ANNEX 12

EXPERT OPINION OF PROFESSOR KEVIN ANDERSON AND DR DAN CALVERLEY ON AUSTRALIA'S EXPORT EMISSIONS

Australia's export emissions and the Paris Agreement temperature commitments

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NB: *All views contained within this report are attributable solely to the authors and do not necessarily reflect those of researchers within their affiliated institutions.*

Contents

Central finding **3**
1 Executive summary **4**
2 Key messages **6**
2.1 The ICJ has established 1.5°C as the relevant benchmark for state conduct. 6
2.2 The remaining carbon budget for 1.5°C is now extremely limited. 6
2.3 Emissions from fossil fuel exports are foreseeable and intended. 6
2.4 Australia is a major contributor to global emissions through exported fossil fuels. 6
2.5 A deliberately conservative and Australia-favourable methodology. 6
2.6 Australia's official export pathways fail even a conservative compatibility test. 7
2.7 Australia's projected coal and LNG exports are incompatible with the Paris temperature commitment and the standard articulated by the ICJ. 7
3 Current climate science **8**
3.1 Commitment to the 1.5°C limit 8
3.2 Remaining carbon budgets 9
3.3 Best available science 10
3.4 Updated remaining carbon budgets 11
3.5 Timescales for 1.5°C and 2°C – why engineered removals won't help 15
4 Fossil fuel exports in a 1.5°C world **17**
4.1 Territorial (end-user) emissions accounting 17
4.2 Most fossil fuels are exported 17
4.3 Producer-based emissions accounting 18
4.4 Apportionment of a functionally exhausted budget 18
4.5 Maximising energy return from emissions budgets 19
4.6 Lifecycle emissions of fossil fuel supply chains 20
5 Australia's contribution to climate change **24**
5.1 Territorial emissions 24
5.2 A major exporter of emissions 24
5.3 Historical contribution to climate change of Australia's fossil fuel exports 25
5.4 Projected future emissions from Australian fossil fuel exports 27
5.4.1 The 'Treasury scenario' 27
5.4.2 The 'DCCEEW scenario' 28
5.5 Review of government export scenarios 29
5.5.1 'DCCEEW scenario' review 29
5.5.2 'Treasury scenario' review 30
5.5.3 Divergence from climate policy in both export scenarios 31
5.6 Government export scenarios vs. 1.5°C pathway 32
5.7 Government export scenarios vs 2°C pathways 34
5.7.1 The 'DCCEEW scenario' and 2°C 36
5.7.2 The 'Treasury scenario' and 2°C 36
6 Conclusion **38**
7 References **40**
Appendices **45**
A1. The choice of Remaining Carbon Budgets from the literature **45**
A2. The choice of more conservative methane reduction scenarios **45**
A3. Methodological assumptions in scenario construction **46**
8 Authorship **50**

Central finding

Australia's projected coal and LNG export pathways are incompatible with the Paris Agreement's 1.5°C and even the 2°C temperature commitments.

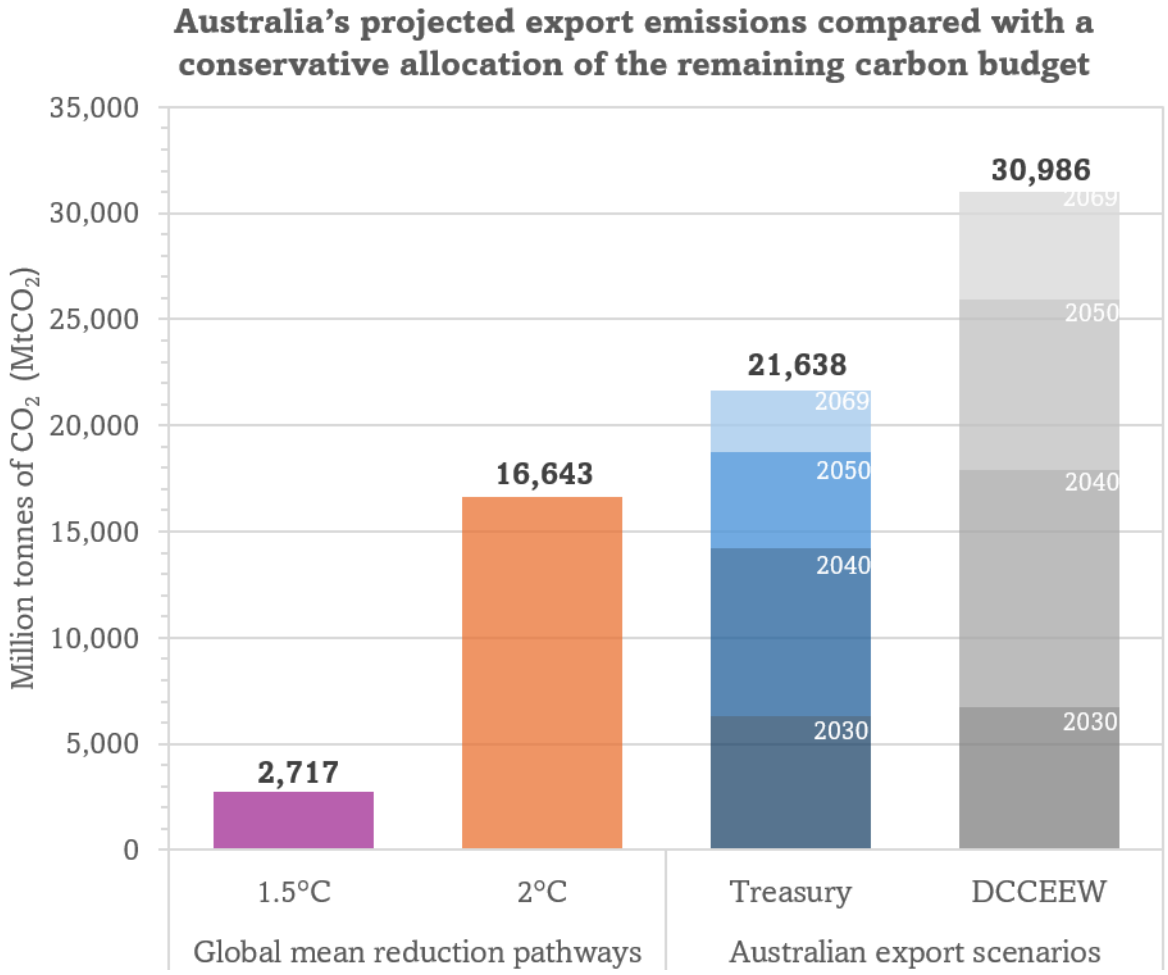


Figure CF1: Stacked column chart of a conservative allocation of 1.5°C and 2°C remaining carbon budgets compared with emissions under the 'Treasury scenario' and 'DCCEEW scenario' (based on Figure 6 in section 5.7 of this report).

This figure underpins the central finding of this report: Australia's projected coal and LNG export pathways are incompatible with the UNFCCC's objective of preventing dangerous anthropogenic interference with the climate system, the Paris Agreement's 1.5°C and 2°C temperature commitments, and the standard of state conduct articulated by the International Court of Justice's advisory opinion on the *Obligations Of States In Respect Of Climate Change*.

This conclusion holds even under assumptions deliberately designed to favour Australia and in absence of considerations of equity, historical responsibility, national capability, and the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC).

1 Executive summary

This report assesses Australia's projected coal and liquefied natural gas (LNG) exports against the Paris Agreement's 1.5°C and 2°C temperature commitments, the best available climate science, and the legal framework articulated by the International Court of Justice (ICJ) in its Advisory Opinion on climate change.

The ICJ has confirmed that the Paris Agreement's objective of limiting warming to 1.5°C provides the relevant benchmark against which state conduct must be assessed. The Court further recognised that states must act in accordance with the best available science and take measures capable of preventing dangerous anthropogenic interference with the climate system.

The best available science indicates that the remaining carbon budget consistent with a 50% probability of limiting warming to 1.5°C is now extremely limited. Assessment of future fossil fuel production and export must therefore be undertaken within the context of rapidly diminishing remaining climate space.

Australia occupies a distinctive position within this framework. While its territorial emissions represent a relatively small share of global emissions, Australia is among the world's largest exporters of coal and LNG. The emissions resulting from combustion of these exported fuels are several times greater than Australia's domestic emissions and constitute a significant contribution to global warming.

The central finding of this report is presented in Figure CF1, which compares projected cumulative emissions from Australia's future coal and LNG exports under the Australian Government's two principal export scenarios with Australia's indicative share of the remaining carbon budgets.

The analysis does not seek to determine Australia's equitable share of the remaining carbon budget. Instead, it applies a simplified allocation based on Australia's current share of global fossil fuel exports and excludes considerations that would imply a more stringent allocation, including historical responsibility, national capability, per-capita emissions, and the principle of common but differentiated responsibilities and respective capabilities (CBDR-RC). Figure CF1 therefore constitutes a conservative compatibility test.

The results are unequivocal.

Under both Australian Government export scenarios, projected cumulative export emissions far exceed Australia's indicative share of the remaining carbon budget. Australia's projected export pathways therefore fail a conservative compatibility test, constructed using assumptions that significantly favour Australia's position.

This finding has implications beyond debates concerning burden-sharing or climate justice. Even under a methodology designed to maximise Australia's permissible contribution to future emissions, Australia's projected coal and LNG exports remain incompatible with the emissions reductions required to achieve the Paris Agreement's temperature commitments.

Accordingly, the report concludes that the continued export of Australian coal and LNG cannot be reconciled with a climate pathway consistent with limiting warming to 1.5°C. Nor can those pathways be regarded as consistent with the precautionary framework embedded within the UNFCCC or the standard of conduct articulated by the ICJ.

The conclusion reached in this report should be regarded as a minimum finding. It is derived from a methodology that systematically favours Australia's position, and that deliberately avoids more demanding interpretations of climate responsibility. Incorporating considerations of historical responsibility, national capability, equity, or CBDR-RC would only strengthen the conclusion reached here.

2 Key messages

2.1 The ICJ has established 1.5°C as the relevant benchmark for state conduct.

The ICJ's Advisory Opinion confirms that state obligations must be assessed against the Paris Agreement's primary temperature goal of limiting warming to 1.5°C and in light of the best available science. The relevant question is therefore whether current policies and activities are compatible with achieving that objective. Scientific evidence and state conduct must be evaluated against today's understanding of climate science and risk, not assumptions that may once have appeared reasonable when remaining carbon budgets were substantially larger.

2.2 The remaining carbon budget for 1.5°C is now extremely limited.

The best available science indicates that the remaining carbon budget associated with a 50% probability of limiting warming to 1.5°C has declined to approximately 88 $GtCO_2$ from the beginning of 2026. At current global emissions rates, this budget will be exhausted within little more than two years. The scale of the remaining budget leaves only room for emissions accompanying the rapid phase out and closure of major fossil fuel export systems.

2.3 Emissions from fossil fuel exports are foreseeable and intended.

Coal and LNG are extracted for the purpose of combustion. The emissions arising from their use are therefore neither incidental nor speculative but are the foreseeable consequence of production and export decisions. Consistent with the ICJ's reasoning, assessment of state responsibility cannot be confined solely to emissions occurring within national borders where states exercise control over activities that materially contribute to global greenhouse gas emissions.

2.4 Australia is a major contributor to global emissions through exported fossil fuels.

Australia's contribution to climate change extends far beyond its territorial emissions. As one of the world's largest exporters of coal and LNG, Australia enables emissions that substantially exceed those released within its own borders. Any assessment of Australia's climate impact that excludes export emissions materially understates its contribution to global warming and the resulting climate harms.

2.5 A deliberately conservative and Australia-favourable methodology.

The report does not attempt to determine Australia's equitable share of the remaining global carbon budget. It does not incorporate historical responsibility, national wealth, capacity to act, per-capita emissions, or the principle of common but differentiated responsibilities and respective capabilities. Instead, Australia's indicative carbon budget

is derived using a highly favourable allocation based on its current share of global fossil fuel exports. The purpose is to test compatibility under assumptions that favour Australia's position.

2.6 Australia's official export pathways fail even a conservative compatibility test.

Figure CF1 compares Australia's projected cumulative export emissions under the Australian Government's two principal export scenarios with Australia's indicative share of the remaining carbon budget under the conservative allocation methodology adopted in this report.

Under both scenarios, projected cumulative emissions far exceed Australia's indicative share of the remaining carbon budget. This conclusion remains unchanged despite the use of assumptions that systematically favour Australian fossil fuel production and exports. The incompatibility is therefore not the product of stringent assumptions or ambitious equity claims; it emerges even under assumptions designed to maximise Australia's allowable emissions space.

2.7 Australia's projected coal and LNG exports are incompatible with the Paris temperature commitment and the standard articulated by the ICJ.

Because Australia's export pathways exceed even a conservative allocation of the remaining carbon budget, they cannot be regarded as compatible with achieving the Paris Agreement's temperature commitments. If considerations of equity, historical responsibility, national capability, and CBDR-RC were incorporated, the discrepancy would become substantially larger. The evidence therefore indicates that continued export of Australian coal and LNG cannot be reconciled with the climate objectives recognised by the Paris Agreement, the precautionary framework of the UNFCCC, and the standard of state conduct identified by the ICJ.

3 Current climate science

3.1 Commitment to the 1.5°C limit

Since the creation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 [1], signatory nations have upheld to "*prevent dangerous anthropogenic interference with the climate system*". It was not until the 2015 Paris Agreement that such 'dangerous anthropogenic interference' was defined politically, as "*[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"* [2]. The implications of exceeding the 2°C and 1.5°C thresholds were subsequently delineated by the IPCC's Special Report on 1.5 (SR1.5) in 2018 [3] and the contribution of IPCC's Working Group II to the Sixth Assessment Report in 2022 [4].

In the decade since the Paris Agreement, empirical evidence has accumulated that impacts previously linked with higher levels of warming are already occurring with greater frequency at temperatures lower than expected [5, Figure SPM.4]. Impacts are harms such as extreme weather events, sea level rise, and damage to or loss of ecosystems and species.

At the same time, the study of Earth systems feedbacks has identified core global and regional systems that are at increased risk of passing irreversible tipping points as warming continues [6]. These are systems on land and sea that historically have kept the climate stable by absorbing some of the excess heat energy from global warming. When a system is pushed too far (for example, when too much ice melts), it changes from having an overall cooling effect on the climate to a self-amplifying, warming effect. Of most immediate concern, the Greenland ice sheet, the West Antarctic ice sheet and boreal permafrost are at risk of passing abrupt and irreversible tipping points between 1.5°C and 2°C. Evidence is also emerging that serious disruption to the Atlantic circulation system (AMOC[1]) is much closer than previously thought, with a very real risk of it shutting down as the Greenland ice sheet continues to melt [7].

