Matter concerning whether new information, if considered by the Minister for the Environment, would have led to them not granting the approval of the Carmichael Coal Mine under the Environmental Protection and Biodiversity Conservation Act 1999

Independent expert report

I have been requested to provide independent expert evidence on the questions raised in the attached correspondence and these questions are repeated in the document below, which constitutes my expert opinion on each of the questions raised.

I have read and complied with the expert practice note and agree to be bound by it.

The expert opinions expressed below derive substantially from my research experience and scientific training in the areas of climate science, impacts and policy responses. My CV with publications and literature is attached which provide an overview of my crosscutting expertise in climate science.

Bill Hare

Perth, 2 October 2020

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Questions

a) What is the current global average temperature relative to pre-industrial times?

The present human-induced increase in global mean temperature <u>as a result of greenhouse gas emissions</u> to date is about 1.16°C above pre-industrial (1850-1900) average[1].

The observed long-term warming trend is human-induced and cannot be explained by any natural drivers (IPCC 2018b). However, on shorter time-scales (months to several years), modes of natural variability such as the Pacific Decadal Oscillation will affect and can dominate the trajectory of the observable global temperature record (Medhaug et al. 2017). While these modes of natural variability influence year-to-year variability, they even out on longer time scales. To identify the human-induced warming from the observational record, averages of 20 years or longer need to be used. Alternatively, specific methods of identifying the human-induced warming can also be deployed.

The global mean warming levels of 1.5°C and 2°C referenced in the long-term temperature goal of the Paris Agreement refers to the human-induced warming only above the pre-industrial climatological average (Joeri Rogelj, Schleussner, and Hare 2017). Inferring conclusions about trends of global average temperature increase from individual years or even months in relation to the achievement of the Paris Agreement long term temperature goal is thus ill-advised. For example the global average warming **above pre-industrial** over the last 20 years is about 0.9°C, about 0.6°C below the 1.5°C, where the current annual average warming indicates only about 0.3°C below the 1.5°C limit.

The adoption of the long-term temperature goal of the Paris Agreement was explicitly linked to an assessment of climate risks and impacts based on the outcome of a multi-year scientific assessment in the context of the United Nations Framework Convention on Climate Change (UNFCCC), the 2013-2015 Review of the Adequacy of the Long-term Goal and its Structured Expert Dialogue[2]. This process was informed by the best available science of the time as reflected in the 5th Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC AR5).

The IPCC AR5 deployed a specific approach to assess global mean temperature increase above pre-industrial levels using observed warming since 1850-1900 until 1986-2005 based on the HadCRUT4 observational dataset and warming projected by climate models thereafter (Stocker et al. 2013). The assessment of climate risks and impacts that informed the Paris Agreement has been based on this method to derive global mean temperature. Other methods, e.g. based on different datasets, might yield slightly different values of

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[1] This estimate of the present **human-induced** follows the methodology of (Haustein et al. 2017)[1] .

[2] https://unfccc.int/topics/science/workstreams/periodic-review

global mean temperature increase, but will not change the impact assessment. Global mean temperature increases linked to the long-term temperature goal of the Paris Agreement should thus be assessed following the methodology established in the IPCC AR5 (Pfleiderer et al. 2018).

Unless otherwise stated here warming levels referred to are climatological average warming above the 1850-1900 industrial baseline.

b) What would be the consequences of global warming of 1.5°C on the Outstanding Universal Value of the Great Barrier Reef Marine Park ('the Great Barrier Reef')?

Global warming to date of close to 1ºC above pre-industrial (1850-1900) has already caused substantial damage to the Great Barrier Reef and significantly negatively affected its Outstanding Universal Value, seriously compromised its integrity and intactness.

The most recent 2019 official Australian Government assessment has downgraded the long-term outlook for the Reef 's ecosystem from *poor* to *very poor* and also found that climate change remains the most serious and pervasive threat to the Great Barrier Reef.

A global warming of 1.5°C threatens, at the least, severe damage to the Outstanding Universal Value of the Great Barrier Reef. In particular Criterion (vii) Exceptional natural beauty, (ix) Ecological and biological processes, and (x) Conservation of biological diversity are likely to suffer severe damage. Criterion (viii) Major stages of earth's history is likely to be severely undermined A further loss of 70–90% of reef-building corals as is projected for a global warming of 1.5ºC will, at the least, severely damage the condition of integrity, which is essential for the Great Barrier Reef to retain its World Heritage listing.

These impacts will result from the combination of massive coral bleaching, extreme marine heatwaves, ocean acidification, more intense tropical cyclone activity and sea level rise and will result in severe damaged with reduced structural complexity and biodiversity of the reef system affecting all criterion. Habitat for marine organisms that depend upon the reef ecosystem will be severely damaged.

The following subsection will outline major causal chains by which global warming and CO_2 emissions will impact the Great Barrier Reef World Heritage Area and indicate how these are likely to interact synergistically to create compounding risks. The final sub-section under this question b) will draw this together into an assessment of how 1.5ºC and 2ºC global warming is likely to impact the Outstanding Universal Value of the Great Barrier Reef Marine Park.

Effects of global warming and CO_2 emissions on the Great Barrier Reef: Causal chains

The rapidly escalating risk to coral reefs with increasing global warming and CO_2 concentrations have been strongly reported in recent IPCC Assessments. The IPCC Special Report on *Global Warming of 1.5 ºC* report (IPCC SR1.5):

"*Even achieving emissions reduction targets consistent with the ambitious goal of* ***1.5°C of global warming*** *under the Paris Agreement* ***will result in the further loss of 70–90% of reef-building corals compared to today, with 99% of corals being lost under warming of 2°C*** *or more above the pre-industrial period*" (IPCC 2018b).

These findings were complemented in the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (IPCC SROCC) with a very high confidence assessment that "*almost all coral reefs will degrade from their current state, even if global warming remains below 2^{O}C, and* ***the remaining shallow coral reef communities will differ in species composition and diversity from present reefs****. […] Any coral reefs that do survive to the end of the century will not be the same because of irreversible changes in habitat structure and functioning, including species extinctions and food web disruptions*" (IPCC 2019) *(IPCC SROCC)*.

Increasingly frequent coral bleaching due to heat stress driven by higher temperatures from global warming is a major driver of coral reef decline and loss. The overall increase in temperatures due to human induced climate change can be exacerbated by climate variability such as El Nino events, whose frequency and intensity are also affected by global warming. Marine heat waves have emerged recently as a direct threat to coral reefs, with high temperatures leading directly to coral mortality. CO_2 emissions to the atmosphere leads directly to ocean acidification, which reduces coral calcification rates posing a threat to the functional integrity of coral reefs and increases susceptibility to disease and high temperatures. Extreme Tropical cyclones have adverse effects on coral reefs, and their projected increase in frequency will exacerbate the effects of bleaching, marine heatwaves and ocean acidification.

Bleaching

The first recorded mass bleaching event along the Great Barrier Reef occurred in 1998, then the hottest year on record. In 2016, half of the shallow water corals died on the northern region of the Great Barrier Reef between March and November (T. P. Hughes et al. 2019). **The IPCC reported in 2018 that the Great Barrier Reef has already lost 50% of shallow-water corals** (IPCC 2018b).

Recurrent bleaching of coral reefs **not only reduces their complexity and biodiversity but can also destroy coral reefs**. Bleached corals are still alive but if heat stress persists they die from lack of food or disease. Depending on extent of the stress coral reefs have been exposed to, they typically take 15-20 years to recover from mass mortality events such as destructive cyclones and mass bleaching events (Heron et al. 2017).

Since 1980 the number of years between pairs of severe bleaching events has reduced fivefold and, by 2016, was only about six years (T. P. Hughes et al. 2018). **In 2020 Great Barrier Reef experienced the most widespread bleaching recorded and is thought to be the second worst of the five bleaching events observed** (T. Hughes and Pratchett 2020). February 2020 had the highest monthly sea surface temperatures ever recorded on the Great Barrier Reef, which led to 25.1% of reefs severely affected, and a further 35% with moderate bleaching. For the first time, severe bleaching struck all three regions of the Great Barrier Reef – the northern, central and now large parts of the southern sections. (T. Hughes and Pratchett 2020).

Bleaching events are projected to become more frequent, widespread and severe with further warming and unmitigated warming is projected to exceed reef survival capacities within the next 10-30 years for majority of World Heritage sites containing coral reefs (Heron et al. 2017). More frequent bleaching events mean the coral reefs will not be able to recover. The impact of bleaching and the capacity for recovery is exacerbated by local pollution, ocean acidification and tropical cyclones.

Under emissions similar to current policies globally it can be expected that all coral reefs in World Heritage sites globally, including the Great Barrier Reef will experience severe annual bleaching by mid-century (Heron et al. 2018). If global mean warming is limited to about 1.5°C Heron et al (Heron et al. 2018) project that the Great Barrier Reef may not experience annual or bi-decadal severe bleaching heat stress events. However with about a 2°C global warming the Great Barrier Reef is projected to experience annual severe bleaching heat stress event shortly after 2050, and bi-decadal severe bleaching heat stress events before 2050 (Heron et al. 2018).

An important caveat on these projections is that they do not account for other stressors including ocean acidification, more intense tropical cyclones, nor the compounding effects of other human activities and pressures.

Direct effects of marine heatwaves

Whilst bleaching has been understood to be the dominant mechanism causing climate change induced degradation and loss of coral reefs, large, intense marine heat waves also result in the direct destruction of coral reefs with immediate mortality and loss of three-dimensional reef structure (Leggat et al. 2019). The biological mechanisms for the effect of extreme heat are different and more direct than bleaching (Leggat et al. 2019).

The scale and intensity of marine heatwaves is projected to increase rapidly with warming. A doubling of **marine heat wave** days has been observed since 1982 (up until 2016), with 87% attributable to human induced global warming (Frölicher, Fischer, and Gruber 2018)**.** With 1.5°C warming, **the number of marine heat wave days is projected to increase on average by a factor of 16** (Frölicher, Fischer, and Gruber 2018)**. Another study estimates that the occurrence frequency of extreme heat** (such as the Coral Sea heat of 2016, that led to the worst coral bleaching event on record) **will be of about 64%** - two out of three years - with 1.5°C warming.

Exacerbating this rise is the increasing frequency of extreme El Niño events with warming, projected to more than double with 1.5°C warming (Wang et al. 2017a) . The most extreme marine heat waves on the GBR are associated with extreme El Niño events. The frequency of such extreme El Niño events is projected to increase rapidly with future warming (Cai et al. 2015). Limiting warming to 1.5°C will nevertheless still avoid substantial risks, as for a 2°C warming extreme El Niño occurrence will almost triple in occurrence probability relative to pre-industrial levels (Wang et al. 2017b).

Ocean acidification

The addition of CO_2 into the atmosphere has numerous direct effects and amongst the most significant is ocean acidification. Since pre-industrial times this has resulted in about a 26% increase in the acidity of the ocean globally (IGBP IOC 2013). Observations around Australia confirm the global picture with acidification occurring generally in the oceans around the continent (Lenton et al. 2016).

The GBR is very sensitive to CO_2 induced ocean acidification (Mongin et al. 2016) and this interacts synergistically with warming to increase coral mortality (Prada et al. 2017a). Evidence is growing that ocean acidification is already impairing coral reef growth (Albright et al. 2016a). Recent work by Guo et al (Guo et al. 2020) has found that ocean acidification on its own has caused a 13% decline in the skeletal density of massive reef building corals on the Great Barrier Reef since 1950.

Increasing ocean acidification reduces calcification rates for many marine organisms including corals, crabs and molluscs and as well affects the biology of organisms often adversely (Pörtner et al. 2014). Reduced calcification rates for coral reefs ultimately reduces the ability of reefs to adjust and survive in the longer term (Albright et al. 2016b).

Warming and ocean acidification act together to increase coral mortality (Prada et al. 2017b). As Guo et al (Guo et al. 2020) note the detection of significant effect of ocean acidification "reinforces concerns that even corals that might survive multiple heatwaves are structurally weakened and increasingly vulnerable to the compounding effects of climate change".

