Supplementary Information for *npj Climate Action* manuscript:

Quantifying the regional to global climate impacts of individual fossil fuel projects to inform decision-making

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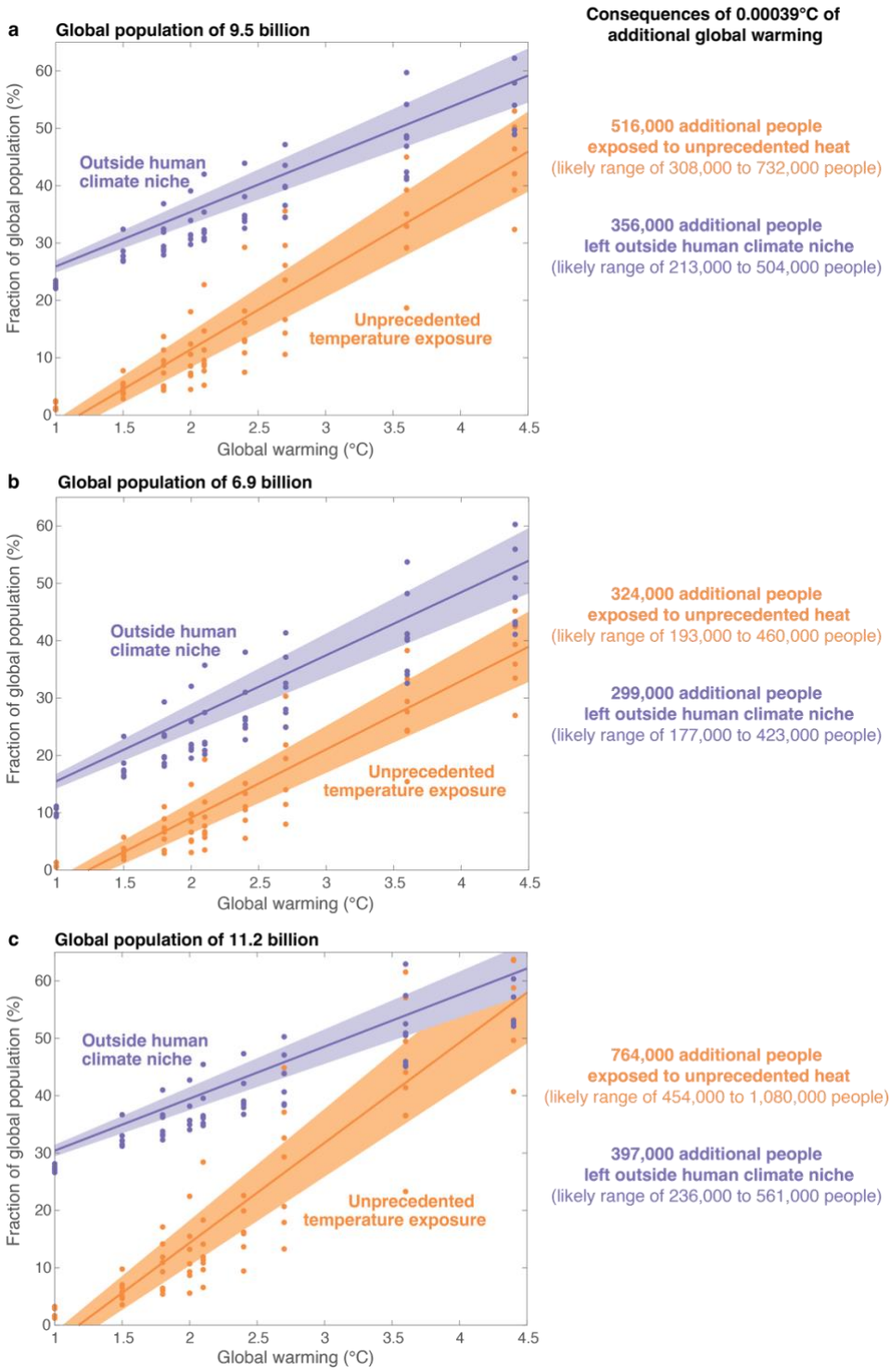
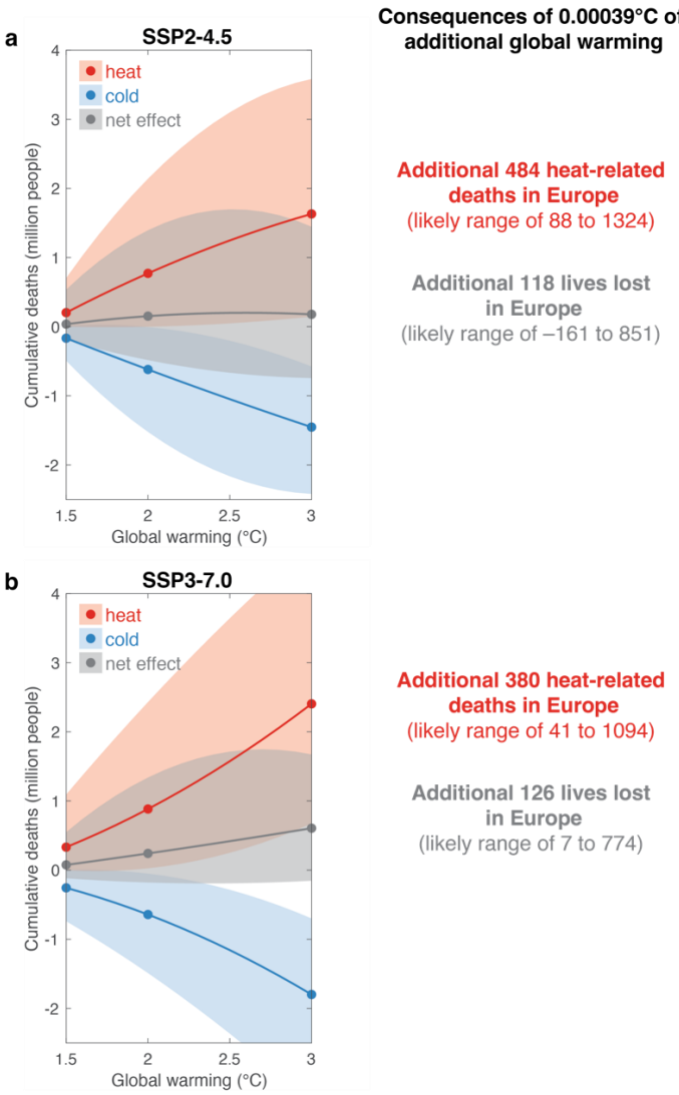
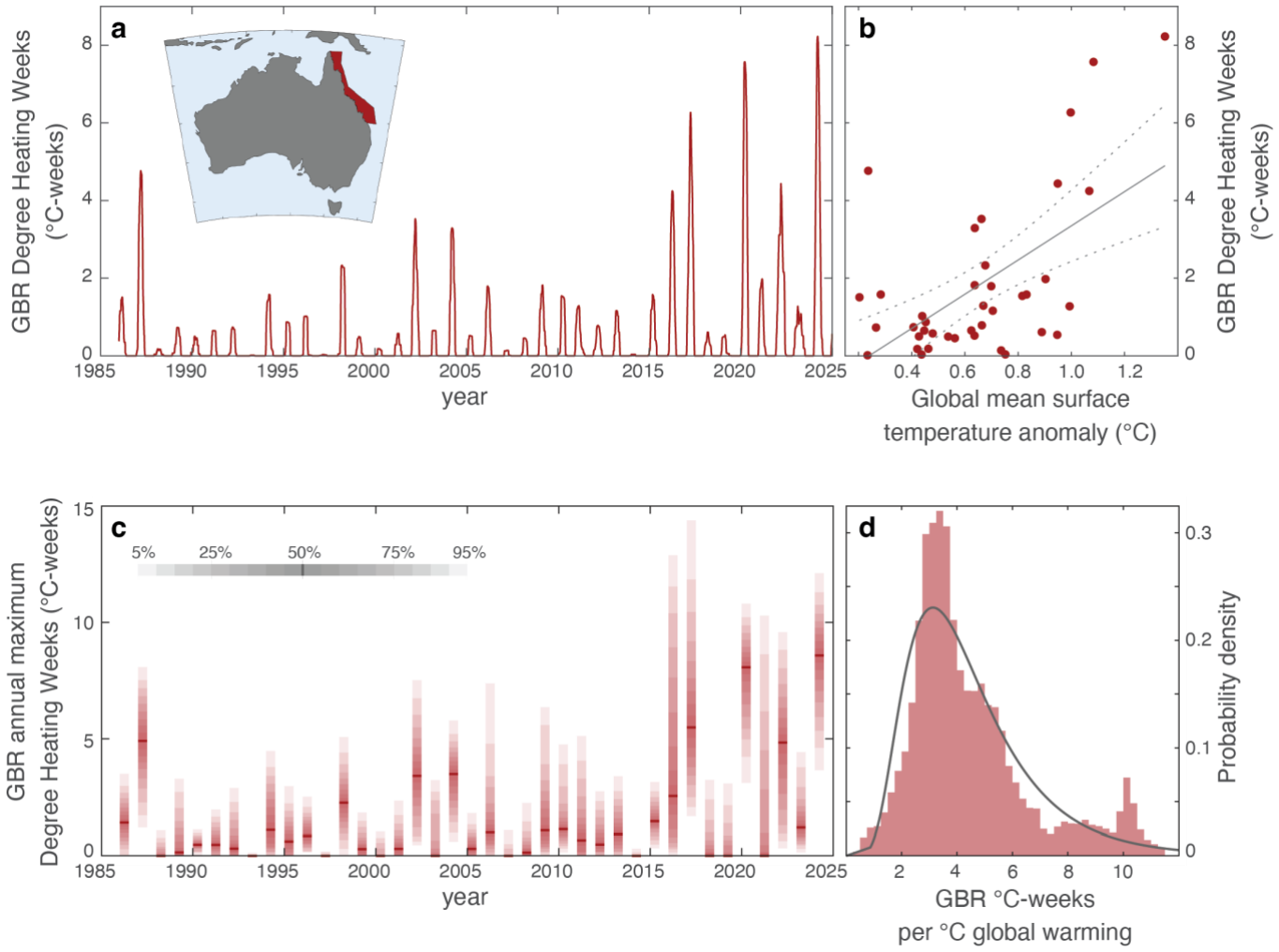