Awareness of the earlier onset of climate impacts and better understanding of the risks of tipping points has contributed to the strengthening of international resolutions to limit warming to 1.5°C, including in the 2021 Glasgow Climate Pact [8] and 2025 Belém Global Mutirão [9]. The 2025 advisory opinion of the International Court of Justice (ICJ) considered the 1.5°C threshold to be the "*agreed primary temperature goal for limiting the global average temperature increase under the Paris Agreement … which requires that mitigation measures be based on the "best available science"* [10]. As such, the ICJ captures the scientifically based shift in emphasis to 1.5°C of warming, rather than 2°C, being the main threshold of concern with respect to preventing "*dangerous anthropogenic interference with the climate system*".

3.2 Remaining carbon budgets

While the temperature commitments of the Paris Agreement marked a watershed in climate negotiations, they were framed in qualitative terms rather than as numerically quantified probabilities. The Paris Agreement formulations "*holding…to well below 2°C*" and "*pursuing efforts*" to limit warming to 1.5°C thus required further interpretation to render as operational, quantitative boundaries.

During the intervening decade, the scientific community has converged on a consensus interpretation of the Paris Agreement's descriptive temperature commitments: achieving around a 50% chance of not exceeding 1.5°C and around 83% chance of not exceeding 2°C. These probability levels reflect accepted conventions in climate and wider risk assessment, whereby 50% is taken as a central estimate of likelihood ("about as likely as not") and 83% sits toward the upper end of the range of "likely" outcomes (66–90%) [11]. These thresholds of likelihood have come to be adopted as *de facto* reference points in both policy and scientific discourse, and are embedded in the IPCC's mitigation and scenario assessments.

Explicit classifications of likelihood levels are associated with quantified remaining carbon budgets – essentially the amount of additional carbon dioxide (CO_2) that may be emitted into the atmosphere for a specified likelihood of a named temperature increase[2]. Carbon budgets are the essential tool through which the best available physical science of the climate system can be translated into actionable policies to limit further global warming. Carbon dioxide is emitted from the combustion of fossil fuels, industrial processes such as cement making, and through deforestation[3]. Hence, remaining carbon budgets establish the amount of fossil fuel combustion and other emitting activities consistent with a particular likelihood of a particular temperature rise, such as a 50% chance of staying below 1.5°C.

The IPCC published remaining carbon budgets for a range of temperature increases in its two most recent assessment reports (AR5 [12] and AR6 [13]) and the Special Report on 1.5°C, with each iteration retrospectively capturing the most up-to-date scientific understanding of the climate system during the period of the relevant assessment cycle. The remaining carbon budgets in the IPCC's 2021 AR6 Working Group I report are the product of the IPCC's sixth assessment cycle, a scientific review process that spanned 2015–2023.

For reference, the remaining carbon budgets from IPCC AR6, updated to the start of 2026[4], are in the region of 260 $GtCO_2$ for a 50% chance of limiting warming to 1.5°C, and 660 $GtCO_2$ for an 83% chance of staying below 2°C. By comparison, annual global emissions from fossil fuels, industrial processes and deforestation are currently around 42 $GtCO_2$, highlighting how rapidly the remaining budgets are being depleted [14].

3.3 Best available science

In the time since the publication of AR6, significant advances have been made in the scientific understanding of the climate mechanisms that relate cumulative emissions to warming [15], [16]. Specifically, notable improvements include:

i. more precise estimates of climate sensitivity, expressed as the Transient Climate Response to cumulative CO_2 Emissions (TCRE);
ii. better understanding of the cooling effects of aerosols (airborne particles such as sulphur dioxide), which can mask the extent of warming;
iii. updated and enhanced assessments of the behaviour of the land carbon sink;
iv. refined projections of the expected level of warming after emissions cease (known as the Zero Emissions Commitment, or ZEC);
v. a better appreciation of the potential weakening of the simple linear relationship between cumulative CO_2 emissions and temperature as emissions approach zero.

The collective outcome of these improvements in scientific understanding is a strong and unambiguous signal that the remaining carbon budgets are substantially smaller than those assessed by the IPCC in its sixth assessment cycle. The work underpinning these recent improvements will in due course feed into revised IPCC carbon budgets, which in turn will be published in the next major assessment report, AR7, scheduled for 2028/29. Indeed, many of the scientists whose work has contributed to recent advances and refinements are IPCC lead authors from the last assessment cycle.

However, the remaining carbon budgets for 1.5°C and 2°C are now so depleted by ongoing high global emissions, that a 50% chance of 1.5°C and 83% chance of staying below 2°C will no longer be viable when IPCC updates its 'official' remaining carbon budgets in AR7 a few years from now. Given the urgency of addressing rising global emissions and securing a rapid transition away from fossil fuels and other sources of emissions, the best available science on remaining carbon budgets must be obtained from a review of peer-reviewed studies published since AR6 and which will in due course feed into AR7 Working Group I.

Such a stance is affirmed by the ICJ Advisory Opinion: *"The standard of diligence may also become more demanding in the light of new scientific or technological knowledge. The Court is aware that scientific research on climate change is well developed. In this regard, reports by the IPCC constitute comprehensive and authoritative* restatements *of the best available science about climate change at the time of their publication."* (emphasis added) [10, Para. 284].

3.4 Updated remaining carbon budgets

The contemporary literature provides a relatively wide range of carbon budgets notionally aligned with the Paris Agreement's temperature commitments. Following discussions with several leading academics in this field, budgets have been selected to inform this report that are considered to:

- reflect, albeit modestly, the UN Framework Convention on Climate Change (UNFCCC) emphasis on "*precaution … to prevent threats of serious or irreversible damage to the climate*"; and
- capture the latest scientific understanding of factors affecting the magnitude of the remaining carbon budgets.

The selected budgets (Table 1 below) are taken from Forster et al., 2025 [16] and incorporate developments in the areas listed i–v in section 3.3 above[5].

The chosen global carbon budgets from the start of 2026 are:

Paris Agreement commitment	**Remaining carbon budget**	**Months of current global emissions left**
For a 50% chance of not exceeding **1.5°C**	**88 $GtCO_2$** [6]	25 *(~ 2 years)*
For an 83% chance of not exceeding **2°C**	538 $GtCO_2$ [7]	153 *(under 13 years)*

Table 1. Updated remaining carbon budgets from the start of 2026 based on Forster et al 2025 [16]. The 1.5°C budget highlighted in red is referred to throughout this report as the 'updated (remaining) carbon budget' for 1.5°C. Current global emissions of CO_2 from fossil fuels, industrial processes, and land use change are 42 $GtCO_2$ per year [14].

In addition, and given the proximity of the 1.5°C threshold (if it has not already been exceeded, see Box 1), the selected budget for 1.5°C adopts assumptions about methane emissions informed by current data and trends, rather than idealised assumptions of rapidly declining emissions[8]. It is also important to note that many assessments focus primarily on 'overshoot' pathways'[9], rather than on budgets associated with remaining within temperature thresholds themselves (see Box 2 below for elaboration of the risks inherent in 'overshoot and return' scenarios). On balance, the budgets outlined here reflect current scientific understanding in a manner broadly consistent with the Paris temperature commitments and the UNFCCC's guidance on precaution.

Box 1: How close is the 1.5°C threshold?

The recurring narrative to 'keep 1.5 alive' in international climate negotiations and national policy contexts is in tension with the widespread view within the scientific community that it may already be too late to prevent global warming from exceeding 1.5°C.

2024 was the first year to be more than 1.5°C warmer than the preindustrial period; at 1.6°C it was the warmest year on record, with 2023 and 2025 the second and third warmest respectively. Global temperatures for the three years 2023–2025 also averaged above 1.5°C, the first time that a three-year period has exceeded that limit [17].

As alarming as this may be, it does not yet represent the strict crossing of the 1.5°C threshold from a climate science perspective, which uses a rolling average over multiple years (the IPCC uses an average over eleven years, others use twenty). A longer term average accounts for a number of factors, including the variation between warmer years influenced by the 'El Niño' ocean circulation (such as in 2024) and cooler 'La Niña' years. Nevertheless, the long-term average global surface temperature is currently at 1.43°C above the pre-industrial era [18].

Section 3.4 of this report notes that the most up-to-date remaining carbon budget for a 50% chance of not exceeding 1.5°C as a long-term average now stands at less than two years' worth of current global emissions. That is to say, the remaining carbon budget is so depleted as to be effectively exhausted. This being so, in all likelihood the world may already have entered the eleven-year period that subsequent long-term averaging will find exceeds 1.5°C of warming.

It is also important to keep in mind that globally, while the rate of increase in fossil fuel growth is now falling, more fossil fuels than ever are still being burned, and the rate of warming itself is still accelerating.

By now it will be obvious that the selected updated remaining carbon budget for 1.5°C amounts to two years of current global emissions. Taken together with the recent temperature record – the last three years averaging above 1.5°C – the remaining carbon budget for 1.5°C is so small as to be, for all practical purposes, exhausted. Nevertheless, the dire significance of passing 1.5°C as a long-term average level of warming cannot be overstated, and mitigation efforts should be deployed with all the more urgency for the nearness of the threshold, whether it ultimately transpires that we have entered the period of its exceedance or not.

Furthermore, the Paris Agreement commitments of 'pursuing 1.5°C' and 'holding to *well below*' 2°C indicate that temperatures above 1.5°C but below 2°C are to be avoided with increasing levels of confidence. Every increment of warming above 1.5°C – each fraction or tenth of a degree Celsius – carries ever increasing risk of triggering tipping points, and generating abrupt and irreversible additional warming.

To this end, although the authors of this report do not consider it feasible to limit global emissions to the remaining carbon budget for 1.5°C, we proceed on the basis that the long-term 1.5°C threshold, whether ultimately avoided, breached, or 'overshot and returned', is an essential anchor point for restricting any further warming and risk to an absolute minimum.

Box 2: Overshoot scenarios

Exceeding a particular temperature threshold with the assumption it can be brought back below the temperature in question is referred to as 'overshoot and return'. Overshoot has most commonly been applied to the 1.5°C threshold, for example in the IPCC Working Group III "no and limited overshoot" (C1) scenarios.

The assumption of 'return', embedded within the concept of overshoot relies on CO_2 being removed from the atmosphere and permanently sequestered in sufficient quantities to bring about a reduction in global average temperature. However, this ostensibly simple description belies the potentially insurmountable challenges and huge risks entailed in attempting such a timely reduction.

To start, even a 0.1°C rise above the 1.5°C threshold would likely require, other things being equal, the capture and sequestration of around 220 $GtCO_2$ (billion tonnes) [19], the equivalent of five years of current global CO_2 emissions. According to the latest data, the rate of capture through 'engineered removals' is around 1.3 $MtCO_2$ per year, of which less than 0.6 $MtCO_2$ is in secure geological storage [20], or around 0.0015% of global CO_2 emissions in 2025.

At present there is no robust evidence that CO_2 removals could be achieved at anything approaching the requisite scale to make 'overshoot and return' timely and viable. Moreover, there is increasing concern that terrestrial and oceanic carbon sinks, which have historically moderated warming, are reducing their carbon uptake as temperatures rise [21]. Some forest carbon sinks are now approaching the point whereby net carbon uptake is beginning to reverse. Likewise, warming oceans are showing signs of diminishing capacity to absorb CO_2 [22]. As these sinks weaken and shift toward becoming net sources, they drive additional radiative forcing, pushing warming beyond what would be expected from anthropogenic emissions alone.

A further set of risks has emerged since the Paris Agreement from scientific advances in the study of Earth system feedbacks, as highlighted in section 3.1 of this report. These 'tipping points' could result in significant nonlinear and irreversible increases in warming and other related impacts, with several key effects at risk of being triggered at warming levels between 1.5°C and 2°C.

So while there is no scientific consensus on the feasibility of the requisite CO_2 removals to achieve the return part of 'overshoot and return', there *is* consensus that overshoot increases the risk of irreversible climate impacts. If warming persists above key thresholds, weakened carbon sinks and activated tipping points could lock in higher temperatures still, leaving us unable to return to the agreed and safer limits.

3.5 Timescales for 1.5°C and 2°C – why engineered removals won't help

Carbon dioxide removal (CDR) is frequently presented as a central component of meeting the 1.5°C target. However, if the UNFCCC edict to '*prevent dangerous anthropogenic interference with the climate system*' is interpreted as a 'do-not-exceed' 1.5°C mitigation framework, CDR can have no meaningful role. The same conclusion broadly applies to carbon capture and storage (CCS) when proposed as a means of prolonging fossil fuel use. The reason is straightforward: as outlined in section 3.4 above, the remaining carbon budget for 1.5°C is extremely small and is being exhausted rapidly, at over 4% per month, leaving no time for either CDR or CCS to scale to climate-relevant levels.

Even under highly optimistic assumptions, scaling either CDR or CCS to gigatonne levels would take at least a decade, and likely considerably longer[10]. By contrast, avoiding exceedance of 1.5°C requires immediate and steep emissions reductions, with complete elimination of emissions before the end of the 2020s. This fundamental mismatch in timescales means that neither CDR nor CCS can materially contribute to staying within the 1.5°C carbon budget. By the time meaningful deployment could occur, the budget for a 50% chance of not exceeding 1.5°C will already have been exhausted. As time progresses and emissions continue to accumulate, this conclusion increasingly applies to the Paris Agreement's 2°C commitment as well (here taken as an 83% chance of not exceeding 2°C).

Reliance on future CDR and CCS also introduces significant additional risks and uncertainties. Large-scale deployment would require vast land areas and water resources – placing it conflict with agricultural and biodiversity imperatives – as well as infrastructure, and robust long-term governance, all of which remain uncertain and contested. Moreover, CCS is frequently used to justify continued fossil fuel extraction and combustion, thereby delaying structural emissions reductions. Such reliance increases the likelihood of overshoot and raises the risk of triggering Earth system feedbacks and tipping points that would place the climate system on a dangerous and potentially irreversible trajectory.

CDR becomes a major contributor only in overshoot-and-return pathways, which implicitly downplay, if not deny, the risks associated with Earth system feedbacks (see Box 2 above). Embedding CDR and CCS within mainstream mitigation strategies therefore transgresses the precautionary principle at the heart of the UNFCCC, which emphasises avoiding dangerous climate change rather than assuming that it can later be reversed. It also sits uneasily with emerging legal expectations, including advisory guidance from the International Court of Justice, which underscores the need for immediate, precautionary action consistent with 1.5°C.

Accordingly, in relation to both the letter and spirit of the UNFCCC and the ICJ's advisory

opinion, neither CDR nor CCS constitutes a meaningful mitigation tool. Instead, both are already acting as dangerous distractions from the urgent and immediate reductions required, including the rapid elimination of fossil fuels for both domestic use and export.

Section 3 Footnotes

[1] The Atlantic Meridional Overturning Circulation – a system of ocean currents that distributes heat and contributes to the regulation of the Earth's climate.

