imprint on the individual records included in CENOGRID is supported by the consistency in the variability of overlapping datasets, which partly mitigates the sampling bias caused by the regional distribution of sites. An additional bias of warmer time intervals like the Paleocene and Eocene is the perception that thermal gradients within the deep-sea were greater than today, making surface temperature reconstruction more complicated. Isotope records of planktic foraminifer to document surface ocean conditions could help here, but early diagenesis tends to bias the records towards deep-sea isotope values (see (*89*)).

For the Cenozoic temperature/ice-volume reconstructions the biases have limited affects. The late Neogene oceans were thermally homogeneous and a greater density of high-resolution available records means we have a greater understanding of the global versus regional imprint on individual records. In the compilation of Cramer et al. 2009, which separated records from different oceans, Eocene benthic foraminiferal $\delta^{18}O$ values seem rather homogenous and suggest minor temperature differentiation amongst deep water source regions. In contrast, $\delta^{18}O$ records from the Pacific Shatsky Rise Site 1209 (*16*) and the Atlantic Walvis Ridge Sites 1262/1263 (*90*) show a consistent pattern from 66 to 45 Ma. Thus, the CENOGRID presented here is assumed to be the currently best global temperature/ice-volume recorder.

For the global benthic foraminiferal carbon isotope record, spatial biases are more important toward the younger part of the record, the Neogene, because of circulation related basin to basin fractionation. Paleogene $\delta^{13}C$ records from Atlantic and Pacific show the same variability but are, as expected, offset and thus can be treated as an average global carbon cycle recorder.

7. Recurrence Analysis

Recurrence analysis (RA) is used to identify transitions between different types of dynamics. A recurrence plot (RP) is a binary matrix where the coordinates of each entry mark the pair of time points with recurring states (*91*). A value one at column i and row j represents that state at time i recurs at time j. A recurrence is defined by the pairwise comparison of all values in the time series, whether their distance is smaller than a predefined threshold. The threshold is selected in a way that the fraction of recurrences is 10% of the number of pairwise comparisons (*92*). The graphical rendering of the RP can be used to get a first visual impression of the type of dynamics and to identify changes of the dynamics. RP is a powerful tool to reveal nontrivial dynamical features, i.e., not only periodic dynamics, but also intermittent regimes or chaos-chaos-transitions. For example, block-like structures in the RP identify epochs where the dynamical system is 'trapped' in a particular state.

We conducted RA on the CENOGRID in the time domain. Analysis was performed on the undetrended (Fig. S32) and detrended isotopes records (Fig. S33). Data were resampled at 0.005 Ma and detrended using a 5th order Butterworth-filter with cutoff-frequency of 0.1 Ma.

An RP contains a number of interesting and important small-scale features, such as single points or diagonal lines (*15*). A diagonal line corresponds to episodes of similar evolution of states. A dominance of single points indicates stochastic processes. The more diagonal lines exist with respect to single points, the more deterministic or predictable the process would be. To quantify this property, the fraction of recurrence points that form diagonal lines with respect to all recurrence points was introduced and is called "Determinism" (DET) (*15*). DET ranges from zero to one. If DET tends to low values, the dynamics is stochastic, whereas high values represent deterministic dynamics.

The temporal change of DET is calculated by using a sliding window approach (window size 1 Ma, moving step size 0.25 Ma). By using a specific bootstrap test, the 95% confidence level for significantly elevated DET values can be determined (*93*). It is important to note that each given DET value corresponds to the center of the moving window. Therefore, the analysis provides insight to significant changes in DET, equal to significant changes in the dynamics of the system, that occur within less than 1 Ma. The method cannot resolve abrupt changes on the order of thousands and tens of thousands of years. Nevertheless, the analysis of the detrended data (Fig. S33) documents distinct white bands in the recurrence plots. These bands mark transitions in the climate dynamics and coincide with major changes or events recorded in benthic foraminifer isotopes.

8. Global Temperature Record and Past Atmospheric CO_2 Levels

We use the approach in (*94*) to transpose the deep-sea temperature changes recorded in the benthic foraminifer oxygen isotope data into average global changes in surface air temperature scaled to the 1961–1990 mean. Deep-sea benthic foraminifer oxygen isotope $\delta^{18}O$ values are controlled by changes in deep-ocean temperature and global ice mass over the Cenozoic (*84*). Therefore, variations in ice growth need to be taken into account prior to estimating deep-ocean temperature changes. Prior to the onset of large polar ice sheets on Antarctica at 34.025 Ma, deep-sea temperature can be approximated assuming that most of the ~1.8‰ increase in $\delta^{18}O$ from the Early Eocene Climate Optimum (EECO) to the end of the Eocene is due to a 7–8°C change in temperature (*1*). After the major onset of a large polar ice sheet in Antarctica at the Eocene-Oligocene Transition (EOT) ice volume and deep-sea temperature changes both contribute to the variance in benthic foraminifer $\delta^{18}O$ values (*95*). With the appearance of larger ice sheets in the Northern Hemisphere the contribution of global ice mass variations to $\delta^{18}O$ values increased at 3.6 Ma and 1.81 Ma. Taking this into account, (*94*) proposed three equations (equations 1 to 3 in Tab. S7) to transfer deep-sea $\delta^{18}O$ values into temperature estimates for the Cenozoic. We applied these three equations to the three time intervals to compensate for different contributions of ice sheet variations to the $\delta^{18}O$ signal. Our intent is not to develop a new scheme to transpose the benthic foraminifer record but just to account for the potential influences of ice-volume during those periods for which major ice-sheet expansion occurred (on Antarctica in the Miocene and the N. Hemisphere at 2.7 Ma) as indicated by independent evidence.

To compare changes in global temperature relative to today, the deep-sea $\delta^{18}O$-derived temperatures have to be transposed into surface air temperature changes. We follow the relation between deep ocean and surface temperature change (equations 4, 5, 6 in Tab. S7) and calculate the temperature change with respect to the Holocene mean temperature of 14.15 °C as given in (*94*).

Estimates for past atmospheric CO_2 levels are compiled from (*96*) and references therein, (*97*) and references therein, and from (*98-106*). Atmospheric CO_2 estimates including the upper and lower estimate were LOESS smoothed in IGOR Pro 8 over 30 data points. References in (*96*) are on the GPTS2012 (*62*). Additional atmospheric CO_2 estimates are on their individual age models, because the uncertainty for atmospheric CO_2 estimates is much larger than the difference between GPTS2012 and our updated GPTS ages.

Supplementary Text

S1 - Earth's Trends, Rhythms, and Aberrations

Trends: The general long-term trends in global climate as represented by the spliced oxygen isotope record (the red curve in Fig. 1) confirm the patterns obtained in the previously published low-resolution stacks (e.g. (*1*)). These trends are partly influenced by modifications in boundary conditions due to tectonic processes (*107*) including continental geography and topography, oceanic gateway locations and bathymetry, but mainly by the concentrations of atmospheric greenhouse gases, finely balanced between volcanic CO_2 outgassing and consumption by weathering of silicate mineral rocks (*108*). It is generally accepted that the overall increase in the relative abundance of oxygen isotopes values reflects the formation of large polar ice sheets and a decrease in mean deep-ocean temperature, a trend that largely corresponds with a long-term decline in atmospheric pCO_2. Supported by more recent independent evidence, its well accepted that the prominent steps towards greater oxygen isotope values mark major stages of polar ice sheet growth: the Eocene/Oligocene Transition (EOT) 34 million years ago with the large scale expansion of the East Antarctic Ice Sheet (EAIS, *17*), the middle Miocene Climate Transition (mMCT, *109*) 13.9 million years ago with the expansion of the West Antarctic Ice Sheet (WAIS) and with the re-expansion or further expansion of the EAIS, and the intensification of the Northern Hemisphere Glaciation ~2.7 million years ago (*110*).

The benthic carbon isotope record, which is generally assumed to be sensitive to changes in the global carbon cycle (*111*), over long time scales, shows a number of key features, most of which often relate to climate (Fig. 1). Aside from the effects of the K/Pg extinctions (*112*), the most striking features of the marine C isotope record are the late Paleocene carbon isotope maximum (PCIM) and the Miocene Monterey Event, thought to represent periods of large changes in organic carbon burial caused by enhanced marine productivity or increased burial of biomass, terrestrial and/or marine (*20, 83, 113-115*). Synchronous with the first major glacial event in the Pliocene at 3.3 Ma (M2), the amplitude in both the carbon and oxygen isotope signal increase on time scales of 10^5 years.

Rhythms: The main contribution of the current study is to reveal the general patterns of rhythmic fluctuations as superposed on the long-term trends. Fluctuations on time scales of 10^4 to 10^5 years dominate early-mid Cenozoic global oxygen and carbon isotope records (the blue curve in Fig. 1) and are related to the short eccentricity oscillations of about 95,000, 124,000 and 405,000 years, more distinctive in the carbon isotope record (Fig. 3). The influence of eccentricity on insolation are small compared to those of obliquity and precession, but it is the only orbital parameter that controls the total amount of solar radiation received by the Earth averaged over the course of one year (*14*). More importantly, eccentricity modulates the amplitude of the precession cycle affecting the intensity of seasons (e.g., during maxima in eccentricity, more intense wet and dry seasons caused a decrease in the net burial of carbon) (*30*). Modeling suggests that low- and mid- latitude processes in the climate system respond in a nonlinear way to insolation forcing (*28, 31-33*). Important feedback to be considered involves the global monsoon which plays a key role in distributing moisture and energy as driven by low-latitude insolation (*31, 32*). The high-resolution isotope record thus documents a nearly 50-million-year sustained dominance of low-latitude processes on Earth's climate system.

After the mMCT at 13.9 Ma, Earth's climatic regime and dynamic response changed with the re-expansion of Antarctic ice sheets and possible initiation of Northern Hemisphere Ice

Sheets (NHIS) in the late Miocene (*111*). After that time, a persistent response to obliquity gains power in the oxygen isotope signal, further strengthening after 7.7 Ma (Fig. 3; *22*, *36*), documenting the increasing influence of high latitudes on global climate variability caused by the expansion of polar ice-sheets. In contrast, carbon cycle dynamics remain strongly paced by eccentricity after the mMCT (*36, 69*), but obliquity only noticeably imprints on carbon isotope variability after 7.7 Ma before becoming the dominant influence in both oxygen and carbon isotopes after 6.4 Ma (*11, 22, 116*) (Fig. 3). About 800,000 years ago, the amplitude in oxygen isotope data, now showing a characteristic asymmetric pattern, increased due to the waxing and waning of large Northern Hemisphere ice sheets. The origin of the prevailing quasi 100-kyr cycle of the ice age is still an unsolved problem, but it is likely not directly related to the 95-kyr and 124-kyr eccentricity cycle. However, from the perspective of the last 66 Myr, the past 800,000 years represent a very unusual time with its asymmetric large scale amplitude fluctuations in oxygen isotope values due to the waxing and waning of massive bipolar ice-sheets.

Aberrations: Aberrations from the background global trends and rhythms are the third important feature of the Cenozoic deep-sea benthic carbon and oxygen isotope record. Transient climate warming events lasting 40-kyr to 200-kyr occurred frequently in the late Paleocene and early Eocene. Known as hyperthermal events, they are characteristically coupled to negative excursions in carbon and oxygen isotope values, which document rapid warming of the climate system on geological time scales associated with large perturbations of the carbon cycle (*4, 16, 39, 117*). By far the largest event, unprecedented in the last 100 million years, was the 5 to 8°C global warming of the Paleocene/Eocene Thermal Maximum (PETM) at ~56 Ma. It is evident that hyperthermals are orbitally forced disruptions in the carbon cycle (*39, 117, 118*) with infrequent and variable additional carbon released from slowly recharging reservoirs (*119*). These transient global warming events are an intrinsic feature of the climate system in the "hothouse mode" as is apparent in the early Eocene. After the East Antarctic Ice Sheet expansion at the EOT at ~34 Ma ago, only the Tortonian Thermal Maximum at 10.75 Ma (*36*) stands out as a potential similar warming event, but its global nature needs to be validated by additional records. High-amplitude variability of $\delta^{18}O$ and $\delta^{13}C$ during the Miocene Climate Optimum is reminiscent of hyperthermals ($\delta^{18}O$ and $\delta^{13}C$ decreases coupled to intense transient carbonate dissolution events). If we assume that pCO_2 level reconstructions around 600 ppm for that time are correct, the climatic implications are major. The detailed isotope record of the Cenozoic encompasses many more anomalies, but of lower magnitude than those discussed above. Many of these were very likely orbitally controlled dynamics in the climate system enhanced by non-linear effects (*30*).

S2 - Milankovitch cycles and astronomical tuning

Periodic variations in Earth's orbit around the Sun have remained relatively uniform over hundreds of millions of years. However, the climatic response to resulting changes in insolation have varied considerably (*1, 71, 108*). Average global temperature over millions of years mostly varied in concert with the concentration of greenhouse gases such as atmospheric CO_2 (*120*). Superposed on the long-term trends, fluctuations omnipresent in deep-sea benthic foraminifer isotope data are driven by variations in Earth's orbital parameters (*121*) with periodicities corresponding to the so-called Milankovitch cycles of precession (19 and 23 kyr), obliquity (41 kyr) and eccentricity (100 and 405 kyr). These cycles are the key quasi-periodic climate influencing changes in Earth's orbital geometry caused by the gravitational interaction of larger bodies in the Solar System (*71*). Although the expression of these cycles in sediments can change with time the heartbeat of climate, the Milankovitch cycles, can be used as a metronome telling time. Such astronomical tuning, the correlation of Milankovitch cycles in sediment archives to numerical computations of insolation is now a cornerstone calibrating the geological time scale (*68*), and central to the contribution of this study.

S3 - Sampling resolution and site location artefacts

We have addressed the sampling biases of the CENOGRID already above. Here we elaborate on the limits and possible artefacts arising from the selection of ocean drilling sites. Sedimentary records are a mix of local, regional and global signals and their interactions. Deep-sea and far offshore ocean drilling records are good records to investigate global changes, as proven in 50 years of scientific ocean drilling. However, on time scales of ten thousand to one million years specific locations are better suited for resolving the higher frequency components of climate variability, in part, because of proximity to certain climate system processes (circulation/weathering). Just as an example, the Ceara Rise (ODP Leg 154) sites with relatively high sedimentation rates for a pelagic region and a location in the western Equatorial Atlantic (i.e., relative to the boundary between Antarctic Bottom Water and Northern Component Water) should record both obliquity and precession. Oligocene-early Miocene records from the eastern South Atlantic Walvis Ridge might not be as sensitive to obliquity (for discussion see (*122*). How much of the signal in the Oligocene-early Miocene Site 1264 $\delta^{18}O$ or $\delta^{13}C$ is local versus global is debatable and can only be assessed with high fidelity records from multiple other sites from different regions and water depths (e.g. (*123*)). Stratigraphically continuous and splices composite scientific ocean drill cores are still rare. It will take another 50 years of scientific ocean drilling to systematically retrieve suitable records and generate high-resolution benthic stable isotope records needed to clearly disentangle regional from global signals as well as regional from global responses to astronomical forcing.

Due to the limited selection of currently available cores the results in our study will be biased towards the particular record used from Atlantic or Pacific. We are confident that the selected records still for the most part mainly reflect a global signal due to their well-connected/ventilated positions within vast ocean regions and high resolution expression of variability mirrored in other records. For the records in CENOGRID, we chose to apply a minimal tuning approach to avoid introduction of precession or obliquity components into the records prior to spectral analysis. The selection of mid- to low-latitude sites could bias the records as well as their position in the water column and thus the origin of the signal recorded. Benthic $\delta^{18}O$ values mainly tell about the climate (temperature) in the areas of deep-water formation (e.g., the high latitudes) and change in seawater isotope composition by ice sheet variations. Benthic $\delta^{13}C$ values are more complex, they mostly reflect the dissolved inorganic carbon inventory of the ocean and are influenced by the ocean circulation patterns. Records will thus be biased depending on their geographic position and influence the outcome of the spectral analysis. Thus artefacts can arise from changing between records. Additionally, the sample resolution (Fig. 28) and sedimentation rate at a given location will bias the outcome. Slow sedimentation rates of much less than 1 cm/kyr tend to amalgamate precession and obliquity related cycles, enhance the amplitude of longer cycles like eccentricity, and potentially lead to cycle misidentification. We use the best resolved records in the CENOGRID to avoid aliased signals or amplitude enhancement.

Different approaches for time series analysis to produce evolutive spectrograms exist. We applied various methods to avoid misinterpretation by method based artefacts. The Evolutive Power Spectral Analysis (Fig. S29) and the evolutionary FFT spectrogram (Fig. 3) give similar results but tend to smear out at significant power intervals. Wavelets generally perform better in identifying brief intervals with significant cyclicity, because this time series analysis tool adjusts window size for each periodicity. We computed 3D wavelets on CENOGRID (Fig. 29), which show a bit more detailed but consistent pattern compared to the Evolutive Power Spectral Analysis and evolutionary FFT spectrogram. The enhanced persistent appearance of obliquity cycles at around 13.9 Ma in $\delta^{18}O$ and 7.7 Ma in $\delta^{13}C$ can be seen in the 3D wavelets as well. These analyses are consistent with findings at multiple locations in different oceanic basins that pervasive obliquity pacing is imprinted in benthic oxygen and carbon isotopic records since the late Miocene to early Pliocene. A similar picture evolved using the Thomson multi-taper method (MTM, (*124*), Fig. S31). The latter method reveals in $\delta^{18}O$ data some more power in the obliquity band around 14.5 Ma, 19.5 Ma, 21 Ma, 23.7 Ma, 30.5 Ma, and 43 Ma. All of these intervals are characterized by low eccentricity modulation of the precession and larger obliquity amplitudes in the astronomical forcing. Higher power intervals in the obliquity band at 56 Ma (Paleocene/Eocene Thermal Maximum) and the Early Eocene Climate Optimum (EECO, 49.14 to 53.26 Ma) are an artifact of the hyperthermal events (*16*). The weak response to obliquity in the early Cenozoic could be partly biased by the selection of sites. Enhanced obliquity cyclicity was reported during the Oligocene from the Pacific ODP Site 1218 (*35*) in benthic stable isotope data, the early Miocene and Oligocene from Southern Ocean ODP Site 1090 (*125*) and Atlantic Ceara Rise ODP Leg 154 sites (*126-130*) in magnetic susceptibility and benthic stable isotope data. In our study we have revised the astronomical tuning for ODP Site 1218 using a minimal tuning approach. Spectral analysis of the benthic data on the new age model reveals less obliquity contribution than previously thought. Higher resolved benthic records spanning the early Miocene and late Oligocene from ODP Site 1264 (Walvis Ridge, (*122*)) and ODP Site U1334 (*123)* show less imprint of obliquity related cyclicity then the previous lower resolution record. We point out here that more detailed records spanning all intervals of the Cenozoic Era are needed to properly resolve the detailed response to astronomical forcing. Low amplitude variability will make this a challenging task for most of the Cenozoic, but we strongly recommend here to generate records at high resolution (2-3 kyr) and on monospecific species to avoid aliasing and distortion of the primary isotope signal.

S4 - Evolution of Earth's global temperature and its coupling to atmospheric CO_2 changes

Since the industrial revolution in the 1850s atmospheric CO_2 concentrations have risen as a result of anthropogenic carbon (C) emission due to fossil-fuel burning and net land use (*131*). At present, concentrations have increased to 415 ppm or by 40% relative to pre-industrial times, and depending on future fossil fuel (FF) consumption will rise following one of several potential C trajectories, or Representative Concentration Pathways (RCP). The response of future climate to anthropogenic carbon release, however, still has a large degree of uncertainty due to the nonlinear behavior of feedbacks in climate models, for example clouds. This is particularly true for scenarios of CO_2 levels exceeding those of the last several million years (~400 ppm) which are closer to the early Eocene levels (>800 ppm). Although reconstructions of deep time climate states and their associated dynamics, cannot be used as direct analogs for future climate due to different climate boundary conditions (e.g., configuration of continents and mountain ranges, etc.), they can be used to assess climate model sensitivity, and thus test hypotheses about feedback mechanisms.