Under current policies ocean acidification will continue to increase (pH decreasing) (Figure 1 below). Eyre and colleagues estimate that coral reefs globally could transition to net dissolution by 2050 (Eyre et al. 2018). The CO_2 reductions needed to limit warming to 1.5°C will lead to CO_2 concentration peaking within a few decades**. Global average ocean acidification could peak in the 2030s and decline close to present levels by 2100** (Climate Analytics 2019a) **under pathways that limit warming to 1.5°C.** This decline could result in increased calcification rates (Albright et al. 2016a), and therefore an avoidance of net dissolution of reef building sediments on the Great Barrier Reef (Climate Analytics 2019a)**.**

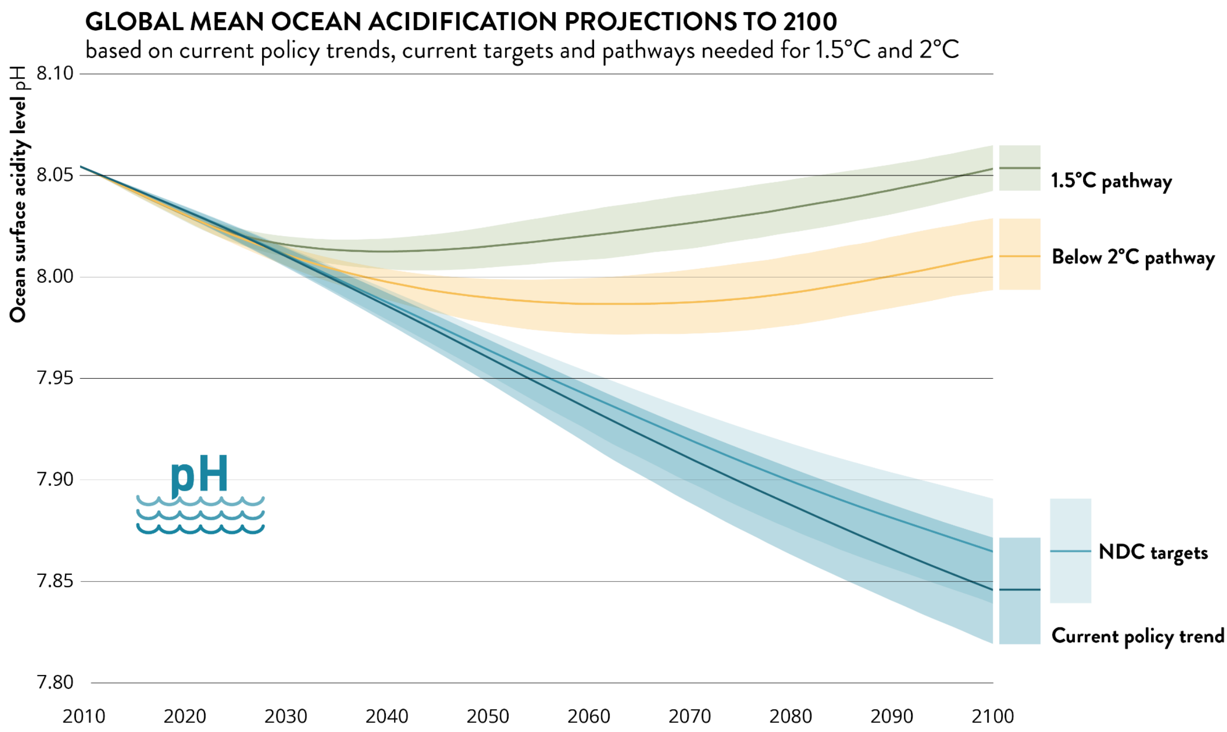

Figure 1: Projected global mean acidification for Paris Agreement 1.5°C compatible scenarios, 2°C l scenarios, and projections under current policy trends and assuming current NDC targets are met. (Source: own calculation of ocean acidification, based on Climate Action Tracker (CAT) (2018) data and method of Bernie et al. (2010). Note these calculations are based on a single model and reflect global mean surface pH, which does not reflect highly variable regional patterns, in particular for coastal regions, not changes in pH at depth.

More intense tropical cyclones

The effects of **tropical cyclones** are likely to interact adversely with warming, reduced calcification driven by increasing ocean acidification and other factors. Limiting warming to 1.5°C would reduce the anticipated increase in intensity of tropical cyclones substantially.

The frequency of high intensity large tropical cyclones is projected to grow as global mean warming intensifies, and is likely to have a significant adverse effect on the Great Barrier Reef. Observed severe ecological impacts of three unusually intense storms in the Great Barrier Reef are thought to have exacerbated the effects of major warming events that contributed to the unprecedented coral mortality of 2016 and 2017. Projections by (Cheal et al. 2017) indicate that the increased intensity of tropical cyclones under a business as usual warming scenario is likely to cause substantial damage to the Great Barrier Reef over the coming century. The effects of tropical cyclones are likely to interact adversely with warming, reduced calcification driven by increasing ocean acidification and other factors. With increasing warming, the number of total storms as well as major tropical cyclones are projected to increase in Australian waters. Recent state of the art high-resolution modelling suggests an increase in the total number of major cyclones (Category 4 and 5) of 80-120% by the end of the century at >4°C warming (Bhatia et al. 2018). Limiting warming to 1.5°C would reduce the anticipated increase in intensity of tropical cyclones substantially.

Sea level rise

Healthy coral reefs may be able to keep up with projected rates of sea level rise over the next several decades. Degraded coral reefs due to increasingly frequent bleaching, direct effects of extreme heatwaves, loss of coral cover, reduced calcification due to ocean acidification, as well as a move towards net dissolution of calcium carbonate sediments, may not be able to keep up (Perry et al. 2018).

Reducing the rate of sea level rise appears critical for the ability of global warming damaged coral reefs to adapt. Recent work by Perry et al (Perry et al. 2018) on reefs in the Atlantic and Indian Oceans indicates that reefs with low coral cover, as can be expected for a 1.5oC or 2oC warming, will likely not keep up with sea level rise projected for 2050 under a 2^{o}C global mean warming. There appears to be no published work on this issue for the Great Barrier Reef, however it is plausible that this finding would also apply to the Reef.

Under a 1.5°C scenario, the rate of sea level rise is likely to be reducing towards 2100 and the end-of-century rate of sea level rise is already about 30% lower than in a 2°C scenario (Schleussner et al. 2016).

Climate change impacts on the Outstanding Universal Value of the Great Barrier Reef

The Great Barrier Reef has been listed on the **World Heritage List** since 1981 for its Outstanding Universal Value. For a site to be inscribed on the List, it must meet at least one out of ten selection criteria. The Great Barrier Reef met all four natural criteria:

- (vii) contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance (summarized here as **Exceptional natural beauty**);
- (viii) outstanding examples representing major stages of earth’s history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features (summarized here as **Major stages of earth’s history**);
- (ix) outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals (summarized here as **Ecological and biological processes**); and
- (x) contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science and conservation (summarized here as **Conservation of biological diversity**).

In addition, for a natural heritage site to be deemed of Outstanding Universal Value, it must meet the condition of **integrity**. Integrity is defined as a measure of the wholeness or intactness of the natural heritage and its attributes.

Impacts of 1°C warming

At present levels of warming of about 1°C above pre-industrial the most recent Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019) finds that the integrity of the World Heritage Area is *"challenged and deteriorating"*:

> *While the property's outstanding universal value as a World Heritage Area remains whole and intact, its integrity is challenged and deteriorating. Given the global scale of human-induced climate change, the size of the property is becoming a less effective buffer to broadscale and cumulative impacts.*

This 2019 Outlook report also finds that the long-term outlook for the Reef 's ecosystem has "deteriorated from *poor* to *very poor*" since the 2014 Outlook Report and, crucially it finds that "*climate change (especially sea temperature rise) remains the most serious and pervasive threat to the Great Barrier Reef*" (Great Barrier Reef Marine Park Authority 2019).

These overall findings are also reflected in the Australian Government's State Party report on the state of conservation of the Great Barrier Reef World Heritage Area, submitted to the World Heritage Centre on 1 December 2019, states:

> *The 2019 Outlook Report concluded that the OUV of the Reef remains whole and intact and maintains many of the elements that make up its OUV, however, components that underpin all four natural criteria have deteriorated since the Reef 's inscription on the World Heritage List. The size of the property is becoming a less effective buffer to broadscale and cumulative threats, primarily due to climate change.* (Australian Government 2019)

An independent scientific review of the 2019 Great Barrier Reef Outlook confirmed these findings and based on a review of observations expressed the view that the integrity of the Great Barrier Reef World Heritage Area has been seriously compromised by the back-to-back coral bleaching in 2016 and 2017 (Tarte and Hughes 2020).

Impacts of 1.5°C warming

Table 1 summarise the results of this review and analysis. Global warming of 1.5°C threatens severe damage to the Outstanding Universal Value of the Great Barrier Reef. In particular Criterion (vii) Exceptional natural beauty, (ix) Ecological and biological processes, and (x) Conservation of biological diversity are likely to suffer severe damage. Criterion (viii) Major stages of earth's history is likely to be severely undermined A further loss of 70–90% of reef-building corals, as is projected for a global warming of 1.5°C, will severely undermine the condition of integrity, which is essential for the Great Barrier Reef to retain its World Heritage listing.

All four criterion are affected, jeopardizing the Outstanding Universal Value of the Great Barrier Reef. Degradation, loss and alterations of the corals threatens the integrity of the

Great Barrier Reef the diversity, complexity, history, size, interactions and superlative beauty of the Great Barrier Reef.

Whilst it is clear that a global warming of 1.5°C will cause, at the least, severe damage to the Outstanding Universal Value of the Great Barrier Reef, severely undermine the integrity of the World Heritage areas it is also clear that this level of warming is fundamentally safer than a global warming of 2°C, which could result in destruction . On this issue the IPCC SR1.5 noted that *"a world in which global warming is restricted to 1.5°C above pre-industrial levels would be a better place for coral reefs than that of a 2°C warmer world, in which coral reefs would mostly disappear*" (Hoegh-Guldberg et al. 2018).

A further important issue in the context of assessing risks is the serious consequences of overshooting the 1.5°C level. This was emphasized IPCC SR1.5 report:

> *"Limiting warming to 1.5°C rather than 2°C can help reduce these risks, but the impacts the world experiences will depend on the specific greenhouse gas emissions 'pathway' taken. The consequences of temporarily overshooting 1.5°C of warming and returning to this level later in the century, for example, could be larger than if temperature stabilizes below 1.5°C. The size and duration of an overshoot will also affect future impacts."* (Hoegh-Guldberg et al. 2018).

Coral reefs are particularly sensitive to every increment of global mean warming and hence overshoot of 1.5oC is particularly risky.

In this context, in particular considering the issue of coal developments, it is very important to understand that energy scenarios consistent with limiting warming to 1.5°C the IPCC SR1.5 Summary for Policy Makers (IPCC 2018b) defined 1.5° compatible pathways as those that hold global warming to 1.5°C or below, with no or only a limited overshoot of this warming level and have **below** 1.5° by 2100 with 50% or greater probability (IPCC 2018b). By 2100 the median warming of 1.5° compatible pathways is back to about 1.3°C (with 90% percentile range of 1.1-1.4°C), which means that the exposure of reefs to extreme heat and ocean acidification will likely be reducing from mid-century.

Table 1 Impact of global warming of 1.5°C and 2°C on Outstanding Universal Value of the Great Barrier Reef

Summary descriptor	Criterion	1°C warming - Great Barrier Reef Outlook Report 2019	Impact at 1.5°C warming	Impact at 2°C warming
Exceptional natural beauty	(vii) contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance.	The natural beauty of the property endures, however, it is under increasing pressure from cumulative impacts above and below the water[3]. At a whole-of-Region level, overall habitats are assessed to be in poor condition, affecting aspects of its natural beauty and phenomena. Widespread coral mortality (as a result of sea temperature extremes in combination with predation by crown-of-thorns starfish) and impacts from severe cyclones, have affected the aesthetics and natural beauty of some parts of the Region[4]. Most prominent threats to the Region's ecosystem include the ongoing chronic effects of increased sea temperature, poor water quality and acute die-offs of corals caused by spikes in summer temperatures.	*Further loss of 70–90% of reef-building corals will at the least* **severely damage** *the* exceptional natural beauty *and aesthetic values of the* Great Barrier Reef, particularly those that are below the water surface. Large scale die off of coral reefs and well as damage to seagrass meadows, with little or no recovery, will **severely damage this criterion.**	*Further loss of 99% of reef-building corals will in all likelihood* **destroy** many of *the* exceptional natural beauty *and aesthetic values of the* Great Barrier Reef, particularly those that are below the water surface. Almost complete loss of coral reefs and damage to seagrass meadows, with little or no recovery, will **destroy this criterion at least for those values** that are below the water surface.
Major stages of earth's history	(viii) outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features.	While the current impacts and changes from disturbances are minor on an evolutionary scale, they are unprecedented and will be long-lasting[5]. Coral calcification rates have decreased in the last 25 years as a result of extreme temperatures and coral bleaching. Processes that influence reef formation and maintain sediment accumulation on reef islands (for example, ocean acidification, sea temperature and sea-level rise) are intensifying in a negative way due to climate change, and pose the greatest threat to the Reef's contemporary geomorphology. The ecological process of reef building has deteriorated since 2014 and is considered poor[6] (Section 3.4.8 of Outlook Report).	*At the least* **severely undermine** this criterion as the ecological and geological processes that have given rise to the Great Barrier Reef would likely be severely damaged. Processes of reef formation that maintain sediment accumulation on reef islands may be close to severely undermined or even close to cessation due to loss of reef building coral, ocean acidification and accelerated reduction in calcification rates. Sea level rise may be approaching, if coral cover loss and damage is at the high end of projections, exceed the limits to which reefs can accrete.	**Severely damage, or even destroy this criterion** processes of reef formation will likely be ended, sediment accumulation on reef islands close to cessation due to loss of reef building coral, ocean acidification and in calcification rates approaching dissolution. Sea level rise rates would likely exceed the limits to which reefs can accrete, so that water depth over any remaining reefs would be increasing.

3 Section 4.2.2 Natural beauty and natural phenomena (criterion vii), Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019)

4 Section 4.5.2 Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019)

5 Section 4.2.3 Major stages of the Earth's evolutionary history (criterion viii), Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019)

6 Section 3.4.8 Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019)

Summary descriptor	Criterion	1°C warming - Great Barrier Reef Outlook Report 2019	Impact at 1.5°C warming	Impact at 2°C warming
		Due to these widespread threats to geomorphology, the Reef's resilience is decreasing and its size is becoming a less effective buffer for this world heritage criterion. This component has deteriorated since 2014.		
Ecological and biological processes	(ix) outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals;	Ecological and biological processes that are fundamental to a functioning ecosystem (for example, reef building, recruitment and symbiosis) are considered to be in poor condition[7]. Since 2014, the condition of one of the most critical physical processes, sea temperature, has deteriorated to very poor condition across a wide area as a result of climate change. This has led to substantial changes in some processes. The global significance of the Reef continues to be underpinned by the form and structure of its organisms, as well as the interconnectedness of the Reef's complex physical, chemical and ecological processes.	Further loss of 70–90% of reef-building corals, combined with extreme temperatures, ocean acidification would *at the least* **severely damage** fundamental ecological and biological processes (reef building, recruitment and symbiosis).	*Further loss of 99% of reef-building corals will in all likelihood* **destroy many of the** fundamental ecological and biological processes that support the reef (reef building, recruitment and symbiosis).
Conservation of biological diversity	(x) contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science and conservation.	Habitats for conservation of biodiversity are deteriorating, with observed loss and alteration of many elements necessary to maintain outstanding universal value[8]. For the first time since Outlook Report assessments began in 2009, habitat loss and degradation has occurred in a number of areas, its condition overall is poor and biodiversity is being affected (Chapter 2 of Outlook Report). Key habitats, such as coral reefs and seagrass meadows, are considered to be in very poor and poor condition, respectively. The habitat and species condition grades reflect the increasing cumulative pressures the Region faces from a changing climate and other anthropogenic impacts.	Further loss of 70–90% of reef-building corals would *at the least* **severely damage the role of the reef for conservation of biological diversity, with the loss of** habitat of many species, particularly this dependent on coral, with a likely increase in the number of threatened and endangered species.	*Further loss of 99% of reef-building corals will in all likelihood* **destroy the role of the reef for conservation of biological diversity, with massive loss of habitats with** likely very substantial increase in the number of threatened and endangered species if not outright extinctions.