Supplementary Figure 1 | The human cost of additional global warming through the human climate niche[1]**.** **a,** Changes in the percentage of global population exposed to unprecedented heat (orange), defined as local climate with average temperature exceeding 29°C, and left outside of the human climate niche (purple) due to global warming in a world with 9.5 billion people (as in Fig. 2a; Methods). Lines (shading) show linear regression (with 95% confidence interval) across the dataset[1,2]. **b**, as in (a) but for a world with 6.9 billion people, and **c**, for a world with 11.2 billion people. Values shown to the right of panels demonstrate the consequences of additional warming that will be caused by the emissions related to the Scarborough project (Methods).



Supplementary Figure 2 | Cumulative excess deaths in Europe under different levels of global warming[3,4]. **a,** Cumulative excess deaths (2015–2099) due to heat (red), cold (blue) and the net effect (grey) under a middle-of-the-road socioeconomic and emissions scenario (SSP2-4.5; as in Fig. 2b; Methods). The best estimate (lines) and 95% confidence interval (shading) of cumulative deaths are shown for climate-change only effects after removing demographic effects in a no climate change scenario. **b**, as in (a) but for a regional-rivalry, very-high-emissions scenario (SSP3-7.0). Values shown to the right of panels demonstrate the consequences of additional warming that will be caused by the emissions related to the Scarborough project, calculated based on the effects of additional warming above 1.5°C of global warming (Methods).



Supplementary Figure 3 | Thermal exposure on the Great Barrier Reef in relation to global warming. a. Daily thermal exposure (red curve) averaged over the Great Barrier Reef (GBR) Marine Park (red shading on inset map) based on Degree Heating Weeks, where daily temperature exposure more than 1°C above climatology is accumulated over moving 12-week moving windows[5,6]. **b**. Linear regression (grey solid line; dashed line 95% confidence interval) of the annual maximum in accumulated GBR Degree Heating Weeks with annual (July–June; GBR summer-centred) global mean surface temperature (red circles). Regression indicates that thermal exposure on the GBR increases by around 4.4 (±1.0 standard error, p = 0.00013) °C-weeks for each 1°C of additional global warming. **c**. Distribution of annual (summer-centred) maximum Degree Heating Weeks across the 12222 5km grid cells in the GBR marine park. **d**. The distribution of the spatial relationship between annual maximum Degree heating Weeks and global mean surface temperature over the GBR marine park (red shading) approximates a lognormal distribution (grey curve), which is used for the uncertainty range around the best estimate relationship (b). Based on this, additional global warming of 0.00039°C (likely range of 0.00024 to 0.00055°C) from the Scarborough project is anticipated to result in an increase in thermal exposure in the GBR marine park of 0.0017°C-weeks (likely range of 0.00060 to 0.0037°C-weeks) (Fig. 2c; Methods).

a Likelihood

	Remote	Highly Unlikely	Unlikely	Possible	Likely	Highly Likely
Frequency	1 in 100,000-1,000,000 years	1 in 10,000 – 100,000 years	1 in 1,000 – 10,000 years	1 in 100 – 1,000 years	1 in 10-100 years	> 1 in 10 years
Probability of event occurrence	< 1%	1% – 5%	6% – 20%	21% – 50%	51% – 80%	> 80%