After removing the contribution of large polar ice-sheets, deep-sea benthic foraminifer oxygen isotope data essentially track mean deep-sea temperature over the Cenozoic (*1*) which can be transferred into average global changes in surface air temperature by scaling to the 1961–1990 average (Fig. S34; (*94*)). Over the same period atmospheric CO_2 levels can be reconstructed by a variety of methods (*132*). Assuming that atmospheric CO_2 concentrations mainly pace Cenozoic climate (*133-135*) a comparison of the RCP results to the average global temperature changes derived from the high-resolution benthic foraminifer record helps to (A) identify periods in Earth's history that are comparable to future scenarios and (B) unravel how dynamic climate evolves in these modes.

At 415 ppm, present day CO_2 levels are similar to those of the middle Pliocene (Fig. S34; (*136*)), before the establishment of a large Northern Hemisphere ice sheet (NHIS). By the year 2100 atmospheric CO_2 could reach 935 ppm, possibly causing a global warming of more than 4° Celsius according to RCP 8.5 (Fig. 31, (*44*)). The Miocene Climate Optimum, more than 15 million years ago, is the most recent period in the Earth's past with similar temperature increase relative to preindustrial (1961-1990), a time with insignificant NHIS and dynamic Antarctic Ice Sheets (e.g. (*137-140*)). If there is no considerable decrease in carbon emissions by the year 2200, atmospheric CO_2 could reach almost 2000 ppm, likely causing a warming of more than 8°C by the year 2300 (*44, 141*). The Earth was as warm during the middle to late Eocene (>40 Ma) and mid-Paleocene (~60 Ma) (Fig.31, (*44*)), a time of no significant polar ice-sheets and CO_2 level much higher than today (*135*). During the EOT, 34 Ma ago, the massive expansion of the Antarctic ice sheet is thought to be related to a CO_2 threshold for the establishment of continental ice sheets (~600 ppm; (*142-144*)). Even under the caution that past climates may not be direct analogues to Earth's short term future, because of non-linearities in forcing and feedbacks of the climate system (*145, 146*), under further unmitigated emissions of CO_2 there is a risk of pushing the climate system towards a state with ephemeral glaciations at the poles, where the climate system will lose a key thermostat and the influence of low-latitude processes on global climate will be strengthened. As is apparent in long-term detailed reconstructions such a major shift between states in climate would be unique in the past 66 Mya. While there have been similar magnitude warming events (e.g., the PETM), the main difference is that during these past events, the planet was already warm and ice-free, so lacking a major amplifying feedback on the climate system. Moreover, despite state, carbon cycle feedbacks have operated to varying degrees. As such, it is very likely that the rate and impacts of future warming will be severe and exceedingly challenging to forecast.

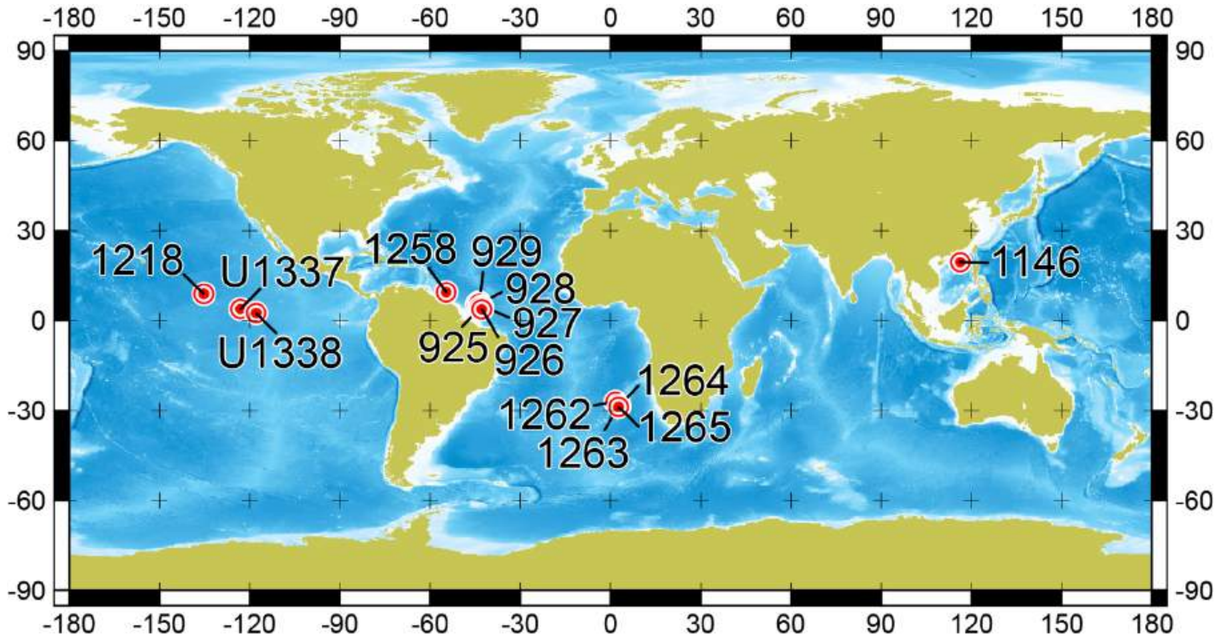


Fig. S1.
Location of ocean drilling sediment cores used to form the Cenozoic high-fidelity benthic stable isotope reference splice.

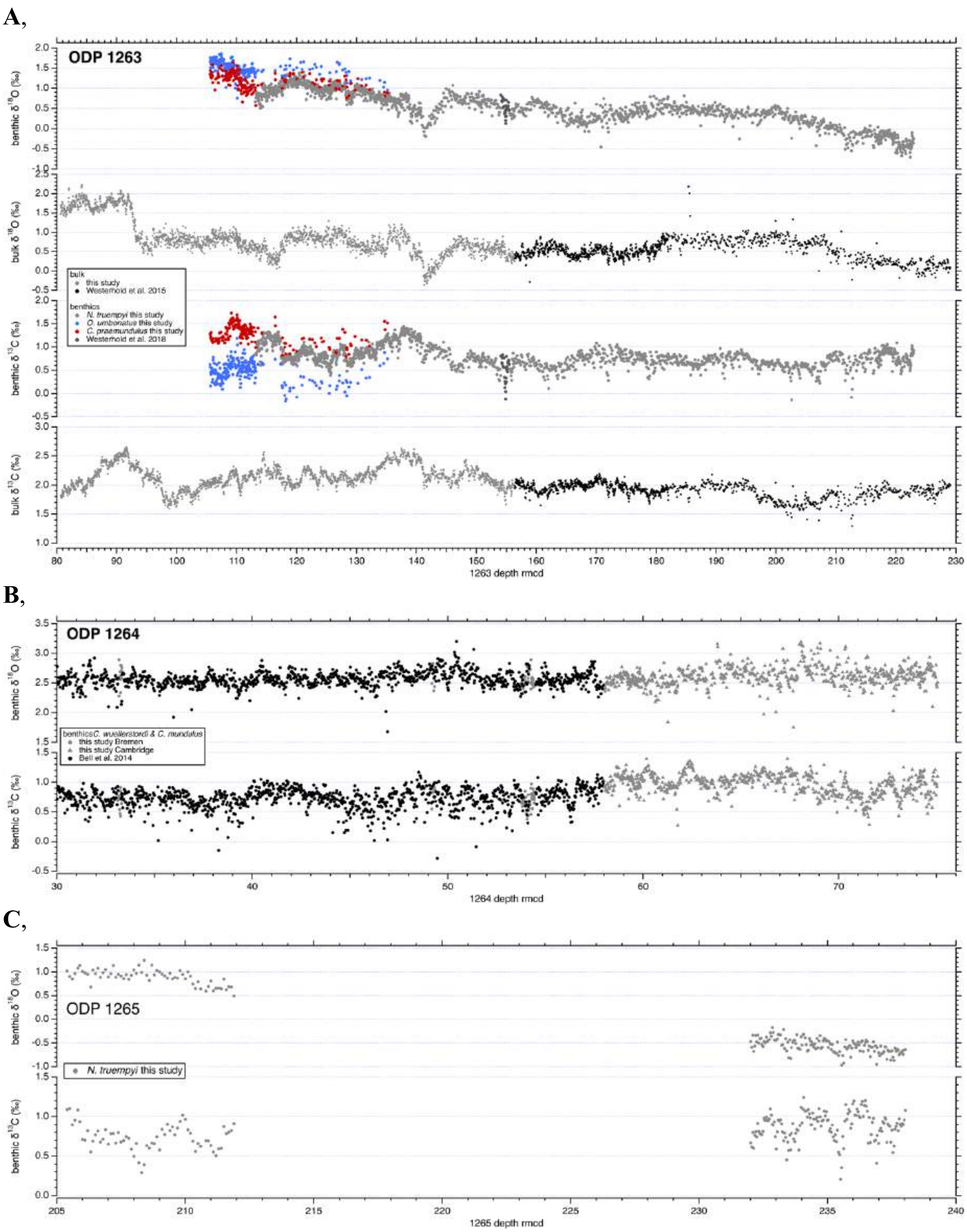


Fig. S2.

Bulk carbonate and benthic foraminifer stable carbon and oxygen isotope data for ODP Sites 1263 (A), 1264 (B) and 1265 (C) plotted versus revised meters composite depth (rmcd).

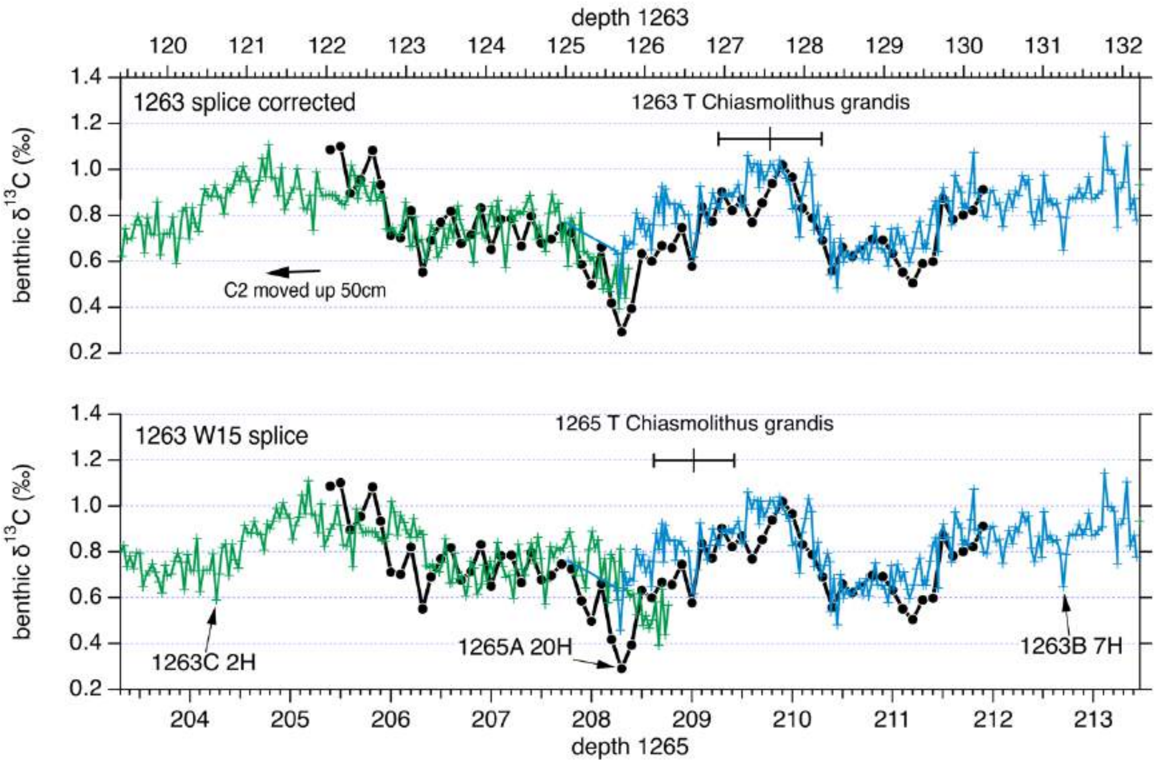


Fig. S3.
Benthic foraminifer carbon isotope data (*N. truempyi*) from ODP Sites 1263 and 1265 to illustrate the correction of the composite drill core depth at Site 1263. Isotope data from Cores 1263C-2H (green) and 1263B-7H (blue) plotted versus depth for Site 1263 (upper x-axis), and for Core 1265A-20H (black) plotted versus depth for Site 1265 (lower x-axis). The lower panel shows the data plotted on the (*48*) (W15) composite depth for Site 1263, the upper panel shows the corrected composite depth for Site 1263 presented in this study. Comparison with the equivalent interval from Site 1265 validates the correction of the composite depth at Site 1263 by moving Core 1263C2H upward by 50cm. The nannofossil event datum of Top *Chiasmolithus grandis* at Sites 1263 and 1265 is given to back-up the correlation between both sites.

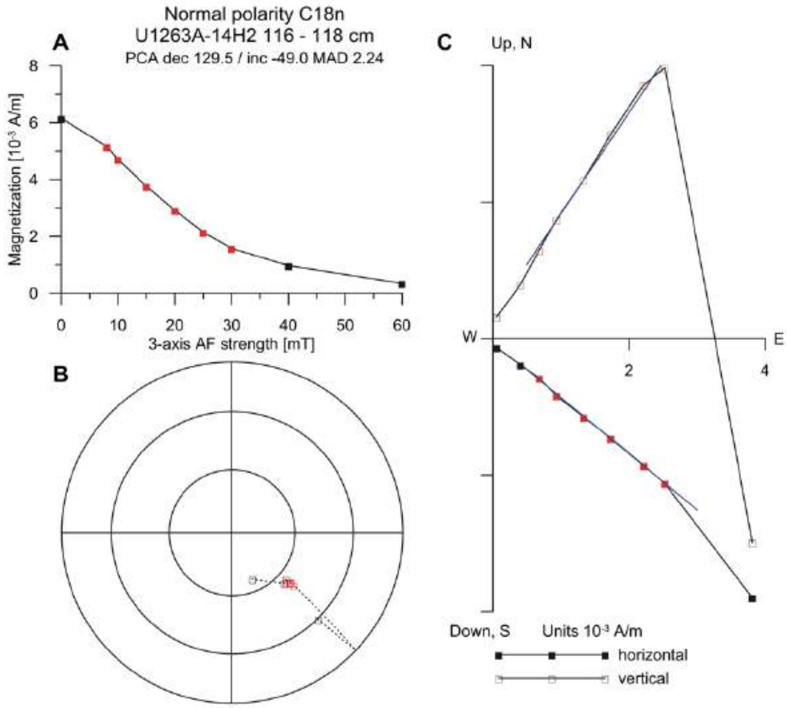


Fig. S4.

Natural remanent magnetization (NRM) data from the 0 to 60 mT AF peak field demagnetization interval for sample U1263A-14H2, 116-118 cm from normal magnetic polarity Chron C18n: (A) intensity of magnetization versus AF peak field; (B) stereographic projection of vector end-points with declination plotted on the circles (N at the top, E to the right) and inclination plotted on the radius (0° on the outer circle; 90° in the center); filled (open) symbols mark data on the upper (lower) hemisphere; (C) orthogonal projections of NRM component data; open (filled) symbols represent projection of vector end-points on the vertical (horizontal) plane; blue lines indicate direction of characteristic remanent magnetization (ChRM).

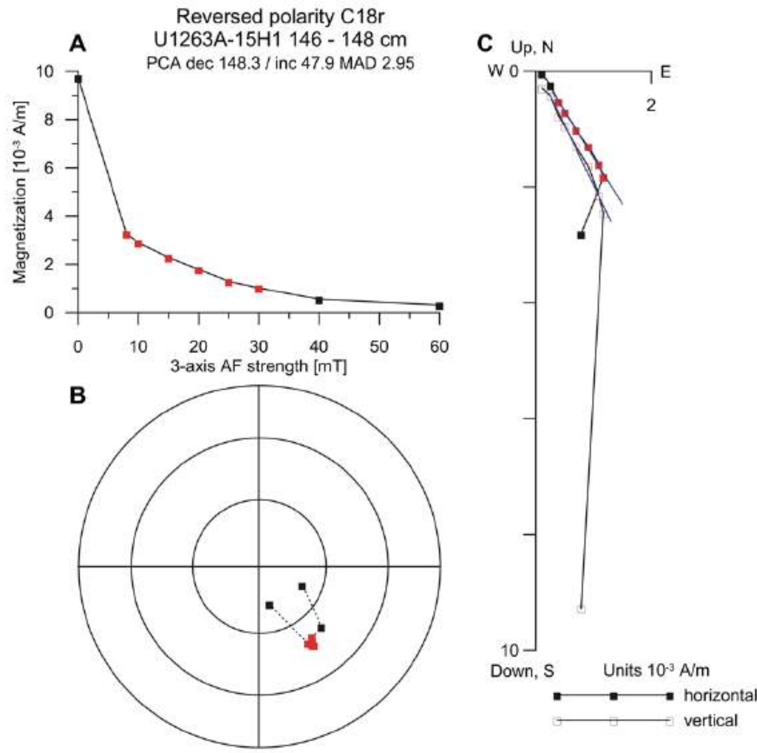


Fig. S5.

Natural remanent magnetization (NRM) data from the 0 to 60 mT AF peak field demagnetization interval for sample U1263A-15H1, 146-148 cm from reversed magnetic polarity Chron C18r: (A) intensity of magnetization versus AF peak field; (B) stereographic projection of vector end-points with declination plotted on the circles (N at the top, E to the right) and inclination plotted on the radius (0° on the outer circle; 90° in the center); filled (open) symbols mark data on the upper (lower) hemisphere; (C) orthogonal projections of NRM component data; open (filled) symbols represent projection of vector end-points on the vertical (horizontal) plane; blue lines indicate direction of characteristic remanent magnetization (ChRM).

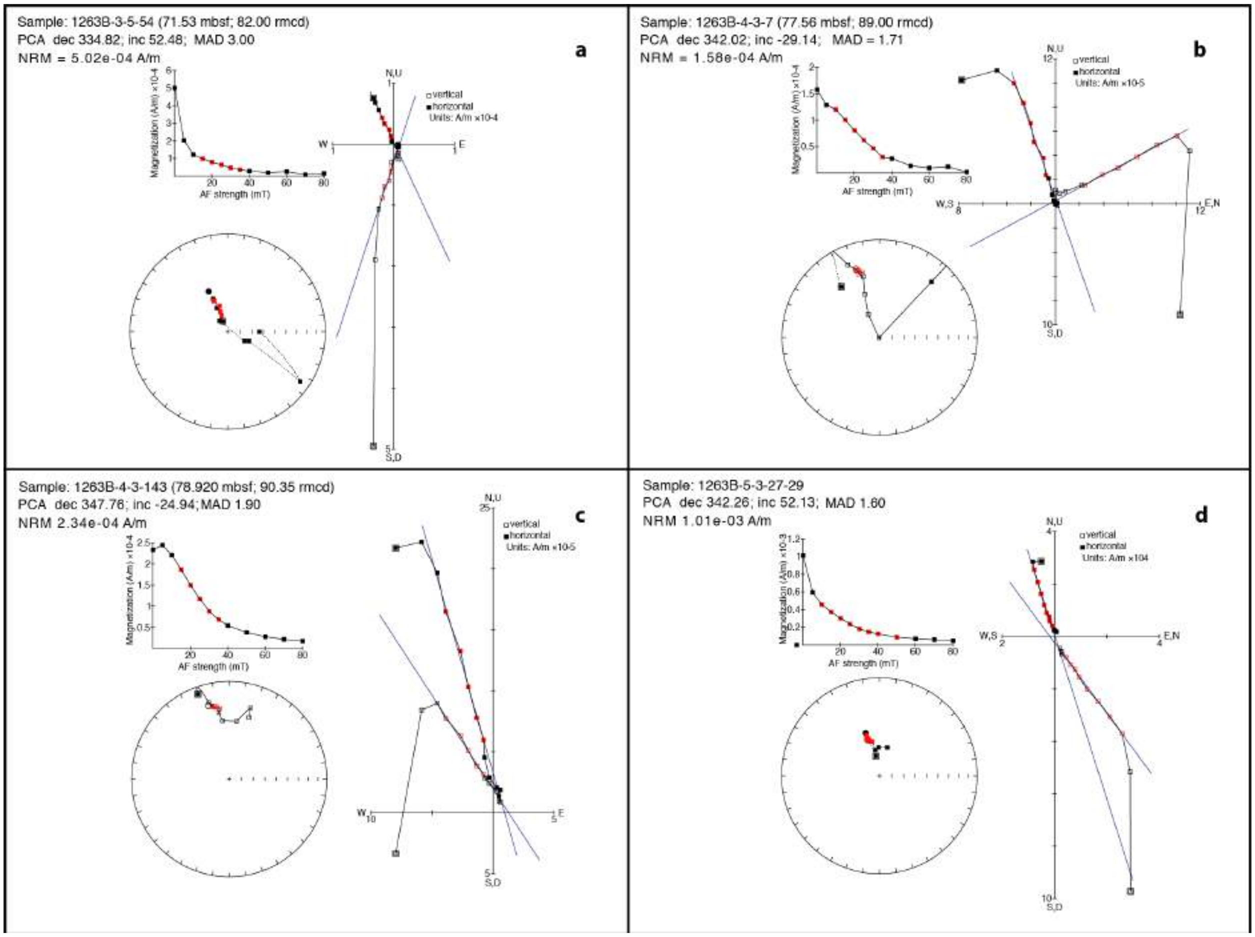


Fig. S6.
AF demagnetization behavior for representative samples from Hole 1263 B. For the vector component diagrams, open (closed) symbols represent projections onto the vertical (horizontal) plane. The blue lines represent linear regression fits that indicate the ChRM direction for each sample. The stereo plots are equal-area stereographic projections, with solid (open) symbols representing points projected onto the lower (upper) hemisphere. Plots were produced using PuffinPlot (*61*).