[7] Section 4.2.4 Ecological and biological processes (criterion ix), Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019)
[8] Section 4.2.5 Habitats for conservation of biodiversity (criterion x), Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019)

Summary descriptor	Criterion	1°C warming - Great Barrier Reef Outlook Report 2019	Impact at 1.5°C warming	Impact at 2°C warming
		Multiple disturbances have transformed coral reef structures on a broad scale across the entire Region and cumulatively hindered the recovery of some coral-dependent species (Sections 2.3.5 and 8.3.1 of Outlook Report).		
Integrity	Integrity (Intactness and wholeness)	Human-induced climate change is challenging the integrity of the World Heritage Area; its size is becoming a less effective buffer against broadscale impacts[9] The widespread loss of coral habitat, warming seas and intensifying external pressures from outside the Region are affecting the property's intactness. Climate change remains the greatest risk to the outstanding universal value of the World Heritage Area and its integrity. While the property remains whole and intact, the condition of many elements that make up the four world heritage criteria are deteriorating.	Further loss of 70–90% of reef-building corals would *at the least* **severely undermine the integrity and intactness o**f the Great Barrier Reef	*Further loss of 99% of reef-building corals will in all likelihood* **destroy the integrity and intactness o**f the Great Barrier Reef coral reef systems.

[9] Section 4.2.6 Integrity, Great Barrier Reef Outlook Report 2019 (Great Barrier Reef Marine Park Authority 2019)

c) What would be the consequences of global warming of 2°C on the Outstanding Universal Value of the Great Barrier Reef?

A sustained global warming of 2°C will likely destroy the Outstanding Universal Value of the Great Barrier Reef. In particular Criterion (vii) Exceptional natural beauty, (ix) Ecological and biological processes, and (x) Conservation of biological diversity are likely to be destroyed. Criterion (viii) Major stages of earth's history are likely to be severely damaged. A further loss of 99% of reef-building corals, as is projected for a global warming of 2°C, will in all likelihood destroy the condition of integrity intactness, which is essential for the Great Barrier Reef to retain its Outstanding Universal Value (see Table 1).

Under a 2°C warming, **99% of the world's corals will be lost** (IPCC, SR15, 2018). With about a 2°C global warming the Great Barrier Reef is projected to experience severe bleaching heat stress annually by the 2050s and bi-decadal severe bleaching heat stress before then, in the 2040s (Heron et al. 2018).

Under a 2°C warming, **the number of marine heat waves will increase on average by a factor of 23** (Frölicher, Fischer, and Gruber 2018)**; the occurrence of extreme heat events** (such as the Coral Sea heat of 2016, that led to the worst coral bleaching event on record) **will become two** out of three years occurrence (King, Karoly, and Henley 2017)**; and the frequency of extreme El Niño events** is projected to **almost triple** (Wang et al. 2017b)**.**

Under 2°C compatible pathways, **peak ocean acidification is greater and exposure to ocean acidification levels much higher than in 1.5°C pathways. Peak ocean acidification will extend until well after the end of this century, whereas in 1.5°C pathways peak ocean acidification should occur by mid-century. End of century ocean acidification levels will still be higher than at present under 2°C warming whereas in 1.5°C pathways ocean acidification is projected to be below present levels by 2100** (Climate Analytics 2019a)**.**

Recent work modelling the effects of ocean acidification on the net precipitation of calcium carbonate ($CaCO_3$) sediment which is essential for reef structures, lagoons and cays indicates the risk of a transition to **net dissolution of $CaCO_3$ sediments under business as usual warming** by mid-century for seven reef locations within the Great Barrier Reef (Eyre et al. 2018). A transition to net dissolution of **$CaCO_3$ sediments compounds the effects of reduced coral calcification caused by ocean acidification** due to loss of material to build habitats such as reef flats, lagoons and cays (Eyre et al. 2018). Based on this work**,** under 2°C compatible pathways it would be **unlikely** for $CaCO_3$ sediments on these reefs to enter a net dissolution state[10].

[10] Eyre et al (Eyre et al. 2018) assume an annual decrease of the aragonite saturation state (Ωar) of about -0.01 based on (Bates et al. 2014). For the purposes of this work an approximate relationship between Ωar and ocean acidification (pH) can be inferred from (Raven, Caldeira, and Elderfield 2005), and based on the ocean acidification scenarios shown in Figure 1 it is easily seen that NDC and current policy trends will yield aragonite saturation state around 2050 similar to those estimated by (Eyre et al. 2018) for that year that would results in net dissolution.

The effects of **tropical cyclones** are likely to interact adversely with warming, reduced calcification driven by increasing ocean acidification and other factors. Under a 2°C scenario, **the frequency of high intensity tropical cyclones will increase** (IPCC 2018b).

The rate of sea level rise is critical for the ability of coral reefs to adapt (fast modification of their environment). Under a 2°C scenario, **future rates of sea level rise will exceed current rates over the full 21st century with no sign of slow-down** (Climate Analytics 2019a).

The effects of these climate stressors on the Outstanding Universal Value of the Great Barrier Reef and its integrity are summarised in see Table 1. Under a sustained 2°C warming it appears likely that all four criterion will be destroyed or severely damaged, and that the integrity (intactness) the Great Barrier Reef, which is essential for it to retain its Outstanding Universal Value is likely to be destroyed.

d) What is the remaining carbon budget for global warming of 1.5°C above pre-industrial times?

To limit global warming to 1.5°C increase above pre-industrial times (1850-1900) with a likely probability, the remaining carbon budget from the start of 2020 is about 235 Gt CO_2 (billion tonnes of CO_2).

The IPCC SR1.5 (IPCC 2018a) estimated the remaining cumulative carbon (carbon budget) that can be emitted for different levels of warming along with uncertainties such as non-CO_2 greenhouse gas scenarios, climate response and sensitivity uncertainties, and geophysical feedbacks (See Table 2.2 (J Rogelj et al. 2018)). Accounting for geophysical feedbacks, the budgets would need to be reduced by an estimated 100 GtCO2. Recently the EU Horizon 2020 research project provided an update of the remaining carbon budget from 1.1.2020 (CONSTRAIN 2019). The reduction in the remaining carbon budgets in the recent CONSTRAIN estimates are due approximately 84 $GtCO_2$ emitted from fossil and land-use change sources in 2018 and 2019 (Friedlingstein et al. 2019) (Table 2).

Critical to defining the carbon budget is defining the probability with which a given temperature level/limit is to be achieved. Two probability levels often referred to in scientific assessments are 50% probability and a likely probability (a 66% or greater chance of limiting warming to the chosen level).

1.5°C above 1850-1900	IPCC SR1.5 without earth system feedbacks	IPCC SR1.5 with earth system feedbacks	CONSTRAIN	CONSTRAIN with earth system feedbacks[11]
	From 1.1.2018	From 1.1.2018	from 1.1.2020	from 1.1.2020
50%	580	480	495	395
>66 %	420	320	335	235

Table 2 1.5°C Carbon budget estimates

Given the extreme risk to the Outstanding Universal Value of the Great Barrier Reef posed by warming, and the strong evidence that limiting warming to a 1.5°C increase above pre-industrial times (1850-1900), or lower, provides the best chance of survival for the reef, the appropriate budget choice is one that gives the reef **a likely or greater chance** of survival and retaining its Outstanding Universal Value and some critical level of integrity. As shown the remaining budget from 1.1.2020 is estimated at about 235 $GtCO_2$ (billion tonnes of CO_2) after accounting for likely geophysical feedbacks (e.g. permafrost melt) (Table 2).

e) What is the remaining carbon budget for global warming of 2°C above pre-industrial times?

To limit global warming to 2°C increase above pre-industrial times (1850-1900) with a likely probability, the remaining carbon budget from the start of 2020 is about 985 $GtCO_2$ (billion tonnes of CO_2).

Following the approach for 1.5°C above, Table 3 below summarizes the remaining carbon budget for holding global warming of 2°C above pre-industrial.

The remaining carbon budget from the start of 2020 is 985 Gt CO_2 for a likely probability of holding below 2°C, and 1,315 Gt CO_2 with a 50% probability.

2oC above 1850-1900	IPCC SR1.5 without earth system feedbacks	IPCC SR1.5 with earth system feedbacks	CONSTRAIN	CONSTRAIN with earth system feedbacks
	From 1.1.2018	From 1.1.2018	from 1.1.2020	from 1.1.2020
50%	1500	1400	1315	1215
>66%	1170	1070	1085	985

Table 3 2°C Carbon budget estimates. Data are rounded to the nearest 5 Gt CO_2.

f) What future emissions are already committed, globally?

If current policies are not significantly improved then it can be estimated that the cumulative GHG emissions from 2020 to 2100 would be in the range 3,700-4,750 $GtCO_2e$.

[11] Data are rounded to the nearest 5 Gt CO_2 (CONSTRAIN report, 2019).

If 1.5°C compatible scenarios are considered as a lower bound on committed CO_2 emissions then net committed emissions would be around 105 $GtCO_2$ by 2100, which is below the 235 GtCO2 budget identified. The massive caveat on this is that this requires deployment of very large-scale negative CO_2 emissions to compensate emissions from fossil fuels.

What is critical is that cumulative CO_2 emissions from Fossil Fuel and Industry CO_2 under the most advanced 1.5°C compatible scenarios between 2020 and 2050 are about 470 $GtCO_2$ [435 - 570 $GtCO_2$][12], about twice the 1.5°C compatible budget for the full century, 2020-2100. This means that these pathways limit warming to 1.5°C by deploying large scale negative CO_2 emissions, so that the cumulative Fossil Fuel and Industry CO_2 emissions are negative -215 $GtCO_2$ from 2051-2100[-90 - -415] $GtCO_2$.

The total Fossil Fuel and Industry CO_2 emissions from 2020 to 2100 in these pathways are about 255 $GtCO_2$ a bit higher than the total 1.5°C compatible CO_2 budget of around 235 $GtCO_2$.

1.5°C compatible Fossil Fuel and Industry CO_2 emissions pathways require a very rapid phase out of coal in the power sector to achieve even these cumulative emissions, which already commit the world to large-scale negative CO_2 emissions.

There are different ways to look at committed emissions.

One way is to estimate emissions that are committed to by current policies, however this needs to be recognised as conditional, in the sense that if current policies change so do the committed emissions. In other words, if governments adopt more aggressive policies then emissions will be lower than present estimates of emissions committed to by current policies.

The Climate Action Tracker analyses various possible global pathways. The current policy (TRENDHI and TRENDLO) evaluate the emission trajectory incorporating the currently implemented mitigations policies as of December 2019. The OPTIMISTIC pathways incorporate planned new policies that are close to becoming law or that are assessed by the Climate Action Tracker as likely to be implemented. The NDC pathways (PLEDGELO, PLEDGEHI) evaluate emissions trajectories that incorporate Paris Agreement nationally determined contributions for 2030. The PLEDGELO2050 additionally includes the effects of those countries with 2050 emissions goals that are embedded in national policies that are assessed by the Climate Action Tracker as likely to be implemented.

The Climate Action Tracker estimates the global effect of current policies and based on its 2019 assessment the emissions committed to by current policies from 2020 to 2100 are estimated in the range 3,700-4,750 $GtCO_2e$.

Scenario	2020-2050	2051-2100	2020-2100
	$GtCO_2e$	$GtCO_2e$	$GtCO_2e$
Current policies			
CAT OPTIMISTIC	1,625	2,099	3,724
CAT TRENDHI	1,792	2,939	4,731
		Paris NDCs	
CAT NDC PLEDGELO	1,494	1,599	3,093
CAT NDC PLEDGELO2050	1,515	1,661	3,176
CAT NDC PLEDGEGHI	1,633	2,026	3,659
SSP2-45 (incl LULUCF)	1,690	1,830	3,520
SSP2-45 (excl LULUCF)	1,620	1,900	3,520

Table 4 Current policy and Paris Agreement GHG emissions commitments. CAT data from CAT Madrid 2019 update, SSP data assessed from https://tntcat.iiasa.ac.at/SspDb on August 1, 2020.

A second way is to ask what emissions are committed to by the present Paris Agreement NDCs, which has similar caveats to the current policy emission commitments.

The Climate Action Tracker also estimates the global effect of Paris Agreement NDCs and based on its 2019 assessment the emissions committed to by current policies from 2020 to 2100 are estimated in the range 3,100-3,700 $GtCO_2e$.

In the scenario literature, the SSP2-45 scenarios are normally taken as reasonable proxies for current policy trajectories including NDCs (Roelfsema et al. 2020). SSP2 is a so-called 'middle of the road' scenario, which utilizes median estimates of future technoeconomic and socioeconomic progression. The '45' in the scenario name corresponds to a specific radiative forcing target assumed in the scenario (i.e., 4.5 Wm^{-2}), which corresponds to the scenario community's approximation of the 2100 warming level due to existing stated policies. SSP2-45 show a range of emissions between 2020-2100 of approximately 3,400-3,700 $GtCO_2e$ when including LULUCF, and 3,100-3,800 $GtCO_2e$ when excluding LULUCF.