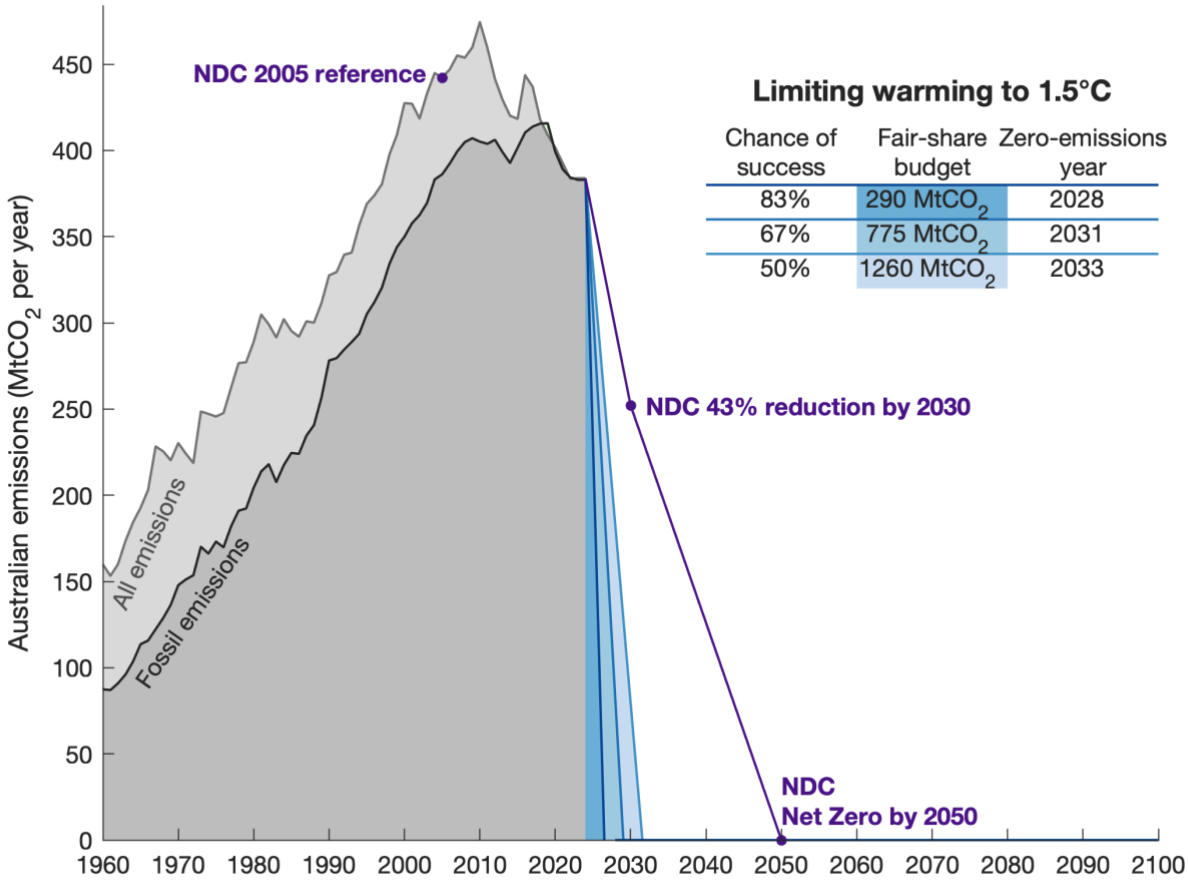
b Consequence

	Environmental Consequence	Social and Cultural Consequence
Catastrophic (A)	Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Catastrophic, long-term impact (>20 years) to a community, social infrastructure or highly valued areas / items of international cultural significance
Major (B)	Major, long-term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Major, long-term impact (5–20 years) to a community, social infrastructure or highly valued areas / items of national cultural significance
Moderate (C)	Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes	Moderate, medium-term impact (2–5 years) to a community, social infrastructure or highly valued areas / items of international cultural significance
Minor (D)	Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems function) or physical or biological attributes	Minor, short-term impact (1–2 years) to a community, or highly valued areas / items of cultural significance
Slight (E)	Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystems function) or physical or biological attributes	Slight, short-term impact (<1 year) to a community, or areas / items of cultural significance
Negligible (F)	No lasting effect (<1 month). Localised impact not significant to environmental receptors	No lasting effect (<1 month). Localised impact not significant to areas / items of cultural significance