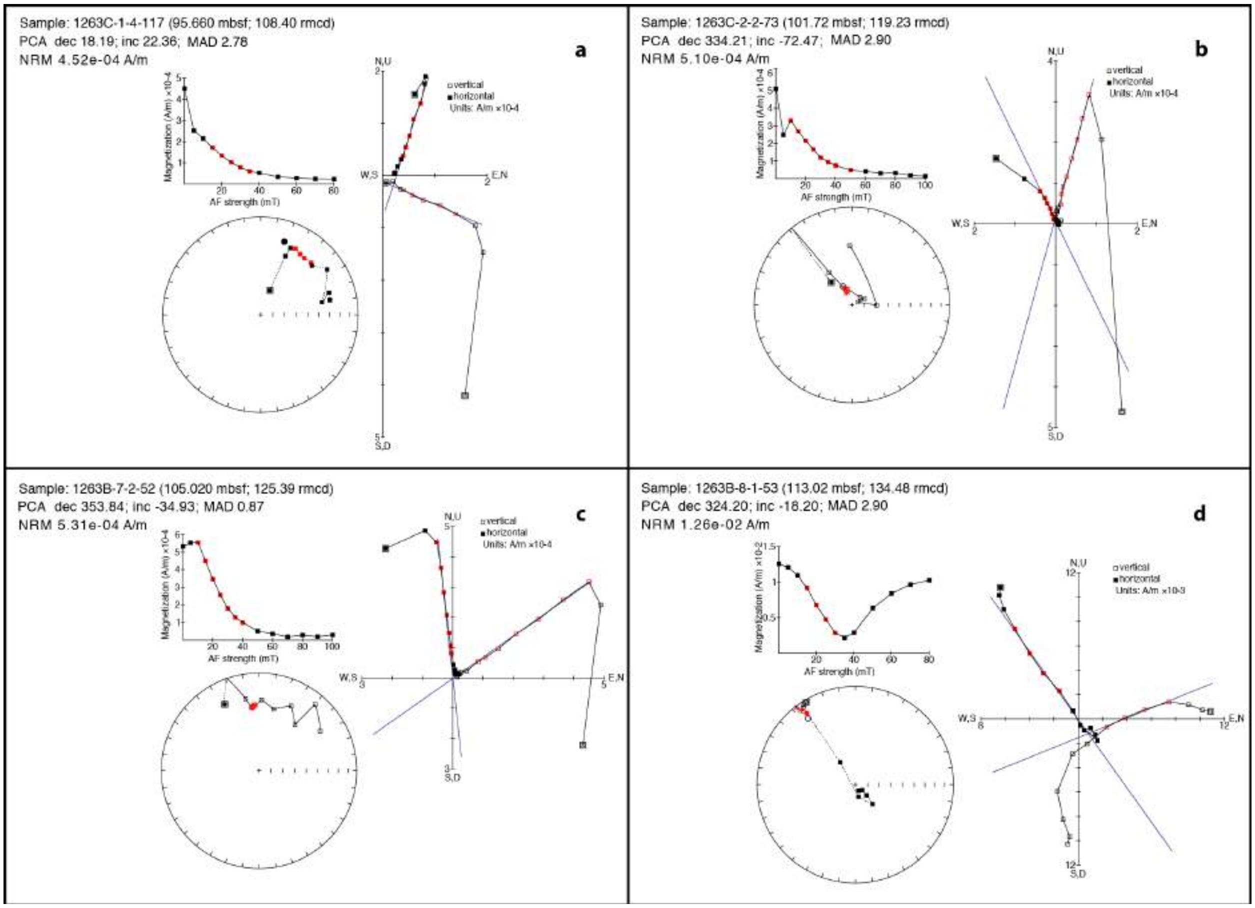


Fig. S7.

AF demagnetization behavior for representative samples from Hole 1263 B and C. For the vector component diagrams, open (closed) symbols represent projections onto the vertical (horizontal) plane. The blue lines represent linear regression fits that indicate the ChRM direction for each sample. The stereo plots are equal-area stereographic projections, with solid (open) symbols representing points projected onto the lower (upper) hemisphere. Plots were produced using PuffinPlot (*61*).

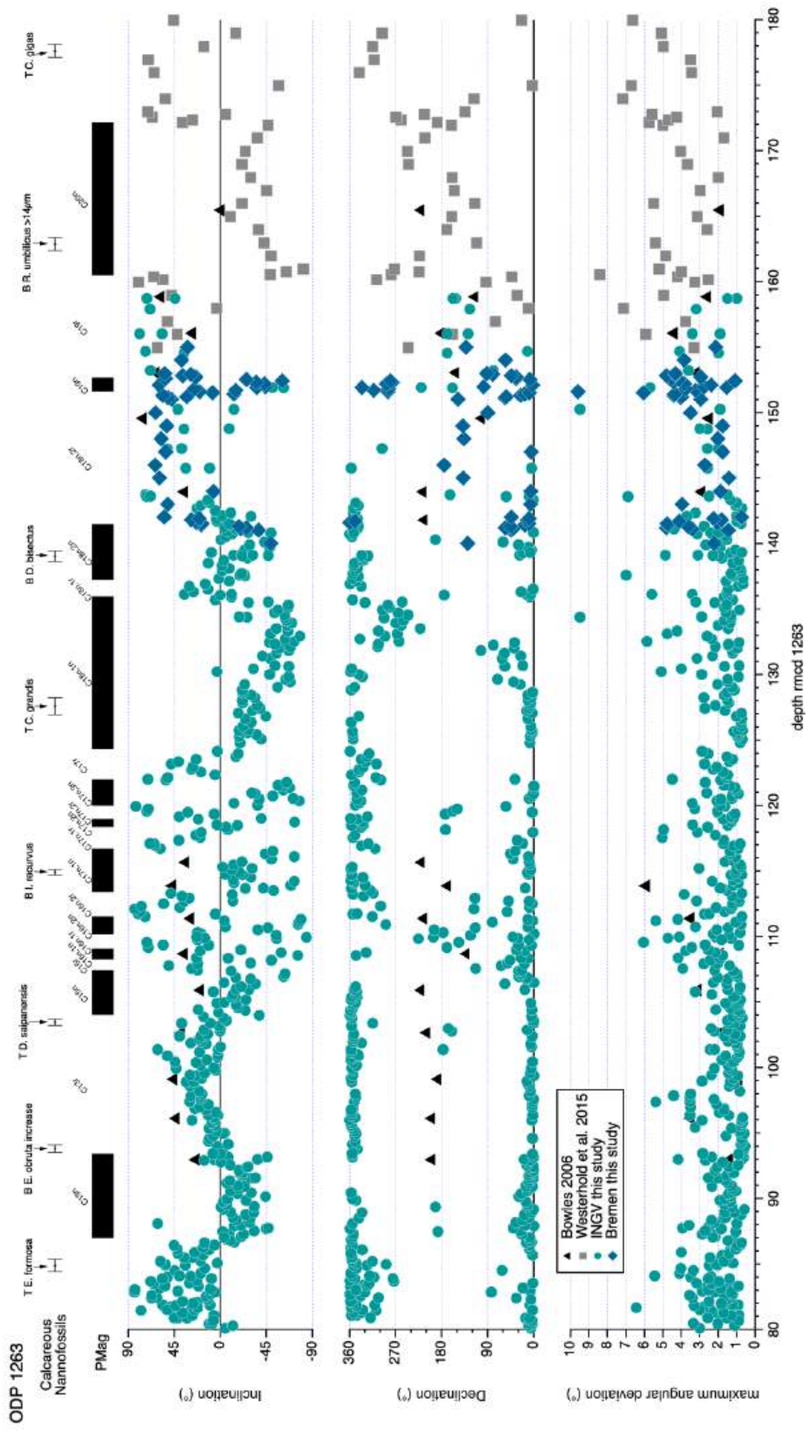


Fig. S8.
Overview of characteristic remanent magnetization results and data versus depth at Site 1263. Maximum angular deviation (MAD), declination and inclination results of discrete samples as well as the final magnetostratigraphic interpretation applying calcareous nannofossil datums.

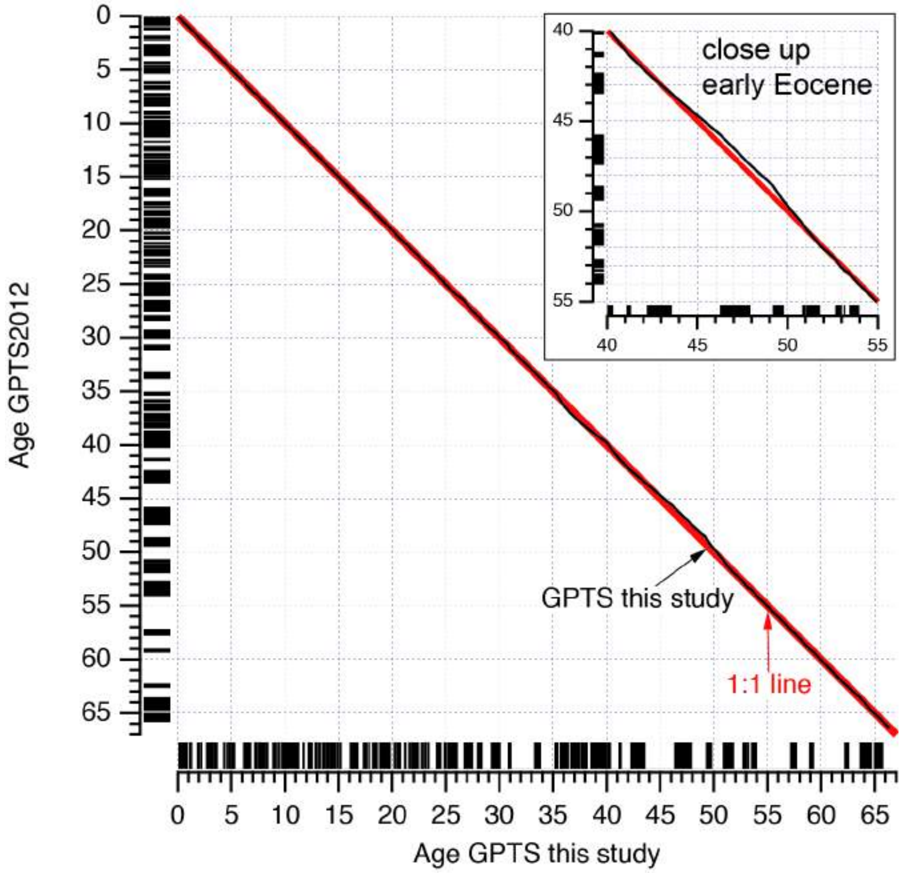


Fig. S9.
Comparison of magnetochron boundary ages between GPTS2012 (*62*) and astronomically tuned ages compiled from ocean drilling sediment cores (this study).

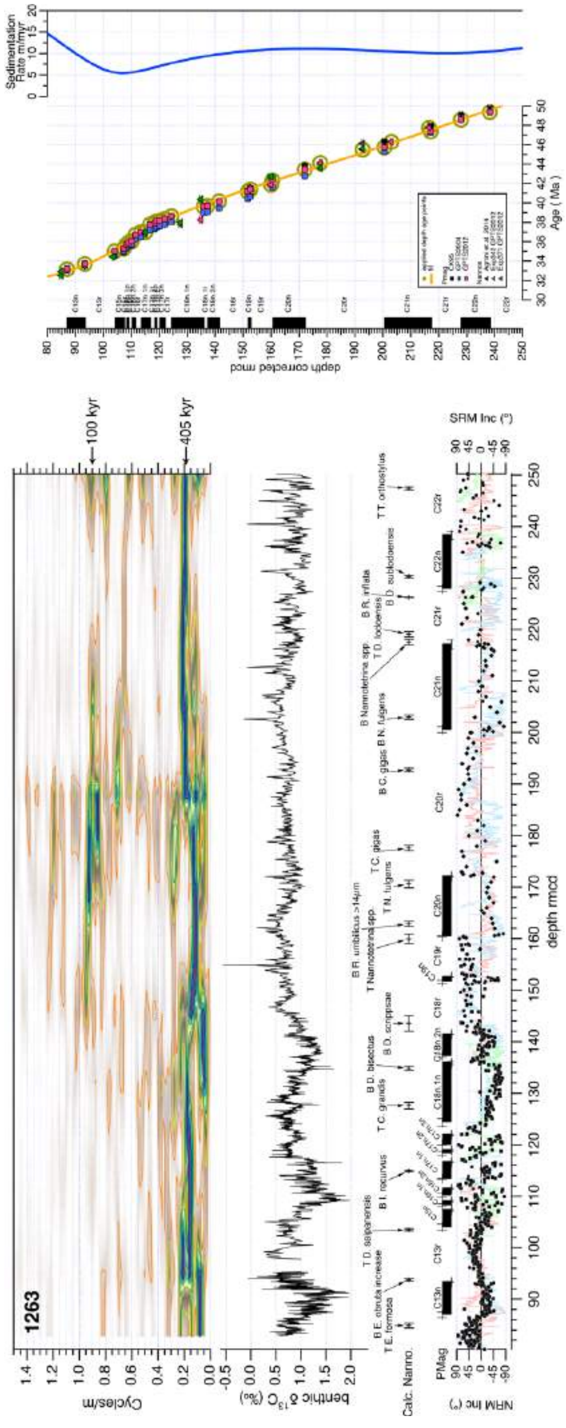
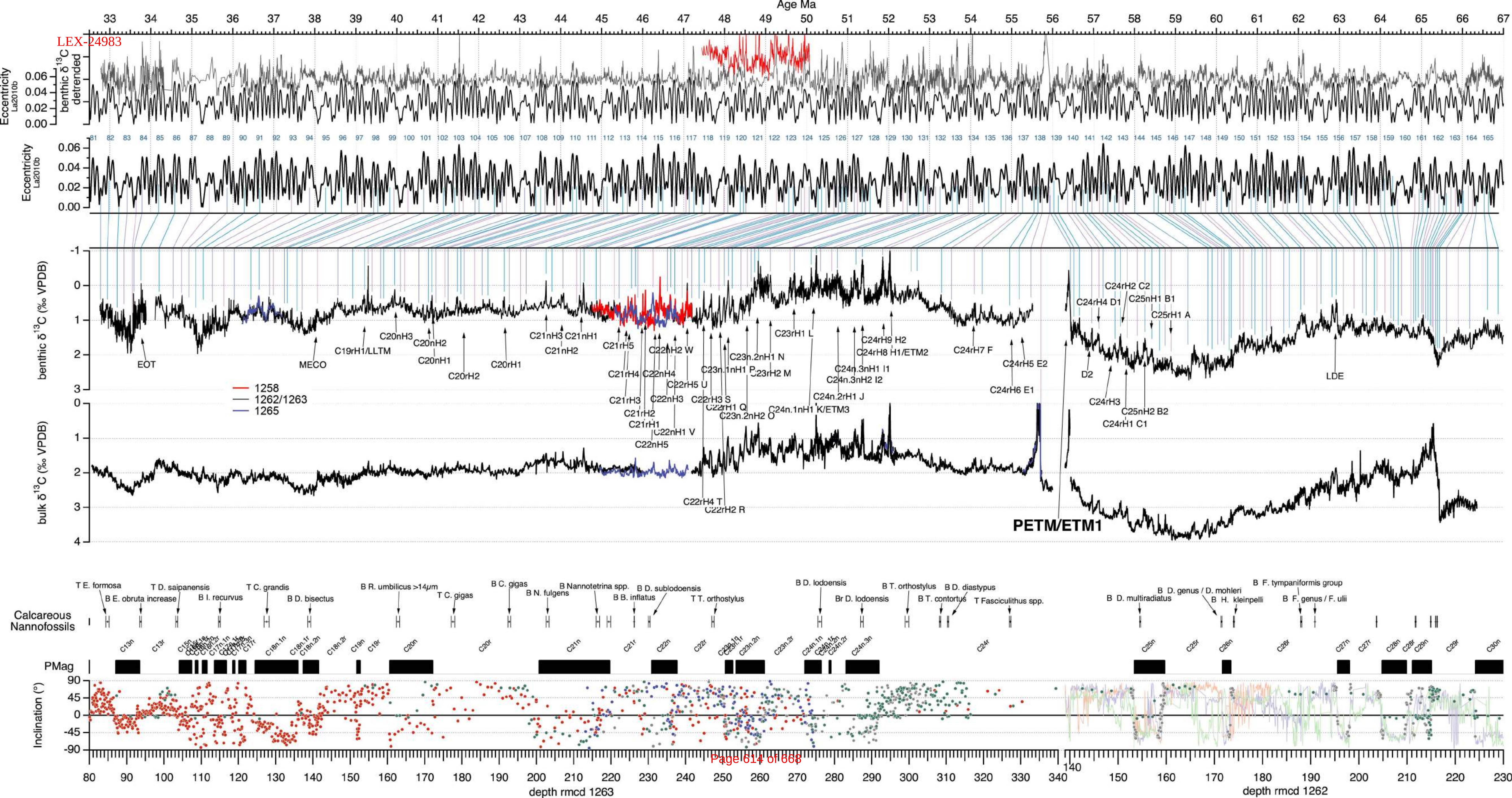


Fig. S10.

Spectral analysis of middle to late Eocene benthic foraminifer carbon isotope data plotted versus depth at Site 1263. Based on the calcareous nannofossil biostratigraphy and the magnetostratigraphy, sedimentation rates can be estimated showing that the dominant cycles with frequency of 0.2 cycles/meter (5 m-long cycles) are related to the 405 kyr eccentricity cycle. Shorter cycles in the order of 0.8 cycles/meter (1.25 m-long cycles) are related to short eccentricity.

Fig. S11. – oversized figure

Astronomical tuning of bulk and benthic foraminifer carbon isotope data from Sites 1258, 1262, 1263 and 1265 spanning the Paleocene and Eocene. For orientation, inclination data with magnetostratigraphic interpretation and calcareous nannofossil event datums are plotted along all available bulk and benthic carbon isotope data versus depth. The published age model for Sites 1262 (Tab. S28) and 1263 (Tab. S29) have been extended in this study from 32.7 to 41.9 Ma at Site 1263 to develop a complete astrochronology for the Paleocene and Eocene. Outstanding events (transitions, hyperthermals, boundaries) are indicated. Target for astronomical tuning was the numerical solution La2010b for eccentricity from (*14*). In the top panel the La2010b solution is plotted with the detrended carbon isotope data to document the good agreement between data and model with respect to the amplitude modulation of short eccentricity.