Another way to look at committed emissions is to ask what emissions are committed to under the most advanced technically and economically feasible scenarios published to date. The most technically and economically advanced scenarios published to date are those limiting warming to 1.5°C as published in the IPCC Special Report on 1.5C and they have cumulative emissions GHG emissions from 2020 until 2100 of 740 [655 - 855] $GtCO_2e$[12]. What is important to understand is that these are net cumulative emissions and may involve significant negative CO_2 emissions particularly in the second half of the century.

So the cumulative total GHG emissions in 1.5°C scenarios from 2020 until 2050 are 810 [700 - 920] $GtCO_2e$ and afterwards 2051-2100 negative emissions of -50 [-160 - 50] $GtCO_2e$.

[12] All calculations here are listed with <median> [<25th percentile> - <75th percentile>]

These pathways also show for Total CO_2 cumulative emissions from 2020 until 2050 are 515 [440 - 625] $GtCO_2$ and from 2051-2100 cumulative emissions CO_2 emissions are negative at around -395 [-220 - -505] $GtCO_2$. Total CO_2 includes emissions from Land Use as well as fossil fuels. Considering only Fossil Fuel and Industry CO_2 emissions, cumulative emissions from 2020 until 2050 is 470 [435 - 570] $GtCO_2$ and afterwards (2051-2100) cumulative emissions CO_2 emissions are negative at around -215 [-90 - -415] $GtCO_2$.

In overall terms, the IPCC SR1.5 1.5°C compatible pathways have cumulative CO_2 emissions of around 105 $GtCO_2$ by 2100, which is below the 235 GtCO2 budget identified in question d above (d) What is the remaining carbon budget for global warming of 1.5°C above pre-industrial times?) for **likely probability of limiting warming to** 1.5°C.

Emissions	2020-2050	2050-2100	2020-2100
Total GHGs ($GtCO_2e$)	815	-50	740
Total CO_2 ($GtCO_2$)	515	-400	105
FF&I CO_2 $GtCO_2$	470	-215	255

Table 5 Median estimates of scenario carbon budgets in each time period for low and no-overshoot 1.5C pathways (rounded to the nearest 5Gt).

In summary, the most advanced scenarios of technically and economically feasible emission reductions over the century indicate that it is likely that CO_2 emissions would exceed the budgets identified above by 2050, and have to be compensated for by negative emissions post 2050.

Scenarios that limit the use of negative emissions are characterised by even stronger near-term emission reductions, for example a reduction of global coal deployment by 2030 by about 80% relative to 2010 (Pathway P1, IPCC SR1.5) and almost complete phase out of all fossil fuels including oil and gas by 2050.

The amount of negative emissions required is thus directly linked to near-term emission reduction actions. Higher emissions than should otherwise be the case for a 1.5°C pathway would entail obligations for the future deployment of negative emissions to compensate. Such obligations can be derived from present (inadequate) mitigation commitments under the Paris Agreement (Fyson et al. 2020). Australia has about 17 tonnes of CO_2 per capita one of the highest per capita emission rates in the world (Monica et al. 2019).

g) What future emissions are already committed from fossil fuel production, globally?

Best estimates of committed CO_2 emissions from existing fossil fuel infrastructure as of 2018 are 658-715 Gt CO_2 some 2.8-3 times the carbon budget for 1.5°C, implying that existing infrastructure would need to be retired before their expected end of lifetimes.

Recent work by Tong and colleagues estimates that there are 658 (226-1779) Gt CO2 committed emissions from existing fossil fuel infrastructure as of 2018. There is a further 188 (37-427) Gt CO2 of emissions from planned fossil fuel infrastructure which would be committed if these were built (Tong, D. et al., 2019). Other recent work by Smith et al. (2019) estimates committed emissions with a median estimate to be 715 Gt CO2 close to that of Tong and colleagues.

The middle range of the values for existing infrastructure exceed the expected carbon budget for 1.5°C from 2018 for likely achievement of the 1.5° limit by more than 50% without consideration of the system feedbacks, and if the latter are accounted for the budget exceedance would be over 100%. Adding planned infrastructure to this total exacerbates the situation significantly increasing the exceedance to 45% and 76% respectively[13].

The results imply that existing (and planned infrastructure, if built) would need to be retired before their expected end of lifetimes. A further implication is that for the middle range of the estimates by Tong et al. (Tong, D. et al., 2019) no new fossil-fuel based infrastructure can be built and/or operated in order to maintain a 1.5°C temperature limit, without resort to very large-scale negative CO_2 emissions to compensate for the budget exceedance.

h) What is the trajectory of emissions from fossil fuels (i.e. increasing, decreasing or steady) that would be consistent with global warming of 1.5 and 2°C?

For 1.5°C compatible pathways emissions of CO_2 from fossil fuels need to be 30% below 2010 CO_2 emission levels by 2030 and reach net zero fossil fuel CO_2 emissions between 2055 and 2060. For 2°C compatible pathways a 12% reduction in emissions of CO_2 from fossil fuels by 2030 is needed and net zero fossil fuel CO_2 emissions are needed by around 2080.

The distribution of scenario emissions pathways assessed by the IPCC in the second chapter of the IPCC SR15 (J Rogelj et al. 2018) show strong and significant reductions (decreasing trends) across 1.5°C and 2°C scenario categories (Figure 2.6, IPCC SR15). These decreasing trends hold when combining SR15 scenario subcategories into single 1.5°C and 2°C distributions, with a stronger decreasing trend for 1.5°C scenarios than 2°C scenarios.

[13] For a 50% probability of limiting warming to 1.5° the middle range of the values for existing infrastructure exceed the expected carbon budget for 1.5C from 2018 by 13% without consideration of the system feedbacks, and if the latter are accounted for the budget exceedance would be 37%. Adding planned infrastructure to this total exacerbates the situation significantly increasing the exceedance to over 100% and over 160% respectively.

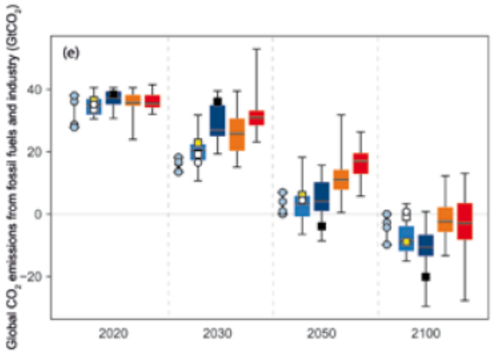

Figure 2 Figure 2.6(e) from SR1.5 Chapter 2 (J Rogelj et al. 2018)

For 1.5°C compatible pathways[14] the IPCC SR1.5 Summary for Policy Makers (IPCC 2018b) found that total CO_2 emissions would need to be reduced by about 45% from 2010 levels by 2030 and reach net zero around 2050. Total CO_2 emissions include land use change, so that specific reductions for emission of CO_2 from fossil fuels are different, with about 30% reduction from 2010 CO_2 emission levels by 2030 and net zero CO_2 emissions between 2055 and 2060.

For 2°C compatible pathways[15] the IPCC SR1.5 found that total CO_2 emissions would need to be reduced by about 20% from 2010 levels by 2030 and reach net zero around 2075 (IPCC 2018b). Total CO_2 emissions include land use change, so that specific reductions for emission of CO_2 from fossil fuels are different, with about a 12% reduction from 2010 levels by 2030 and net zero emissions around 2080.

These results are shown graphically in Figure 3 below based on date from the IPCC SR1.5 database (Huppmann 2018) for 1.5°C compatible pathways (no, or limited overshoot of 1.5°C) and for 2°C pathways (likely probability).

[14] With no or limited overshoot of 1.5°C
[15] Based on a 66% probability of staying below 2°C

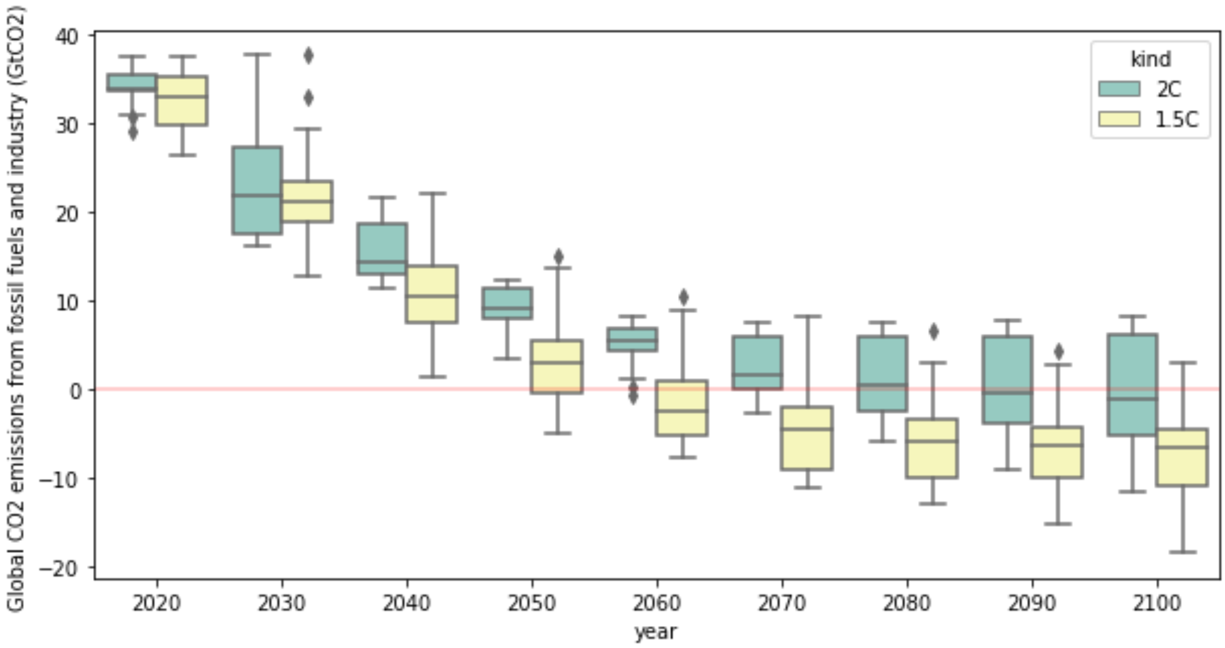

Figure 3 Combined Energy Supply and Demand CO_2 emissions from the SR15 database (Huppmann 2018) *for scenarios classified as 1.5 or 2C based on own calculations*

i) Is new coal production consistent with limiting global warming to 1.5°C?

There are multiple lines of evidence that show it is highly likely, if not virtually certain, that new coal production is inconsistent with limiting global warming to 1.5C.

This question is understood to relate to the addition of new coal production capacity, above present levels.

The IPCC SR1.5 found with high confidence that in 1.5C compatible pathways (with limited or no overshoot) the use of coal in electricity production "shows a steep reduction in all pathways and would be reduced to close to 0% (0–2%) of electricity" by 2050. Coal use in primary energy was found by 2030 to be reduced by 61 to 78% compared to 2010 levels, and by 2050 reduced by 73 to 97% compared to 2010 levels (IPCC 2018b).

In 2019 an assessment was published on the extent to which projected fossil fuel production by country and globally was consistent with 1.5° and 2°C global warming limits. This shows that the total projected level of coal production by all countries is 280% higher than what would be consistent with a 1.5°C pathway in 2030, and 540% higher in 2040 (SEI et al. 2019). Almost 70% of the projected production in 2030 is from China (2.7 Gt) and India (1.1 Gt) alone, with Australia projected to be the next largest producer making up over 10% of global production (570 Mt).

Figure 4 below shows 1.5°C compatible production level pathways compared to these implied by present plans and projections globally. It can be seen that the production levels consistent with the 1.5° pathways decrease rapidly and that the planned and projected production levels remain far above 1.5° consistent pathways over the projection period to 2040. From this it can be concluded that present plans and production projections are fundamentally inconsistent with Paris Agreement compatible pathways, and hence any new production capacity would exacerbate, or continue to sustain this highly adverse situation.

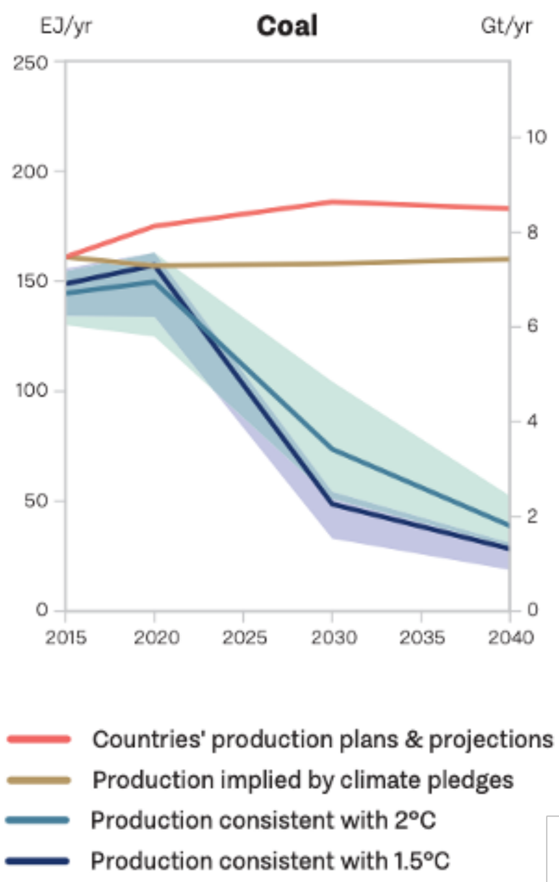

Figure 4 Projected vs. 1.5°C and 2.0°C compatible coal production (SEI et al. 2019)

Another line of evidence that indicates the incompatibility of present plans and projected production of coal with either 1.5 or 2° warming limits comes from assessments of how much carbon can be burnt against available reserves and resources. McGlade and Ekins (McGlade and Ekins 2015) showed unambiguously that reserves and resources identified in 2010 of coal were completely inconsistent with limiting warming to 2°C. Figure 5 below compares their estimates of reserves[16] and resources of fossil fuels.