[2] While carbon budgets refer to carbon dioxide only, they are premised on underlying assumptions about the emissions of non-CO_2 greenhouse gases, particularly methane. Appendix A2 contains further information about methane emissions assumptions underpinning contemporary carbon budgets.

[3] Carbon budgets refer to anthropogenic emissions of CO_2 only.

[4] IPCC AR6's headline remaining carbon budgets are from the start of 2020, so are updated here by subtracting global CO_2 emissions recorded for the intervening six years, obtained from Global Carbon Project [56].

[5] See Appendix A1 for further information about the selection of remaining carbon budgets from the contemporary scientific literature.

[6] This value is based on the RCB of 130 $GtCO_2$ from the start of 2025 in Forster et al. 2025, Table 8 in the main text – i.e. with global emissions of 42.2 $GtCO_2$ subtracted for 2025 [14]. The value of 130 $GtCO_2$ is lower than that presented in Table S8 in the supplementary information, as it adopts a more reasoned, but still optimistic, assessment of methane emissions.

[7] This value is also from Forster et al. 2025, in this case based on 580 $GtCO_2$ from the start of 2025 (taken from Table S8 in the supplementary information) and with 42.2 $GtCO_2$ subtracted for global emissions in 2025 [14]. In this case the value of 580 $GtCO_2$ is lower than that presented in Table 8 of the main text, in significant part as a consequence of an improved characterisation of the 'zero-emission commitment'.

[8] See Appendix A2 for further information about methane emissions assumptions.

[9] The more accurate term is 'overshoot and return', although the vital 'return' element is often omitted.

[10] All major CDR approaches – including bioenergy with carbon capture (BECCS), direct air carbon capture and storage (DACCS), and enhanced weathering – face substantial technical, economic, and ecological constraints. Similarly, large-scale CCS deployment faces persistent challenges related to infrastructure development, storage integrity, energy penalties, and cost.

4 Fossil fuel exports in a 1.5°C world

4.1 Territorial (end-user) emissions accounting

Climate change is an inherently global problem, and the warming atmosphere is indifferent to where greenhouse gases are emitted; total cumulative emissions are all that registers. Nonetheless, wealthier industrialised nations have demonstrably emitted and continue to emit far more than their poorer neighbours, thus bearing more responsibility for rising temperatures.

This fundamental inequality – both of nations' historical and current contributions to causing climate change, and of nations' capacities to make rapid changes to their infrastructure and transition off fossil fuel use – is reflected in the UNFCCC's Article 3, in the principle of "*Common but Differentiated Responsibilities and Respective Capabilities*" (CBDR-RC) [1]. In short, CBDR-RC recognises that wealthier, high-emitting countries should cut their emissions faster than those that are still in the process of developing their economies and infrastructures. This principle of international equity has been reaffirmed every international climate treaty and declaration since the establishment of the UNFCCC in 1992.

Historically, nations have taken accountability only for the emissions that occur within their borders – what are usually referred to as 'territorial emissions'. This form of accounting identifies a country's emissions from the fossil fuels burned within its territory, as well as from its domestic industries, agriculture, waste management, and land use[11]. Territorial emissions accounting is the conventional basis for allocating national shares of a remaining carbon budget through a variety of 'apportionment regimes', many of which strive to capture the equity principle of CBDR-RC to greater or lesser extents.

4.2 Most fossil fuels are exported

In the three-and-a-half decades since the UNFCCC, global emissions from fossil fuels have increased every single year, with the single exception of 2020 under the COVID-19 pandemic confinements [16]. Emissions continue to rise because more fossil fuels are being produced and combusted year-on-year. However, fossil fuel reserves are not distributed evenly throughout the countries of the world; less than half of all countries have hydrocarbon deposits in quantities sufficient to support extractive industries of significance. In 2024, just eighteen countries together accounted for the production of 91% of global coal, 76% of global oil, and 73% of global gas [23].

The economic advantages to a country of having large hydrocarbon deposits within its territory are self-evident, particularly if quantities of highly tradable – that is to say exportable – oil or gas are present. It is also clear that conventional, end-user based, territorial emissions accounting is failing to arrest the ongoing escalation of fossil fuel use.

Fossil fuels, once extracted, must inevitably be combusted[12]; global storage capacity for such bulky commodities is limited to just a few months' surplus production of oil, gas, and coal [24], [25].

Placing sole responsibility on end-users for the emissions that unavoidably arise once a quantity of fossil fuel is produced is to ignore the enormous economic incentive that exists for continuing to extract, produce, and export fossil fuels.

4.3 Producer-based emissions accounting

While conventional territorial, or end-user, accounting has dominated the mitigation space for decades, increasing attention is now being paid to forms of producer-based accountability for emissions from fossil fuels. In its 2025 Advisory Opinion, the International Court of Justice stated: "*Failure of a State to take appropriate action to protect the climate system from GHG emissions — including through fossil fuel production, fossil fuel consumption, the granting of fossil fuel exploration licences or the provision of fossil fuel subsidies — may constitute an internationally wrongful act which is attributable to that State.*" [10, Para. 427]. Furthermore, there is an obligation of states "*to regulate the activities of private actors as a matter of due diligence*" [10, Para. 428].

National legislatures are also beginning to encode consideration of producer-based accountability for the emissions from the fossil fuels they produce. For example, in the United Kingdom, the Department for Energy Security and Net Zero issued 'Supplementary Guidance for assessing the effects on downstream scope 3 emissions on climate from offshore oil and gas projects' in 2025. Scope 3 emissions are those that result when the fossil fuel is combusted at point of end-use, which under the Supplementary Guidance must now be assessed cumulatively alongside existing production against 'global climate objectives' for any new oil or gas extraction project [26].

The academic and scientific community has also explored and defined systems of accountability for fossil fuel emissions on a producer rather than purely end-user basis [27–31]. Apportionment mechanisms have been proposed that take account of the extent to which producer nations are financially dependent on 'economic rents' from exporting fossil fuels, which directly affects their capacity (or wherewithal) to rapidly make a 'just transition' away from producing fossil fuels. Producer-focused budgetary apportionment regimes such as these are a useful and illustrative adjunct to end-user based, territorial apportionment, and bring into sharp relief the role of exported fossil fuels as a key subset of production.

4.4 Apportionment of a functionally exhausted budget

Critically, for any budgetary apportionment system to have practical application – whether end-user-based or producer-based – there must be a viable remaining carbon budget still

available to apportion. As shown in sections 3.4 and 3.5 above, this is simply no longer the case for a 50% chance of not exceeding 1.5°C, for which the updated remaining carbon budget amounts to two years of current global emissions. That budget is, to all intents and purposes, functionally depleted. To comply, global emissions would have to be brought down on a straight-line reduction pathway starting today and reaching zero by the end of 2029, and remain at (or below) zero thereafter. No existing international apportionment regime can be meaningfully applied to such a negligible remaining carbon budget within the timeframe it entails.

Nevertheless, all signatory nations to the Paris Agreement have undertaken a commitment to limit warming to the 'primary temperature goal' of 1.5°C (by consensus interpreted as a 50% probability of staying below that temperature, see section 3.2 above). The Advisory Opinion of the International Court of Justice found that the Paris Agreement places on states "*an obligation to pursue measures which are capable of achieving the objectives set out in their successive nationally determined contributions*", which themselves must be "*capable of achieving the temperature goal of limiting global warming to 1.5°C above pre-industrial levels*" [10, Para. 457].

Notwithstanding the negligible remaining carbon budget for 1.5°C and binding international commitments to cut emissions in line with limiting warming to 1.5°C, it is worth emphasizing again that every fraction of a degree above 1.5°C of warming carries ever increasing risk of worsening climate impacts (harms) and of triggering tipping points that would generate abrupt and irreversible additional warming.

Therefore, Section 5 of this report treats the 1.5°C threshold as a 'live prospect', in order to highlight the scale of disconnect between very tight carbon budget constraints and ongoing production and export of fossil fuels from Australia. Section 5.7 goes on to consider Australia's fossil fuel exports in the context of the Paris Agreement's upper temperature threshold of "well below 2°C".

4.5 Maximising energy return from emissions budgets

The primary purpose of combusting fossil fuels is to provide energy. Constrained by the extremely tight remaining carbon budgets for 1.5°C (two years of current global emissions) and 2°C (less than thirteen years of current global emissions) it is logical to maximise the amount of useful energy that may be extracted from fossil fuels before the budget is completely consumed. In very simple terms, less energy dense forms of fossil fuels result in greater quantities of emissions during combustion per unit of energy released.

In ascending order of energy density, the principal fossil fuel types have been traditionally ranked as follows:

Fuel type	IPCC emissions factor, tCO_2/toe	Energy density[13]
Brown coal (lignite)[14]	4.23	Low
Black coal (bituminous coal)	3.96	
Coking coal (metallurgical coal)	3.96	
Crude oil	3.07	
Natural gas liquids (LNG)	2.69 *	
Liquefied petroleum gases (LPG)	2.64	
Pipeline methane (natural gas)	2.35	High

Table 2. IPCC Default global average emission factors for stationary combustion in the energy industries, in tonnes of CO_2 per tonne of oil equivalent [32].

Table 2 above gives emissions factors for the carbon dioxide (only) that is released when fuel is combusted, which is applicable for calculating the emissions that will erode the remaining carbon budget. However, CO_2 emissions factors for fuel combustion do not give the full picture with regard to the contribution to climate change, as non-CO_2 gases – most importantly methane and, to a lesser extent, nitrous oxide – also arise to varying degrees during the full lifecycle of extraction, production, transport and distribution for each fossil fuel type.

To maximise energy yield from the rapidly dwindling remaining carbon budgets, the immediate cessation of coal production, exports, and combustion is the obvious first priority.

4.6 Lifecycle emissions of fossil fuel supply chains

The asterisk * in Table 2 draws attention to the fact that liquefied natural gas (LNG, also referred to as natural gas liquids) has disproportionately high lifecycle emissions compared to other fossil fuels (associated with the energy required to cryogenically liquefy the feed gas, pressurise and transport it by tanker, before finally re-gasifying and distributing it to end-users), which are not captured by the default IPCC stationary combustion emissions factors for CO_2 in Table 2.

Fugitive emissions[15] of methane, which may arise at multiple points in the lifecycle of all fossil fuel production and substantially increase their overall impact on the climate, is a particular issue for both LNG and coal (see Box 3).

Box 3: LNG – cleaner than coal? The importance of fugitive emissions

Natural gas (methane) is often portrayed as a 'transition fuel', offering an easy win for emissions reductions by displacing coal in electricity generation. Indeed, of the main fossil fuels, natural gas yields the highest energy return per tonne of CO_2 emitted, when the gas is transported and distributed by pipeline (Table 2). That being so, natural gas is 75% carbon, by no means a 'clean fuel' when combusted. Fugitive emissions of methane (which may occur during extraction, processing, transport or end use), also create a significant additional warming burden over and above the CO_2 from combustion.

Liquefied natural gas (LNG), while chemically still methane, has undergone additional energy-intensive treatment to facilitate its transportation where pipelines are not economically feasible, principally by ocean-going super-tankers. This makes LNG a highly tradeable (exportable) commodity, with the global LNG trade now approaching the level of global pipeline gas exports. The intensive processing and handling of gas throughout the supply chain makes LNG particularly susceptible to fugitive emissions, which add substantially to the full lifecycle emissions of greenhouse gases from LNG. The near-term climate impact of fugitive methane outweighs that of the combustion of the methane itself if fugitive emissions exceed 3.2% of feed gas[16] [33], [34].

Methane is a far more potent greenhouse gas than CO_2, causing 83 times more warming than CO_2 on a tonne-per-tonne basis when integrated over 20 years (GWP20), and 26 times more when integrated over 100 years (GWP100). The majority of lifecycle assessments of fossil fuel supply chains have traditionally calculated the effects of fugitive methane over 100 years, using GWP100. However, given the imminent risks associated with breaching the 1.5°C threshold, focusing only on long-term warming from methane is inappropriate. Methane's high warming potential in the next twenty years is what counts, if tipping points in Earth systems feedbacks are not to be triggered above 1.5°C (see Box 2).

When lifecycle emissions are calculated using GWP20, LNG can rank nearer to coal than pipeline gas, depending on fugitive emissions rates and the trade route in question (see Table 3). Australia-to-Asia LNG supply chains sit towards the 'upper end of the middle', with lifecycle emissions below USA-to-Europe, but higher than Qatar, Algeria and Russia-to-Europe.

This ranking is a result of Australia's officially tight controls on fugitive emissions leaks (reported as 0.7%), which utilise site-specific monitoring data to estimate total methane emissions (i.e. a 'bottom-up' approach). However, remote sensing using satellite data (a 'top-down' approach) has consistently found regional

methane emissions from fossil fuel extraction to be significantly higher than bottom-up inventories, principally because bottom-up sampling can miss 20–50% of emissions from 'super-emitter events' (short pulses of high emissions) [35].

In the case of Australia, recent analysis has found that top-down satellite-based estimates put methane emissions 15% higher than the average of bottom-up estimates, although some key bottom-up methods (including UNFCCC) produced estimates 25–40% lower than the bottom-up average for the oil and gas sector [36].

Fuel type or route	$kgCO_2eq/MWh$
'Supercritical' coal	900
USA to Europe LNG	748
Australia to Asia LNG	683
Russian pipeline gas	580
Algerian pipeline gas	560
Qatar to Europe LNG	527

Table 3. Lifecycle emissions intensities for electrical output from coal compared with LNG and pipeline gas, when warming from methane is integrated over twenty years using GWP20. ('Supercritical coal' refers to modern, efficient coal power plant) [37].

The lifecycle emissions intensities shown in Table 3 are for electrical output, rather than in units of CO_2-equivalent per energy unit input, therefore cannot be directly compared with the values in Table 2, or with the remaining carbon budgets for CO_2 only. However, the relatively high warming potential of methane from the LNG supply chain (compared with pipeline gas, for instance) makes it clear that LNG should not be viewed as a 'clean option' compared with modern, 'supercritical' coal-fired generation. As a consequence, production, export and use of LNG on high emissions intensity routes must be rapidly ended if critical climate thresholds, 1.5°C to 2°C, are not to be breached by non-CO_2 warming above that underpinning the calculation of remaining carbon budgets.

Section 4 Footnotes

[11] Territorial emissions are sometimes contrasted with 'consumption emissions', an alternative form of accounting whereby countries are allocated the extra-territorial emissions from the energy used to produce the goods and services that they consume (very broadly calculated as: domestic emissions, plus emissions from 'imports minus exports'). This form of consumption emissions accounting is complex and lacks a consensus methodology for reporting and attribution, so is harder to implement in mitigation policy than the standard territorial method. However, both territorial and consumption-based accounting methods attribute responsibility for emissions to the end-users of energy, they merely differ with respect to who (or where) is considered the final end-user.