Age Ma
Eccentricity La2010b
benthic δ13C detrended
Eccentricity La2010b
benthic δ13C (‰ VPDB)
EOT
MECO
C19rH1/LLTM
C20nH3
C20nH2
C20nH1
C20rH2
C20rH1
C21nH3 C21nH1
C21nH2
C21rH5
C21rH4
C21rH3
C21rH2
C21rH1
C22nH4
C22nH3
C22nH5
C22nH2 W
C22nH1 V
C22rH5 U
C22rH3 S
C22rH1 Q
C22rH4 T
C22rH2 R
C23n.1nH1 P
C23n.2nH1 N
C23n.2nH2 O
C23rH2 M
C23rH1 L
C24n.1nH1 K/ETM3
C24n.2rH1 J
C24n.3nH1 I1
C24n.3nH2 I2
C24rH9 H2
C24rH8 H1/ETM2
C24rH7 F
C24rH5 E2
C24rH6 E1
C24rH4 D1
C24rH2 C2
C25nH1 B1
C25rH1 A
D2
C24rH3
C25nH2 B2
C24rH1 C1
LDE
PETM/ETM1
1258
1262/1263
1265
bulk δ13C (‰ VPDB)
T E. formosa
B E. obruta increase
T D. saipanensis
B I. recurvus
T C. grandis
B D. bisectus
B R. umbilicus >14µm
T C. gigas
B C. gigas
B N. fulgens
B Nannotetrina spp.
B B. inflatus
B D. sublodoensis
T T. orthostylus
B D. lodoensis
Br D. lodoensis
B T. orthostylus
B T. contortus
B D. diastypus
T Fasciculithus spp.
B D. multiradiatus
B D. genus / D. mohleri
B H. kleinpelli
B F. tympaniformis group
B F. genus / F. ulii
Calcareous Nannofossils
PMag
C13n
C13r
C15n
C18n.1n
C18n.1r
C18n.2n
C18n.2r
C19n
C19r
C20n
C20r
C21n
C21r
C22n
C22r
C23n.2n
C23n.2r
C24n.1n
C24n.3n
C24r
C25n
C25r
C26n
C26r
C27n
C27r
C28n
C28r
C29n
C29r
C30n
Inclination (°)
depth rmcd 1263
depth rmcd 1262

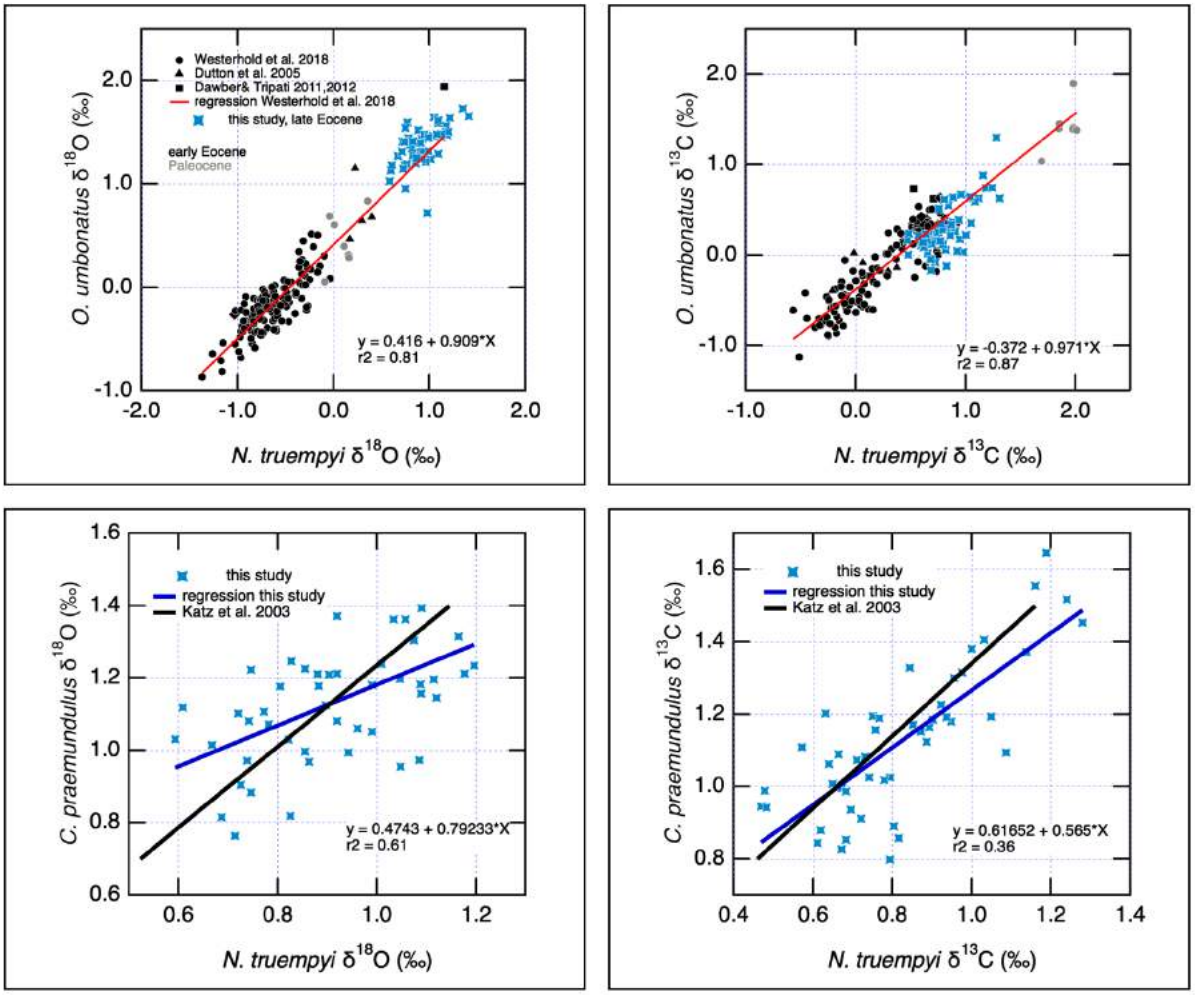


Fig. S12.

Paired isotope analysis of benthic foraminifers *N. truempyi*, *O. umbonatus*, and *C. praemundulus* for (left) $\delta^{18}O$ and (right) $\delta^{13}C$. Paleocene, gray; Eocene, black; Eocene this study in dark red. The light red linear regression line for $\delta^{18}O$ and $\delta^{13}C$ paired analysis of *N. truempyi*, and *O. umbonatus* (*16*) include data from (*16, 147-149*) to establish the isotopic adjustment (i.e., correction) factor for benthic foraminifers from Site 1209. The 1263 data from our study of the late Eocene fall on the established regression line from Site 1209. $\delta^{18}O$ and $\delta^{13}C$ paired analysis of *N. truempyi* and *C. praemundulus* provide a regression line to adjust between the species. See Tab. S2 for details on correction factors used in this study.

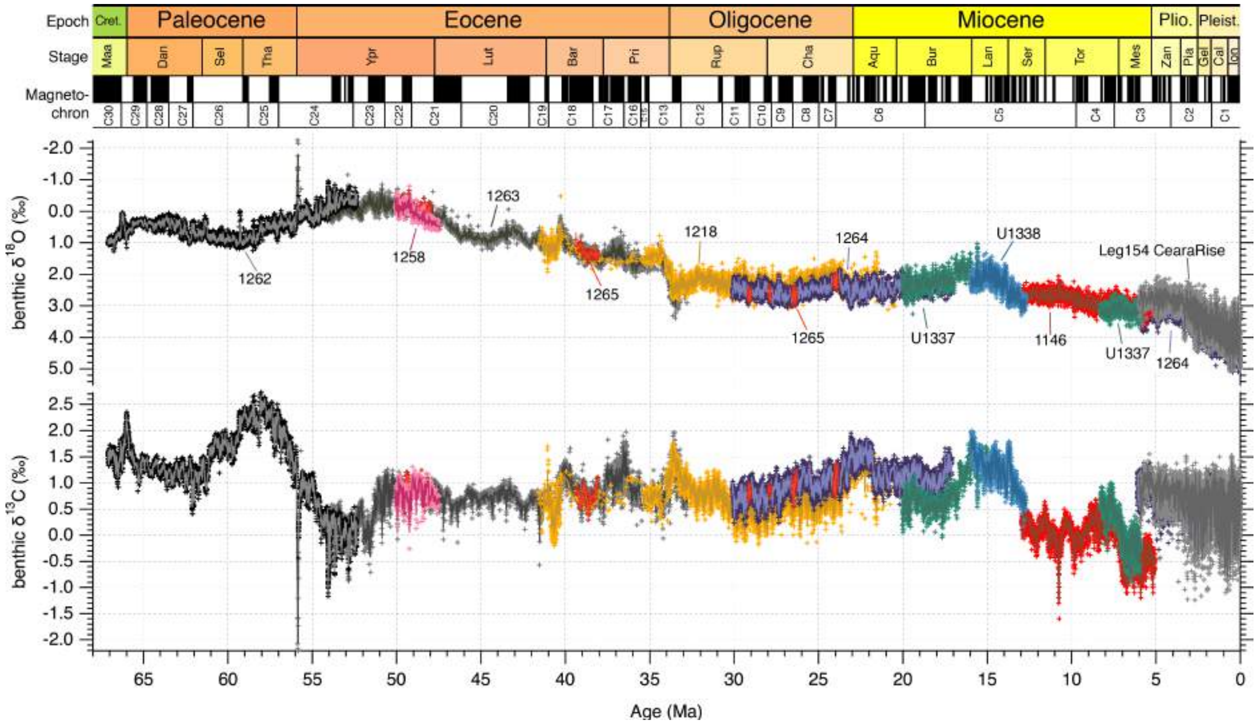


Fig. S13.
Complete benthic foraminifer stable carbon and oxygen isotope records and 10-point LOESS smooth on astrochronology used for building the Cenozoic reference splice.

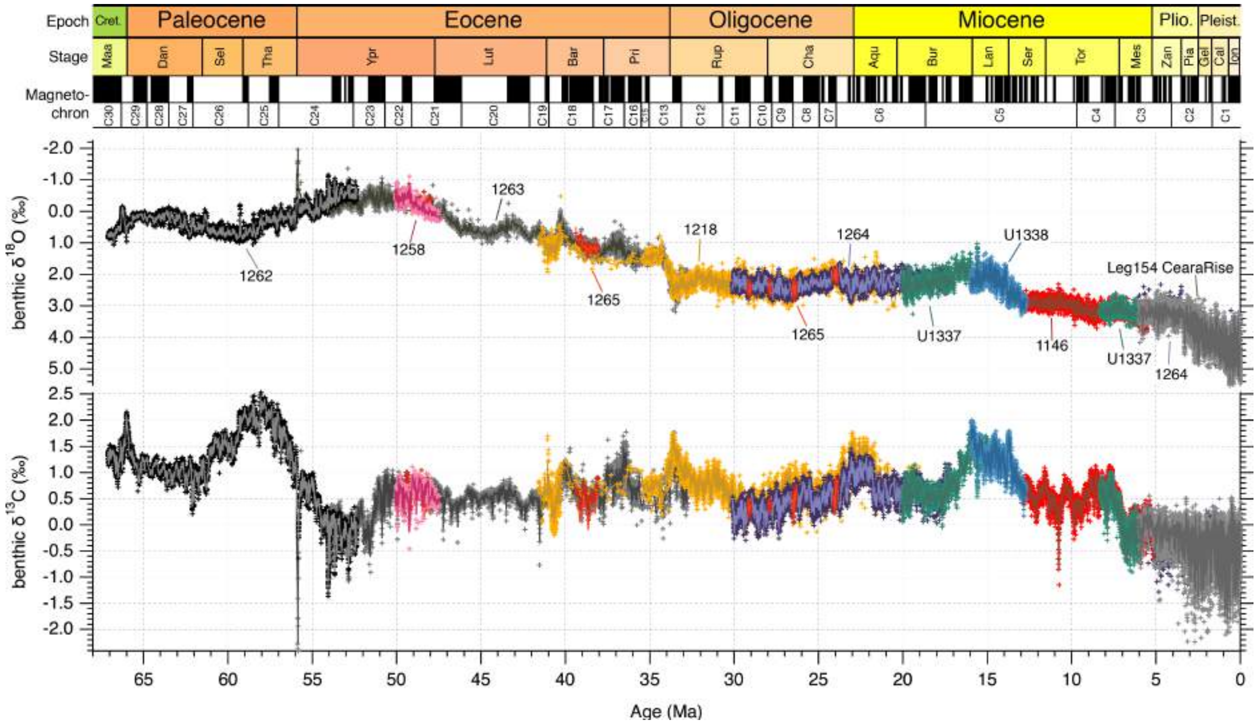


Fig. S14.

Benthic foraminifer stable carbon and oxygen isotope records and 10-point LOESS smooth on an astrochronological timescale used to build the Cenozoic reference splice. $\delta^{18}O$ and $\delta^{13}C$ values of the records are offset as given in Tab. S4 to get rid of interbasin offsets to form a continuous record without offsets due to switches between different records.

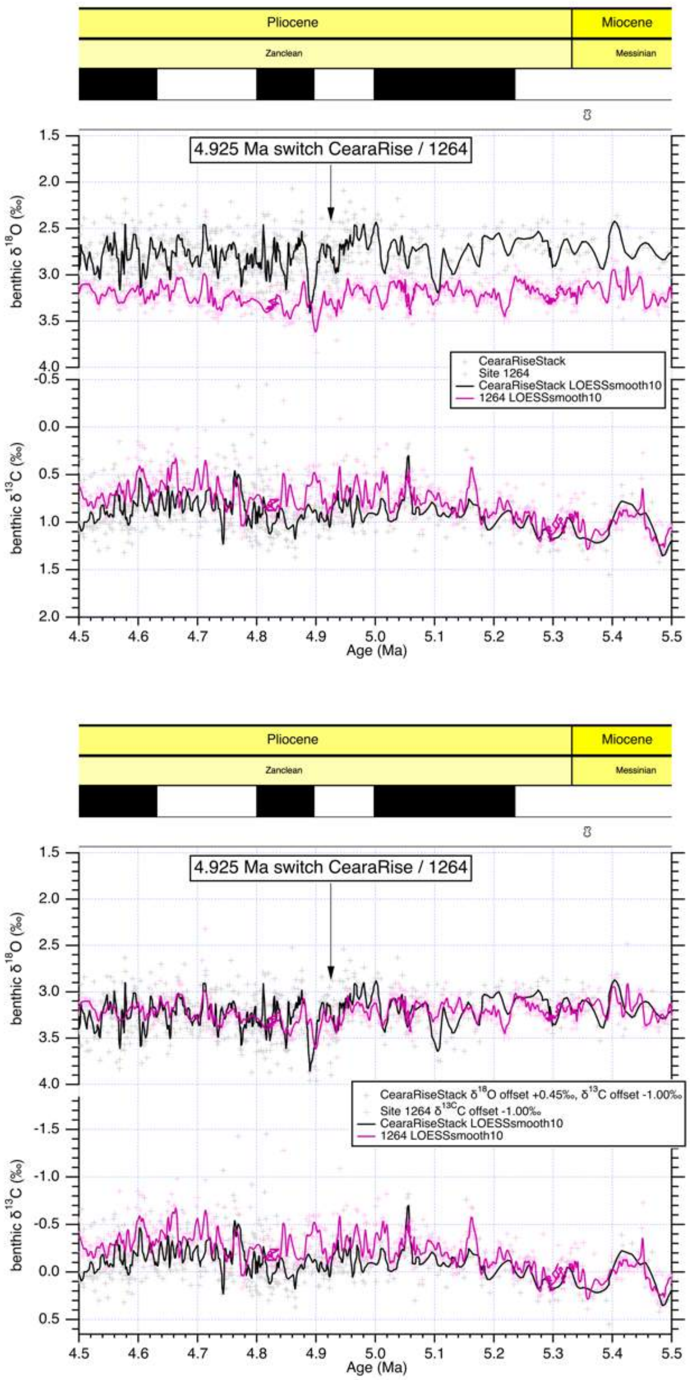
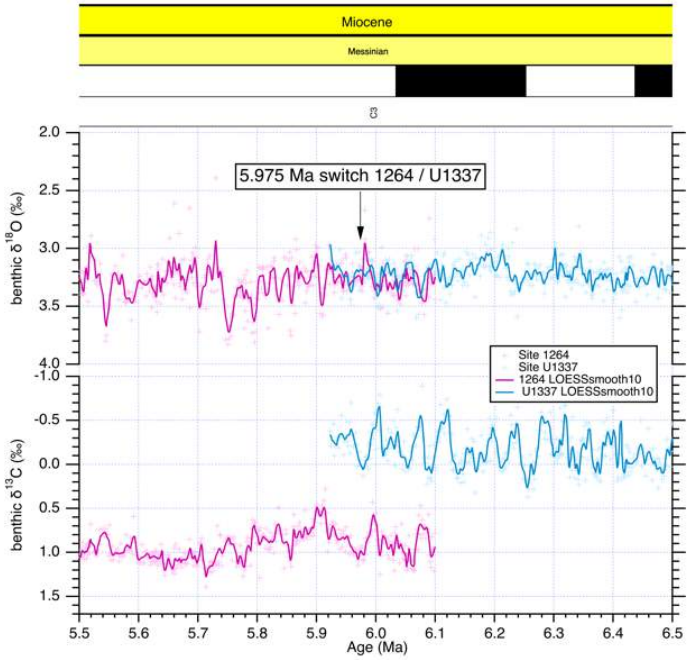


Fig. S15.

Switch at 4.925 Ma from Ceara Rise Stack to Site 1264. Top: benthic $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Ceara Rise and Site 1264 spanning 4.5 to 5.5 Ma across reference record switch at 4.925 Ma.



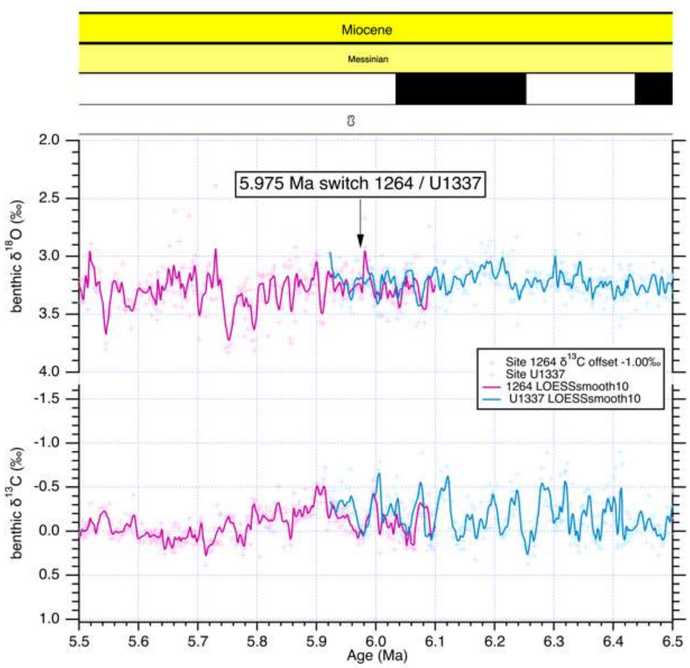


Fig. S16.

Switch at 5.975 Ma from Site 1264 to Site U1337. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Site 1264 and Site U1337 spanning 5.5 to 6.5 Ma across reference record switch at 5.975 Ma.

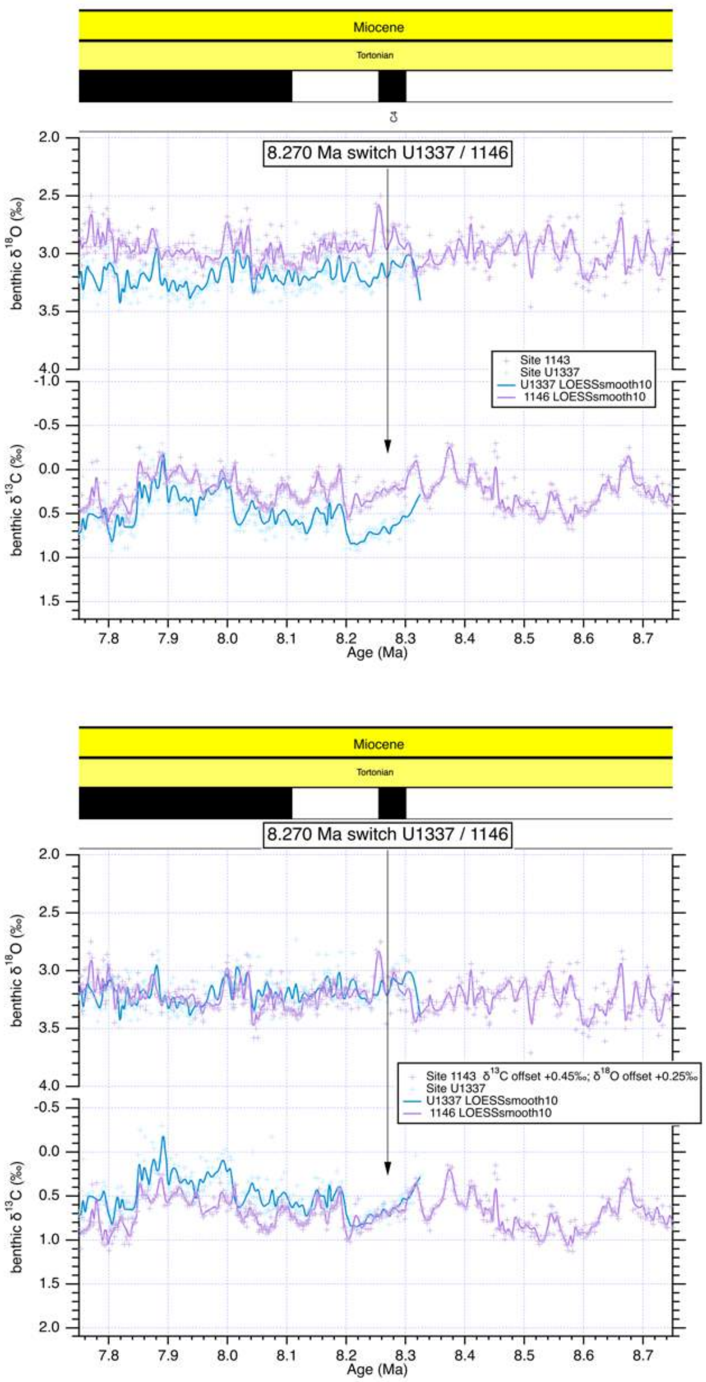


Fig. S17.