[16] McGlade and Ekin define reserves as a subset of resources that "recoverable under current economic conditions and have a specific probability of being produced". Reserves are closest to planned and project production.

Comparison of McGlade and Ekins estimates of Coal reserves vs 1.5oC pathways

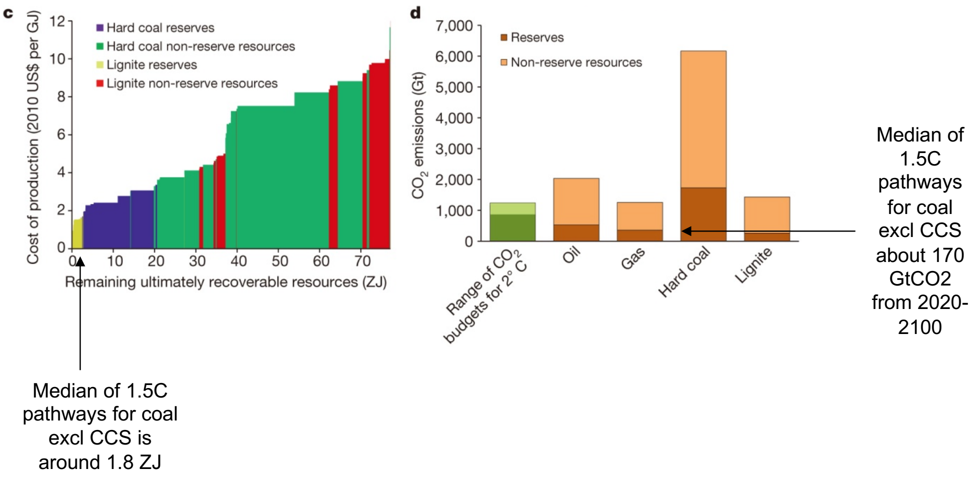

Figure 1c) and d) from McGlade & Ekins *Nature* **517**, 187-190 (2015) doi:10.1038/nature14016

Figure 5 Comparison of McGlade and Ekins (2015) coal reserves with levels of consumption and CO2 emissions consistent with 1.5oC compatible pathways. Coal use in energy supply and emissions are shown for coal use excluding CCS and calculated from 1.5°C pathway database.

It is clear from globally published data that available reserves of coal have been increasing over the last 20 years in absolute terms and measured by the number of years of current-year production that reserves represent. In 1999, the reserve to annual production ratio was about 120 years and in 2019 was 132 years, according to the BP Statistical Review of world energy[17]. What this indicates is that economically recoverable reserves are sufficient for more than a century at present rates of consumption. Whilst not a direct indication, this ratio supports the view that additional production will simply make a bad situation worse.

Finally, taking into consideration existing fossil fuel infrastructure estimates of Tong, D. et al., 2019 (658-846 Gt CO_2) and Smith et al., 2019 (715 $GtCO_2$)[18] – both of which significantly exceed the 235 $GtCO_2$ 1.5C carbon budget – additional fossil fuel infrastructure, like new coal production infrastructure, would contribute further to committed emissions.

In summary these lines of evidence strongly support the conclusion that new coal production is highly likely, if not virtually certain, to be inconsistent with limiting global warming to 1.5C.

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[17] http://www.bp.com/statisticalreview

[18] See response to question g

j) Is new coal production consistent with limiting global warming to 2°C?

It is highly unlikely that new coal production is consistent with limiting global warming to 2°C.

The total projected level of coal production by all countries is 150% higher than what would be consistent with a 2°C pathway in 2030, and 360% higher than in 2040 (SEI et al. 2019). The pathway depicting the 2°C compatible production level in Figure 4 above represents the median of scenarios that have at least a 66% chance of limiting warming to 2.0°C throughout the 21st century. Therefore, it is highly unlikely that new coal production is consistent with limiting global warming to 2°C.

k) What emissions would result from burning the coal authorised to be produced under the EPBC Approval 2010/5736 for the Carmichael Coal Mine and Rail Infrastructure Project (‘**the Action**’) (i.e. 60 million tonnes per annum for 60 years)?

Total CO_2 emissions from the coal authorised to be produced over the 60 year life of the project is about 7.8 $GtCO_2$. The authorised production would consume about 3.3% of the carbon budget remaining to limit warming to 1.5°C with a likely probability and about 0.9% of the budget for 2°C with a likely probability.

The amount of coal authorised to be produced from the Carmichael Coal Mine is 60 million tons per annum over a period of 60 years. The EIS documents indicate a slightly lower production

The greenhouse gas emissions from burning coal include the CO_2 emitted by coal when it is combusted as well as the nitrous oxide emitted as part of the combustion process. In addition, one needs to consider the methane released in the coalmining process, which is only released because of the intent to burn the coal.

The weighting of nitrous oxide and methane compared to CO_2 is conventionally done using 100 year global warming potentials (GWPs). Recently the Australian government has moved towards using IPCC AR5 GWPs[19] (IPCC 2014) which increases the GWP of methane to 28 compared to 21 as was used in the Adani EIS (Adani Mining Pty Ltd 2013a). At the same time the GWP of N_2O was reduced to 265 compared to the value 298 previously used in the National Greenhouse Gas Accounts (Australian Government 2017).

[19] https://www.legislation.gov.au/Details/F2020L00826/Explanatory%20Statement/Text

To calculate CO_2 emissions, an energy value of Carmichael Coal of 24.1 GJ/t[20] of coal is used, which lies between the values for sub-bituminous (21) and bituminous coal (27) given in the Australian emission factors (Australian Government 2017)[21].

	Mt Coal/yr	CO_2 $MtCO_2$	CH_4 - $MtCO_2e$	N_20 $MtCO_2e$	$MtCO_2e$
Project SEIS Carmichael Coal Mine - Underground	11.1	1,449	1.33	2.9	1,453
Project SEIS Carmichael Coal Mine- Open Cut	43.2	5,638	0.60	11.1	5,650
Project SEIS Carmichael Coal Mine – Total	54.3	7,087	1.93	14.0	7,103
Carmichael - Total Authorised	**60**	7,831	2.13	15.5	7,848

Table 6 Emissions from burning coal from the Carmichael Coal Mine and Rail Infrastructure Project. Assumed 24.1 GJ/t coal energy content, 90 kg CO2/GJ released on combustion

Total CO_2 emissions from the coal authorised to be produced over the 60 year life of the project is about 7.8 $GtCO_2$ (This would be 8.7 $GtCO_2$ if the standard Australian energy value for bituminous coal were used[21]). The project SEIS (Queensland Government 2014)(Adani Mining Pty Ltd 2013b)(Adani Mining Pty Ltd 2013a) indicates a lower level of average production, 54.3 megatons of coal per year and consequently a lower level of CO_2 emissions from combustion, 7.1 $GtCO_2$ (7.9 $GtCO_2$ if the standard Australian energy value for bituminous coal were used[21]).

The authorised production would emit CO_2 emissions equivalent to between 2.0% and 3.3% (2.2-3 7%. if the standard Australian energy value for bituminous coal were used[21]) of the carbon budget remaining in 2020 to limit warming to 1.5°C for a 50% and likely probability respectively and about 0.9% of the budget to hold warming below 2°C with a likely probability.

l) What global mean temperature change, if any, would result from the emissions from the Action?

The emissions from the Action (EPBC Approval 2010/5736 for the Carmichael Coal Mine and Rail Infrastructure Project) would likely lead to a +0.0035°C global mean temperature change (16–84% range of +0.0017 to +0.0053°C)[22].

[20] Based on the average of Table 4 at https://en.wikipedia.org/wiki/Galilee_Basin as cited by https://reneweconomy.com.au/fact-check-is-australian-coal-really-cleaner-than-indian-coal-and-does-it-even-matter-76430/

[21] See Table 1 (Australian Government 2017).

[22] This calculation is based on the TCRE (Transient Climate Response to cumulative carbon Emissions, or ratio of warming per unit of cumulative CO_2 emissions) given by the IPCC Fifth Assessment Report (IPCC 2014).

m) What percentage contribution, if any, would the Action make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 1.5°C?

Whilst there is no single mechanistic way of calculating the percentage contribution of the Action on the Outstanding Universal Values there are several different quantitative perspectives that illustrate the significance of the scale of the CO_2 emissions arising from the Action compared to national and international budgets or emissions consistent with limiting warming to 1.5°C or 2°C. These lines of evidence are outlined below.

Scale of the Action compared to 1.5°C carbon budget

The Action will use about 3.3% of the projected remaining carbon budget for 1.5°C and increase the likelihood of 1.5°C warming being breached. Thus, the 1.5°C limit will be reached faster with the Action, jeopardizing the Outstanding Universal Value of the Great Barrier Reef, as described in questions b).

If the fraction of the remaining carbon budget for 1.5°C consumed by the Action (3.3%) is used as a proxy for the damage due to the Action and linearly extrapolated to the area of the Great Barrier Reef, the damage due to, or related to, the Action would amount to about 7,960-10,230 square kilometres severely damaged or lost (assuming total area GBR area 344,400 square kilometres[23]).

Scale of the Action compared to coal use consistent with 1.5°C

As noted in the answer to question i), (i) Is new coal production consistent with limiting global warming to 1.5°C?)), the IPCC SR1.5 found that total coal use needs to decline and approach very low levels compared with today within about 30 years, i.e. by 2050. Thermal coal use needs to decline even more rapidly with the use of coal in electricity production steeply reducing to close to 0% (0–2%) of electricity by 2050. According to the Climate Analytics' 2019 report *Global and regional coal phase-out requirements of the Paris Agreement: Insights from the IPCC Special Report on 1.5°C* (Climate Analytics 2019a), OECD nations should phase out coal in the power sector by about 2030, and the rest of the world by 2040, to limit global warming to 1.5°C. **Both the start-up and projected 60 years of running of the Action are therefore not compatible with limiting warming 1.5°C.**

[23] This is an indicative value only and relates to area of the Great Barrier Reef as a whole. As there are no available attribution studies for fractional effects of carbon emissions on loss of coral reefs and other values in the Great Barrier Reef, one way to gain perspective on the relative role of the actions in the damage to the reef is to relate the fraction of carbon budget used to the loss of corals, and in turn assume that this relates to damage or loss values to the larger Great Barrier Reef area. This is not a rigorous approach however it does provide a proxy for scaling the effect of additional CO2 emissions from Actions to the impacts that are projected for 1.5°C warming. The loss of coral reefs at 1.5° warming globally above pre-industrial is projected to be 70-90% and there is no reason to expect that this will be fundamentally different for the Great Barrier Reef. In the absence of deterministic projections of the implications of the loss of corals to loss of values for the Great Barrier Reef as a whole, this proxy approach assumes that the loss of values as a whole scales with the projected loss of corals. This is a conservative assumption, given that one of the critical world Heritage values relates to the integrity of the Great Barrier Reef, and its integrity, which is essential for the Great Barrier Reef to retain its World Heritage listing, may well break down long before 70 to 90% of corals are actually lost. The area of the Great Barrier Reef is taken from http://www.gbrmpa.gov.au/the-reef/reef-facts

Scale of the Action compared to Australian carbon budget for 1.5°C

If the Australian carbon budget for 1.5°C were close to its contribution to global CO2 emissions (0.9%) it would be about 2.1 $GtCO_2$. The CO_2 emissions from the Action are about 3.9 times larger than the Australian carbon budget.

Scale of Action compared Indian carbon budget for 1.5°C

If the Indian carbon budget for 1.5°C were close to its contribution to global CO_2 emissions (about 8%) it would be about 18.8 $GtCO_2$. The CO_2 emissions from the Action are about 47% of this Indian carbon budget.

The emissions from the Action are close to (98-100%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

n) What percentage contribution, if any, would the Action make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 2°C?

Whilst there is no single mechanistic way of calculating the percentage contribution of the Action on the Outstanding Universal Values there are several different quantitative perspectives that illustrate the significance of the scale of the CO_2 emissions arising from the Action compared to national and international budgets or emissions consistent with limiting warming to 1.5°C or 2°C. These lines of evidence are outlined below.

Scale of the Action compared to 2°C carbon budget

The Action will use 0.8% of the projected carbon budget of the 2°C scenario and increase the likelihood of 1.5°C warming being breached, in the absence of compensating emission reductions elsewhere. Thus, the 2°C limit will be reached faster with the Action, jeopardizing the Outstanding Universal Value of the Great Barrier Reef, as described in questions b) and c).

Scale of the Action compared to coal use consistent with 2°C

As shown in Figure 4 above - from the UNEP Production Gap report (SEI et al. 2019) - the rate of reduction in coal use is nearly as fast in 2°C scenario as in 1.5°C compatible pathways, with reductions starting immediately. Further, our own analysis shows (Climate Analytics 2019b) staying below the 2°C implies a dramatic decrease of unabated coal use for power generation, reaching close to zero by 2050.

These lines of evidence are a strong indication that **both the start-up and the projected 60 years of running of the Action are therefore not compatible with holding warming below 2°C.**

Scale of the Action compared to Australian carbon budget for 2°C

If the Australian carbon budget for 2°C were close to its contribution to global CO2 emissions (0.9%) it would be about 8.9 $GtCO_2$. The CO_2 emissions from the Action is close to 90% of the Australian carbon budget for 2°C.