[12] Non-energy use (or 'non-combustion end use') of fossil fuels is averages around 6.4% of total energy supply [57], although a large proportion of this fraction still emits at end-of-life.

[13] The ranking given here is according to mass-based energy density. By volume, oil and liquid petroleum products are more energy dense than pipeline natural gas.

[14] Included for reference, lignite is not typically exported.

[15] Fugitive emissions include vented emissions, leak emissions, and flaring emissions, as per the IPCC definition [58].

[16] Using GWP20.

5 Australia's contribution to climate change

5.1 Territorial emissions

Australia's territorial emissions from energy and industrial processes of 387 $MtCO_2$ made it the 16th highest emitting country in 2024[17]. Combined with CO_2 from land use change[18] and emissions from international aviation and shipping, Australia's total territorial CO_2 emissions in 2024 were around 419 $MtCO_2$ [38], [39]. Around 12% of Australia's territorial CO_2 emissions (excluding land use) are from producing fossil fuels for export[19] [40].

It has the 10th highest per capita emissions in the world, at around 16 tonnes of CO_2 per Australian citizen [41, Fig. 9], over three times the global mean of 4.7 tCO_2 per person [38]. Note that this global mean is skewed by very high emissions in wealthy countries; in 2021 half of the global population emitted less than 2.9 tCO_2 per person [42]. Australia was responsible for 1% of global CO_2 emissions in 2024, from just 0.33% of the world's population.

Furthermore, Australia is a wealthy country, with GDP per capita of $72,111[20] in 2024, almost three times the world mean of $24,526 [43], placing it around the twentieth wealthiest country in the world on that basis.

It is clear from this snapshot alone that Australia bears considerable responsibility for causing climate change, well in excess of its 1% contribution to annual emissions. Were the updated remaining carbon budget for 1.5°C shared out on an equal per capita basis, Australia would use up its share of the budget in just eight months if it continued at its current rate of emissions, on the basis of territorial emissions alone.

5.2 A major exporter of emissions

Australia's contribution to causing climate change extends far beyond its domestic emissions, though. It is amongst the world's biggest exporters of fossil fuels, in 2024 ranking number one in the world for exports of coal for steel-making (otherwise known as metallurgical, 'met' coal or coking coal), second only to Indonesia for exports of thermal coal, and second equal (with Qatar, behind USA) for exports of liquefied natural gas (LNG).

Based on the CO_2 emissions from the combustion of exported fuels alone, Australia's exports routinely place it the top four of all fossil fuel exporting countries in the world [44]. However, Australia exports predominantly coal and LNG, the most emissions intensive (or 'dirtiest') fossil fuels available – associated with high lifecycle emissions of methane (see section 4.6 above), which place it higher still among fossil fuel exporting nations.

Australia exports comparable amounts of thermal coal (for power generation), steel-making or metallurgical coal, and LNG (Figure 1), on an energy equivalence basis.

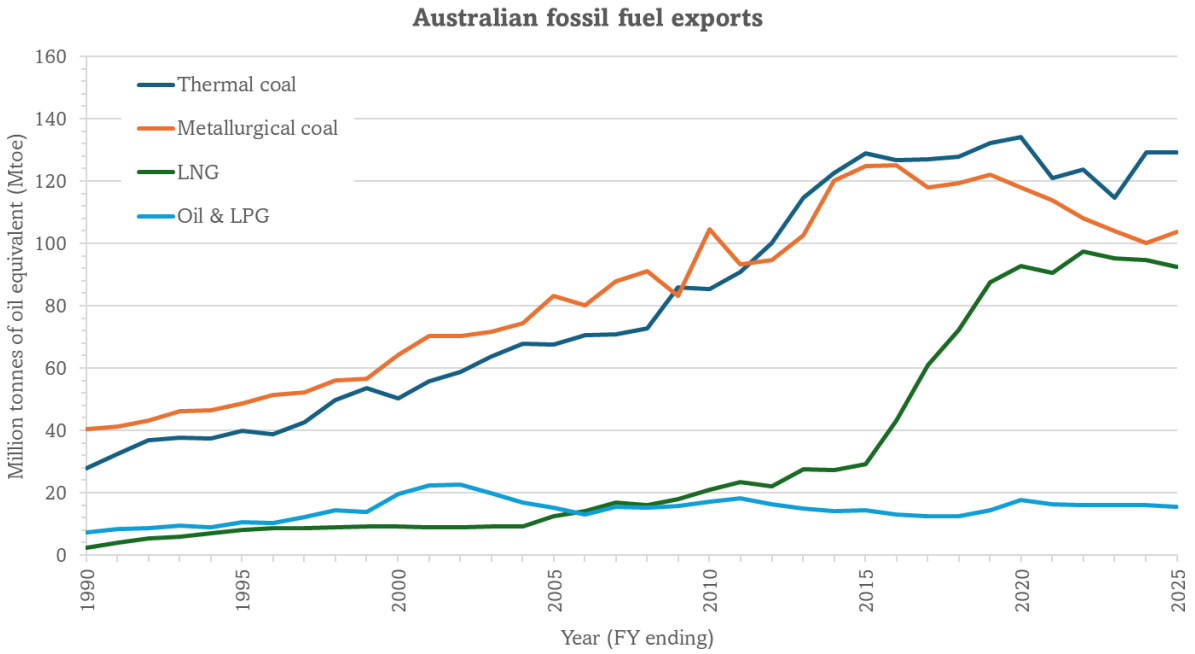


Figure 1. Historical Australian exports of fossil fuels by type in energy equivalent units. Sources: [45], [46].

5.3 Historical contribution to climate change of Australia's fossil fuel exports

Australia's exports of thermal and metallurgical coal grew steadily for three decades to peak around 2015. Thereafter, thermal coal output has held more or less at peak levels of around 200 million tonnes (product) annually, while metallurgical coal output has slightly declined from 188 million tonnes to around 150 million tonnes annually. Exports of LNG were negligible throughout the 1990s and 2010s before expanding rapidly year on year from 25 million tonnes (product) in 2015 to current output of around 80 million tonnes per year. Australia exports relatively small quantities of crude oil and liquefied petroleum gases, in the range of ten to fifteen million tonnes of product combined each year.

These annual fuel export quantities have been converted into the CO_2 emissions that result when they are combusted, using standard energy equivalence conversion factors [46] and IPCC emissions factors [32]. They are plotted as a time series in Figure 2 and summarised in Table 4. This CO_2-only assessment enables comparison with remaining carbon budgets. Non-CO_2 lifecycle emissions such as fugitive methane are not included here, but increase the overall greenhouse gas footprint of fossil fuel exports, particularly for coal and LNG (see section 4.6 above).

The 'export share of production emissions' is the quantity of CO_2 emissions from the production of all fossil fuels that accrues from exported fossil fuels[21].

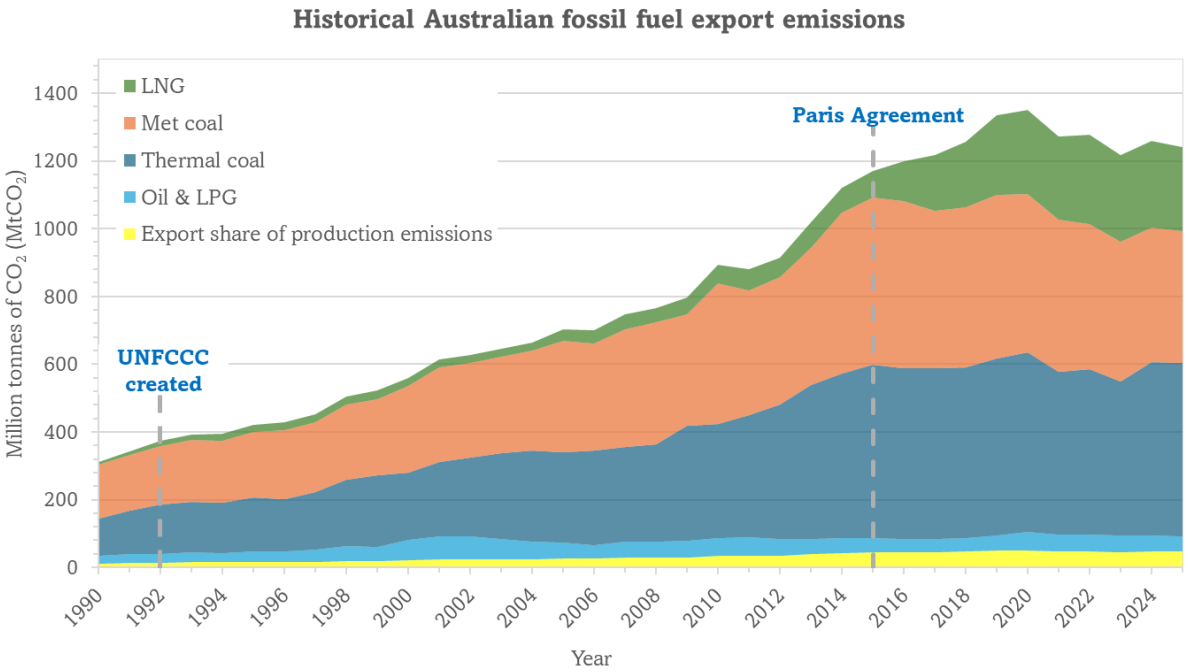


Figure 2. Historical CO_2 emissions from combustion of Australian exports of fossil fuels by type. Sources: [40], [45], [46]

Fuel type / source	**$MtCO_2$ in 2025**	**Cumulative emissions 1990–2025, $MtCO_2$**
Thermal coal	512	11,758
Metallurgical coal	411	11,980
LNG	249	3,138
Oil and LPG	46	1,587
Export share of production emissions	48	1,118
TOTAL	**1,265**	**29,582**

Table 4. Summary of current annual combustion emissions from Australian fossil fuel exports by type, and historical cumulative combustion emissions since 1990. Sources: [40], [45], [46]

Figure 2 and Table 4 show cumulative emissions from Australian fossil fuel exports since 1990, the year of the IPCC's first assessment report and the establishment of guidelines for national greenhouse gas inventories. 1990 is widely used as a baseline year in national inventories and emissions reduction policies. Since 1990, Australian fossil fuel exports have resulted in cumulative emissions equivalent to more than a third of the entire remaining global carbon budget for 1.5°C (combustion CO_2 only). Since the 1992 United Nations Framework Convention on Climate Change, Australian emissions from Australian exports of fossil fuels have more than tripled. Export emissions continued to rise even after Australia ratified the 2015 Paris Agreement, and they currently stand 6% higher than a decade ago.

5.4 Projected future emissions from Australian fossil fuel exports

Estimates of future production and exports of each type of fossil fuel are published by the Australian government Department of Industry, Science and Resources (DISR) for the next five years [47]. Looking beyond 2031, several departments of the Australian Government offer alternative scenarios, the two foremost of which indicate distinctly different trajectories for exports of fossil fuels, as described in the following subsections.

5.4.1 The 'Treasury scenario'

The Australian Government Treasury's high-level modelling and analysis report, *Australia's Net Zero Transformation* (*ANZT*) [48], describes a set of hypothetical pathways to bring Australia's territorial emissions to 'net zero'. As part of the pathway for the resources sector, the report contains three very broadly delineated trajectories for output (i.e. production) of coal and LNG, in recognition of the territorial emissions that are generated during extraction and processing of fossil fuels. The Treasury's output trajectories are based on the International Energy Agency's 2023 *World Energy Outlook* (WEO 2023) 'Announced Pledges Scenario' (APS) of global energy demand[22]. The APS is said to be "*associated with a temperature rise of 1.7 °C in 2100 (with a 50% probability)*" [49]. That is to say, the demand scenario on which the Treasury's modelled fossil fuel output is based is explicitly not aligned with 1.5°C.

For the purposes of this analysis, we focus on the Treasury's central 'Baseline Scenario' (hereafter referred to as the 'Treasury scenario'), which posits that coal output will reduce by 47% by 2035, and by 72% by 2050. Similarly, it assumes that gas and LNG output will reduce by 27% by 2035, and by 67% by 2050. In each case reductions are against a 2025 baseline. While these headline reductions are for output (production), examination of the cited enables the quantification of export pathways for coal and LNG implied by the Treasury scenarios. The export pathway for LNG is taken from the 2024 Australian Government report *Future Gas Strategy*[23] [50], for coal it is taken from the 2023 IEA *World Energy Outlook* [49] and DISR *Resources and Energy Quarterly* (*REQ*) [47], as cited in the Technical Appendices to *ANZT*.

The outcome in terms of the combustion emissions resulting from export of fossil fuels under the 'Treasury scenario' is plotted in Figure 3 below. While this is necessarily an 'interpretation' (owing to the very limited data made publicly available about the composition of the Treasury's scenarios), it is at every step the most generous interpretation that it is reasonable to make[24].

The emissions pathway beyond 2050 is not indicated in the Treasury report, although the Baseline Scenario clearly contains significant ongoing output (and by extension export and combustion) of fossil fuels. The conservative assumption made in our interpretation is that output and exports continue to fall at the same rate as between 2040 and 2050, simply extrapolating this trajectory until zero is reached in 2067.