Switch at 8.270 Ma from Site U1337 to Site 1146. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Site U1337 and Site 1146 spanning 7.75 to 8.75 Ma across reference record switch at 8.270 Ma.

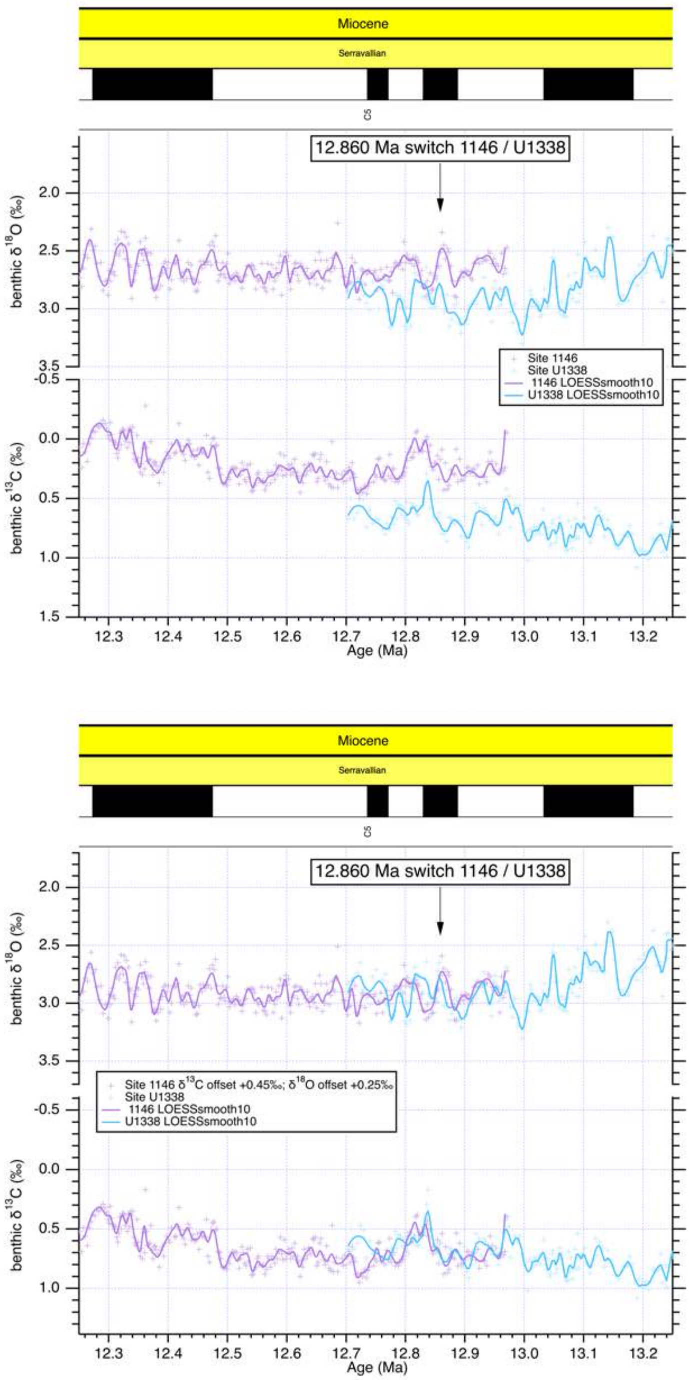


Fig. S18.

Switch at 12.860 Ma from Site 1146 to Site U1338. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Site 1146 to Site U1338 spanning 12.25 to 13.25 Ma across reference record switch at 12.860 Ma.

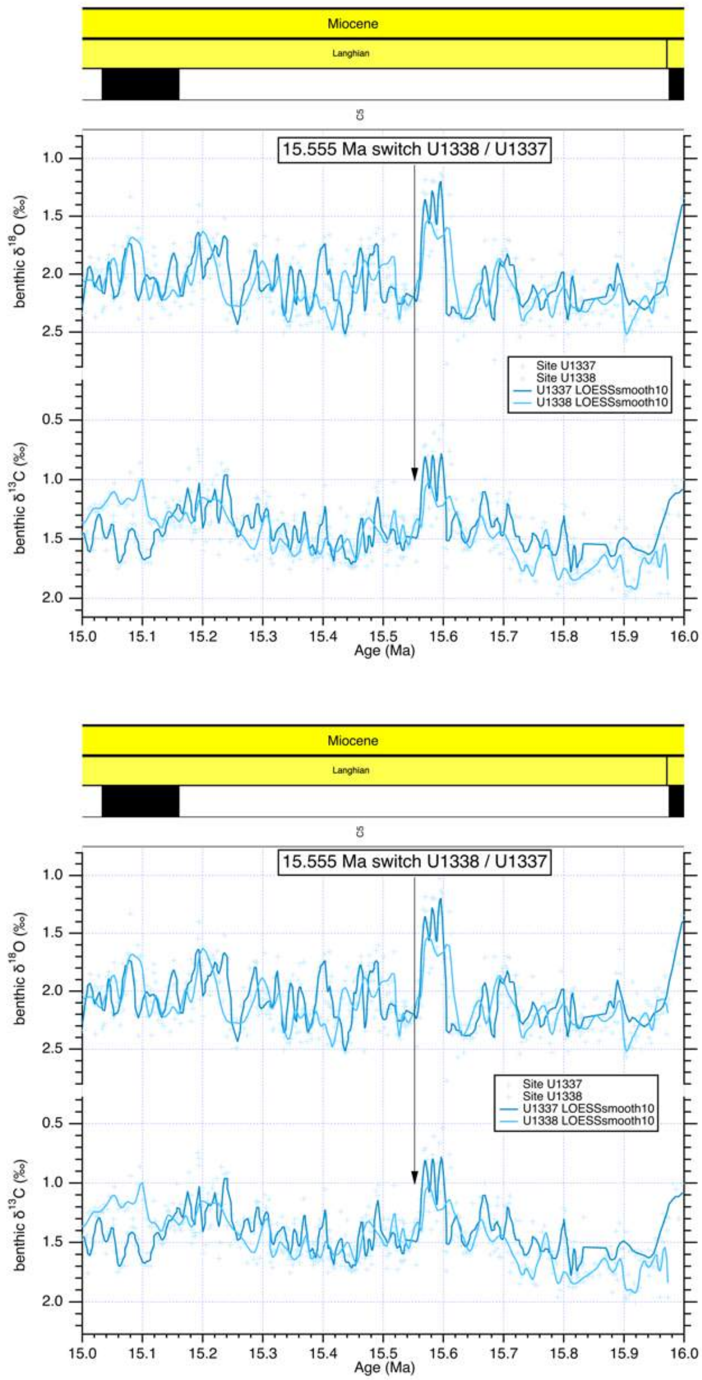


Fig. S19.

Switch at 15.555 Ma from Site U1338 to Site U1337. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Site U1338 to Site U1337 spanning 15.00 to 16.00 Ma across reference record switch at 15.555 Ma.

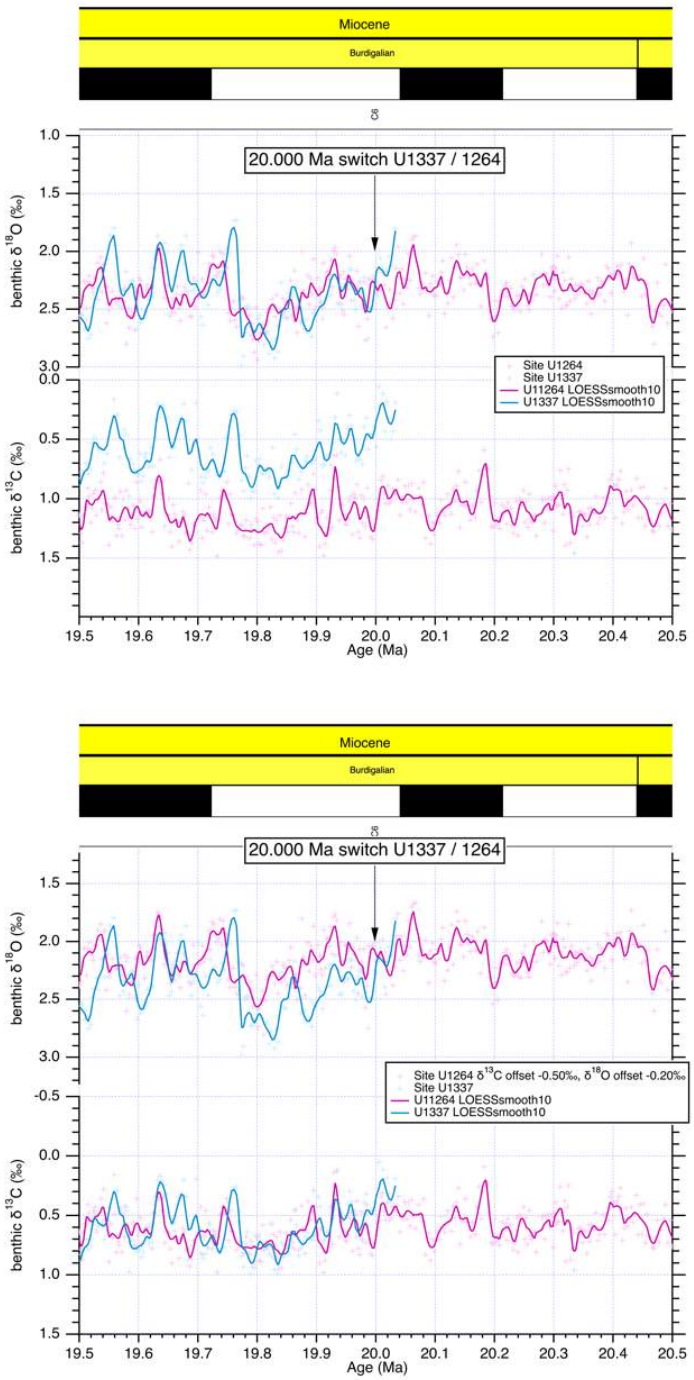


Fig. S20.

Switch at 20.000 Ma from Site U1337 to Sites 1264/1265. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Site U1337 to Sites 1264/65 spanning 19.50 to 20.50 Ma across reference record switch at 20.000 Ma.

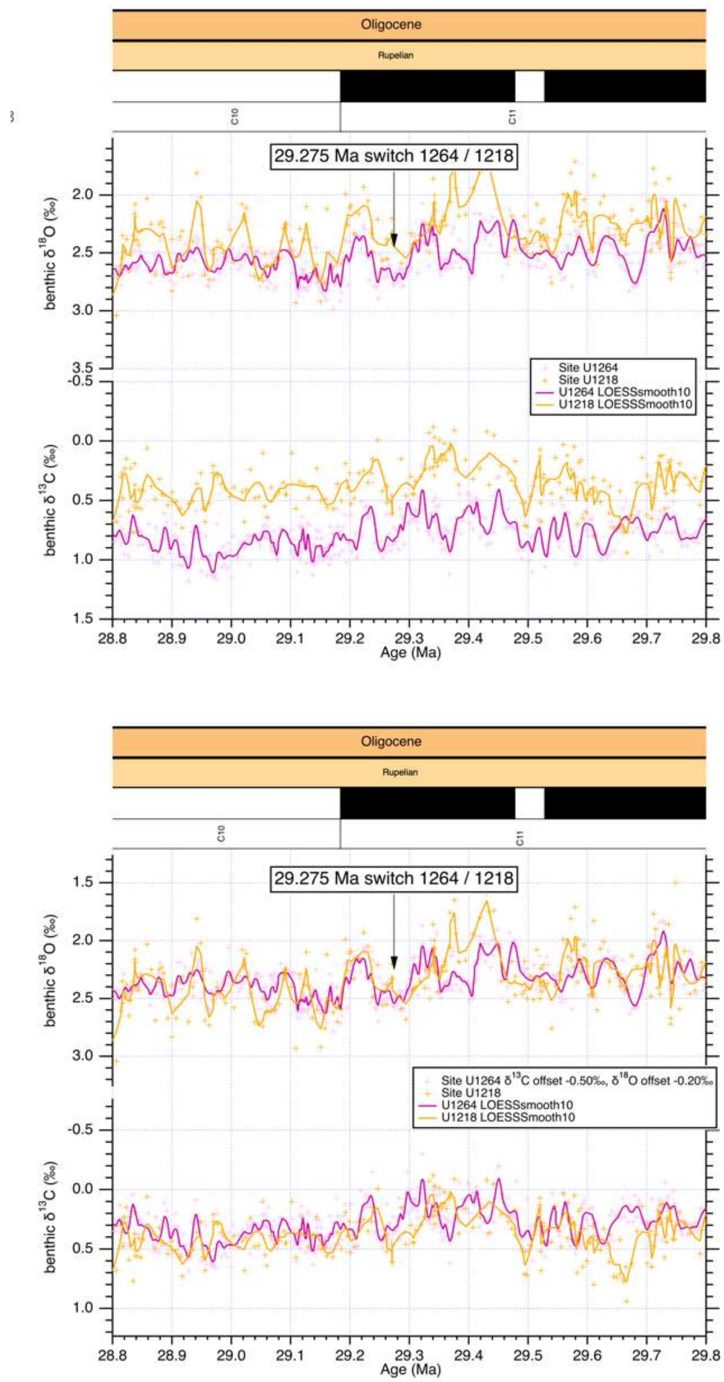


Fig. S21.

Switch at 29.275 Ma from Sites 1264/1265 to Site 1218. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Sites 1264/65 to Site 1218 spanning 28.80 to 29.80 Ma across reference record switch at 29.275 Ma.

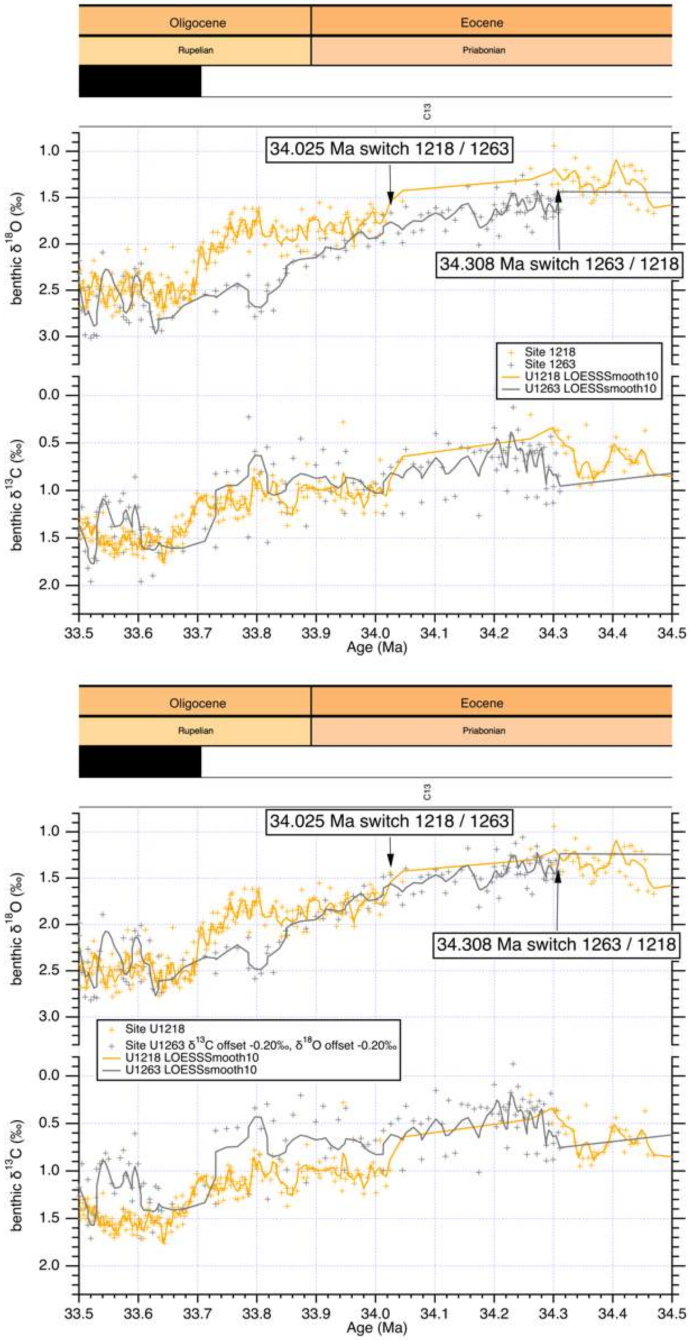


Fig. S22.

Switch at 34.025 Ma from Site 1218 to Site 1263 and back at 34.308 Ma. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for Site 1218 to Site 1263 and back spanning 33.50 to 34.50 Ma across reference record switch at 34.025 and 34.308 Ma.

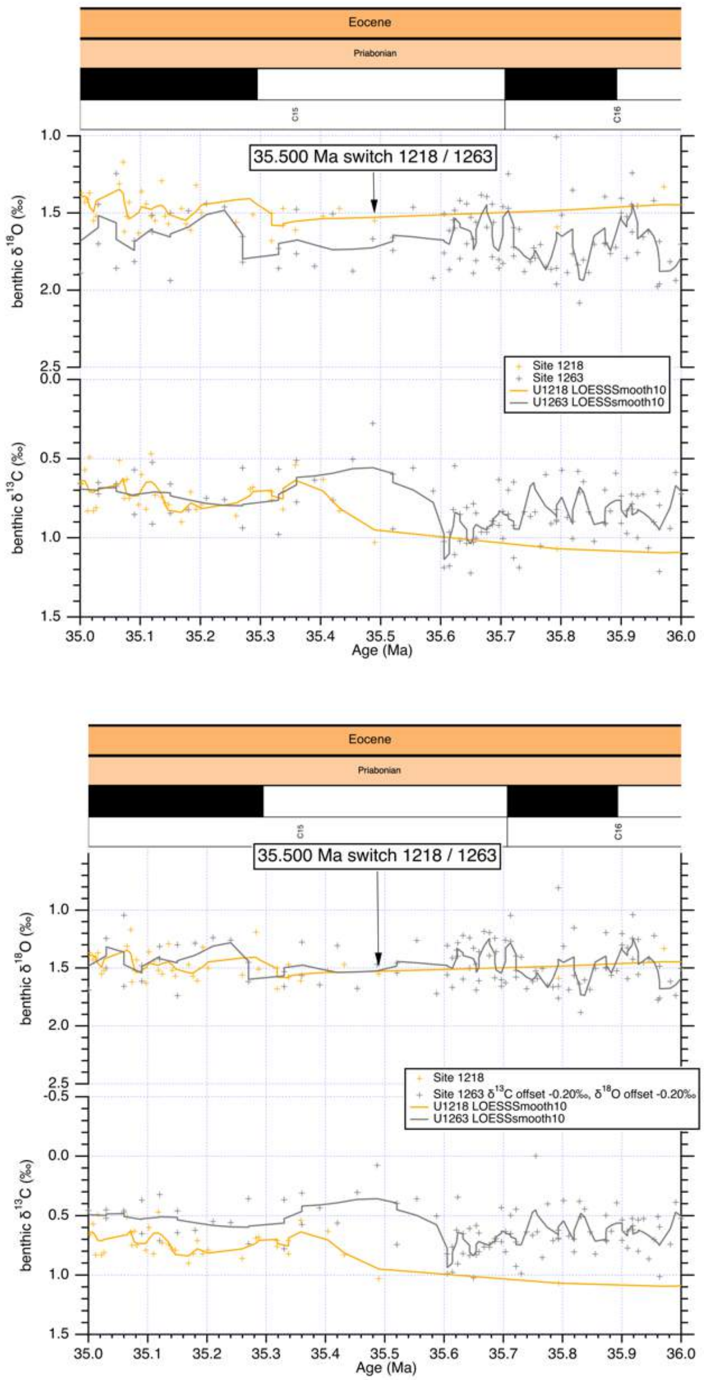


Fig. S23.