Scale of the Action compared Indian carbon budget for 2°C

If the Indian carbon budget for 2°C were close to its contribution to global CO_2 emissions (about 8%) it would be about 79 $GtCO_2$. The CO_2 emissions from the Action are about 10% of this 2°C Indian carbon budget.

As noted above the emissions from the Action are close to (98-100%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

o) In your opinion, will the Action have a significant impact on the Outstanding Universal Value of the Great Barrier Reef?

The Action will substantially increase the difficulty for the world getting on to a 1.5°C compatible mitigation pathway, which will already cause serious damage to the Outstanding Universal Value of the Great Barrier Reef. It will therefore significantly increase the likelihood of the world exceeding 1.5°C by a wide margin and of warming reaching well above 2°C. At 2°C or above the Outstanding Universal Value of the Great Barrier Reef is likely to be destroyed.

The Action is completely inconsistent with the thermal coal phase out pathway needed for the world – and India – to limit global warming to 1.5°C, which implies phasing out all coal power plants for OECD nations by around 2030 and the rest of the world by 2040. The emissions from the Action are close to (98-100%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS) (International Energy Agency (IEA). 2017). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

By continuing coal production for decades beyond when a global coal phase out is required to limit warming to 1.5°C, the Action and the Secondary Actions will contribute to secondary effects encouraging coal use by contributing to maintaining a global coal infrastructure and place downward pressure on coal prices.

The Action will consume a significant fraction, 3.3%, of the global carbon budget available if warming is to be limited to 1.5°C. The Action will consume about 47% of an domestic Indian carbon for 1.5°C if this were calculated proportion to India's recent share of global CO_2 emissions (about 8%).

As explained in questions b) and c), global warming has already had a severe impact on the Great Barrier Reef. Even if the global mean temperature is limited to 1.5°C, the impact on the Outstanding Universal Value of the Great Barrier Reef will be critical including loss of 70-90% of the corals, degradation of the remaining corals, and other damages. By undermining the ability of the world to take the measures needed, including a rapid coal phase out, to get on to a 1.5ºC compatible mitigation pathway, the Action adds significantly to the risk of the Outstanding Universal Value of the Great Barrier Reef being severely damaged (1.5ºC) or destroyed (2ºC).

If the damage to the Great Barrier Reef due to the Action was quantified as a linear extrapolation from the fraction of the global 1.5ºC carbon budget consumed by the Action (3.3%) to area, as a proxy for the scale of severe damage to the Great Barrier Reef, this would amount to about 7,960-10,230 square kilometres severely damaged or lost (assuming total area GBR area 344,400 square kilometres[24]).

The Action is incompatible with the protection of the Great Barrier Reef.

Additional Questions

p) What emissions would result from burning the coal anticipated to be produced under the approved EIS for the China Stone Coal Mine of 22 November 2018 (i.e. 48 million tonnes per annum 1 for 50 years) and the 2013 agreement between Resolve Coal and Adani Australia Pty Ltd for the Hyde Park Coal Mine (i.e. 10 million tonnes per annum for 30 years)2 (together, 'the Secondary Actions')?

China Stone

Total CO_2 approved emissions from the China Coal Mine to be produced over its 50 year life is about 5.2 $GtCO_2$ equivalent to between about 2.2% of the carbon budget remaining to limit warming to 1.5°C and about 0.5% of the budget to hold warming to 2°C.

[24] See footnote 23

The China Stone mine is expected at peak production to "produce up to 38 million tonnes per annum (Mtpa) of coal for export to the Asian market, principally China". The total mine life is planned at around 50 years (Queensland Government 2018).

As the mine will also produce its own power for the mining activities actual production of coal will be significantly higher at around 55 Mtpa (see page 117 of (Queensland Government 2018)[25]). The mine will be both an open-cut and underground coal mine, and production is expected to start in year 3[26] of the project, implying a 48 year production. This leads to a total coal production estimate of about 2,640 Mt.

However, the (Queensland Government 2018) assessment indicates total (ROM) coal extraction from open-cut and underground operations to be 1.3Mt (see page 60 in (Queensland Government 2018)). This equates to an average of 27.8 Mt per year over the Project's stated 48-year production life, about half of the above estimate.

To calculate CO_2 emissions an energy value of 24.1 GJ/t[27] of coal is used, which lies between the values for sub-bituminous (21) and bituminous coal (27), given in the Australian emission factors (Australian Government 2017)[28].

	Mt Coal/yr	$MtCO_2$	CH4 - $MtCO_2e$[29]	N20-$MtCO_2e$	$MtCO_2e$
China Stone Coal Mine at max production	55.0	5,742	1.56	13	5,757
China Stone Coal Mine as in Queensland Govt	27.8	2,898	0.79	6	2,905
China Stone Coal Mine under approved EIS	48	5,220	1.41	12	5,233

Table 7 Emissions from burning coal from the ***China Stone****. Assumed 24.1 GJ/t coal energy content, 90 kg CO2/GJ released on combustion*

Total CO_2 emissions from the China Coal Mine to be produced over its 50 year life is in the range 2.9-5.7 $GtCO_2$ (This would be 8.7 $GtCO_2$ if the standard Australian energy value for bituminous coal were used[21]), with the EIS approved CO_2 emissions being around 5.2 $GtCO_2$. These CO_2 emissions are equivalent to about 2.2% of the carbon budget remaining in 2020 to limit warming to 1.5°C with a likely probability and about 0.5% of the budget to hold warming below 2°C with a likely probability.

[25] Page 117: "The project proposes to establish a greenfield open-cut and underground coal mine in the Galilee Basin as a commercial energy resource for the supply of thermal coal to overseas markets. At peak operations the project would open-cut and underground mine up to approximately 55 Mtpa of ROM coal, which equates to approximately 38 Mtpa of thermal coal product for the export market."

[26] Page 12 of (Hansen Bailey 2017b): "First coal production from the open cut and underground mines is scheduled for Project Year 3, once initial mine development works have been completed. Open cut mining is expected to be completed by Project Year 32 and underground mining would continue until Project Year 49. Mining will be followed by a final rehabilitation and decommissioning period."

[27] Based on the average of Table 4 at https://en.wikipedia.org/wiki/Galilee_Basin as cited by https://reneweconomy.com.au/fact-check-is-australian-coal-really-cleaner-than-indian-coal-and-does-it-even-matter-76430/

[28] See Table 1 (Australian Government 2017).

[29] These estimates are based on the average CH4 emission intensity for the Adani Carmichael Mine above due to lack of data for the China Stone Mine. This may be an under-estimate. Chapter 15 of the EIS, Table 15-2 indicates expected average fugitive emissions of 0.359 ktCO2e, which over 48 years is around 17.2 $GtCO_2e$ (Hansen Bailey 2017a), some 11-22 times higher than estimated here.

Hyde Park

Total CO_2 emissions from the Hyde Park Mine over its 30 year life would be about 0.7 $GtCO_2$, equivalent to about 0.3% of the carbon budget remaining to limit warming to 1.5°C and 0.1% of the budget to for 2°C.

Initial concept planning suggests the potential for at least a **30-year mine life producing 10 Mt/year** of coal for export[30].

	Mt Coal/yr	MtCO2	CH4 - MtCO2e	N20-MtCO2e	MtCO2e
Hyde Park Coal Mine	10	667	0.22	1.5	668

*Table 8 Emissions from burning coal from the **Hyde Park mine**. Assumed 24.7 GJ/t coal energy content, 90 kg CO2/GJ released on combustion*

Total CO_2 emissions from the Hyde Park Mine to be produced over its 30 year life would be about 0.7 $GtCO_2$. These CO2 emissions are equivalent to 0.2-0.3% of the carbon budget remaining in 2020 to limit warming to 1.5°C and 0.1% of the budget to hold warming below 2°C with a likely probability.

To calculate CO_2 emissions an energy value of 24.7 GJ/t[31] of coal is used, which lies between the values for sub-bituminous (21) and bituminous coal (27) given in the Australian emission factors (Australian Government 2017)[32].

q) What emissions would result from burning the coal anticipated to be produced by the Action and the Secondary Actions together?

Total CO_2 emissions authorised to be produced by "the Action" and the "Secondary Actions" are estimated 13.7 $GtCO_2$, equivalent to 5.8% of the carbon budget remaining to limited warming to 1.5°C and about 1.4% of the budget to hold warming to 2°C.

Total estimated CO2 emissions authorised to be produced by "the Action" (Carmichael coal mine) and the "Secondary Actions" (China Stone and Hyde Park coal mines) are 13,700 Mt CO_2.

These CO_2 emissions are equivalent to 5.8% of the carbon budget remaining in 2020 if warming is to be limited to 1.5°C and about 1.4% of the budget to hold warming below 2°C with a likely probability (>66%).

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[30] https://www.bioregionalassessments.gov.au/assessments/12-resource-assessment-galilee-subregion/123114-hyde-park-coal-project

[31] Based on the average of Table 4 at https://en.wikipedia.org/wiki/Galilee_Basin as cited by https://reneweconomy.com.au/fact-check-is-australian-coal-really-cleaner-than-indian-coal-and-does-it-even-matter-76430/

[32] See Table 1 (Australian Government 2017).

Mine	$GtCO_2$	% of 1.5oC budget	% of 2oC budget
Carmichael (Authorised production)	7.8	3.3%	0.9%
China Stone Coal Mine (Authorised production)	5.2	2.2%	0.5%
Hyde Park Coal Mine	0.7	0.3%	0.1%
Total	13.7[33]	5.8%	1.4%[34]

Table 9 CO_2 emissions from the Action and the Secondary Actions.

r) What global mean temperature change, if any, would result from the emissions from the Action and the Secondary Actions together?

The Action and the Secondary Actions together would likely lead to a +0.0068°C global mean temperature change (16–84% range of +0.0030 to +0.0094°C)[35].

s) What percentage contribution, if any, would the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 1.5°C?

Whilst there is no single mechanistic way of calculating the percentage contribution of the Action on the Outstanding Universal Values there are several different quantitative perspectives that illustrate the significance of the scale of the CO_2 emissions arising from the Action compared to national and international budgets or emissions consistent with limiting warming to 1.5°C or 2°C. These lines of evidence are outlined below.

Scale of the Action and the Secondary Actions compared to 1.5°C carbon budget

The Action and the Secondary Actions will use about 5.8% of the projected remaining carbon budget for 1.5°C and increase the likelihood of 1.5°C warming being breached. Thus, the 1.5°C limit will be reached faster with the Action, jeopardizing the Outstanding Universal Value of the Great Barrier Reef, as described in questions b).

If the fraction of the 1.5ºC carbon budget (5.8%) consumed by the Action and the Secondary Actions were linearly extrapolated to area, as a proxy for the scale of damage to the Great Barrier Reef due to these Actions, this would amount to about 13,980-17,980 square kilometres being severely damaged or lost (assuming total area GBR area 344,400 square kilometres[36]).

[33] Difference in column sum due to rounding.
[34] Difference in column sum due to rounding.
[35] This calculation is based on the TCRE (Transient Climate Response to cumulative carbon Emissions, or ratio of warming per unit of cumulative CO_2 emissions) given by the IPCC Fifth Assessment Report (IPCC 2014). The IPCC has assessed the likely range for TCRE of 0.8°C to 2.5°C per 1000 PgC around a central value.
[36] See footnote 23

Scale of the Action and the Secondary Actions compared to coal use consistent with 1.5°C

As noted in the answer to question i), (i) Is new coal production consistent with limiting global warming to 1.5°C?)), the IPCC SR1.5 found that total coal use needs to decline and approach very low levels compared with today within about 30 years, i.e. by 2050. Thermal coal use needs to decline even more rapidly with the use of coal in electricity production steeply reducing to close to 0% (0–2%) of electricity by 2050. According to the Climate Analytics' 2019 report *Global and regional coal phase-out requirements of the Paris Agreement: Insights from the IPCC Special Report on 1.5°C* (Climate Analytics 2019a), OECD nations should phase out coal in the power sector by about 2030, and the rest of the world by 2040, to limit global warming to 1.5°C. **Both the start-up and projected 60 years of running of the Action and the Secondary Actions are therefore not compatible with limiting warming 1.5°C.**

Scale of the Action and the Secondary Actions compared to Australian carbon budget for 1.5°C

If the Australian carbon budget for 1.5°C were close to its contribution to global CO2 emissions (0.9%) it would be about 2.1 $GtCO_2$. The CO_2 emissions from the Action and the Secondary Actions are about 6.5 times larger than the Australian domestic carbon budget.

Scale of the Action and the Secondary Actions compared Indian carbon budget for 1.5°C

If the Indian carbon budget for 1.5°C were close to its contribution to global CO_2 emissions (about 8%) it would be about 19 $GtCO_2$. The CO_2 emissions from the Action and the Secondary Actions are about 73% of this Indian carbon budget.

The emissions from the Action and the Secondary Actions would be nearly double (171-196%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS) (International Energy Agency (IEA). 2017). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

t) What percentage contribution, if any, would the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 2°C?

Whilst there is no single mechanistic way of calculating the percentage contribution of the Action on the Outstanding Universal Values there are several different quantitative perspectives that illustrate the significance of the scale of the CO_2 emissions arising from the Action compared to national and international budgets or emissions consistent with limiting warming to 1.5°C or 2°C. These lines of evidence are outlined below.

Scale of the Action and the Secondary Actions compared to 2°C carbon budget

The Action and the Secondary Actions will use about 1.4% of the projected carbon budget for limiting warming to 2°C and increase the likelihood of 1.5°C warming being breached, in the absence of compensating emission reductions elsewhere. Thus, the 2°C limit will be reached faster with the Action, jeopardizing the Outstanding Universal Value of the Great Barrier Reef, as described in questions b) and c).