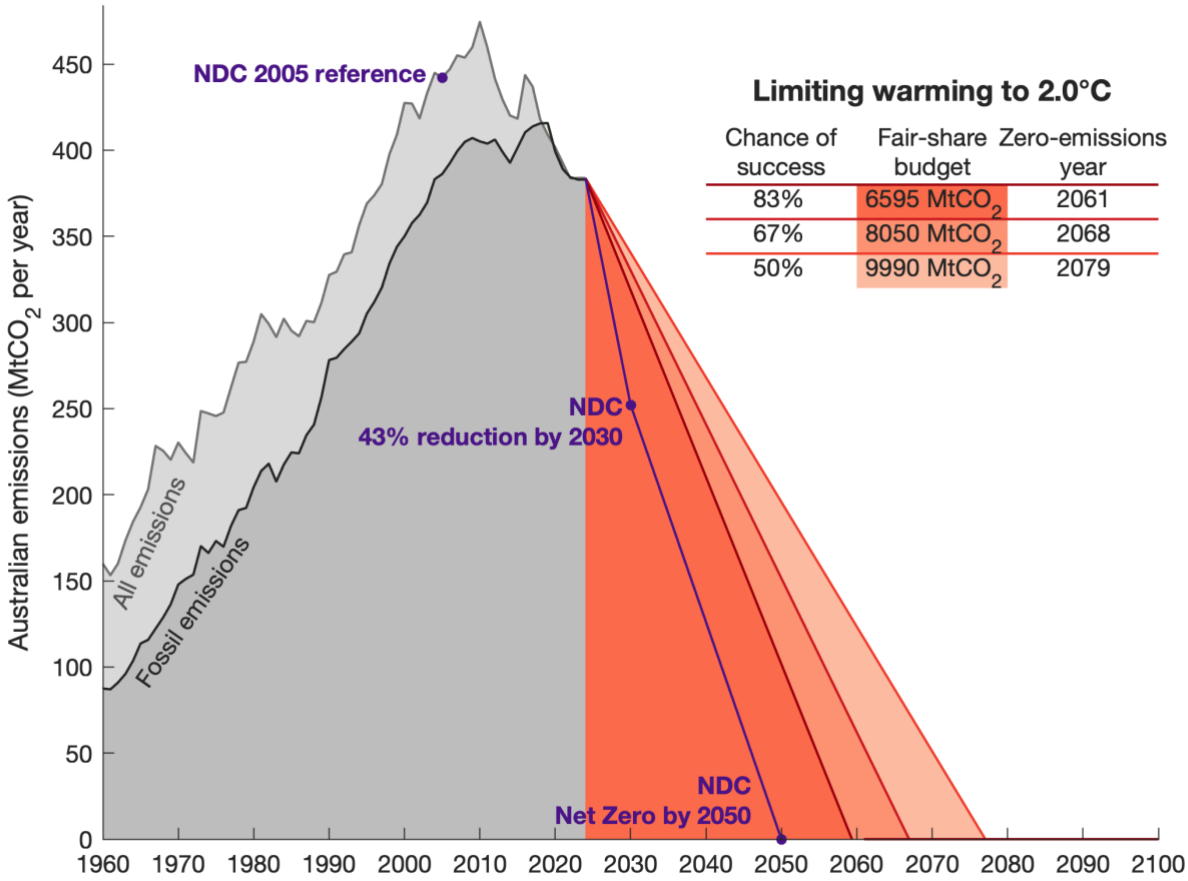
c Risk

	Remote	Highly Unlikely	Unlikely	Possible	Likely	Highly Likely
Catastrophic	Moderate	High	Very High	Severe	Severe	Severe
Major	Moderate	Moderate	High	Very High	Severe	Severe
Moderate	Moderate	Moderate	Moderate	High	Very High	Severe
Minor	Low	Moderate	Moderate	Moderate	High	Very High
Slight	Low	Low	Moderate	Moderate	Moderate	High
Negligible	Low	Low	Low	Moderate	Moderate	Moderate

Supplementary Figure 4 | Summary of key elements of Scarborough offshore project proposal risk assessment framework for environmental and social/cultural consequences. Risk is assessed according to the likelihood of an outcome and the consequences of that outcome. Based on the risk assessment framework for environmental risk levels in ref. [7] (see Figure 6-3, page 329 of ref [7]).



Supplementary Figure 5 | Australia's emission reduction pathway commitment in the context of the remaining carbon budget for limiting warming to 1.5°C. a. Australia's historical CO_2 emissions from 1960 to 2024 are shown for fossil (black) and total (grey) emissions, along with Australia's current Nationally Determined Contribution (NDC; purple) for emission reductions of 43% by 2030 (relative to 2005 levels) and net-zero emissions by 2050. Blue shading and table details show linear emission reduction pathways from the start of 2025 that are consistent with Australia's fair share of the remaining global carbon budget for limiting warming to 1.5°C (Methods).