Switch at 35.500 Ma from Site 1218 to Site 1263. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for 1218 to 1263 spanning 35.00 to 36.00 Ma across reference record switch at 35.500 Ma.

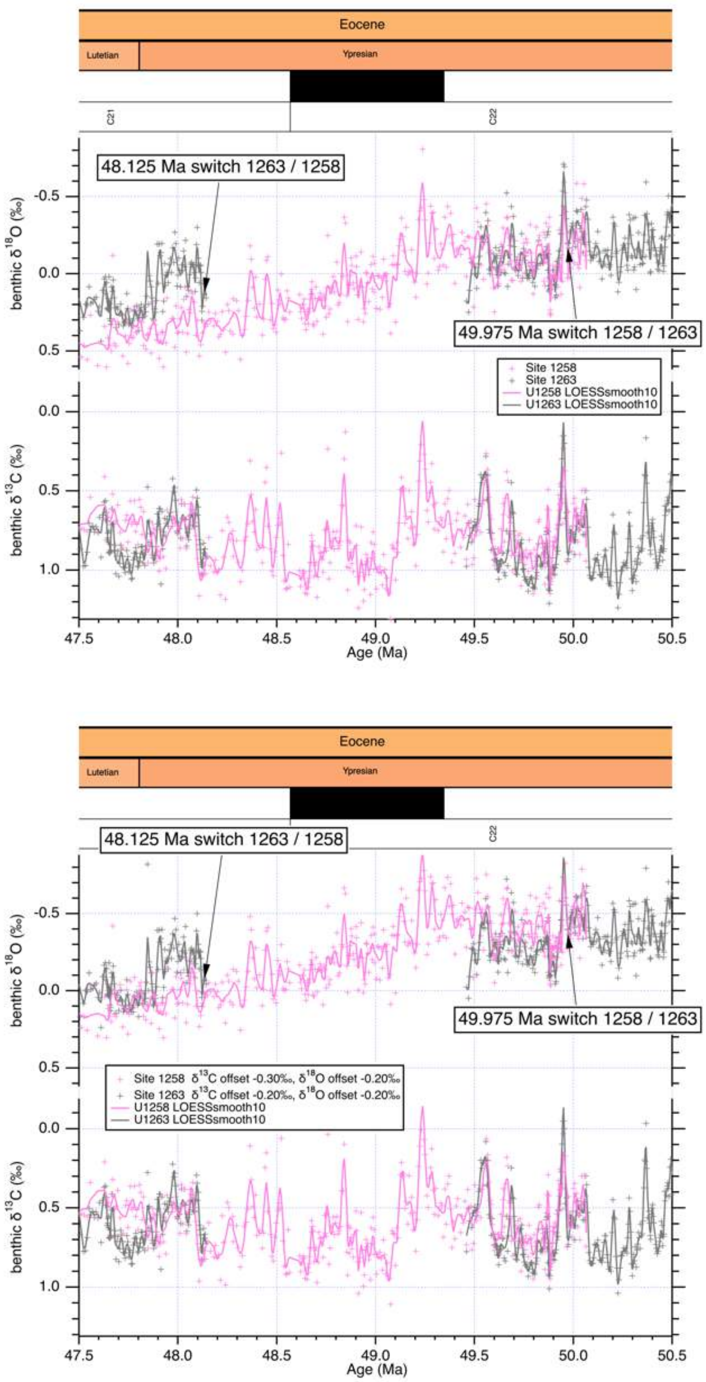


Fig. S24.

Switch at 48.125 Ma from Site 1263 to Site 1258 and back to Site 1263 at 49.975 Ma. Top: benthic foraminifer $\delta^{13}C$ and $\delta^{18}O$ raw data. Bottom: benthic data with offset for 1263 to 1258 and back to 1263 spanning 47.50 to 50.50 Ma across reference record switches at 48.125 Ma and 49.975 Ma.

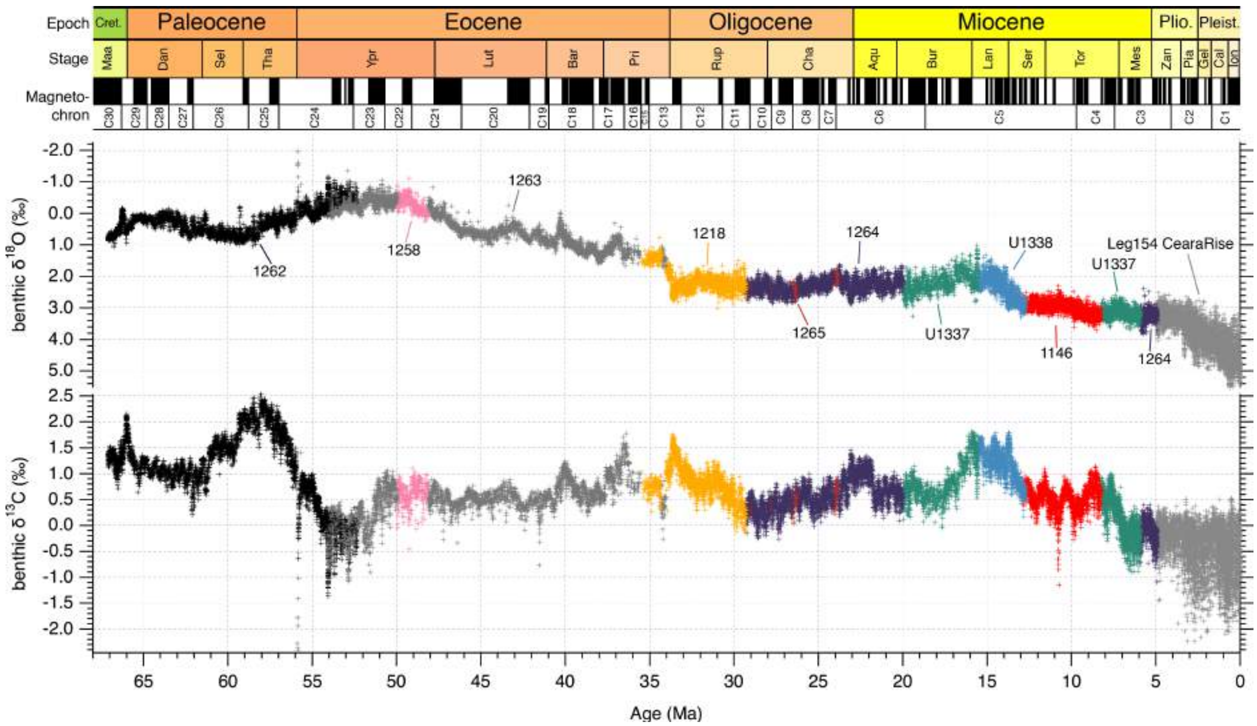


Fig. S25.
Combined astronomically-tuned benthic foraminifer stable carbon and oxygen isotope records forming the Cenozoic reference splice.

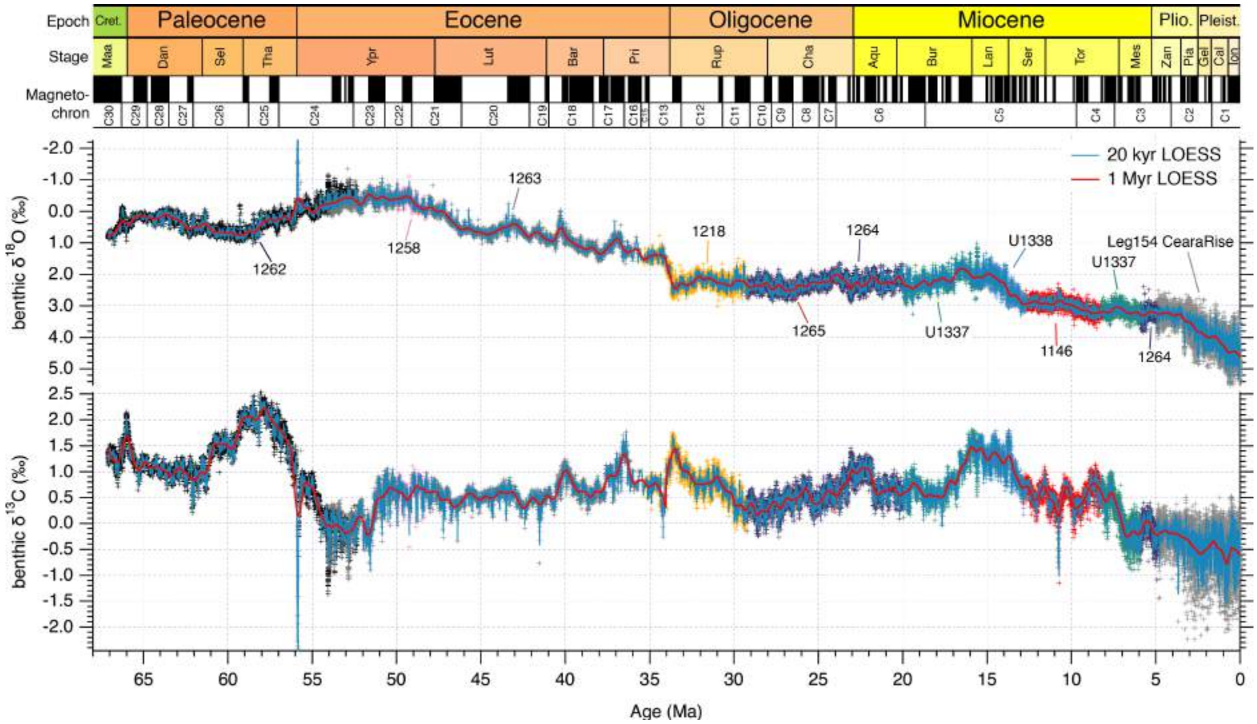


Fig. S26.
Short- and long-term LOESS smooth of the astronomically-tuned combined benthic foraminifer stable carbon and oxygen isotope records forming the Cenozoic global reference benthic carbon and oxygen isotope dataset (CENOGRID).

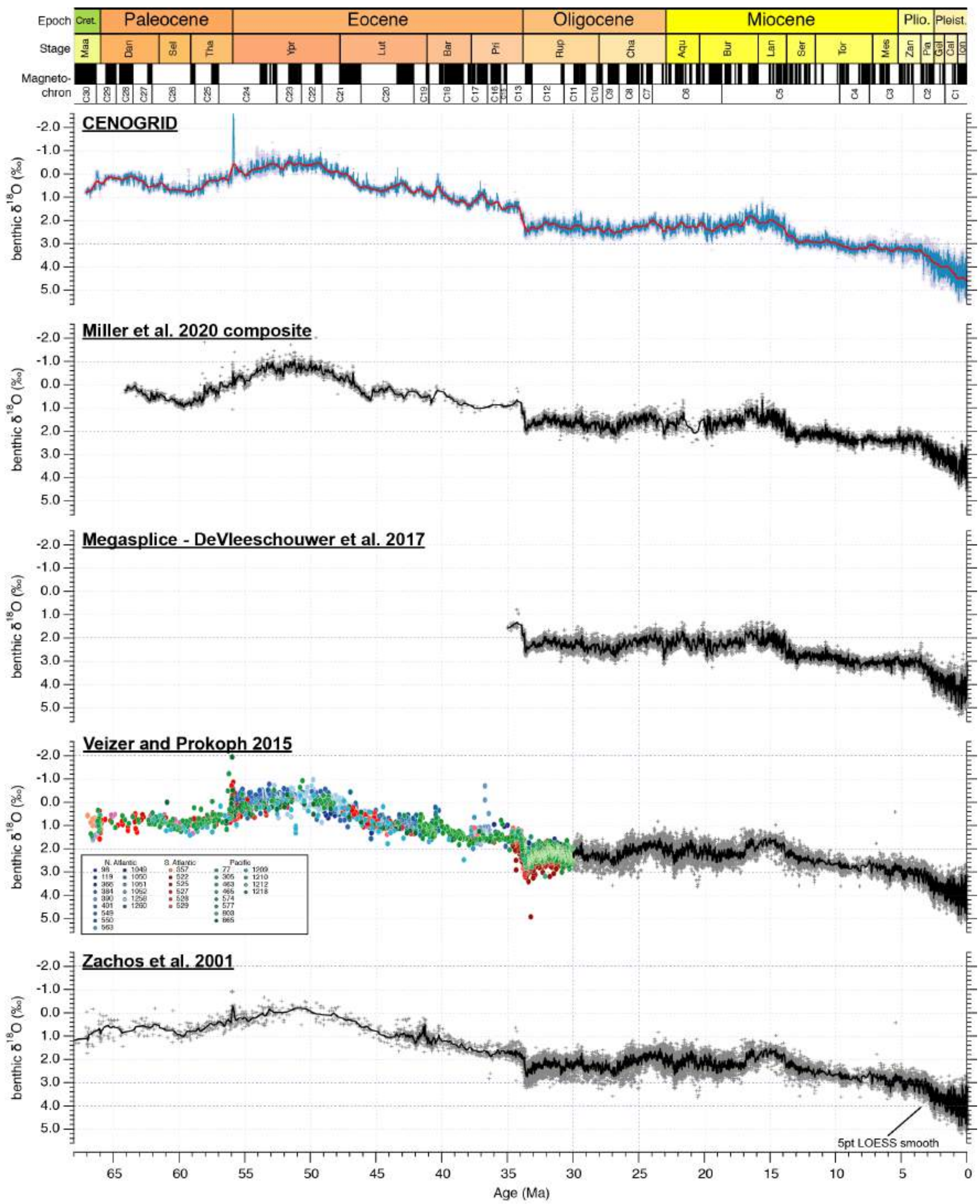


Fig. S27.
Benthic foraminifer stable oxygen isotope compilations from (*8*) and (*1*) as well as the Megasplice of (*5*) and the recent composite of (*10*) compared to the new composite Cenozoic reference global benthic carbon and oxygen isotope dataset (CENOGRID). Note the low resolution in the Paleocene and Eocene for the previous compilations.

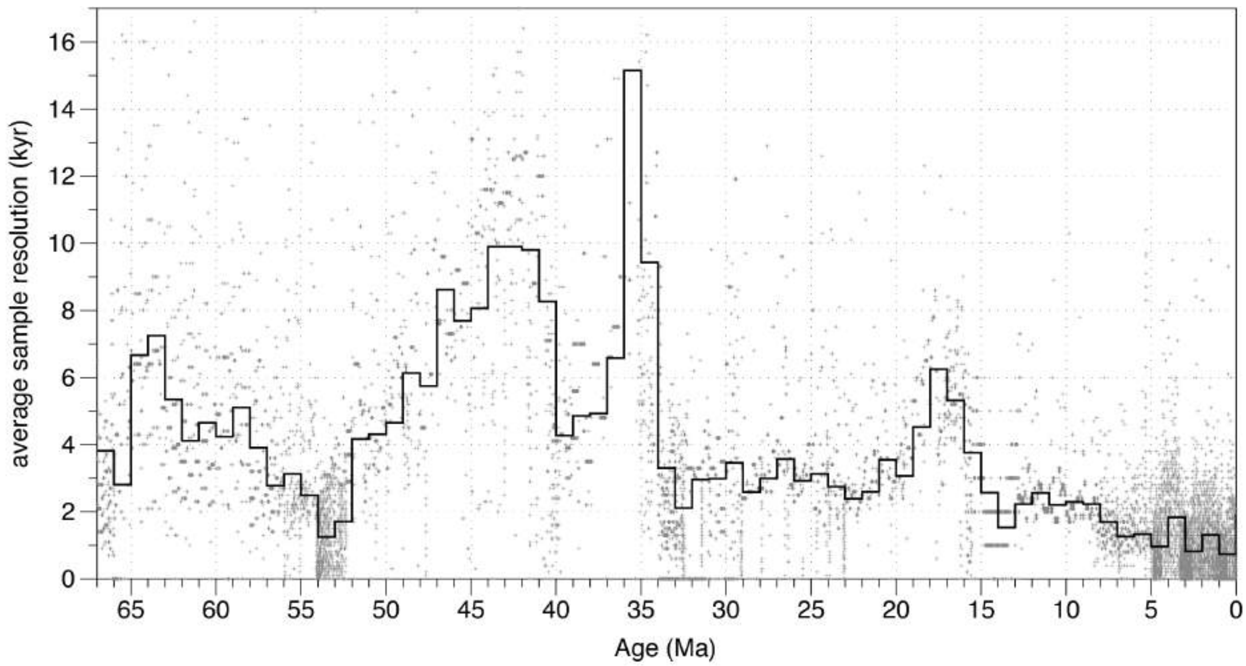


Fig. S28.
Average sample resolution over one million year intervals for the CENOGRID benthic stable isotope data.

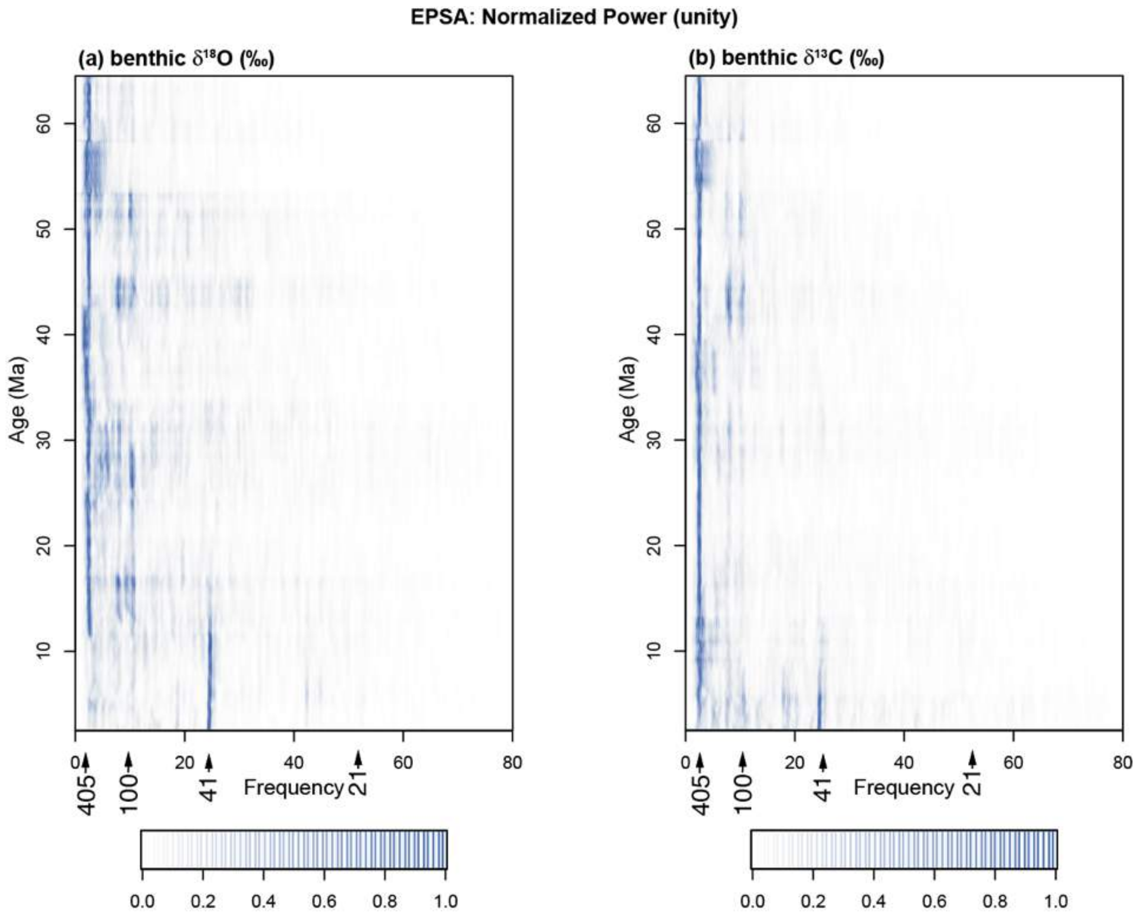


Fig. S29.
Evolutive Power Spectral Analysis (EPSA) on the short-term LOESS smooth of the astronomically-tuned CENOGRID using ASTROCHRON (*150*). The EPSA documents, as in Fig. 2, the dominance of the 405 kyr and ~100 kyr eccentricity cycles from 67 to 13.9 Ma. After 13.9 Ma enhanced obliquity related cyclicity appears first in the oxygen isotope record. In the carbon isotope data obliquity becomes more dominant around 7.7 million years ago. Isotope data have been detrended by the long-term LOESS smooth trend and evenly samples every 2 kyr. The following code was used to compute the spectra in ASTROCHRON:
eha(dat,tbw=2,65536,0,80,0.02,5,demean=T,detrend=T,siglevel=0.90,sigID=F,ydir=1,output=0, pl=2,palette=3,centerZero=T,ncolors=100,"Frequency","Location",genplot=4,verbose=T).