Scale of the Action and the Secondary Actions compared to coal use consistent with 2°C

As shown in Figure 4 above - from the UNEP Production Gap report (SEI et al. 2019) - the rate of reduction in coal use is nearly as fast in 2°C scenario as in 1.5°C compatible pathways, with reductions starting immediately. Further, our own analysis shows (Climate Analytics 2019b) staying below the 2°C implies a dramatic decrease of unabated coal use for power generation, reaching close to zero by 2050.

These lines of evidence are a strong indication that **both the start-up and the projected 60 years of running of the Action and the Secondary Actions are therefore not compatible with holding warming below 2°C.**

Scale of the Action and the Secondary Actions compared to Australian carbon budget for 2°C

If the Australian carbon budget for 2°C were close to its contribution to global CO_2 emissions (0.9%) it would be about 8.9 $GtCO_2$. The CO_2 emissions from the Action and the Secondary Actions is about 55% greater than the Australian carbon budget for 2°C.

Scale of the Action and the Secondary Actions compared Indian carbon budget for 2°C

If the Indian carbon budget for 2°C were close to its contribution to global CO_2 emissions (about 8%) it would be about 79 $GtCO_2$. The CO_2 emissions from the Action are about 17% of this 2°C Indian carbon budget.

As noted above the emissions from the Action and the Secondary Actions would be nearly double (171-196%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS) (International Energy Agency (IEA). 2017). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

u) In your opinion, will the Action and the Secondary Actions together have a significant impact on the Outstanding Universal Value of the Great Barrier Reef?

The Action and the Secondary Actions will substantially increase the difficulty for the world of getting on to a 1.5°C compatible mitigation pathway, which will already cause serious damage to the Outstanding Universal Value of the Great Barrier Reef. It will therefore significantly increase the likelihood of the world exceeding 1.5°C by a wide margin and of warming reaching well above 2°C. At 2°C or above the Outstanding Universal Value of the Great Barrier Reef is likely to be destroyed.

The Action and the Secondary Actions are inconsistent with the thermal coal phase out pathway needed for the world – and India – to limit global warming to 1.5°C, which implies phasing out all coal power plants for OECD nations by around 2030 and the rest of the world by 2040. The emissions from the Action and the Secondary Actions would be nearly double (171-196%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS) (International Energy Agency (IEA). 2017). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

By continuing coal production for decades beyond when a global coal phase out is required to limit warming to 1.5°C, the Action and the Secondary Actions will contribute to secondary effects encouraging coal use by contributing to maintaining a global coal infrastructure and place downward pressure on coal prices.

The Action and the Secondary Actions will consume a significant fraction, 5.8%, of the global carbon budget available if warming is to be limited to 1.5°C. The Action and the Secondary Actions will consume about 73% of domestic Indian carbon for 1.5°C if this were calculated in proportion to India's recent share of global CO_2 emissions (about 8%).

As explained in questions b) and c), global warming has already had a severe impact on the Great Barrier Reef for a global warming of 1.1°C . Limiting global warming to 1.5°C will still result in severe damage to the Outstanding Universal Value of the Great Barrier Reef, including loss of 70-90% of the corals, degradation of the remaining corals, and other damages. By undermining the ability of the world to take the measures needed and to transition to a 1.5°C compatible pathway for the energy system globally and in India, which requires a rapid thermal coal phase out, the Action and the Secondary Actions adds significantly to the risk of the Outstanding Universal Value of the Great Barrier Reef being severely damaged (1.5°C) or destroyed (2°C).

If the damage to the Great Barrier Reef was quantified as a linear extrapolation from the fraction of the global 1.5°C carbon budget consumed by the Action and the Secondary Actions (5.8%) to the area of the Reef, as a proxy for the scale of severe damage to the Great Barrier Reef, this would amount to about 13,980-17,980 square kilometres being severely damaged or lost (assuming total area GBR area 344,400 square kilometres[37]).

As outlined above, the Great Barrier Reef has already been significantly damaged by global warming of about 1°C. The Australian Government has stated that *components of the reef that underpin all four natural criteria have deteriorated since the Reef 's inscription on the World Heritage List* and the World Heritage Area's *integrity is challenged and deteriorating.*

[37] See footnote 23

Global warming of 1.5°C threatens severe damage to the Outstanding Universal Value of the Great Barrier Reef and to the condition of integrity of the World Heritage Area. As reported above if **global warming extends above 1.5°C [for any significant period of time] a further 0.5°C of warming to 2°C will [very likely] destroy the Outstanding Universal Value of the Great Barrier Reef and the condition of integrity of the World Heritage Area. Warming beyond 2°C appears likely to result in the extirpation Great Barrier Reef.**

The Action and the Secondary Actions are incompatible with the protection of the Great Barrier Reef.

Further Additional Questions

v) In your opinion, what percentage contribution, if any, would 50% of the emissions resulting from burning the coal anticipated to be produced by the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 1.5°C?

Whilst there is no single mechanistic way of calculating the percentage contribution of the Action on the Outstanding Universal Values there are several different quantitative perspectives that illustrate the significance of the scale of the CO_2 emissions arising from the Action compared to national and international budgets or emissions consistent with limiting warming to 1.5°C or 2°C. These lines of evidence are outlined below.

Scale of 50% of the emissions resulting from the Action and the Secondary Actions compared to 1.5°C carbon budget

50% of the emissions resulting from the Action and the Secondary Actions will use about 2.9% of the projected remaining carbon budget for 1.5°C and increase the likelihood of 1.5°C warming being breached. Thus, the 1.5°C limit will be reached faster with the Action, jeopardizing the Outstanding Universal Value of the Great Barrier Reef, as described in questions b).

If the fraction of the remaining carbon budget for 1.5°C consumed by the Action and the Secondary Actions (5.8%) were linearly extrapolated to the area of the Reef, as a proxy for the scale of damage to the Great Barrier Reef, this would amount to about 6,990-8,990 square kilometres being severely damaged (assuming total area GBR area 344,400 square kilometres[38]).

[38] See footnote 23

Scale of 50% of the emissions resulting from the Action and the Secondary Actions compared to coal use consistent with 1.5°C

As noted in the answer to question i) (i) Is new coal production consistent with limiting global warming to 1.5°C?), the IPCC SR1.5 found that total coal use needs to decline and approach very low levels compared with today within about 30 years, i.e. by 2050. Thermal coal use needs to decline even more rapidly with the use of coal in electricity production steeply reducing to close to 0% (0–2%) of electricity by 2050. According to the Climate Analytics' 2019 report *Global and regional coal phase-out requirements of the Paris Agreement: Insights from the IPCC Special Report on 1.5°C* (Climate Analytics 2019a), OECD nations should phase out coal in the power sector by about 2030, and the rest of the world by 2040, to limit global warming to 1.5°C. **Both the start-up and projected 60 years of running of the Action and the Secondary Actions are therefore not compatible with limiting warming 1.5°C.**

Scale of 50% of the emissions resulting from the Action and the Secondary Actions compared to Australian carbon budget for 1.5°C

If the Australian carbon budget for 1.5°C were close to its contribution to global CO2 emissions (0.9%) it would be about 2.1 $GtCO_2$. 50% of the CO_2 emissions from the Action and the Secondary Actions are about 3.2 times larger than the Australian domestic carbon budget.

Scale of 50% of the emissions resulting from the Action and the Secondary Actions compared Indian carbon budget for 1.5°C

If the Indian carbon budget for 1.5°C were close to its contribution to global CO_2 emissions (about 8%) it would be about 19 $GtCO_2$. 50% of the CO_2 emissions from the Action and the Secondary Actions are about 36% of this Indian carbon budget.

50% of the emissions from the Action and the Secondary Actions would be close to (85-98%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS) (International Energy Agency (IEA). 2017). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

w) In your opinion, what percentage contribution, if any, would 50% of the emissions resulting from burning the coal anticipated to be produced by the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 2°C?

Whilst there is no single mechanistic way of calculating the percentage contribution of the Action on the Outstanding Universal Values there are several different quantitative perspectives that illustrate the significance of the scale of the CO_2 emissions arising from the

Action compared to national and international budgets or emissions consistent with limiting warming to 1.5°C or 2°C. These lines of evidence are outlined below.

Scale of the Action and the Secondary Actions compared to 2°C carbon budget

50% of the CO_2 emissions resulting from the Action and the Secondary Actions will use about 0.7% of the projected carbon budget for limiting warming to 2°C and increase the likelihood of 1.5°C warming being breached, in the absence of compensating emission reductions elsewhere. Thus, the 2°C limit will be reached faster with the Action, jeopardizing the Outstanding Universal Value of the Great Barrier Reef, as described in questions b) and c).

Scale of the Action and the Secondary Actions compared to coal use consistent with 2°C

As shown in Figure 4 above - from the UNEP Production Gap report (SEI et al. 2019) - the rate of reduction in coal use is nearly as fast in 2°C scenario as in 1.5°C compatible pathways, with reductions starting immediately. Further, our own analysis shows (Climate Analytics 2019b) staying below the 2°C implies a dramatic decrease of unabated coal use for power generation, reaching close to zero by 2050.

These lines of evidence are a strong indication that **both the start-up and the projected 60 years of running of the Action and the Secondary Actions are therefore not compatible with holding warming below 2°C.**

Scale of the Action and the Secondary Actions compared to Australian carbon budget for 2°C

If the Australian carbon budget for 2°C were close to its contribution to global CO_2 emissions (0.9%) it would be about 8.9 $GtCO_2$. 50% of the CO_2 emissions resulting from the Action and the Secondary Actions is equivalent to about 75% of the Australian carbon budget for 2°C.

Scale of the Action and the Secondary Actions compared Indian carbon budget for 2°C

If the Indian carbon budget for 2°C were close to its contribution to global CO_2 emissions (about 8%) it would be about 79 $GtCO_2$. 50% of the CO_2 emissions resulting from the Action and the Secondary Actions are about 8% of this 2°C Indian carbon budget.

50% of the emissions from the Action and the Secondary Actions would be close to (85-98%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS) (International Energy Agency (IEA). 2017) In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

x) In your opinion, will 50% of the expected emissions from burning the coal anticipated to be produced by the Action and the Secondary Actions together have a significant impact on the Outstanding Universal Value of the Great Barrier Reef?

50% of the CO_2 emissions from the Action and the Secondary Actions will substantially increase the difficulty for the world of getting on to a 1.5°C compatible mitigation pathway, which will already cause serious damage to the Outstanding Universal Value of the Great Barrier Reef. The Action and the Secondary Actions will therefore significantly increase the likelihood of the world exceeding 1.5°C by a wide margin and of warming reaching well above 2°C. At 2°C or above the Outstanding Universal Value of the Great Barrier Reef is likely to be destroyed.

The Action and the Secondary Actions are inconsistent with the thermal coal phase out pathway needed for the world – and India –, almost irrespective of what fraction of emissions are counted, to limit global warming to 1.5°C. Mitigation pathways compatible with 1.5°C, which implies phasing out all unabated coal power plants for OECD nations by around 2030 and the rest of the world by around 2040. By continuing coal production for decades beyond when a global coal phase out is required to limit warming to 1.5°C, the Action and the Secondary Actions will contribute to secondary effects encouraging coal use by contributing to maintaining a global coal infrastructure and place downward pressure on coal prices.

50% of the emissions from the Action and the Secondary Actions would be close to (85-98%) the Indian power sector emissions from coal that would occur under the IEA's Below 2° Scenario (B2DS) (International Energy Agency (IEA). 2017). In other words importing this coal into India could contradict India being able to successfully achieve the phase-out of coal anticipated to be necessary to limit warming below 2°C.

50% of the CO_2 emissions resulting from the Action and the Secondary Actions will consume a significant fraction, 2.9%, of the global carbon budget available if warming is to be limited to 1.5°C. These emissions will consume about 37% of an domestic Indian carbon for 1.5°C if this were calculated in proportion to India's recent share of global CO_2 emissions (about 8%).

As explained in questions b) and c), global warming has already had a severe impact on the Great Barrier Reef for a global warming of 1.1°C . Limiting global warming to 1.5°C will still result in severe damage to the Outstanding Universal Value of the Great Barrier Reef, including loss of 70-90% of the corals, degradation of the remaining corals, and other damages. By undermining the ability of the world to take the measures needed and to transition to a 1.5°C compatible pathway for the energy system globally and in India, which requires a rapid thermal coal phase out the Action and the Secondary Actions adds significantly to the risk of the Outstanding Universal Value of the Great Barrier Reef being severely damaged (1.5°C) or destroyed (2°C).

If the damage to the Great Barrier Reef due to 50% of the Action and the Secondary Actions was quantified as a linear extrapolation from the fraction of the global 1.5°C carbon budget (2.9%) to the area of the Reef, as a proxy for the scale of severe damage to the Great Barrier Reef, this would amount to about 6,990-8,990 square kilometres being severely damaged or lost (assuming total area GBR area 344,400 square kilometres[39]).

As outlined above, the Great Barrier Reef has already been significantly damaged by global warming of about 1.1°C. The Australian Government has stated that *components that underpin all four natural criteria have deteriorated since the Reef 's inscription on the World Heritage List* and the World Heritage Area's *integrity is challenged and deteriorating.*

Global warming of 1.5°C threatens severe damage to the Outstanding Universal Value of the Great Barrier Reef and to the condition of integrity of the World Heritage Area. As reported above if **global warming extends above 1.5°C [for any significant period of time] a further 0.5°C of warming to 2°C will [very likely] destroy the Outstanding Universal Value of the Great Barrier Reef and the condition of integrity of the World Heritage Area. Warming beyond 2°C appears likely to result in the extirpation Great Barrier Reef.**

The Action and the Secondary Actions are incompatible with the protection of the Great Barrier Reef.

[39] See footnote 23

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Attachment 1: Curriculum Vitae

Bill Hare

FOUNDER OF CLIMATE ANALYTICS

CEO / SENIOR SCIENTIST

PROFILE

Bill Hare is a physicist and climate scientist with 30 years' experience in science, impacts and policy responses to climate change and stratospheric ozone depletion. He is a founder and CEO of Climate Analytics, which was established to synthesise and advance scientific knowledge on climate change and provide state-of-the-art solutions to global and national climate change policy challenges.