Supplementary Figure 6 | Australia's emission reduction pathway commitment in the context of the remaining carbon budget for limiting warming to 2.0°C. a. Australia's historical CO_2 emissions from 1960 to 2024 are shown for fossil (black) and total (grey) emissions, along with Australia's current Nationally Determined Contribution (NDC; purple) for emission reductions of 43% by 2030 (relative to 2005 levels) and net-zero emissions by 2050. Red shading and table details show linear emission reduction pathways from the start of 2025 that are consistent with Australia's fair share of the remaining global carbon budget for limiting warming to 2.0°C (Methods).

Supplementary Table 1. Illustrative examples of the reported impacts and context of anticipated greenhouse gas emissions as described by the proponents of recently approved/proposed fossil fuel projects in Australia. References to page numbers and tables refer to the places in the footnoted proposal documents where these statements can be found. These illustrative examples demonstrate commonalities across proponents and jurisdictions in the descriptions of project climate impacts, and are only a small number of all newly approved and proposed coal, oil and gas projects in Australia as reported in 2024 summary of major resource and energy projects by the Office of the Chief Economist (includes 50 coal and 44 oil and gas projects; https://www.industry.gov.au/publications/resources-and-energy-major-projects-2024)

Fossil fuel project, type (and proponent/s)	Lifecycle and anticipated emissions	Reported climate warming contribution	Reported climate change consequences	Reported emissions context
Scarborough Project, Western Australia Offshore Gas (Woodside)[i]	31 years of production, commencing in 2026 (2026–2057 project life). 778.53 Mt CO_2-e over project life (28.42 Mt CO_2-e per year). (Table 7-20)	It is not possible to link GHG emissions from Scarborough with climate change or any particular climate-related impact given that the estimated emissions associated with Scarborough are negligible in the context of existing and future predicted global GHG concentrations. (p. 399) It is not possible to link GHG emissions from Scarborough to a measurable increase in global temperature or other climate change impacts. (p. 399)	Due to the relatively small contribution to global GHG emissions from Scarborough, it is not considered feasible to correlate the potential impact of Scarborough GHG emissions on receptors, including Matters of National Environmental Significance. (p. 392) The impact significance level of routine GHG emissions from Scarborough has been evaluated as Negligible (F) for all receptors. (p. 399)	Annual emissions equivalent to 0.076% to 0.113% of global energy system emissions projected in 2030 using International Energy agency scenarios. (Table 7-21) GHG emissions from Scarborough are expected to result in a reduction of net global atmospheric GHG concentrations by displacing higher carbon intensive energy sources. (p. 397)
Crux Project, Western Australia Offshore Gas (Shell)[ii]	40 years of production, commencing in 2025 (2025–2065 project life). Emissions to 2041 have previously been approved, this proposal extends project to 2065. 440 Mt CO_2-e for project life (11.31 Mt CO_2-e per year). (Table 8-25)	Emissions from the Crux project are a small portion of emission inventories. This suggests a similarly small contribution to global temperature increases even though there is no calculable direct relationship. (pp. 360-361) It is argued that calculating the Crux project's specific contribution to climate change would be speculative and would likely provide unreliable, inaccurate, and uncertain results. (p. 362)	The relatively small percentage of global emissions should not be used to understate the seriousness of the threat of environmental degradation from climate change. Rather it clarifies the source of the threat being from global emissions quantities rather than from emissions from the Crux project. (p. 361) It is speculative to assess the impacts of the Crux project's GHG emissions noting that, on a qualitative basis, the impacts from Crux GHG emissions are unlikely to be a substantial cause of an increase in global temperature and Crux GHG emissions are also unlikely to be a substantial cause of climate	Annual emissions from Crux project are equivalent to 0.499% of Australian emissions in 2018, and 0.0302% of global emissions in 2018. (Table 8-26)

Project proposal documents available from:
[i] Scarborough Offshore Project Proposal: https://info.nopsema.gov.au/offshore_projects/41/show_public
[ii] Crux Project Offshore Project Proposal: https://info.nopsema.gov.au/offshore_projects/40/show_public