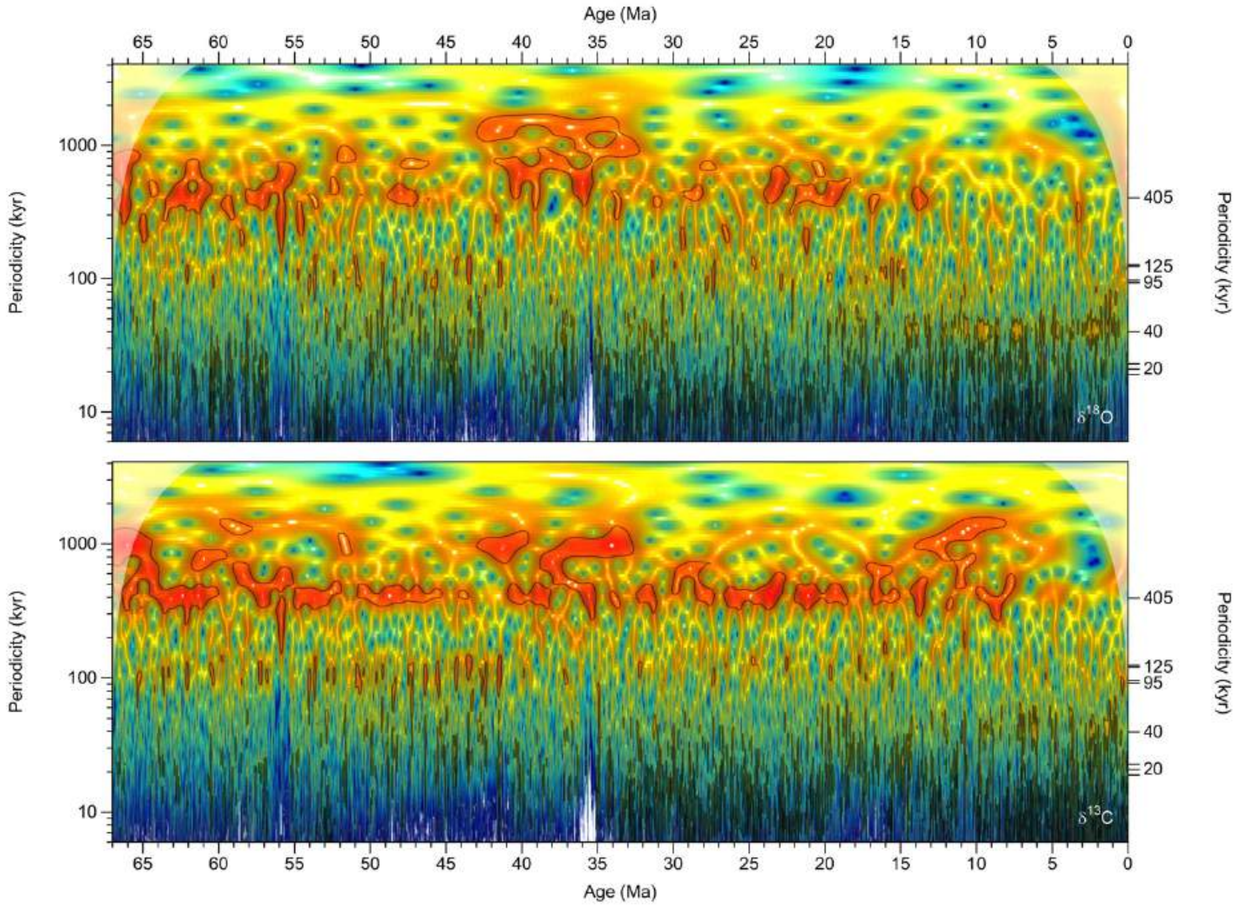


Fig. S30.

3D wavelets of the CENOGRID. Wavelet analysis of the Cenogrid $\delta^{18}O$ (top panel) and $\delta^{13}C$ (bottom panel), using a Morlet transform (*151,152*). Prior to wavelet analysis the records were resampled at 2.5 kyr resolution, detrended using a Notch filter (frequency = 0.0 Myr^{-1}, bandwidth = 1.0 Myr^{-1}) (*153*), and normalized using a 1-Myr sliding window. Gray lines indicate the 95% significance contours. Shaded areas indicate the cone of influence.

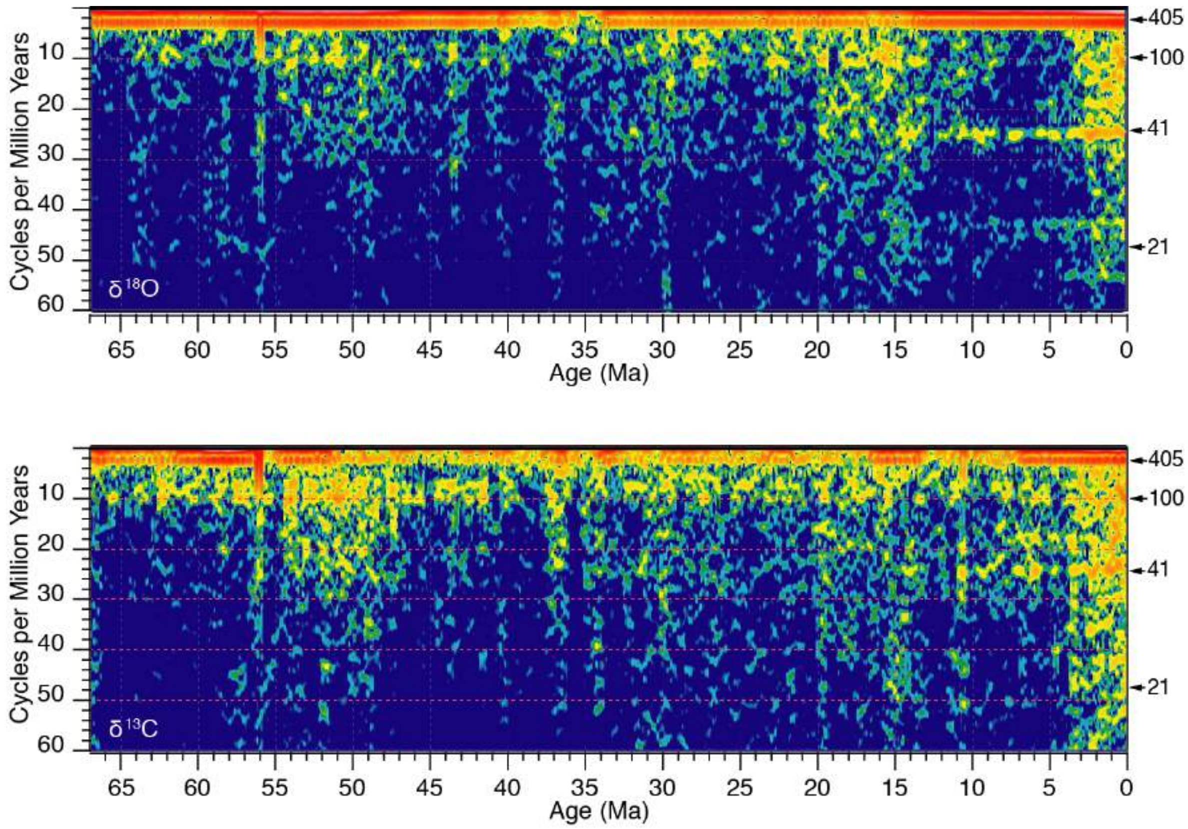


Fig. S31.
Evolutive spectra of CENOGRID computed using the Thomson Multi-taper method (*124*), with v.0.0.7 Spectrogram tool (https://paloz.marum.de/confluence/display/ESPUBLIC/Spectrogram). Data were interpolated to even time steps, and then computed with 700kyr windows stepped every 70kyr. MTM settings were bandwidth product: 3, number of tapers: 4. For the isotope data, the amplitudes are displayed on a logarithmic scale.

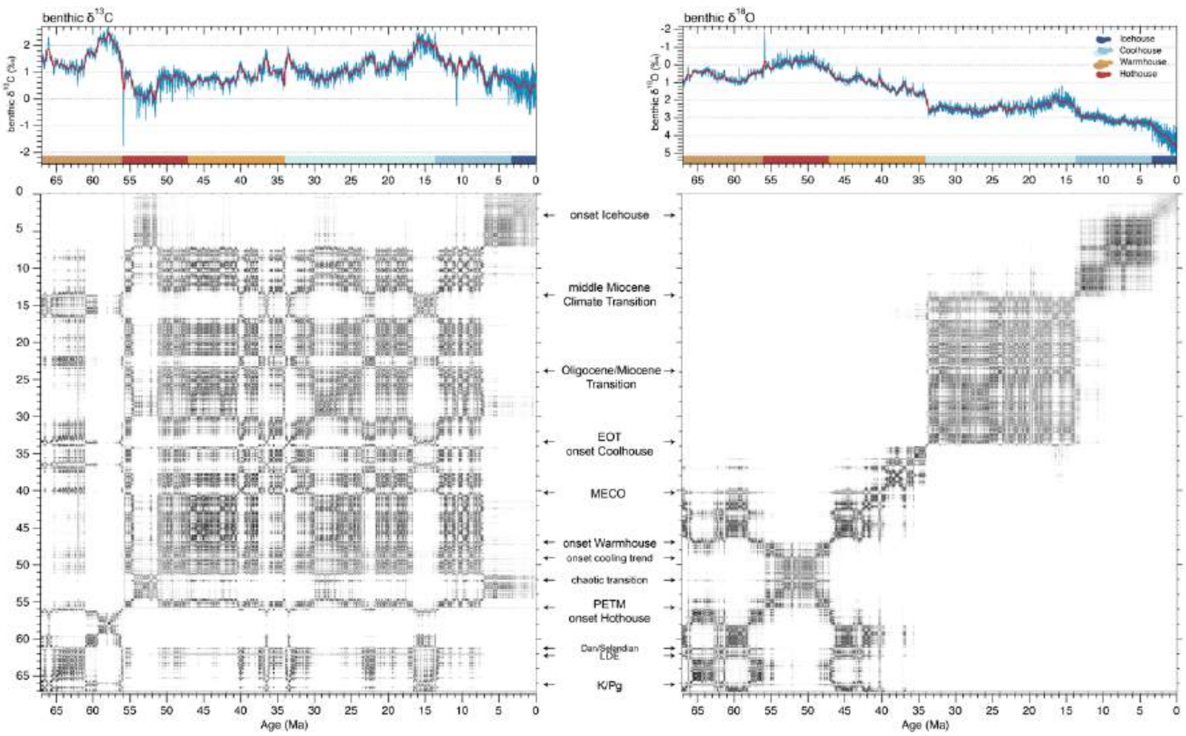


Fig. S32.

Recurrence Plot of undetrended benthic foraminifer carbon (left) and oxygen (right) isotope data versus age; important transitions and events given.

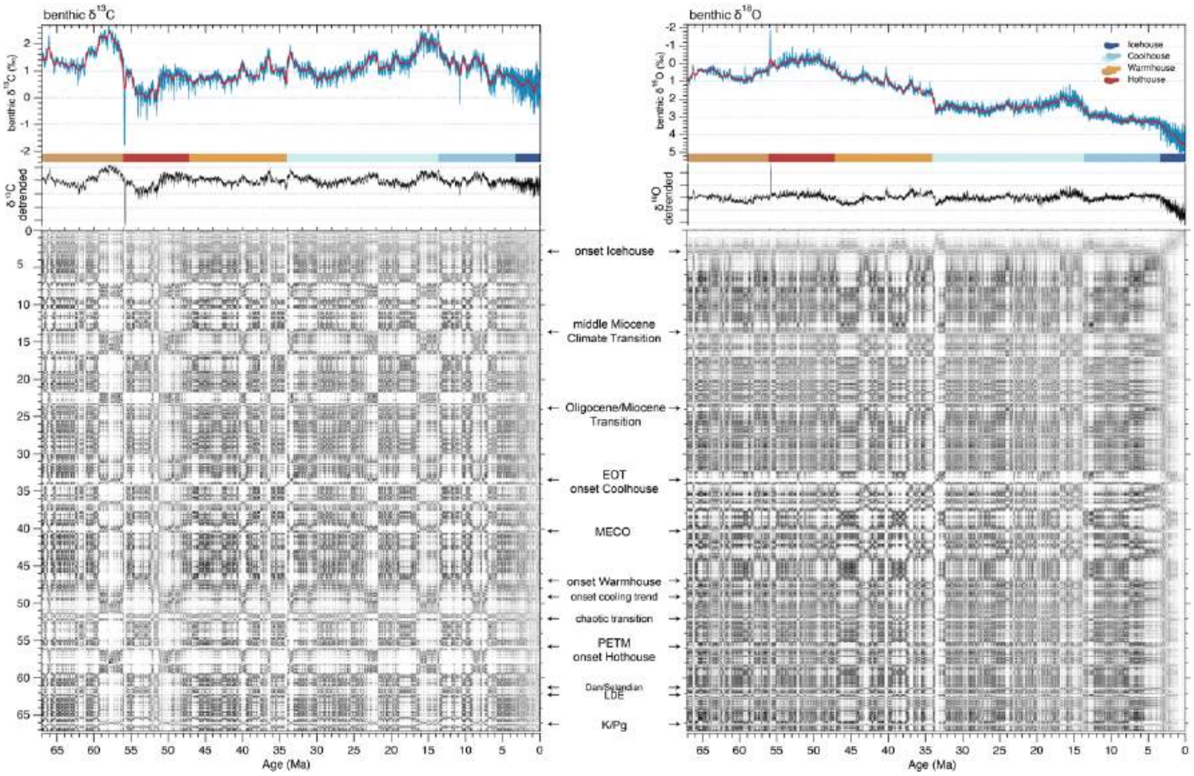


Fig. S33.
Recurrence Plot of detrended benthic foraminifer carbon (left) and oxygen (right) isotope data versus age; important transitions and events given. Note: transparent areas mark transition zones and events.

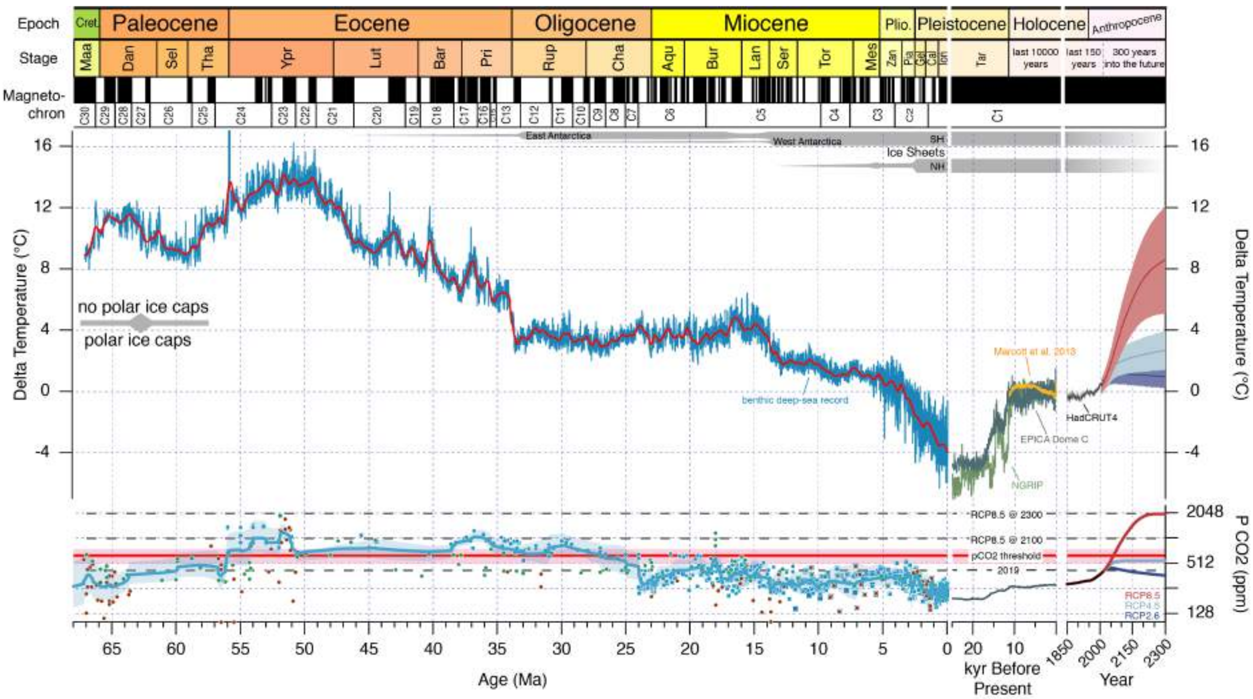


Fig. S34.

Past and future trends in global mean temperature and atmospheric CO_2. Deep-sea benthic foraminifer oxygen isotope values spanning the last 67 million years are a measure of global temperature and ice volume. Here the record was first converted to a deep-sea temperature and then projected to surface air temperature change (94). Temperature is relative to the 1961–1990 global mean, and plotted along with estimates for past atmospheric CO_2 levels (see *Section 6. and supplementary Text S1*). Temperature and CO_2 data from ice core records of the last 25,000 years illustrate the transition from the last glacial to the current warmer period, the Holocene. Historic data from 1850 to today ((*154, 155*); 415 ppm www.esrl.noaa.gov/gmd/ccgg/trends) show the distinct increase for both constituents after 1950 marking the onset of the Anthropocene (*156*). Future projections for global temperature (*44*) and CO_2 (*141*) for three Representative Concentration Pathways (RCP) scenarios in relation to the benthic deep-sea record suggest that by 2100 the climate state will be comparable to the Miocene Climate Optimum (~16 million years ago), way beyond the threshold for nucleating continental ice sheets (*142*). If emissions are constant after 2100 and are not stabilized before 2250, global climate by 2300 might enter the hothouse world of the early Eocene (~50 million years ago) with its multiple global warming events and no large ice sheets at the poles.