As CEO Bill leads Climate Analytics, an international non-profit organisation, headquartered in Berlin. Climate Analytics has grown to become multidisciplinary and diverse team includes scientists, implementation strategy, legal, economics, mitigation and energy transformation, and climate finance experts, as well as policy analysts with well-founded experience in the international climate and energy transformation arena and with country support. Under his leadership a major focus of Climate Analytics is on high quality, science and policy relevant research and advice in relation all key aspects of the Paris Agreement's 1.5°C temperature limit. Through its unique position at the interface between science, policy and practice, and with its excellent international networks, Climate Analytics has established itself as a strategic knowledge partner for key matters concerning climate research, policy, and energy transformation and was recently ranked 12 out of 244 think tanks globally.

Bill has contributed actively to the development of the international climate regime since 1989, including the negotiation of the 1992 UN Framework Convention on Climate Change, the 1997 Kyoto Protocol, and the Paris Agreement in 2015. Throughout this time supported international and regional scientific assessment processes, including the IPCC, in different capacities to the present time, and has contributed to the development of scientific knowledge and literature of climate change, impacts and policy responses .

He was a Lead Author for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, for which the IPCC was awarded the Nobel Peace Prize in 2007. He led the influential World Bank Turn Down the Heat reports series in 2013-2014, and has authored, or co-authored, many peer-reviewed articles in leading academic journals including Nature Climate Change, Nature, Climatic Change, Regional Environmental Change, and Climate Policy.

In 2008 he was awarded Doctor of Science *honoris causa*, by Murdoch University, Western Australia for his contribution to climate change. He is now Adjunct Professor, Murdoch

He is also one of the leaders of the Climate Action Tracker, recognised as one of the most credible sources of information on national and global action on climate change.

Bill is a graduate of Murdoch University in Western Australia, and is now an Adjunct Professor, Murdoch University, School of Engineering, Perth Western Australia since 2017 and a visiting scientist at the Potsdam Institute for Climate Impact Research, Germany since 2001.

Research Profile

Research Gate indexes

https://www.researchgate.net/profile/Bill_Hare/reputation

RG Score 32.21 higher than 90% of ResearchGate members'

h-index 30

Top h cited research:
Greenhouse-Gas Emission Targets For Limiting Global Warming To 2°C

Google Scholar indexes

https://scholar.google.com/citations?user=FN7Faj0AAAAJ&hl=en

Cited by

	All
Citations	19964
h-index	38
i10-index	66

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Selection of Publications: Journals and Book Chapters

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Attachment 2: 5 March 2020 Letter requesting Independent expert report

5 March 2020

Bill Hare
Climate Analytics
Adjunct Professor, Murdoch University

By email: bill.hare@climateanalytics.org

CONFIDENTIAL AND PRIVILEGED

Dear Professor Hare,

Re: Independent expert report

1. We act for Ms Claire Galvin from Cairns, Queensland.

2. Our client wishes to retain your services to provide an independent expert report on matters relevant to your area of expertise.

3. The matter concerns whether new information, if considered by the Minister for the Environment, would have led to them not granting the approval of the Carmichael Coal Mine under the *Environmental Protection and Biodiversity Conservation Act 1999*.

4. The task we would like to ask you to undertake, as an independent expert, is to:
   - review the relevant information contained in the attached Expert Evidence Practice note; and
   - provide your expert opinion, in the form of a written report, in response to each of the questions at paragraph 10 below.

Your duty as an expert

5. Please read the **attached** Federal Court of Australia's *Expert Evidence Practice Note* and Annexure A to it, which is the *Harmonised Expert Witness Code of Conduct* ('**Expert Witness Code of Conduct**'). Please ensure that you prepare your report in

accordance with the Expert Evidence Practice Note and that you familiarise yourself with and abide by the Expert Witness Code of Conduct.

6. The manner in which you present the information in your report is a matter for you, provided the material is presented in a form which is clear for a court, should the matter become litigious.

7. In order for your report to be admissible as expert evidence, in the event that this matter becomes litigious, it must comply with the enclosed Expert Evidence Practice note, including the Expert Witness
Code of Conduct. Please ensure that your report is consistent with the Expert Witness Code of Conduct and contains each of the items identified in paragraph 3 of that Code.

8. Please include in your report a description of your qualifications and experience, including any relevant publications or research. It is acceptable for this to be done by way of attaching a current curriculum vitae. In outlining your experience we would request that you detail any particular knowledge, experience or qualifications you have in relation to the questions.

9. We request that you provide us with a draft of your report for review before finalising it. We emphasise that the purpose of this is not to influence the conclusions or recommendations you make, but to ensure that the language and expression of the report is clear and complies with the formal legal requirements of an expert report.

10. ***Questions***

a) What is the current global average temperature relative to pre-industrial times?

b) What would be the consequences of global warming of 1.5°C on the Outstanding Universal
Value of the Great Barrier Reef Marine Park (**'the Great Barrier Reef'**)?

c) What would be the consequences of global warming of 2°C on the Outstanding Universal Value of the Great Barrier Reef?

d) What is the remaining carbon budget for global warming of 1.5°C above pre-industrial times?

e) What is the remaining carbon budget for global warming of 2°C above pre-industrial times?

f) What future emissions are already committed, globally?

g) What future emissions are already committed from fossil fuel production, globally?

h) What is the trajectory of emissions from fossil fuels (i.e. increasing, decreasing or steady) that would be consistent with global warming of 1.5 and 2°C?

i) Is new coal production consistent with limiting global warming to 1.5°C?

j) Is new coal production consistent with limiting global warming to 2°C?

k) What emissions would result from burning the coal authorised to be produced under the EPBC
Approval 2010/5736 for the Carmichael Coal Mine and Rail Infrastructure Project ('**the Action**') (i.e. 60 million tonnes per annum [40] for 60 years[2])?

3

l) What global mean temperature change, if any, would result from the emissions from the Action?

m) What percentage contribution, if any, would the Action make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 1.5°C?

n) What percentage contribution, if any, would the Action make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 2°C?

o) In your opinion, will the Action have a significant impact on the Outstanding Universal Value of the Great Barrier Reef?

[40] Carmichael Coal Mine and Rail project is anticipated to have a production rate of approximately 60 Mtpa over 60 years. See *Carmichael Coal Mine and Rail project: Coordinator-General's Evaluation Report on the environmental impact statement* (**Carmichael Coal Mine Report**) (May 2014), pp 2, 2.2 http://statedevelopment.qld.gov.au/resources/project/carmichael/carmichael-coal-mine-and-rail-cg-report-may2014.pdf [2] Carmichael Coal Mine Report (May 2014), pp 10, 2.2.3.

11. Please contact me if you require any further information for the preparation of your report.

12. Unfortunately our client is not in a position to offer expert fees. We are hoping you will consider providing this expert report on a pro bono basis.

13. Our client would like to receive your expert report by 27 March 2020**.** This timing is negotiable based on your availability.

Yours sincerely,

Ariane Wilkinson

Senior Lawyer

Attachment - Expert Evidence Practice Note

Attachment 3: Letter 20 May 2020 requesting Independent expert report – additional questions

20 May 2020

Bill Hare
Climate Analytics
Adjunct Professor, Murdoch University

By email: bill.hare@climateanalytics.org

CONFIDENTIAL AND PRIVILEGED

Dear Professor Hare,

Re: Independent expert report – additional questions

1. We act for Ms Claire Galvin from Cairns, Queensland.

2. We refer you to our letter of instruction to you of 5 March 2020, in which we asked you to provide an independent expert report on matters relevant to your area of expertise.

3. We ask that, as well as responding to the questions in our letter to you of the 5 March 2020 at paragraph 10 (a) – (o), you also provide your expert opinion, in the form of a written report, in response to each of the additional questions set out at paragraph 9 (p) – (u) of this letter.

Your duty as an expert

4. As stated in the letter of instruction of 5 March 2020, we ask that you please read the **attached**
Federal Court of Australia's *Expert Evidence Practice Note* and Annexure A to it, which is the *Harmonised Expert Witness Code of Conduct* ('**Expert Witness Code of Conduct**'). Please ensure that you prepare your report in accordance with the Expert Evidence Practice Note and that you familiarise yourself with and abide by the Expert Witness Code of Conduct.

5. The manner in which you present the information in your report is a matter for you, provided the material is presented in a form which is clear for a court, should the matter become litigious.

6. In order for your report to be admissible as expert evidence, in the event that this matter becomes litigious, it must comply with the enclosed Expert Evidence Practice note, including the Expert Witness Code of Conduct. Please ensure that your report is consistent with the Expert Witness Code of Conduct and contains each of the items identified in paragraph 3 of that Code.

7. Please include in your report a description of your qualifications and experience, including any relevant publications or research. It is acceptable for this to be done by way of attaching a current curriculum vitae. In outlining your experience we would request that you detail any particular knowledge, experience or qualifications you have in relation to the questions.

8. We request that you provide us with a draft of your report for review before finalising it. We emphasise that the purpose of this is not to influence the conclusions or recommendations you make, but to ensure that the language and expression of the report is clear and complies with the formal legal requirements of an expert report.

Additional Questions

p) What emissions would result from burning the coal anticipated to be produced under the approved EIS for the China Stone Coal Mine of 22 November 2018 (i.e. 48 million tonnes per annum [41] for 50 years) *and* the 2013 agreement between Resolve Coal and Adani Australia Pty Ltd for the Hyde Park Coal Mine (ie. 10 million tonnes per annum for 30 years)[42] (together, '**the Secondary Actions'**)?

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[41] China Stone Coal Project is anticipated to have a production rate of approximately 38 Mtpa over 50 years. See
Coordinator General's evaluation report on the environmental impact statement – China Stone Coal project (22 November 2018) 2.3, p 6 (accessible at: http://statedevelopment.qld.gov.au/resources/project/china-stone-coal-project/chinastone-coal-project-eis.pdf).

[42] Commonwealth Bioregional Assessments states that 'initial concept planning suggests the potential for at least a 30 year mine life producing ten Mt/year': Bioregional assessments, *Hyde Park Coal Project*, 32 (accessible at: https://www.bioregionalassessments.gov.au/assessments/12-resource-assessment-galilee-subregion/123114-hyde-parkcoal-project).

q) What emissions would result from burning the coal anticipated to be produced by the Action and the Secondary Actions together?

r) What global mean temperature change, if any, would result from the emissions from the Action and the Secondary Actions together?

s) What percentage contribution, if any, would the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 1.5°C?

t) What percentage contribution, if any, would the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 2°C?

u) In your opinion, will the Action and the Secondary Actions together have a significant impact on the Outstanding Universal Value of the Great Barrier Reef?

10. Please contact me if you require any further information for the preparation of

your report. Yours sincerely,

Ariane
Wilkinson
Senior
Lawyer
Attachment - Expert Evidence Practice Note

Attachment 4: Letter 11 August 2020 requesting Independent expert report – further additional questions

Environmental Justice Australia

11 August 2020

Bill Hare
Climate Analytics
Adjunct Professor, Murdoch University

By email: bill.hare@climateanalytics.org

CONFIDENTIAL AND PRIVILEGED

Dear Professor Hare,

Re: Independent expert report – further additional questions

1. We act for Ms Claire Galvin from Cairns, Queensland.

2. We refer you to our letters of instruction to you of 5 March 2020 and 20 May 2020, in which we asked you to provide an independent expert report on matters relevant to your area of expertise.

3. We ask that, as well as responding to the questions in our letters to you of the 5 March 2020 at paragraph 10 (a) – (o) and 20 May 2020 questions (p) – (u), you also provide your expert opinion, in the form of a written report, in response to the additional questions set out at paragraph 8 of this letter.

Your duty as an expert

4. As stated in the letters of instruction of 5 March 2020 and 20 May 2020, we ask that you please read the **attached** Federal Court of Australia's *Expert Evidence Practice Note* and Annexure A to it, which is the *Harmonised Expert Witness Code of Conduct* ('**Expert Witness Code of Conduct**'). Please ensure that you prepare your report in accordance with the Expert Evidence Practice Note and that you familiarise yourself with and abide by the Expert Witness Code of Conduct.

5. The manner in which you present the information in your report is a matter for you, provided the material is presented in a form which is clear for a court, should the matter become litigious.

6. In order for your report to be admissible as expert evidence, in the event that this matter becomes litigious, it must comply with the enclosed Expert Evidence Practice note, including the Expert Witness Code of Conduct. Please ensure that your report is consistent with the Expert Witness Code of Conduct and contains each of the items identified in paragraph 3 of that Code.

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7. Please include in your report a description of your qualifications and experience, including any relevant publications or research. It is acceptable for this to be done by way of attaching a current curriculum vitae. In outlining your experience we would request that you detail any particular knowledge, experience or qualifications you have in relation to the questions.

Additional Questions

v) In your opinion, what percentage contribution, if any, would 50% of the emissions resulting from burning the coal anticipated to be produced by the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 1.5°C?
w) In your opinion, what percentage contribution, if any, would 50% of the emissions resulting from burning the coal anticipated to be produced by the Action and the Secondary Actions together make to impacts on the Outstanding Universal Value of the Great Barrier Reef at 2°C?
x) In your opinion, will 50% of the expected emissions from burning the coal anticipated to be produced by the Action and the Secondary Actions together have a significant impact on the Outstanding Universal Value of the Great Barrier Reef?

9. Thank you for agreeing to provide your final report by **Friday 21 August 2020.**

10. Please contact me if you require any further information for the preparation of

your report. Yours sincerely,

Ariane
Wilkinson
Senior
Lawyer
Attachment - Expert Evidence Practice Note