Fossil fuel project, type (and proponent/s)	Lifecycle and anticipated emissions	Reported climate warming contribution	Reported climate change consequences	Reported emissions context
			change impacts to the Australian environment. (p. 363) The impact of project GHG emissions is assessed to be minor for all receptors (Tables 8-29 and 8-32) No significant impacts to the Australian environment attributable to the Crux project, including for Matters of National Environmental Significance (Tables 8-30 and 8-33)	
Gorgon Gas Development Backfill fields, Western Australia Offshore Gas (Chevron)[iii]	The Development has a notional 2026 to 2070 project life (page 3), resulting in greenhouse gas emissions of ~60 Mt CO_2-e per year. (Table 8-12, p. 327)	Anthropogenic changes to the global climate system cannot be directly attributed to any one development or emission source or product, as they are the result of the net accumulation of global GHGs (emissions minus sinks) in the atmosphere since the industrial revolution. (Table 8-12, p. 329) The changing regulatory and international initiatives on climate change (e.g. which may result in changing reduction targets and timeframes) will also influence the total global GHG emissions in the future – making future prediction of changes to climate systems inaccurate. As a contribution to the anthropogenic influence on the global climate system cannot be directly attributed to any one development, no further assessment has been completed. (Table 8–12, p. 330)	As a contribution to the anthropogenic influence on the global climate system cannot be directly attributed to any one development, no further assessment has been completed. (Table 8–12, p. 330)	The total direct and indirect GHG emissions from activities associated with the Development are ~60 Mtpa CO_2-e, which represents ~0.14–0.4% reduction in the total remaining global carbon budget, which is a de minimis[*] decrease. The impact of contribution to the global carbon budget has been evaluated as having the potential to result in an Incidental (6) consequence. (Table 8-12, p. 327) *An incidental consequence is defined as a negligible disturbance/impact, and/or the impact is reversible within a very short period of time (e.g., days to months). (Table 7-4, p. 286)*

[iii] Gorgon Gas Development: Backfill Fields Offshore Project Proposal: https://www.nopsema.gov.au/sites/default/files/documents/Gorgon%20Gas%20Development-%20Backfill%20Fields%20OPP%20-%20Submission%20%2303%20-%20Revision%202%20-%2011%20July%202024.pdf

[*] *de minimis*: lacking significance or importance**:** so minor as to merit disregard (Merriam-Webster dictionary)

Fossil fuel project, type (and proponent/s)	Lifecycle and anticipated emissions	Reported climate warming contribution	Reported climate change consequences	Reported emissions context
Barossa, Northern Territory Offshore Gas (ConocoPhillips, SK E&S and Santos)[iv]	25 years of production, with target start in 2023. (Table ES-1) 3.4 Mt CO_2-e per year for scope 1 production only. (Table 4-7, p. 128) *No estimates of Scope 3 emissions are given.*	Greenhouse gas emissions will cause an incremental increase in domestic and global GHG emissions concentrations, however they are not considered to have a determinable local-scale impact. (p. 338)	The potential impacts and risks associated with atmospheric emissions from the project are considered broadly acceptable given: The residual risk is low given: - The location of the project in the open ocean, which is well removed from nearest residential or sensitive populations of the Tiwi Islands of NT coast - The relatively minor contribution (0.5–0.7%) of the domestic GHG emissions profile (Table 6-28).	Australia's annual total emissions for the year to June 2016 are estimated to be 536.5 Mt CO_2-e. Therefore, the emissions from the project will represent approximately 0.5–0.7% of the domestic emissions profile. (p. 338)
East Coast Project, Otway Basin, Victoria Offshore Gas (Cooper Energy)[v]	25 years of production, commencing in 2025 (2025–2050 project life). 43.6 Mt CO_2-e over project life (1.75 Mt CO_2-e per year). (Table 8-44)	The impact on climate systems from an increase in GHG emissions as a result of the East Coast Project is evaluated to have a consequence of level 1 based on the minor contribution to Australian and Victorian carbon budgets. (p. 526) The activity aligns with Australia's climate targets. By not preventing Australia reaching these targets, this effort is recognised to significantly reduce the risks and impacts of climate change (p. 421).	The impact on ecosystems from an increase in GHG emissions as a result of the East Coast Project is evaluated to have a consequence of level 1 based on the minor contribution to Australian and Victorian carbon budgets. Given the minor contribution to carbon budgets, indirect emissions are not a substantial cause of the physical effects of climate change on Matters of National Environmental Significance. Therefore, these physical effects are not considered impacts. (p. 531) Emissions associated with the project will have a minor contribution to carbon budgets, and as such will not prevent the protection of ecological values. (p. 423)	GHG emissions from activities defined in this proposal will not prevent Australia from meeting greenhouse gas commitments as per the Paris Agreement. (p. 419).