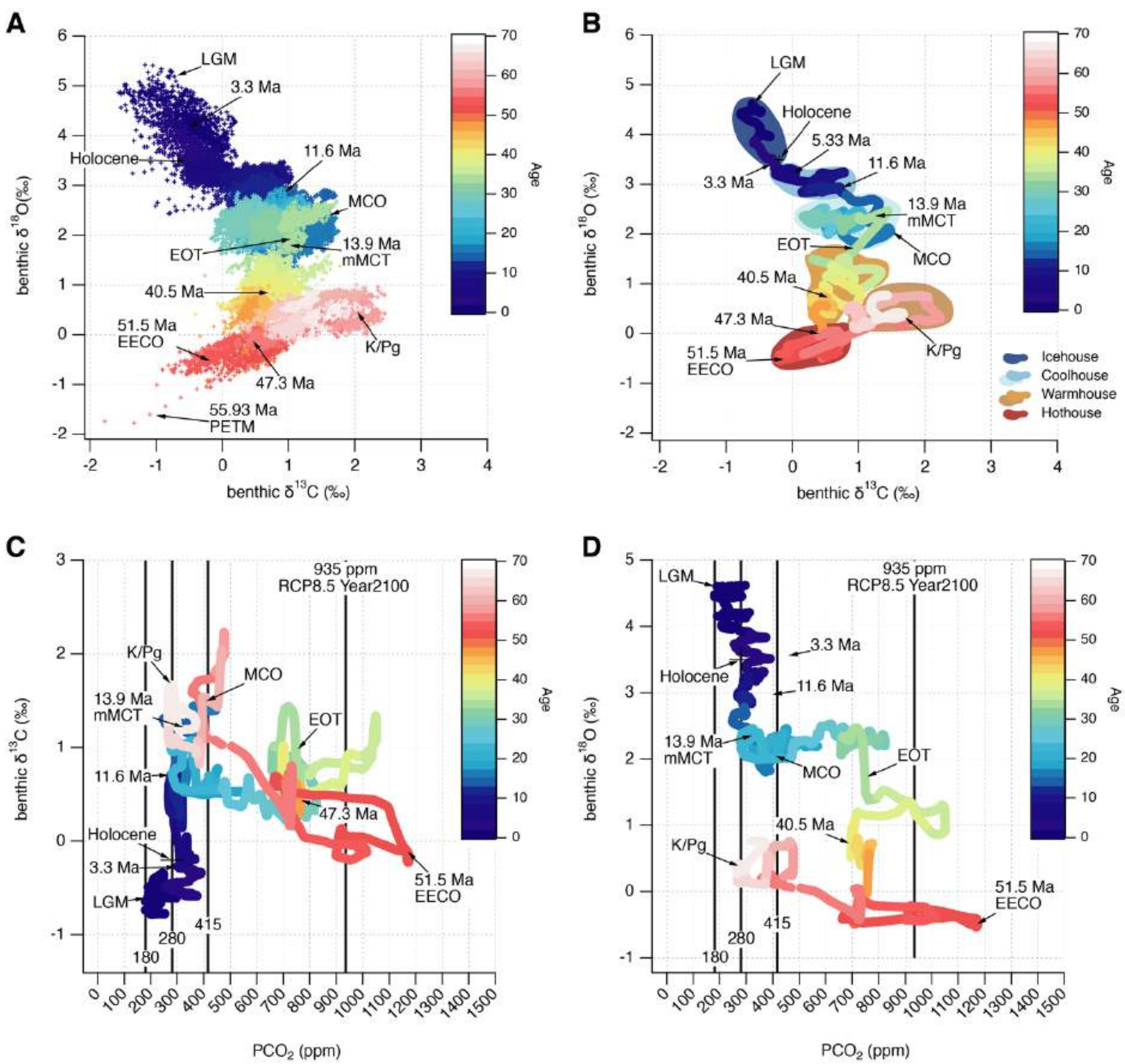


Fig. S35.
Scatter plots of deep-sea benthic high-resolution (A) and long-term (B) carbon versus oxygen isotope data variations as well as long-term atmospheric CO_2 concentrations versus benthic carbon (C) and oxygen (D) isotope data. The relation to atmospheric CO_2 concentrations for both carbon and oxygen, as representative for the global carbon cycle and temperature trends, suggests that the present climate system as of today 415 ppm CO_2 is comparable to the Coolhouse in the Miocene, but will move abruptly into the Warmhouse or even Hothouse by 2100 if emissions of CO_2 are not diminished.

Table S1.
Details on the applied age models for the CENOGRID

Interval	Site	Source / Note
0 to 6 Ma	925, 926, 927, 928, 929	Wilkens et al. 2017, Zeeden et al. 2013, Drury et al. 2017 (*22, 56, 157*)
0 to 6.1 Ma	1264	3.3 to 6.1 Drury (*52*), Bell et al. 2014 (*53*) updated 0 to 3.3 Ma
5.9 to 8.3 Ma	U1337	Drury et al. 2017 (*22*)
5.1 to 13 Ma	1146	Holbourn et al. 2018 (*69*), corrected due to a doubling of strata in the composite record (158)
12.7 to 16 Ma	U1338	Holbourn et al. 2014 (*70*)
15 to 20 Ma	U1337	Holbourn et al. 2015 (*20*)
17 to 30.7 Ma	1264, 1265	Liebrand et al. 2016 (*122*)
18.6 to 41.3 Ma	1218	18.6 to 28.8 Ma Pälike et al. 2006 (*35*) refined to minimal tuning 28.8 to 30.8 Ma this study to connect above and below 30.8 to 41.3 Ma Westerhold et al. 2014 (*159*)
32.7 to 42 Ma	1263, 1265	this study, Rivero-Cuesta et al. 2019 (*160*)
42 to 67 Ma	1258, 1262, 1263	Westerhold et al. 2017, 2018 (*16, 54*) with a refinement for 48.4 to 49.6 Ma and from Barnet et al. 2019 (*90*) updated to La2010b

Age models for each site given in Tab. S24 to S32.

Table S2.
Isotopic correction factors applied for Paleocene and Eocene benthic foraminifer stable isotopes

Taxa pairs		Formula	Source
Cibicidoides	O18	(Cib * 0.89) - 0.10 = Nutt	Katz et al. 2003 (*12*)
N. truempyi	C13	Cib - 0.34 = Nutt	Katz et al. 2003 (*12*)
Cibicidoides	O18	Orid - 0.28 = Cib	Katz et al. 2003 (*12*)
Oridorsalis	C13	Orid + 0.72 = Cib	Katz et al. 2003 (*12*)
N. truempyi	O18	(Orid - 0.416) / 0.909 = Nutt	Westerhold et al. 2018 (*16*)
Oridorsalis	C13	(Orid + 0.372) / 0.971 = Nutt	Westerhold et al. 2018 (*16*)
N. truempyi	O18	(Cprae - 0.474) / 0.792 = Nutt	this study
C. praemundulus	C13	(Cprae - 0.617) / 0.565 = Nutt	this study

Table S3.

Adjustment factors applied to the isotopic measurements of benthic foraminifer species in order to obtain the best estimates of oxygen isotopic equilibrium and carbon isotopic composition of ocean deep-water dissolved CO_2.

Species	Abbr.	d18O Offset	d13C offset	Source
Paleocene/Eocene				
Cib	CSPP	+0.64	0.00	Shackleton et al., 1984 (*83*)
Nutt	NTRUE	+0.40	0.00	Shackleton et al., 1984 (*83*)
Oligocene/Neogene				
Cibicidoides kullenbergi	CKULL	0.64	0.00	Shackleton et al. 1995 (*161*)
Cibicidoides wuellerstorfi	CWUEL	0.64	0.00	Shackleton et al. 1984 (*83*)
Cibicidoides spp.	CSPP	0.50	0.00	Shackleton et al. 1984 (*83*)
Cibicidoides bradyii	CBRA	0.64	0.00	Bickert et al. 1997 (*162*)
Cibicidoides cicatricosus	CCIC	0.64	0.00	Bickert et al. 1997 (*162*)
Globocassidulina subglobosa	GLOSUB	-0.10	0.50	Shackleton et al. 1995 (*161*)
Gyroidina orbicularis	GORB	0.00	0.00	Shackleton et al. 1995 (*161*)
Nuttalides umbonifera	NUMB	0.35	0.00	Shackleton and Hall 1997 (*163*)
Oridorsalis spp.	ORID	0.00	1.00	Shackleton et al. 1995 (*161*)
Oridorsalis umbonatus	OUMB	0.00	1.00	Shackleton et al. 1984 (*83*)
Pyrgo murrhina	PMUR	0.00	0.90	Shackleton and Opdyke 1973 (*164*)
Uvigerina spp.	UVIG	0.00	0.90	Shackleton et al. 1995 (*161*)

Table S4.

Applied offsets for individual stable isotope records using equatorial Pacific records as global baseline

Site	Source of benthic data	Age Interval	$\delta^{18}O$	$\delta^{13}C$
Ceara Rise	Wilkens et al. 2017 (*56*)	0.000 to 4.925 Ma	+0.45 ‰	-1.00 ‰
1264	this study, Bell et al. 2014 (*53*)	4.925 to 5.975 Ma	±0.00 ‰	-1.00 ‰
1146	Holbourn et al. 2013,'18 (*36, 69*)	8.270 to 12.860 Ma	+0.25 ‰	+0.45 ‰
1264	Liebrand et al. 2016 (*122*)	20.000 to 29.275 Ma	-0.20 ‰	-0.50 ‰
1263	Riesselmann et al. 2007 (*51*)	34.025 to 34.308 Ma	-0.20 ‰	-0.20 ‰
1263	this study	34.308 to 48.125 Ma	-0.20 ‰	-0.20 ‰
1258	Sexton et al. 2011 (*165*)	48.125 to 49.975 Ma	-0.30 ‰	-0.20 ‰
in the interval older than 49.975 Ma all records from Leg 208			-0.20 ‰	-0.20 ‰

Table S5.

Definition of intervals and records used to define a complete high fidelity benthic foraminifer stable isotope reference splice

Age Interval	Site	Source of benthic stable isotope data
0 to 4.925 Ma	925, 926, 927 928,929	Bickert et al. 1997, deMenocal et al. 1997, Tiedemann and Franz 1997, Billups et al. 1998, Franz and Tiedemann 2002
4.925 to 5.975 Ma	1264	this study, Bell et al. 2014
5.975 to 8.270 Ma	U1337	Drury et al. 2017, Tian et al. 2018
8.270 to 12.860 Ma	1146	Holbourn et al. 2007, 2013, 2018
12.860 to 15.555 Ma	U1338	Holbourn et al. 2014
15.555 to 20.000 Ma	U1337	Tian et al. 2014, Holbourn et al. 2015
20.000 to 29.275 Ma	1264, 1265	Liebrand et al. 2011, 2016
29.275 to 34.025 Ma	1218	Lear et al. 2004, Wade and Pälike 2004, Pälike et al. 2006, Coxall et al. 2005, Coxall and Wilson 2011
34.025 to 34.308	1263	Riesselmann et al. 2007
34.308 to 35.500	1218	Lear et al. 2004, Coxall et al. 2005, Coxall and Wilson 2011
35.500 to 48.125 Ma	1263	this study, Boscolo Galazzo et al. 2014, Westerhold et al. 2018
48.125 to 49.975 Ma	1258	Sexton et al. 2011
49.975 to 67.103 Ma	1262, 1263	Lauretano et al. 2015, 2016, 2018; Littler et al. 2014; Barnet et al. 2017, 2019; Stab et al. 2010; Hull et al. 2020, Thomas et al. 2018

Citations: (*17, 20, 22, 35, 36, 51, 53, 69, 70, 79, 90, 122, 162, 165-184)*

Table S6.

Benthic foraminifer reference splice average resolution and smoothing details

Action item	0.000 to 34.025 Ma	34.025 to 67.100 Ma	
Average sample resolution	2 kyr	4.4 kyr	
Binning interval	2 kyr	5 kyr	
Resampling resolution	2 kyr	5 kyr	
LOESS smooth of resampled series	10 points	5 points	= 20kyr
Long term LOESS smooth	500 points	250 points	= 1 myr

Note: To minimize the effects of outliers the records were smoothed in IGOR Pro 8 using a nonparametric LOESS quadratic regression smooth with a tricube locally-weighted function. For sample resolution overview see Fig. S28.

Table S7.
Equations to calculate deep-sea temperature and surface air temperature (Hansen et al. 2013) (*94*).

Deep Sea Temperature T_{do}		
0.000 to 3.660	T_{do} (°C) = 1 – 4.4 * ((δ18O (‰) – 3.25) / 3)	(1)
3.600 to 34.025	T_{do} (°C) = 5 – 8 * ((δ18O (‰) – 1.75) / 3)	(2)
34.025 to 67.000	T_{do} (°C) = (−4 * δ18O (‰)) + 12	(3)
Surface air temperature change T_S		
0.000 to 1.810	T_s (°C) = 2 * Tdo + 12.25	(4)
1.810 to 5.330	T_s (°C) = 2.5 * Tdo + 12.15	(5)
5.330 to 67.000	T_s (°C) = Tdo + 14.15	(6)
Temperature anomaly with respect to average global temperature from 1961-1990		
Delta Temperature = Surface air temperature – 14.15 (Holocene mean temperature)		(7)

Captions for Tables S8 to S34

S8. Site 1263 benthic foraminifer stable carbon and oxygen isotope data generated for this study.
S9. Site 1264 benthic foraminifer stable carbon and oxygen isotope data generated for this study.
S10. Site 1265 benthic foraminifer stable carbon and oxygen isotope data generated for this study.
S11. Site 1263 bulk stable carbon and oxygen isotope data generated for this study and published elsewhere.
S12. Offsets applied to cores from Holes 1263A, 1263B, 1263C.
S13. List of tie points to create the revised composite depth scale (rmcd) for Site 1263.
S14. Mapping pairs for Site 1263 to correlate intervals outside the splice to the splice.
S15. Revised site-to-site correlation tie points between Sites 1263 and 1265.
S16. Revised site-to-site correlation tie points between Sites 1263 and 1267.
S17. Revised site-to-site correlation tie points between Site 1263s and 1262.
S18. Calcareous Nannofossil Events at Site 1263.
S19. Characteristic remanent magnetization for discrete samples from Site 1263.
S20. Magnetostratigraphic interpretation of characteristic remanent magnetization for Site 1263.
S21. Position and tuned ages for Site 1263 magnetochron boundaries.
S22. Combined magnetochron boundaries from ocean drilling cores from 20 to 66.4 Ma.
S23. Cenozoic Geomagnetic Polarity Time Scale.
S24. Age model Site 926 Ceara Rise.
S25. Age model Site 1146.
S26. Age model Site 1218.
S27. Age model Site 1258.
S28. Age model Site 1262.
S29. Age model Site 1263.
S30. Age model Site 1264.
S31. Age model Site U1337.
S32. Age model Site U1338.
S33. Cenozoic deep-sea benthic foraminifer stable carbon and oxygen isotope reference splice.
S34. Binned and LOESS smoothed Cenozoic deep-sea benthic foraminifer stable carbon and oxygen isotope reference splice.

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LEX-24983

Gmail

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Notes from our conference regarding your expert report - Sharma v Minister for the Environment VID607/2020

s. 47F(1) @equitygenerationlawyers.com> Tue, Dec 1, 2020 at 2:58 PM
To: Will Steffen <s. 47F(1) >
Cc: David Barnden <david@equitygenerationlawyers.com>

Dear Will,

Thank you for your time in conference today.

As discussed, we look forward to seeing the final draft of your report as soon as it is available (as discussed, our deadline for filing and serving our evidence is this Friday, **4 December 2020**).

As discussed this morning in conference, you may wish to consider the following matters when finalising your report:

1. Could you please set out the text of each question you were asked in your original letter of instruction above each of your responses? This will serve to make the report 'self-contained' for the reader (as they don't need to flip between the letter of instruction and report to make sense of your responses).
2. In your discussion of scenario 1 and scenario 2, you refer to a study by McGlade and Ekins. We understand that this study refers to 'reserves' and 'resources', and contains certain conclusions about 'existing reserves'. In order to give context to your discussion of this report and its findings, it may be of assistance to include some detail about these matters in your report.
3. Are you able to explain (a) what Representative Concentration Pathways are, (b) how they are typically used (and for what purpose) in a climate science context, and (c) how they correspond (either approximately or otherwise) with the scenarios that are the subject of your report?
4. You have previously been provided with a copy of the Federal Court's Practice Note on Expert Evidence (it is available online here: https://www.fedcourt.gov.au/law-and-practice/practice-documents/practice-notes/gpn-expt). In finalising your report, please check your report against all of the requirements of the Practice Note, with particular regard to the following:
   a. Cl 5.2(a): the report should contain an acknowledgement that as an expert, you have read and complied with the Practice Note and agree to be bound by it, and that your opinions are based wholly or substantially on specialised knowledge arising from your training, study or experience as an expert;
   b. Cl 5.2(c): you must sign the final report and attach or exhibit to it copies of (i) documents that contain any instructions given to you (such as your original letter of instruction, and this email) and (ii) any documents and materials that you have been instructed to consider;
   c. Annexure A, cl 3(d) and (e): your report must state, specify or provide the assumptions and material facts on which the opinions expressed in your report are based, and must state, specify or provide the reasons for, and any literature or materials utilised in support of, such opinion;
   d. Annexure A, cl 3(i): your report must contain a declaration that as an expert, you have made all the inquiries which you believe are desirable and appropriate (save for any matters explicitly identified in the report), and that no matters of significance which you regard as relevant have, to your knowledge, been withheld from the Court.

As discussed, we provide these comments to you for the purpose of ensuring that your report complies with the Practice Note. For the avoidance of doubt, these comments are not intended to suggest any change to (or otherwise interfere with) the content of your conclusions or opinions in this matter (which are exclusively matters for you as an independent expert witness).

Please let us know if you would like to discuss any of these matters.

Regards,

s. 47F(1)

Lawyer
Equity Generation Lawyers
Pronouns: He/him

s. 47F(1)

NOTICE OF FILING

This document was lodged electronically in the FEDERAL COURT OF AUSTRALIA (FCA) on 17/01/2021 5:30:42 PM AEDT and has been accepted for filing under the Court's Rules. Details of filing follow and important additional information about these are set out below.

Details of Filing

Document Lodged:	Expert Report
File Number:	VID607/2020
File Title:	ANJALI SHARMA & ORS (BY THEIR LITIGATION REPRESENTATIVE SISTER MARIE BRIGID ARTHUR) v MINISTER FOR THE ENVIRONMENT (COMMONWEALTH)
Registry:	VICTORIA REGISTRY - FEDERAL COURT OF AUSTRALIA

Sia Lagos

Dated: 17/01/2021 5:30:50 PM AEDT

Registrar

Important Information

As required by the Court's Rules, this Notice has been inserted as the first page of the document which has been accepted for electronic filing. It is now taken to be part of that document for the purposes of the proceeding in the Court and contains important information for all parties to that proceeding. It must be included in the document served on each of those parties.

The date and time of lodgment also shown above are the date and time that the document was received by the Court. Under the Court's Rules the date of filing of the document is the day it was lodged (if that is a business day for the Registry which accepts it and the document was received by 4.30 pm local time at that Registry) or otherwise the next working day for that Registry.

Supplementary Report for Equity Generation Lawyers on:

Anjali Sharma v Minister for the Environment
Federal Court of Australia | VID 607/2020

Federal Court of Australia

17 January 2021

Professor Will Steffen
Emeritus Professor, The Australian National University, Canberra ACT 0200
Senior Fellow, Stockholm Resilience Centre

I refer to the further letter of instructions dated 12 January 2021 (attached).

I have read Expert Evidence Practice Note (GPN-EXPT), and, in particular, acknowledge the following:

- I have read and complied with the Practice Note and agree to be bound by it, and that my opinions are based wholly or substantially on specialised knowledge arising from my training, study and experience as an expert for well over 30 years;

- I have signed this supplementary report at the end.

- I declare that I have made all of the inquiries and investigations that I believe are desirable and appropriate to this supplementary report. I have not withheld any matters of significance from the Court.

This supplementary report is a response to the advice that the original estimates of Scope 1, Scope 2 and Scope 3 CO2-e emissions, as quoted in point 28, have now been amended. Question 29 is directly based on the emissions estimates of point 28.

I have read through the further letter of instructions (12 January 2021) and confirm that it does not change my response to Question 29, nor does it change my original report in any other way. Thus, my original report stands as is.

s. 47F(1)

Will Steffen
17 January 2021

Equity Generation Lawyers

12 January 2020

Professor Will Steffen
Emeritus Professor, Fenner School of Environment & Society
Australian National University

By email only: s. 47F(1)

Dear Professor Steffen

Anjali Sharma v Minister for the Environment
Federal Court of Australia | VID 607/2020

1. We refer to our letter of instruction dated 27 October 2020 and your expert report dated 7 December 2020.
2. Could you please prepare a short supplementary report.
3. In our letter assumptions were provided at Question 28 on the materiality of the Project. The assumptions in that paragraph were based on the project as a whole, being the 'original approval' plus the 'extension project'. However, the figures given were in error, as the Project you were asked about in our letter was confined to the extension project.
4. As you made clear in answering questions 28 and 29, you answered those questions by reference to the assumptions provided (and set out in your answer to question 28).
5. You are now instructed to assume that, if approved, the Project (ie, the 'extension project' only) would in the future, by the extraction, transportation and combustion of the coal from the Project:

    (a) decrease Scope 1 emissions by about 1 Mt CO2-e;

    (b) increase Scope 2 emissions by about 0.15 Mt CO2-e; and

    (c) increase Scope 3 emissions by about 100 Mt CO2-e.

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6. Please provide a supplementary report answering Question 29 in our original letter by reference to the updated assumptions above.

Yours sincerely

s. 47F(1)

David Barnden
Principal Lawyer