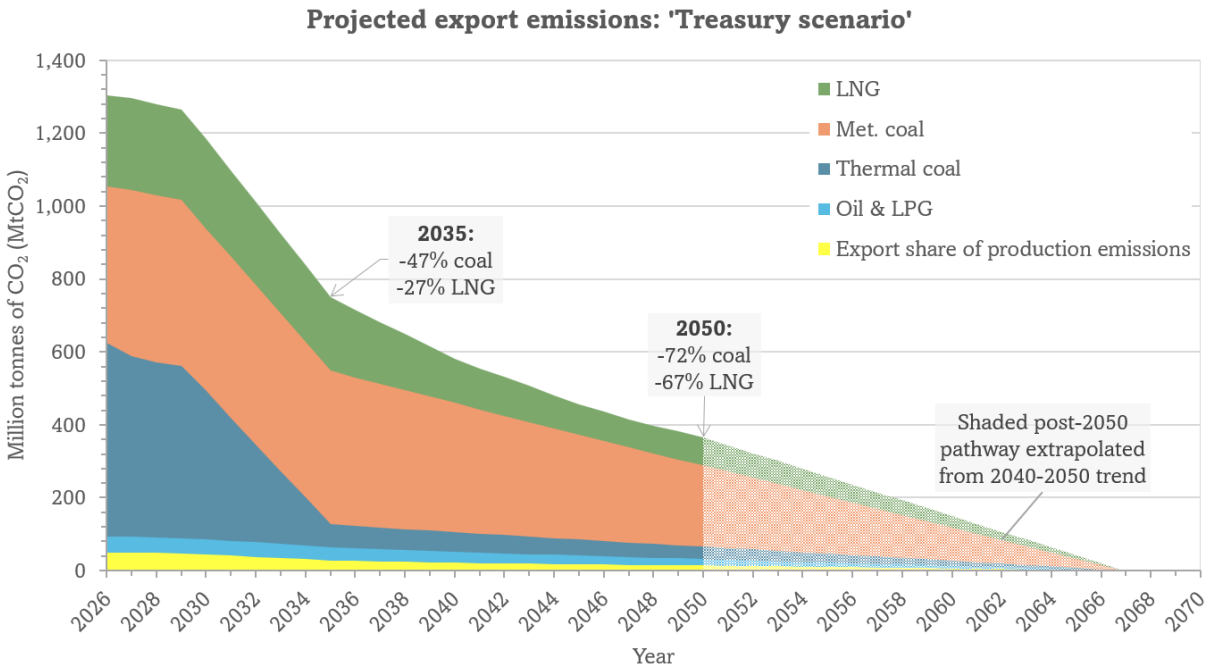


Figure 3. Projected combustion CO_2 emissions from Australian exports of fossil fuels by type, based on Treasury *Australia's Net Zero Transformation*, 'Baseline Scenario' and its cited sources. Sources: [40], [46], [47], [48]

5.4.2 The 'DCCEEW scenario'

The Australian Government Department of Climate Change, Energy, Environment and Water (DCCEEW) publishes detailed statistical datasets, including the *Quarterly Update of Australia's National Greenhouse Gas Inventory*, which contains projections for coal and LNG output to 2040 [51, Fig. ST8]. Unlike the Treasury Baseline scenario, which assumes that output of both fuels will decline markedly over the next decade, the DCCEEW's projections are for only a modest decline in thermal coal output, output of metallurgical coal holding steady at current levels out to 2040, and fluctuating but still relatively high output of LNG until the mid-2030s, before it slowly declines.

The outcome in terms of the combustion emissions resulting from Australian fossil fuel exports indicated in the DCCEEW's *Quarterly Update* projections is plotted in Figure 4 below (hereafter referred to as the 'DCCEEW scenario'). As with the 'Treasury scenario', this interpretation is conservatively generous in the assumptions made to quantify export emissions[25].

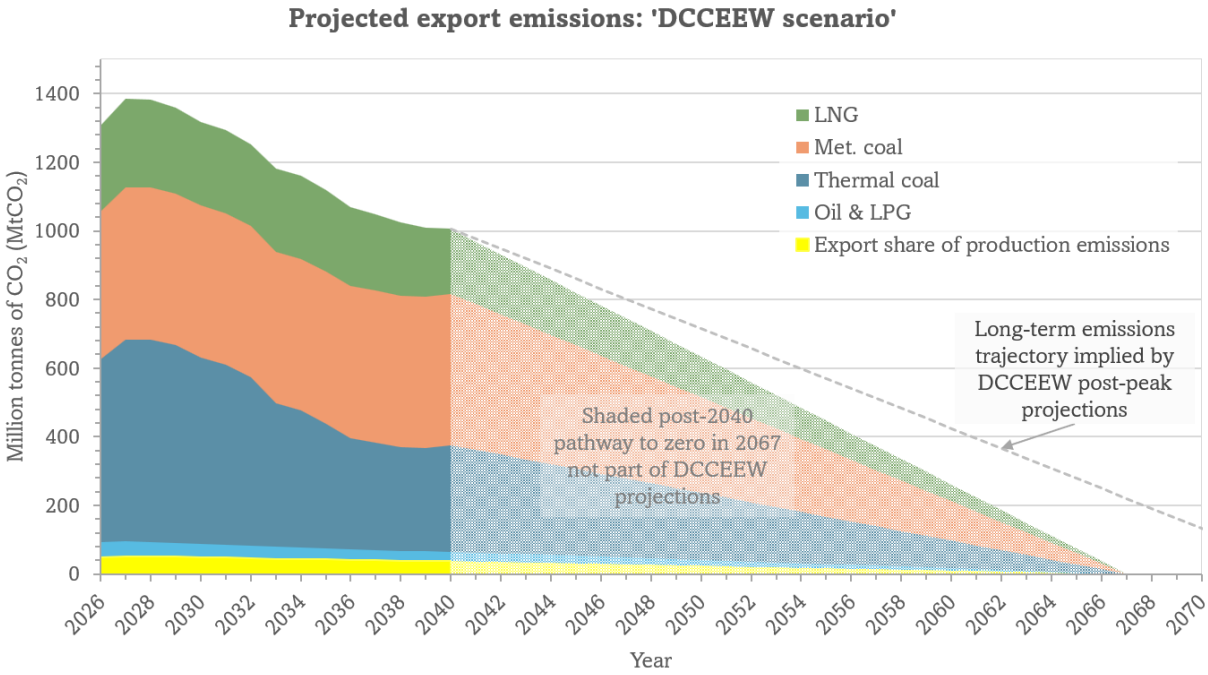


Figure 4. Projected combustion CO_2 emissions from Australian exports of fossil fuels by type, based on DCCEEW projections for coal and LNG. Sources: [40], [46], [47], [51]

For consistency and to allow meaningful comparison with the 'Treasury scenario', export emissions under the 'DCCEEW scenario' have been extrapolated to reach zero in the same year as implied by the post-2040 trajectory in the 'Treasury scenario' (2067). This is again a generous (or optimistic) interpretation, given that the trajectory of exports between the peak year (2027) and the end of the DCCEEW's published projection data (2040) suggests that export emissions would continue until 2075 (the grey dashed line in Figure 4), and would thereby generate a greater cumulative emissions burden than we attribute to the scenario here.

5.5 Review of government export scenarios

While both the 'Treasury scenario' and the DCCEEW projections agree that growth in production (and by extension, export) of coal and LNG has already ended or is about to do so, they differ significantly in their assessment of the rapidity with which the ensuing decline is expected to occur[26].

5.5.1 'DCCEEW scenario' review

The DCCEEW report, *Quarterly Update of Australia's National Greenhouse Gas Inventory: September 2025*, has this to say about the divergence between its own projections and the Treasury's:

> "*The Treasury's* Australia's Net Zero Transformation: Treasury Modelling Analysis *estimates a more rapid decline in Australian fossil fuel production. This is in part due to different assumptions around global climate action. The Treasury scenarios show potential*

pathways for Australia to net zero by 2050 in the context of global action to limit warming to well below 2 degrees Celsius. Whereas these [DCCEEW] *energy projections conservatively reflect current policies and measures in Australia and overseas.*" [51]

The DCCEEW projections are in reasonably close agreement with the shorter term forecasts issued by the DISR. However, industry analysts have criticised current DISR forecasts for being bullish about exports of metallurgical coal, and for overestimating export volumes in the past [52]. In the report *Australia's coal outlook in a warming world: Insights from integrated assessment models*, the authors state:

"*DISR forecasts have historically overestimated Australia's coal exports, particularly for metallurgical coal, as highlighted in analysis by IEEFA… This is likely a result of a range of factors including optimistic assumptions about project development; high price assumptions; and underestimation of structural demand trends in key importers.*" [53]

5.5.2 'Treasury scenario' review

Among the sources for output and exports of coal in the Treasury Baseline scenario in *ANZT* are the DISR Resources and Energy Quarterly projections (REQ March 2024), and the Announced Pledges Scenario (APS) from the IEA's WEO 2023. While still included up to WEO 2024 (the most recent available edition at the time of the Treasury's *ANZT* report), the IEA has since withdrawn the APS, pending analysis of the most recent NDCs.

Review of the IEA's WEO 2023 coal export data [49, Fig. 3.29] suggests that the headline reductions in output in the Treasury Baseline scenario are aligned less with the IEA's APS exploratory scenario, than with the IEA's Net Zero Emissions 2050 (NZE) scenario – a normative (speculative) scenario that goes beyond current international policy pledges. Specifically, the IEA WEO 2023 projects Australian exports of coal down by only 5% in 2030, and down by 49% in 2050 (both against their 2022 baseline). While the milestone years and baseline are different to those used in *ANZT* (47% reduction by 2035, 72% by 2050, against 2025), the APS reductions are not consistent with a plausible pathway to deliver the *ANZT* Baseline Scenario reductions. While the IEA WEO APS values are for exports rather than output, given that Australia exports over 90% of its coal output, the discrepancy cannot be explained by a rebalancing of domestic and export use. The IEA's NZE scenario, on the other hand, posits Australian exports of coal down 25% in 2030, and down 74% in 2050 – a pathway which does correspond to the headline reductions in the Treasury's *ANZT*.

Our interpretation of coal exports under the Treasury Baseline scenario applies the WEO APS pathway until 2030, then takes the headline reductions of 47% in 2035 and 72% in 2050 at face value, while noting that such longer-term reductions are not underpinned by the exploratory Announced Pledges Scenario, but would require additional international action as per the IEA's normative NZE scenario.

It is worth noting that under all the IEA WEO 2023 scenarios (STEPS, APS and NZE), Australia becomes the biggest exporter of coal in the world by some margin in 2030 and 2050.

The 'Treasury scenario' takes as its source for future LNG output the IEA's WEO 2023 Announced Pledges Scenario (APS), and for exports the 2024 *Future Gas Strategy* (Australian Government), which itself references the IEA WEO 2023. As previously noted, the IEA has withdrawn the APS pending review. In its report *Gas 2025*, the IEA suggests that the medium-term market outlook for Asia is for growth in LNG demand (increase by 11% by 2030, compared with 2024), noting also that Australian 'export growth potential' could be 'dampened' to 2030 by low levels of investment in new LNG capacity and growth in domestic gas demand [54]. Therefore, although the APS is no longer part of the IEA scenario suite, the expectation remains that Australian LNG exports will stay flat or decline slightly out to 2030, which is broadly consistent with the *Future Gas Strategy* APS-aligned pathway.

It is revealing that the *Future Gas Strategy* states that, *"In all the scenarios considered in this strategy, Australia's LNG exports decline by 2050 (note this is not a policy setting)."* [50, p. 47]

5.5.3 Divergence from climate policy in both export scenarios

While the Treasury and DCCEEW projections come from very different interpretations of future demand for coal and LNG, they are both essentially passive with regard to addressing the urgent need to rapidly reduce all emissions in line with updated remaining carbon budgets for 1.5°C and 2°C. Notwithstanding the Australian government's high-level political endorsement of the Paris Agreement temperature and equity commitments, neither the Treasury nor DCCEEW assumptions about future export levels show any active hand in regulating or controlling export emissions on the part of Australia. The assumption in both cases is that exports will simply track global market demands, which may be higher or lower depending on what climate policies are enacted in Australia's export markets. It is only on this latter point that the projections differ.

The view taken by the authors of this report is that future projections of exports in a rapidly changing and volatile world should be treated merely as simple heuristics, or exploratory learning tools, to illustrate the outcomes of 'what if…?' scenarios. Taking the two government scenarios described above largely at face value, it is possible to estimate the extent to which export emissions under each fit within a 1.5–2°C carbon budget framing. However, Australia has neither policies nor stated intentions to limit exports of fossil fuels consistent with its obligations under the Paris Agreement. With this in mind, the two government export scenarios outlined here should be treated as speculative.

5.6 Government export scenarios vs. 1.5°C pathway

Figure 4 below shows total annual combustion emissions for fossil fuel exports on both the 'Treasury scenario' and the 'DCCEEW scenario' plotted as time series (the grey and blue dashed lines), compared with the trajectory that exports would have to take to comply with the mean global reduction pathway based on the remaining carbon budget for 50% chance of not exceeding 1.5°C. The 'mean global pathway' assumes that all sources of emissions in the world fall at the same average rate, so that the proportion of the 1.5°C remaining carbon budget allocated to Australian fossil fuel exports is the same as the proportion of current global emissions occupied by Australian fossil fuel exports. In other words, a proportion of the remaining carbon budget is 'grandfathered' to Australian fossil fuel exports based on their current levels[27].

The shaded areas under the dashed lines represents the cumulative emissions entailed by the government export scenarios.

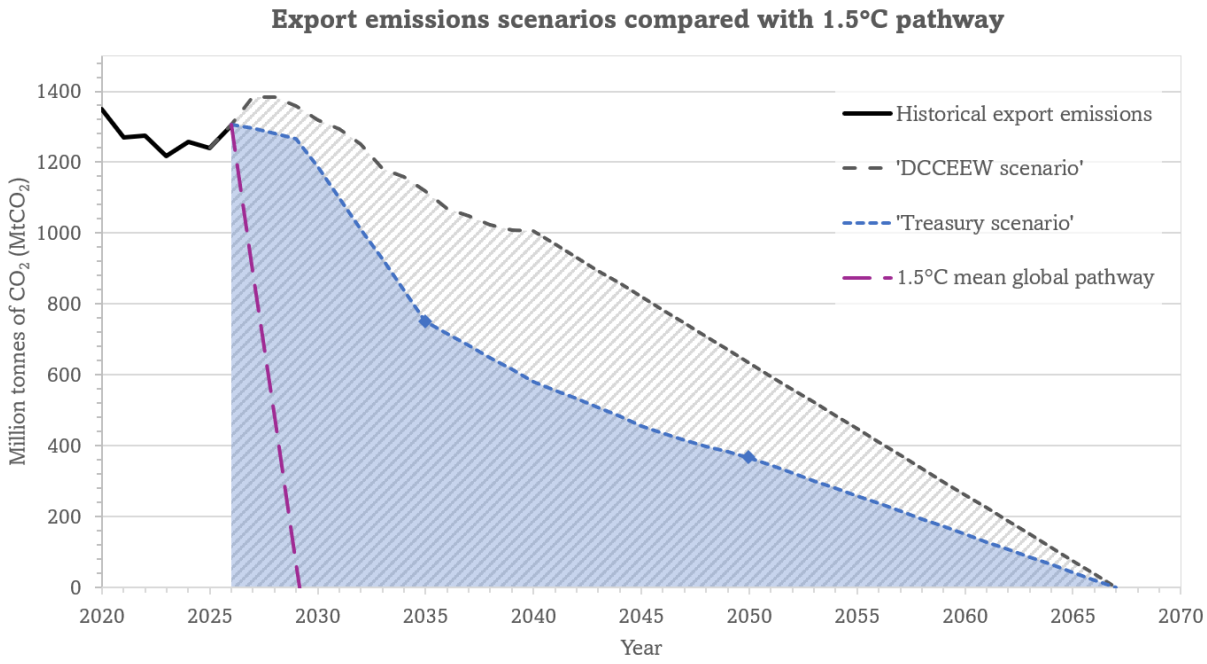


Figure 4. CO_2 emissions from combustion of Australian exports of fossil fuels under Treasury and DCCEEW scenarios, compared with the global average emission reduction pathway required to stay within the updated remaining carbon budget for 50% chance of 1.5°C. Sources: [14], [16], [45], [46], [47], [48], [49], [51]

This illustration is necessarily crude in terms of apportionment – it assumes that every single source of emissions in the world will follow the same rate of reduction from recorded 2025 levels to zero by the end of 2029, in order that the 88 $GtCO_2$ remaining carbon budget for 1.5°C be respected. However, as discussed in section 4.4, *all* apportionment regimes fall apart under the constraint of such a tight remaining budget, which contains less than two years of current global emissions. Such a constraint permits absolutely no room for manoeuvre; not for substitution between fossil fuels, nor even for

the very weakest interpretation of equity, which would require wealthy, high-emitting countries like Australia to cut their emissions *faster* than the global mean shown here.