[iv] Barossa Area Development, Offshore Project Proposal: https://www.nopsema.gov.au/sites/default/files/documents/2021-03/A598152.pdf

[v] East Coast Supply Project, Otway Basin Offshore Project Proposal: https://www.nopsema.gov.au/sites/default/files/documents/OPP - East Coast Supply Project - Rev 2 - December 2024.pdf

Fossil fuel project, type (and proponent/s)	Lifecycle and anticipated emissions	Reported climate warming contribution	Reported climate change consequences	Reported emissions context
Narrabri Gas Project, New South Wales Coal-Seam Gas (Santos)[vi]	Commencing 2025 with 25-year assessment period (2025–2050 project life). 120.5 Mt CO_2-e over project life (4.73 Mt CO_2-e per year). (Tables 24-2 and 24-3, p. 24-4, Appendix R-i)	*Contribution of the project to climate warming is not discussed.*	Given the environmental benefits of low-carbon energy sources, the project is consistent with the principles of ecologically sustainable development. As such, the residual environmental risk presented by the project with regard to greenhouse gas emissions is low (p. 24-8)	The annual direct (Scope 1) emissions from the project are equivalent to less than 0.2% of Australia's current* annual emissions, and less than 0.002% of global greenhouse gas emissions (p. 24-1, p. 24-4). **current annual emissions use 2014 emissions values.* The relatively small incremental increase (less than 0.2%) in Australia's annual greenhouse gas emissions associated with the project, and its contribution to global emissions, should be considered in terms of the net environmental benefit of the natural gas generated by the project (p. 24-5).
Bulga Optimisation Project (modifications 3 and 7), New South Wales Thermal and Metallurgical Coal (Glencore. Report prepared by Umwelt environmental consultants)[vii]	Extending life by 21 years (to end of 2039). Additional 114 Mt CO_2-e over project life (5.45 Mt CO_2-e per year). (Table 6.9).	The proposed modification will contribute to global emissions, however the extent to which global emissions and atmospheric concentrations of greenhouse gases have a demonstratable impact on climate change will be largely driven by the global response to reducing total global emissions. (p. 83)	The relative environmental impact of the proposed modification is likely to be relative to its proportion of global greenhouse gas emissions. (p. 83) *A risk assessment is not given for the contributions of the project to climate change impacts.*	The proposed modification will contribute approximately 0.0004% to global CO_2-e emissions* per annum, based on scope 1 emissions only. (p. 83) **Based on forecast 2025 global emissions.*

[vi] Narrabri Gas Project Environmental Impact Statement: https://www.planningportal.nsw.gov.au/major-projects/projects/narrabri-gas
[vii] Bulga Optimisation Project (modifications 3 and 7) Environmental Impact Statement: https://www.planningportal.nsw.gov.au/major-projects/projects/mod-3-bulga-optimisation-project

Fossil fuel project, type (and proponent/s)	Lifecycle and anticipated emissions	Reported climate warming contribution	Reported climate change consequences	Reported emissions context
Kevin's Corner, Galilee Basin, Queensland Thermal Coal (GVK Hancock)[viii]	30-year project life, no commencement year at present. Scope 1 and 2 emissions of 58.6 Mt CO_2-e over project life (2.02 Mt CO_2-e per year). (Table 14-4) *No estimates of Scope 3 emissions are given.*	*Risk assessment is presented for the risks of climate change on mining operations. (Section 14.3.2)* *Contribution of the project to climate warming is not discussed.*	*A risk assessment is not given for the contributions of the project to climate change impacts.*	Scope 1 and 2 emissions are 0.35% of Australian emissions, and 1.26% of Queensland emissions*. (Tables 14-5 and 14-6) **Based on 2008 emission inventories.*
Carmicheal Mine, Galilee Basin, Queensland Thermal Coal (Bravas/Adani)[ix]	90-year project, commenced in 2021 (equating to a project life of 2021 to 2110). Scope 1 and 2 emissions of 206 Mt CO_2-e over the 90-year project life (2.29 Mt CO_2-e per year). (p. 8-2) *No estimates of Scope 3 emissions are given.*	It is recognised that the construction and operation of the project will result in the generation of GHG emissions. (p. 8-4) *Contribution of the project to climate warming is not discussed.*	*A risk assessment is not given for the contributions of the project to climate change impacts.*	Emissions from the project will contribute to Queensland's overall GHG emissions over an extended period of time. (p. 8-6) Annual scope 1 and 2 emissions from the project are estimated to be approximately 2% of Queensland's 2009 GHG emissions, and approximately 0.6% of Australia's 2009 GHG emissions. (p.8-2)

[viii] Kevin's Corner Project Environmental Impact Statement: https://www.statedevelopment.qld.gov.au/coordinator-general/assessments-and-approvals/coordinated-projects/completed-projects/kevin-s-corner-project

[ix] Carmichael Coal Mine Environmental Impact Statement: https://www.statedevelopment.qld.gov.au/coordinator-general/assessments-and-approvals/coordinated-projects/completed-projects/carmichael-coal-mine-and-rail-project/eis-documents

Supplementary References

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7 Woodside. Scarborough Offshore Project Proposal. 825 (2020). https://info.nopsema.gov.au/offshore_projects/41/show_public