In these simple but logical terms, it is evident that whichever of the government export pathways is assumed makes no meaningful difference to staying at or below 1.5°C. Neither export scenario comes anywhere close to the level of reductions demanded by the remaining carbon budget for a 50% chance of 1.5°C.

To make this point numerically, Table 5 shows the cumulative emissions under the two government export scenarios (shaded areas on Figure 4) for five, ten and fifteen year periods and until the assumed zero emissions year, against the cumulative emissions that would result if Australian fossil fuel exports followed the mean global reduction rate dictated by the remaining carbon budget for 1.5°C.

	Cumulative emissions from fossil fuel exports, $MtCO_2$		
Period	**1.5°C mean global pathway**	**'Treasury scenario'**	**'DCCEEW scenario'**
2026–2030	2,717	6,333	6,751
2026–2035		10,956	12,754
2026–2040		14,200	17,909
2026–2067*		21,638	30,986

Table 5. Summary of cumulative CO_2 emissions from production and combustion of Australian fossil fuel exports following the reductions in the 'Treasury scenario' and the 'DCCEEW scenario', compared with the cumulative emissions under the pathway required by the updated remaining carbon budget for 1.5°C, based on the mean global reduction rate (grandfathering, see footnote 27). *Export emissions reach zero in 2067 following the post-2040 trend in the 'Treasury scenario', so the same constraint has been applied to DCCEEW scenario here. Sources: same as Figure 4.

Even under the highly optimistic 'Treasury scenario', export emissions in the remainder of the 2020s alone are more than double the emissions on the mean global pathway for 1.5°C, and are higher still under the DCCEEW-based scenario. Export scenario emissions for subsequent time periods are tabulated to highlight that both export scenarios continue to generate huge quantities of CO_2 emissions long after the remaining carbon budget for 1.5°C will have been extinguished by the end of 2029.

5.7 Government export scenarios vs 2°C pathways

With the imminent depletion of the 1.5°C budget, temperature increments above that threshold are also in critical danger of being breached as emissions continue to accumulate in the atmosphere. While the main focus of this report is the 1.5°C 'primary temperature goal' of the Paris Agreement, the 2°C threshold is also fast approaching and should be considered with respect to ongoing exports and consumption of fossil fuels.

Figure 5 below shows total annual combustion emissions from fossil fuel exports on both the 'Treasury scenario' and the 'DCCEEW scenario' plotted as time series (the grey and blue dashed lines), compared with two illustrative Australian export emissions pathways (the orange and purple broken lines) constrained by the remaining global carbon budget for 83% chance of not exceeding 2°C (see section 3.4). The shaded areas under the dashed lines represents the cumulative emissions entailed by the government export pathways.
It is important to recognise that the 2°C pathways shown in Figure 5 take absolutely no account of the principle of equity. They reflect the rate at which Australian fossil fuel exports would have to decline if all sources of emissions in the world were to follow the same mean reduction rate. In other words, these pathways assume that a 'share' of the remaining global carbon budget is allocated to Australian fossil fuel exports exactly in proportion to the current contribution to annual global emissions from Australian fossil fuel exports. In essence, this is a 'grandfathering' allocation, which is not compatible with the principle of international equity.

Defining pathways that take proper account of equity would require a much more thorough and nuanced treatment of the range of available apportionment methodologies, and of how such regimes may be applied to export emissions (rather than to territorial emissions, as they are conventionally applied). Such a treatment is beyond the scope of this report, the primary focus of which is the 1.5°C commitment. See Box 4 below for more about the relationship between equity and the 2°C remaining carbon budget.

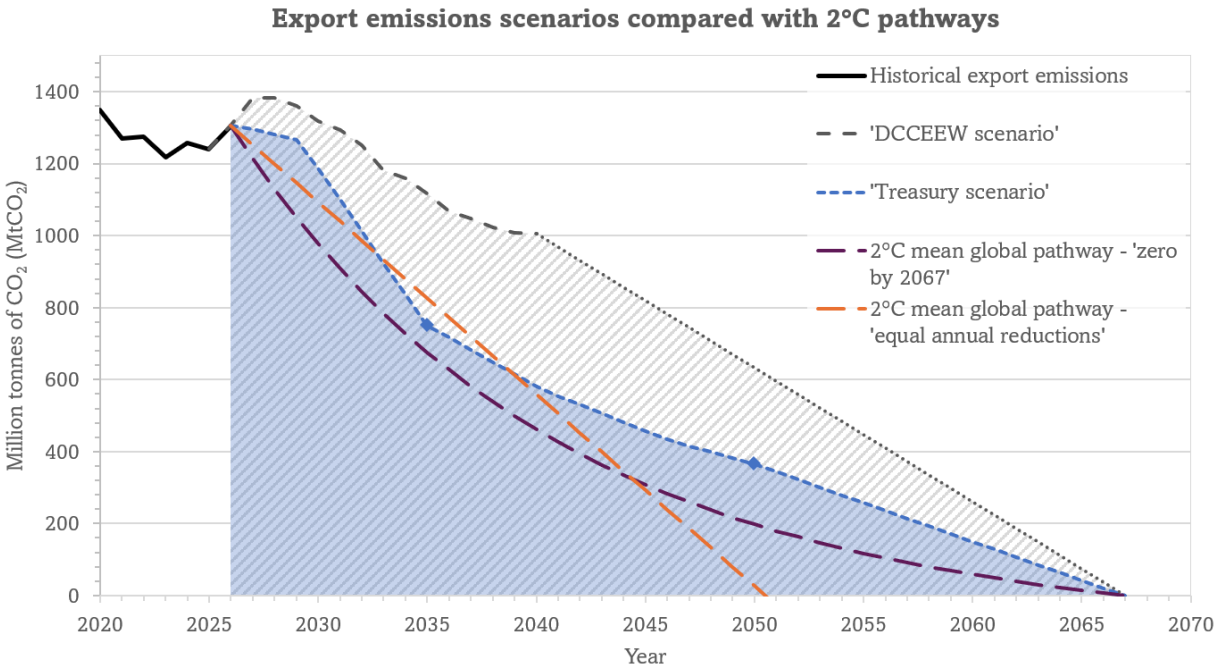


Figure 5. CO_2 emissions from combustion of Australian exports of fossil fuels under 'Treasury' and 'DCCEEW scenarios', compared with two illustrative global average emission reduction pathways to stay within the updated remaining carbon budget for an 83% chance of 2°C. The 'zero by 2067' pathway starts with annual reductions of 7.1% per year, rising through 8% per year by the mid-2040s, with still higher rates towards the end. It is designed to reach zero in the same year as the trajectory extrapolated from the 'Treasury scenario'[28], while keeping to the same cumulative emissions (area under the curve) as the straight line pathway. Note that these mean global pathways take no account of the principle of equity – Australia's current export emissions are simply 'grandfathered' here as a share of the remaining global carbon budget. Sources: same as Figure 4.

Box 4: Equity and 2°C pathways

While the larger remaining budget for 2°C allows more leeway for different pathway shapes than for 1.5°C, the envelope of plausible 2°C trajectories is nevertheless fairly tightly constrained, both by the finite budget itself (the area under the curve – the same in both of the 2°C pathways in Figure 5) and by practical 'feasibility' considerations[29].

The mean global emissions reduction pathways shown in Figure 5 are presented to illustrate the bare minimum rates of reduction compatible with the remaining carbon budget for an 83% chance of 2°C.

If proper account were taken of the central importance of equity under a 2°C timeframe, then the budget space available to Australian fossil fuel exports would be substantially smaller than that used to derive the two pathways plotted. The reduction in budget space under more equitable apportionment would force 2°C-compatible pathways to reach zero emissions considerably earlier than shown,

which in turn would demand higher annual rates of reduction and make the pathway curves appear even steeper.

The principle of international equity is typically codified as 'Common but Differentiated Responsibilities, and Respective Capabilities', or CBDR-RC, as defined in Article 3 of the UNFCCC (see section 4.1 above) and reasserted in every high level climate treaty since, including Article 4.1 of the Paris Agreement.

5.7.1 The 'DCCEEW scenario' and 2°C

It is clear from a glance at Figure 5 that emissions under the 'DCCEEW scenario' for Australian fossil fuel exports are far in excess of any plausible pathway for 2°C, even those based on a 'grandfathered' budget or mean global reduction rate. The shaded area bounded by the grey dashed line of the 'DCCEEW scenario' is far bigger than the 2°C budget – the (equal) areas under the orange and purple broken lines. Table 6 demonstrates this numerically, and Figure 6 below further illustrates the extent of the excess.

5.7.2 The 'Treasury scenario' and 2°C

The interpretation of the 'Treasury scenario' shown in Figure 5 shows emissions initially exceeding the equal annual reductions 2°C mean global pathway (straight line), briefly dipping beneath it in 2030s, then increasingly exceeding it after 2040. Conversely, emissions in the 'Treasury scenario' clearly exceed at every stage a 2°C mean global pathway in which emissions continue until 2067 (the end date implied by the trajectory of the 'Treasury scenario' after 2040). The amount of blue shaded area above the purple broken line ('zero by 2067') is the same as that above the orange broken line ('equal annual reductions').

It should be kept in mind that the 'Treasury scenario' pathway shape as depicted in this report is premised on a generous interpretation of the very limited datapoints (marked as blue diamonds on Figure 5) and information available about Australian fossil fuel exports in *Australia's Net Zero Transformation*, the source material for the scenario. If fossil fuel exports were not to fall at the very optimistic rate supposed here in the early years, then even if the proposed reductions in output and exports were somehow delivered in the milestone years of 2035 and 2050, accumulated emissions would even further exceed the 2°C mean global pathways.

It bears repeating that these are heuristic 2°C pathways, which assume that all sources of emissions in the world are cut at exactly the same average rate. By contrast, the principle of international equity (as ratified by Australia and every signatory nation to the UNFCCC and Paris Agreement, *inter alia*) demands that wealthy countries, such as Australia, take the lead by cutting their emissions faster than poorer countries (see Box 4).

As above, Table 6 numerically quantifies the budgetary exceedance by the 'Treasury scenario'; Figure 6 illustrates the same.

	Cumulative emissions from fossil fuel exports, $MtCO_2$		
Period	**2°C mean global pathways**	**'Treasury scenario'**	**'DCCEEW scenario'**
2026–2040	16,643	14,200	17,909
2026–2050		18,725	25,918
2026–2067*		21,638	30,986

Table 6. Summary of cumulative CO_2 emissions from production and combustion of Australian fossil fuel exports following the reductions in the 'Treasury scenario' and the 'DCCEEW scenario', compared with the cumulative emissions under pathways required by the updated remaining carbon budget for 2°C, based on mean global reduction rate (grandfathering, see footnote 27). *Export emissions reach zero in 2067 following the post-2040 trend in the 'Treasury scenario', so the same constraint has been applied to DCCEEW scenario here. Sources: same as Figure 4.

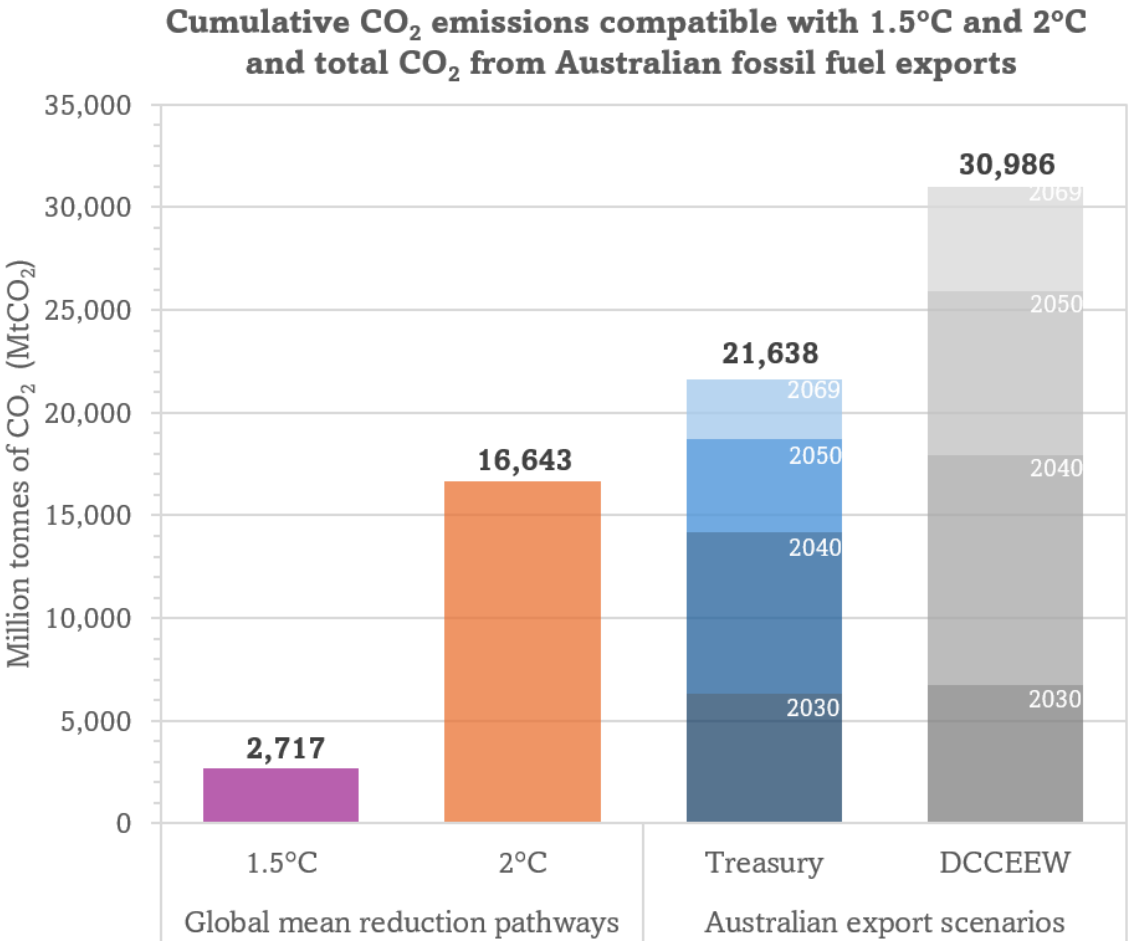


Figure 6. Stacked column chart of 1.5°C and 2°C remaining carbon budgets compared with emissions under the 'Treasury scenario' and 'DCCEEW scenario'. This figure is repeated as CF1 at the start of the report.

6 Conclusion

The question addressed by this report is not whether Australia should receive a smaller allocation of the remaining carbon budget under principles of equity, historical responsibility, capability, or CBDR-RC. The report deliberately sets those questions aside. The question addressed is whether Australia's projected coal and LNG export pathways are compatible with the Paris Agreement temperature goals under assumptions favourable to Australia. The evidence is unequivocal, they are not.

Section 5 Footnotes

[17] Australia emitted 387 $MtCO_2$ from energy and industrial processes in 2024, compared with global emissions of 38,599 $MtCO_2$ [38].

[18] Emissions from land use change are notoriously difficult to quantify with precision. The Global Carbon Project uses an ensemble of several methodologies to produce estimates of land use change emissions for every country. The Global Carbon Project's value of 5.4 Tg/C/ yr for Australian net land use emissions in 2024 equates to 19.8 $MtCO_2$. This differs substantially from the value of -94 $MtCO_2$ (net negative) from land use submitted by the Australian Government to UNFCCC [39].

[19] Energy and industrial CO_2 emissions plus international bunkers, but excluding land use.

[20] Current international dollars, adjusted for purchasing power parity (PPP).

[21] See Appendix A3 for methodology.

[22] Note that the APS is a purely 'exploratory scenario' (as opposed to a 'normative scenario' in the typology of the IEA), whereby it is assumed that every promised emission reduction pledge announced in the then current NDCs and longer 'net-zero' targets are delivered in full and on time. It is not in any sense a 'forecast' of global energy demand, contrary to it being referred to as such in the Treasury's *Australia's Net Zero Transformation* report.

[23] The headline reductions for fossil fuels in the Treasury report *ANZT* are for output of 'coal' and of 'gas and LNG'. The export pathway described in the *Future Gas Strategy* (*FGS*) is for LNG only, and does not deliver a reduction in 2035 equivalent to the 27% cut for 'gas and LNG' output given in *ANZT*. Therefore it is assumed that the Treasury Baseline scenario makes use of reductions in (pipeline) gas output for domestic markets to account for the 'abatement shortfall' between the 18% reduction in LNG exports by 2035 (cf. 2025) in *FGS* and the 27% reduction in gas and LNG output in *ANZT*. As such, the pathway for LNG exports in our interpretation of the 'Treasury scenario' does not deliver reductions in exports matching those for output given in *ANZT* in 2035 and 2050.

[24] See Appendix A3 for full methodological assumptions in the quantification of the 'Treasury Scenario'.

[25] See Appendix A3 for full methodological assumptions in the quantification of the 'DCCEEW scenario'.

[26] In the 'DCCEEW scenario' as shown in Figure 4, export emissions in 2026 are shown at the level forecast in DISR's Resources and Energy Quarterly, March 2025. All subsequent years are based on Figure ST8 in DCCEEW Quarterly Update of Australia's National Greenhouse Gas Inventory, September 2025. This is a methodological assumption made about 2026 export emissions (the current year) for consistency across all the scenarios and pathways in this report. In the DCCEEW projections, 2026 exports are slightly higher than the 2027 level shown here (which would entail more emissions), with 2026 being the peak year.

[27] Specifically, Australian export emissions are forecast to be 1.31 $GtCO_2$ in 2026 (based on DISR REQ Dec 2025, plus an adjustment for production emissions attributable to exports), which represents 3.1% of annual

global emissions of 42.2 $GtCO_2$ [14]. This percentage is used for calculation of the temperature constrained 'mean global pathways' for Australian exports of fossil fuels in this report. The global total is for 2025 rather than a forecast total for 2026 – a necessary methodological assumption, which slightly privileges Australian exports. Were export emissions for 2025 (1.24 $GtCO_2$) used as the basis for the comparison, then cumulative emissions under the 'mean global pathway' would be constrained to 2.94% of global emissions for Australian fossil fuel exports. In such a case, the straight-line mean global pathway would be forfeit in the first year, as expected export emissions in 2026 immediately exceed the pathway, in turn bringing the zero year for 1.5°C forward to 2028.

[28] The 'zero by 2067' pathway is produced by slightly modifying an equal annual percentage (exponential) reduction to bring emissions to zero. Exponential curves are 'asymptotic', meaning that they never reach actual zero.

[29] For example, pathways that continue at current levels of emissions until reaching a hard stop when the budget is entirely used up are deemed infeasible.

7 References

[1] United Nations, “United Nations Framework Convention on Climate Change,” 1992. doi: 10.35935/edr/31.2513.

[2] UNFCCC, “Paris Agreement to the United Nations Framework Convention on Climate Change,” Paris, Dec. 2015. Accessed: Feb. 05, 2025. [Online]. Available: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

[3] IPCC, “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,” 2018. [Online]. Available: https://www.ipcc.ch/sr15/

[4] IPCC, “Climate Change 2022 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.,” Cambridge University Press, Jun. 2023. doi: 10.1017/9781009325844.

[5] K. Calvin *et al.*, “IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.,” Jul. 2023. doi: 10.59327/IPCC/AR6-9789291691647.

[6] T. M. Lenton *et al.*, “Tipping elements in the Earth’s climate system,” *Proceedings of the National Academy of Sciences*, vol. 105, no. 6, pp. 1786–1793, Feb. 2008, doi: 10.1073/pnas.0705414105.

[7] S. Rahmstorf and P. Uotila, “Open Letter by Climate Scientists to the Nordic Council of Ministers ,” Reykjavik, Oct. 2024. [Online]. Available: https://en.vedur.is/media/ads_in_header/AMOC-letter_Final.pdf

[8] UNFCCC, *Glasgow Climate Pact (Decision -/CP.26)*. 2021. [Online]. Available: https://unfccc.int/documents/310475

[9] UNFCCC, “Global Mutirão: Uniting humanity in a global mobilization against climate change,” Belem, 2025. [Online]. Available: https://unfccc.int/sites/default/files/resource/cma2025_L24_adv.pdf

[10] International Court of Justice, “Obligations of States in respect of Climate Change (Advisory Opinion),” 2025. [Online]. Available: https://www.icj-cij.org/case/187

[11] M. D. Mastrandrea *et al.*, “Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties,” vol. 9, no. October, pp. 11–14, 2010, [Online]. Available: https://www.ipcc.ch/site/assets/uploads/2018/05/uncertainty-guidance-note.pdf

[12] IPCC, “Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,” Cambridge University Press, Cambridge, UK, and New York, USA, 2013. [Online]. Available: https://www.ipcc.ch/report/ar5/wg1/

[13] IPCC, "Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change ," Cambridge University Press, Jul. 2023. doi: 10.1017/9781009157896.

[14] P. Friedlingstein *et al.*, "Global Carbon Budget 2025," *Earth Syst. Sci. Data*, vol. 18, no. 5, pp. 3211–3288, 2026, doi: 10.5194/essd-18-3211-2026.

[15] R. D. Lamboll, Z. R. J. Nicholls, C. J. Smith, J. S. Kikstra, E. Byers, and J. Rogelj, "Assessing the size and uncertainty of remaining carbon budgets," *Nat. Clim. Chang.*, vol. 13, no. 12, pp. 1360–1367, Dec. 2023, doi: 10.1038/s41558-023-01848-5.

[16] P. M. Forster *et al.*, "Indicators of Global Climate Change 2025: annual update of key indicators of the state of the climate system and human influence," *Earth System Science Data Discussions*, vol. 2026, pp. 1–87, 2026, doi: 10.5194/essd-2026-287.

[17] Copernicus, "Copernicus: 2025 was the third hottest year on record," Bonn, Jan. 2026. [Online]. Available: https://climate.copernicus.eu/copernicus-2025-was-third-hottest-year-record

[18] Copernicus, "C3S global temperature trend monitor. How close are we to reaching a global warming of 1.5˚C?" [Online]. Available: https://apps.climate.copernicus.eu/global-temperature-trend-monitor/

[19] Z. Hausfather, "Analysis: What the new IPCC report says about when world may pass 1.5C and 2C," CarbonBrief. [Online]. Available: https://www.carbonbrief.org/analysis-what-the-new-ipcc-report-says-about-when-world-may-pass-1-5c-and-2c

[20] S. M. , Smith *et al.*, "The State of Carbon Dioxide Removal 2024 - 2nd Edition. A global, independent scientific assessment of Carbon Dioxide Removal," 2024. [Online]. Available: DOI 10.17605/OSF.IO/F85QJ

[21] Future Earth, The Earth League, and WCRP, "10 New Insights in Climate Science 2025/2026," Stockholm, 2025. doi: 10.5281/zenodo.17328963.

[22] P. Friedlingstein *et al.*, "Emerging climate impact on carbon sinks in a consolidated carbon budget," *Nature*, vol. 649, no. 8095, pp. 98–103, 2026, doi: 10.1038/s41586-025-09802-5.

[23] World Energy Data, "Major Fossil Fuel Nations." [Online]. Available: https://www.worldenergydata.org/major-fossil-fuel-nations/

[24] US EIA, "Electric Power Sector Coal Stocks: March 2026." [Online]. Available: https://www.eia.gov/electricity/monthly/update/coal-stocks.php

[25] B. Cahill, "The Oil Inventory Challenge," Center for Strategic and International Studies. Accessed: Feb. 11, 2022. [Online]. Available: https://www.csis.org/analysis/oil-inventory-challenge

[26] Department for Energy Security and Net Zero (DESNZ), "Environmental Impact Assessment (EIA) – Assessing effects of downstream scope 3 emissions on climate (Supplementary guidance)," Jun. 2025. [Online]. Available:

https://assets.publishing.service.gov.uk/media/6853fa3d1203c00468ba2b15/Supplementary_guidance_-_Effects_of_Scope_3_Emissions.pdf

[27] D. Calverley and K. Anderson, "Phaseout Pathways for Fossil Fuel Production Within Paris-compliant Carbon Budgets ," Manchester, 2022. [Online]. Available: https://research.manchester.ac.uk/en/publications/phaseout-pathways-for-fossil-fuel-production-within-paris-complia

[28] K. Trout *et al.*, "Existing fossil fuel extraction would warm the world beyond 1.5 °C," *Environmental Research Letters*, vol. 17, no. 6, p. 064010, Jun. 2022, doi: 10.1088/1748-9326/ac6228.

[29] C. McGlade and P. Ekins, "Un-burnable oil: An examination of oil resource utilisation in a decarbonised energy system," *Energy Policy*, vol. 64, pp. 102–112, 2014, doi: 10.1016/j.enpol.2013.09.042.

[30] D. Welsby, J. Price, S. Pye, and P. Ekins, "Unextractable fossil fuels in a 1.5 °C world," *Nature 2021 597:7875*, vol. 597, no. 7875, pp. 230–234, Sep. 2021, doi: 10.1038/s41586-021-03821-8.

[31] S. Pye, S. Bradley, N. Hughes, J. Price, D. Welsby, and P. Ekins, "An equitable redistribution of unburnable carbon," *Nat. Commun.*, vol. 11, no. 1, pp. 1–9, 2020, doi: 10.1038/s41467-020-17679-3.

[32] IPCC, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 2: Stationary combustion," 2019. [Online]. Available: https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/2_Volume2/19R_V2_2_Ch02_Stationary_Combustion.pdf

[33] R. A. Alvarez, S. W. Pacala, J. J. Winebrake, W. L. Chameides, and S. P. Hamburg, "Greater focus needed on methane leakage from natural gas infrastructure," *Proceedings of the National Academy of Sciences*, vol. 109, no. 17, pp. 6435–6440, 2012, doi: 10.1073/pnas.1202407109.

[34] D. Lafleur, T. Forcey, H. Saddler, and M. Sandiford, "A review of current and future methane emissions from Australian unconventional oil and gas production," Melbourne, 2016. [Online]. Available: https://australiainstitute.org.au/report/a-review-of-current-and-future-methane-emissions-from-australian-unconventional-oil-and-gas-production/

[35] B. B. Alem, B. Chen, H. Zhang, and U. Iqbal, "Comparative Review of Global Methane Budget Estimation: Top-Down, Bottom-Up, and Integrated Approaches," *Remote Sens. (Basel).*, vol. 18, no. 9, 2026, doi: 10.3390/rs18091336.

[36] K. Tibrewal *et al.*, "Assessment of methane emissions from oil, gas and coal sectors across inventories and atmospheric inversions," *Commun. Earth Environ.*, vol. 5, no. 1, p. 26, 2024, doi: 10.1038/s43247-023-01190-w.

[37] A. Albatayneh and M. Khwaileh, "The Greenhouse Gas Footprint of LNG Pathways From Major Exporters," *Int. J. Energy Res.*, vol. 2026, no. 1, p. 8861256, Jan. 2026, doi: https://doi.org/10.1155/er/8861256.

[38] R. M. Andrew and G. Peters, "Global Carbon Project: Global carbon atlas, fossil

fuel emissions, territorial." [Online]. Available: https://globalcarbonatlas.org/emissions/carbon-emissions/

[39] DCCEEW, "Australia's National Greenhouse Accounts - UNFCCC/Paris Agreement inventory," Canberra, 2026. [Online]. Available: https://greenhouseaccounts.climatechange.gov.au

[40] Climate Analytics, "Australia's global fossil fuel carbon footprint," Aug. 2024. [Online]. Available: https://climateanalytics.org/publications/australias-global-fossil-fuel-carbon-footprint

[41] Department of Climate Change Energy the Environment and Water (DCCEEW), "Australia's emissions projections 2025," Nov. 2025. [Online]. Available: https://www.dcceew.gov.au/climate-change/publications/australias-emissions-projections-2025

[42] T. Schulz, "2021 Worldwide CO2 Emissions, based on IEA (2023), 'Greenhouse gas emissions from energy,'" Sep. 2023. [Online]. Available: https://aqalgroup.com/2021-worldwide-co2-emissions/

[43] World Bank, "GDP per capita (current US$)," 2026. [Online]. Available: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=AU

[44] Energy Institute, "Statistical Review of World Energy," 2025. [Online]. Available: https://www.energyinst.org/statistical-review/resources-and-data-downloads

[45] Department of Industry Science and Resources (DISR), "Resources and energy quarterly: December 2025," Dec. 2025. [Online]. Available: https://www.industry.gov.au/publications/resources-and-energy-quarterly-december-2025

[46] BP, "Approximate conversion factors: Statistical Review of World Energy," 2021. [Online]. Available: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-approximate-conversion-factors.pdf

[47] Department of Industry Science and Resources (DISR), "Resources and energy quarterly: March 2024 and March 2025," Mar. 2025. [Online]. Available: https://www.industry.gov.au/publications/resources-and-energy-quarterly-march-2025

[48] Australian Government Treasury, "Australia's net zero transformation: Treasury modelling and analysis," Sep. 2025. [Online]. Available: https://treasury.gov.au/publication/p2025-700922

[49] IEA, "World Energy Outlook 2023," Oct. 2023. [Online]. Available: https://www.iea.org/reports/world-energy-outlook-2023

[50] Department of Industry Science and Resources (DISR), "Future Gas Strategy," Jun. 2024. [Online]. Available: https://www.industry.gov.au/publications/future-gas-strategy

[51] Department of Climate Change Energy the Environment and Water (DCCEEW), "Quarterly Update of Australia's National Greenhouse Gas Inventory: September 2025," 2025. [Online]. Available: https://www.dcceew.gov.au/climate-

change/publications/national-greenhouse-gas-inventory-quarterly-update-september-2025

[52] Institute for Energy Economics & Financial Analysis (IEEFA), "Australian coal exports face numerous downside risks, new projections show." [Online]. Available: https://ieefa.org/resources/australian-coal-exports-face-numerous-downside-risks-new-projections-show

[53] R. Burdon, A. Talberg, K. Spiller, M. Meinshausen, and J. Lewis, "Australia's coal outlook in a warming world: Insights from integrated assessment models," Dec. 2025. [Online]. Available: https://legacy.climate-resource.com/reports/decarb-futures/2025-12-11_Australias_coal_outlook_in_a_warming_world.pdf

[54] IEA, "Gas 2025: Analysis and forecasts to 2030," 2025. [Online]. Available: https://www.iea.org/reports/gas-2025

[55] J. Rogelj and R. D. Lamboll, "Substantial reductions in non-CO2 greenhouse gas emissions reductions implied by IPCC estimates of the remaining carbon budget," *Commun. Earth Environ.*, vol. 5, no. 1, p. 35, Jan. 2024, doi: 10.1038/s43247-023-01168-8.

[56] Global Carbon Project, "Supplemental data of Global Carbon Budget 2025 (Version 1.0) [Data set]," 2026. [Online]. Available: https://doi.org/10.18160/gcp-2025

[57] Science-based Targets Initiative, "Annex A - Non-energy uses of petroleum and gas products," 2020. [Online]. Available: https://sciencebasedtargets.org/wp-content/uploads/2020/08/OG-Annex-A-Non-energy-uses-of-petroleum-and-gas-products-2.pdf

[58] IPCC, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 4: Fugitive emissions," 2019. [Online]. Available: https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/2_Volume2/19R_V2_4_Ch04_Fugitive_Emissions.pdf

Appendices

A1. The choice of Remaining Carbon Budgets from the literature

We judge that recent improvements in understanding of the five key factors i–v outlined in section 3.4, when considered alongside the precautionary requirements of the UNFCCC, support adoption of the carbon budget framework proposed by Forster et al 2025 [16]. This conclusion follows ongoing engagement and discussion with several leading authors of the principal carbon budget studies.

An alternative position would favour the slightly more recent budgets presented by Friedlingstein et al 2025 [14]. However, these estimates are derived through an approach that effectively averages the budgets of Forster et al 2025 and Lamboll et al 2023 [15], supplemented with updated parameter values from the IPCC's Sixth Assessment Report [14, L. 1993 onwards]. While methodologically transparent, this averaging procedure dilutes the impact of more recent advances in understanding that have emerged since AR6.

Therefore, in light of these developments, we consider the budgets presented by Forster et al 2025, which are constructed independently of an averaging framework and more directly reflect updated scientific insights, to be better suited to the analytical objectives of this study.

A2. The choice of more conservative methane reduction scenarios

Understanding the role of near-term methane emissions (up to twenty years) is critical when determining remaining carbon budgets for the Paris Agreement's 1.5°C and, to a lesser degree, 2°C commitments [55] . Methane has a much stronger warming effect over short timescales than when assessed over the more typical century timescale. In addition, a significant proportion of methane emissions (around 40%) arise from natural sources, with a credible risk that these emissions are increasing as warming continues.

Anthropogenic methane emissions arise primarily from agriculture, fossil fuel production and use, waste management, and bioenergy. While options exist to control and potentially reduce these emissions, there are no meaningful opportunities for major reductions within the timeframe relevant to the 1.5°C commitment. Even with the slightly longer timeline associated with 2°C, opportunities for reducing anthropogenic emissions are very limited.

Given these constraints, alongside the uncertainty surrounding natural methane emissions, the carbon budget adopted in section 3.4 of this report for 1.5°C eschews assumptions of rapid near-term methane reductions. Instead, it adopts a carbon budget underpinned by more conservative, but still optimistic, methane pathways that better

reflect current trends and practical mitigation constraints, while still assuming levels of ambition broadly comparable to those required for CO_2 emissions.

A3. Methodological assumptions in scenario construction

In all cases, product export volumes were obtained first, before converting to resultant combustion CO_2 emissions using IPCC emissions factors for stationary combustion [32]. For all fossil fuel types in both scenarios, 2026 export volumes are set at the DISR REQ Mar 2025 forecast for 2026 [47], for consistency across scenarios and pathways in this report.

A3.1 'Treasury scenario'

Coal

1. Of the various sources cited for coal exports in the Technical Appendices to *ANZT*, the most conservative is found in the IEA WEO 2023 APS assumption of a 5% reduction for total coal exports by 2030 (against 2022 baseline, based on Figure 3.29 of WEO 2023). This reduction is applied to total coal exports in 2030; values between 2026 and 2030 are interpolated.
2. Trajectory between 2030 and 2035 is set to produce a 47% reduction in total coal exports in 2035 (against 2025).
3. Trajectory between 2035 and 2050 is set to produce a 72% reduction in total coal exports in 2050 (against 2025), relative share of met to thermal coal .
4. Metallurgical (met) coal exports are set at the levels forecast in the DISR REQ Mar 2025, whereby met coal exports peak in 2028, and remain higher than 2026 levels in 2031.
5. After the end of the DISR projections in 2031, met coal exports are set by reducing annual volumes at the post-peak compound annual growth rate (CAGR) of -1.2% until 2035.
6. For each year from 2035 to 2050, met coal exports are set at the same proportion of total coal exports (following the above trajectory) as they are assumed to be in 2035.
7. Thermal coal exports between 2026 and 2050 are set by subtracting met coal exports from total coal exports, as above.
8. The post-2050 trajectory follows the 2040–2050 trajectory of total export emissions, until zero emissions is reached (in 2067). Relative shares for each fossil fuel type are held at their respective shares of total fossil fuel export emissions in 2050. 2040 is the point at which the combined export trajectory 'settles down', subsequently showing no steeper reductions in exports.

LNG

1. The source cited for LNG exports is the APS-aligned pathway in the *Future Gas Strategy* (*FGS*), May 2024, which gives export volumes out to 2050.
2. Historical export volumes in recent years are underestimated in Figure 14 of the *FGS*.

In recognition of this, these export volumes were uplifted to the levels recorded in DISR REQ December 2025 historical emissions.

3. The APS-aligned pathway from *FGS* Figure 14 was then applied to the corrected export volumes by indexing to 2026.
4. The post-2050 LNG trajectory follows the 2040–2050 combined trajectory for total export emissions until zero emissions (2067), at its 2050 share of total fossil fuel export emissions.

Oil

1. Cited sources for oil exports include DISR projections, IEA WEO 2023 and a paywalled Wood Mackenzie industry report.
2. Of the publicly available material, the IEA WEO 2023 has global oil combustion emissions declining slowly, at -1.1% per year between 2022 and 2030, and at -2.9% per year between 2022 and 2050, under the APS.
3. By comparison, the DISR March 2024 projections has exports of oil declining, at -4.4% per year from 2022 to 2029.
4. The DISR REQ March 2025 rate of reduction between 2026 and 2030 for oil is assumed as a straight line pathway (i.e. exports in 2030 are obtained using the CAGR, then equal annual decrements in export volumes are applied retrospectively for each year in the series to arrive at the 2030 level).
5. Between 2030 and 2050, the IEA APS 2022–2050 rate of reduction is assumed, again as a straight line pathway to arrive at the level of 2050 exports calculated using the CAGR.
6. Post-2050 oil trajectory follows the 2040-2050 trajectory for total export emissions to zero emissions (2067) at its 2050 share of total fossil fuel export emissions.

LPG

1. The DISR REQ March 2024 forecast has LPG exports increasing by around 5% per year out to 2029. However, the subsequent DISR REQ March 2025 forecast has LPG declining at -1.7% per year after its peak in 2024 until 2030 (oil remains at -4.4% p.a. as per the previous REQ).
2. The DISR REQ March 2025 rate of reduction for LPG between 2026 and 2030 is assumed as a straight line pathway to arrive at the level of 2030 exports calculated using the CAGR.
3. Between 2030 and 2050, the rate of reduction shown by oil between 2035 and 2050 (4.1% per year) is applied to LPG, again as a straight-line pathway to arrive at the 2050 exports, calculated using the CAGR. This is done to harmonise the long-term LPG export trajectory with the oil trajectory described above, with which it shares a common feedstock.
4. The post-2050 the LPG export trajectory follows the 2040-2050 trajectory for total export emissions to zero emissions (2067) at its 2050 share of total fossil fuel export emissions.

A3.2 'DCCEEW scenario'

Coal

1. Total coal production volumes to 2040 were obtained from DCCEEW's *Quarterly Update to Australia's National Greenhouse Gas Inventory*, September 2025, Figure ST8 data tables. The DCCEEW projections are for 'run of mine' coal output, also referred to as 'raw coal' – unprocessed material containing rock and other contaminants that are removed prior to export or use.
2. Although there are variations between the DISR long-term historical data for coal production and the DCCEEW historical data, there is increasing convergence between the datasets during the last seven years, such that the DISR forecasts to 2031 fit well with the DCCEEW output projections.
3. The *Quarterly Update* states that demand for metallurgical coal is projected to remain around current levels to 2040. Met coal exports are therefore set at the level at which they 'stabilise' in 2031 in the DISR REQ March 2025, held constant from 2027 until 2040. Note that the DISR forecast is for met coal exports to increase until a peak in 2029 – whereas here it is conservatively assumed that the post peak export levels apply immediately from 2027.
4. Exports of thermal coal out to 2040 are set by the following method.
   a. The mean proportion of saleable black coal (i.e. 'exportable' thermal coal plus met coal) in the DCCEEW projections is calculated by dividing DISR annual production quantities of saleable black coal by the corresponding year's run of mine production in the DCCEEW projections. Between 2025 and 2030, saleable black coal makes up 73% of DCCEEW run of mine coal on average.
   b. This average percentage share is then applied to the DCCEEW run of mine projections for each year out to 2040 to give saleable thermal and met coal combined.
   c. The mean proportion that exported coal (thermal plus met) makes up of saleable black coal is obtained from the DISR REQ March 2025 projections. Between 2025 and 2030, exports make up 94% of saleable black coal on average.
   d. Thermal coal exports are calculated by subtracting annual exports of met coal (step 3 above) from the projected export component of DCCEEW saleable black coal (steps 4b and 4c above).
5. The post-2040 coal trajectory is set by bringing total fossil fuel export emissions to zero in 2067, the same year as the 'Treasury scenario' trajectory reaches zero. Met coal and thermal coal remain at the same relative proportions of total export emissions as in 2040.

LNG

1. Total LNG production volumes to 2040 were obtained from DCCEEW's *Quarterly Update to Australia's National Greenhouse Gas Inventory*, September 2025, Figure ST8 data tables.
2. Since Australia exports virtually all of its produced LNG, no further adjustment was necessary to render the production volumes as exports.
3. The post-2040 LNG trajectory is set by bringing total fossil fuel export emissions to zero in 2067, the same year as the 'Treasury scenario' trajectory reaches zero, with LNG occupying its 2040 relative share throughout.

Oil and LPG

Projection data for oil and LPG are not featured in the *Quarterly Update*, therefore the same methodological assumptions used to construct the oil and LPG export emissions pathway in the 'Treasury scenario' are applied in the 'DCCEEW scenario'.

A3.3 Export share of production emissions

In both the 'Treasury scenario' and 'DCCEEW scenario' an additional quantity of emissions is included to reflect the CO_2 combustion emissions that occur territorially in Australia during the extraction, processing and distribution of fossil fuels for export. This is referred to throughout this report as the 'export share of production emissions'.

The export share of production emissions used in quantification of the export scenarios in this report is based the 2023 report by Climate Analytics, which found that an additional 46 $MtCO_2$ was emitted in producing fossil fuels specifically for export from Australia in 2023. This value is applied *pro-rata* to total export emissions in subsequent years in this analysis (while it is important to recognise and account for these emissions, they contribute less than 4% of the total combustion emissions arising from Australian exports of fossil fuels).

The detailed methodology for Climate Analytics' calculation of the export-share of emissions for the production of each fossil fuel type from various government datasets is available in the methodological appendix to their 2023 report [40, pp. 44–45].

8 Authorship

Dan Calverley holds a PhD in environmental engineering from the School of Mechanical, Aerospace and Civil Engineering at the University of Manchester, an MSc in pollution and environmental control from the University of Manchester, and an MA in Philosophy from the University of Aberdeen. He is a visiting researcher at the Tyndall Centre for Climate Change Research (the UK's leading interdisciplinary and academic climate change research centre) in the School of Engineering at the University of Manchester; specialising in mitigation pathways, carbon budgets and fossil fuel phaseout scenarios. He was the lead researcher and author of the highly cited 2022 Tyndall/International Institute for Sustainable Development report, *Phaseout Pathways for Fossil Fuel Production within Paris-compliant carbon budgets*. Prior to his academic career he worked in local government as a pollution control officer.

Kevin Anderson holds a PhD in energy and climate change and an MSc in pollution and environmental control, both from the University of Manchester, and a BSc in mechanical engineering from UMIST. He holds a joint professorship in energy and climate change at the School of Engineering at the University of Manchester, and at Uppsala University in Sweden. For over thirty years Kevin has specialised in the science of climate change, carbon budget analysis and mitigation scenarios, and has numerous peer-reviewed publications in prestigious scientific journals in the field. He has been a member of the Tyndall Centre since 2001, an organisation where he previously served both as the deputy director and director. Kevin has given written and verbal scientific evidence to a range of parliamentary committees, to various UK government departments, including BEIS, DEFRA, DfT, and the Treasury, as well as to the UK Climate Change Committee (CCC), and the EU Commission and Parliament. He served as the scientific advisor to both the Welsh Government's Climate Change Commission and the Scottish Government's Climate Assembly. Prior to academia, Kevin worked for a decade as an engineer, principally in the petrochemical and offshore oil industry.