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Implications for Australia of a 1.5°C future

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Implications for Australia of a 1.5°C future

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ABSTRACT

The Paris Agreement, which Australia has signed and intends to ratify by the year's end, was a landmark achievement, signalling a strong international commitment to fighting climate change. Yet countries' near-term commitments under the Paris Agreement fall far short of the effort needed to achieve the stated goals of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels". If we want to be reasonably confident that we can keep warming below 1.5°C or even 2°C, climate science shows our remaining "carbon budget" is extremely limited. At the current pace of emissions, we would exhaust the global budget within a few years. Every day we delay increases the chance of failure, with particularly dire implications for the world's poor, who are particularly vulnerable to climate change impacts. A reasonable likelihood of limiting warming to below 1.5°C arguably implies a global carbon budget of less than (and perhaps significantly less than) 250 billion tonnes of carbon dioxide equivalent (Gt CO_2) from the start of 2015. Australia's share of this budget, by the most generous measure, equals less than six years of its current emissions. Australia faces extremely costly and potentially highly disruptive impacts if global warming exceeds 1.5°C or even 2°C, as is almost certain without much greater mitigation efforts. An equitable and concerted global response to the climate crisis would see Australia, one of the world's most technologically and economically developed countries, standing at the forefront. Its transformation to a post-carbon era must be rapid and comprehensive, and include diversification away from fossil extraction for energy and export.

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EXECUTIVE SUMMARY

A massive body of scientific research shows unequivocally that climate change poses a grave threat to society. Equally clear is that society has the technological and economic capacity to respond to the threat, but must do so promptly and decisively if the response is to be effective.

The Paris Agreement, which Australia has signed and intends to ratify by the year's end, was a landmark achievement, signalling a strong international commitment to fighting climate change. Recognising that climate change poses an "urgent and irreversible threat to human society", world leaders committed to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

Yet countries' near-term commitments under the Paris Agreement fall far short of the effort needed to achieve the stated goals. If we want to be reasonably confident that we can keep warming below 1.5°C or even 2°C, climate science shows our remaining "carbon budget" is extremely limited. At the current pace of emissions, we would exhaust the global budget within a few years. Every day we wait to sharply curtail carbon emissions increases the chance of failure. This delay is especially unfair to the world's poor, who stand to suffer the most from climate disruption.

Some climate change mitigation strategies seek to stretch the carbon budget in the near-term, assuming that in the future we can make up for it by deploying "negative emissions" technologies and processes on a large scale. However, most of these measures are still technologically unproven and, even if they ultimately prove feasible, may involve ecological and social costs that society deems unacceptably high, especially given the need for large amounts of productive land. The measures might also prove less effective than predicted at reducing the impacts of climate change, particularly if climate system "tipping points" or thresholds have been passed. As we develop climate strategies today, It would thus be premature – and very risky – to take for granted that "negative emissions" options will be available in the future.

Ultimately, there is exceedingly little carbon budget remaining if we are to limit warming to below 1.5°C. There is simply no room for delay. A reasonable likelihood of limiting warming to below 1.5°C arguably implies a global carbon budget of less than (and perhaps significantly less than) 250 billion tonnes of carbon dioxide equivalent (Gt CO_2) from the start of 2015. Australia's share of this budget, by the most generous measure, equals less than six years of its current emissions.

Australia faces extremely costly and, potentially, highly disruptive impacts if global warming exceeds 1.5°C or even 2°C, as is almost certain without much greater mitigation efforts. An equitable and concerted global response to the climate crisis would see Australia, one of the world's most technologically and economically developed countries, standing at the forefront. Its transformation to a post-carbon era must be rapid and comprehensive, and include diversification away from fossil extraction for energy and export. As a population with amongst the highest per capita emissions in the world, and as an economy that is especially dependent on the mining and burning of fossil fuels, Australia's transformation is especially urgent. The available greenhouse gas budget is simply too small to allow for further delay.

1. INTRODUCTION: THE CHALLENGE AHEAD

Australia is already suffering severe impacts from climate change. From the unprecedented bleaching occurring across the Great Barrier Reef (Hughes et al. 2016; Steffen and Rice 2016), to the record high temperatures (Steffen and Fenwick 2016), to the effects on food production (Hughes et al. 2015), to the worsening bush fire conditions (Climate Council of Australia 2016a) and the destruction of Tasmania's ancient forests (Hughes and Fenwick 2015), Australians are being confronted with stark harbingers of the impacts that worsening climate change will bring (Reisinger et al. 2014).

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement recently approved under it, Australia has signalled its engagement in the global effort to mitigate climate change. Among the most significant commitments made by Australia and the rest of the global community in Paris was to agree to a stringent and explicit limit to allowable global warming. The signatories committed to hold the increase in the global average temperature "to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels". They also commit to achieving this "in a manner that does not threaten food production" and that will "reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" (UNFCCC 2015b, Art. 2).

Each of those three elements of the Paris Agreement's overarching objective is important, and each has implications for Australia, which are the focus of in this report. The first, by committing to limit warming to "well below 2°C", with efforts to stay below 1.5°C, immediately sets limits on the available greenhouse gas budget, and thus the allowable global emissions pathways. The second makes it clear that climate action cannot come at the expense of food production, which has implications for measures involving land use, especially the potential diversion of arable land for carbon sequestration or biofuels production. The third element places the global effort in the context of equity, with implications for the allocation of effort among countries.

2. HOW BIG IS THE AVAILABLE CARBON BUDGET?

By any reckoning, there is very little room for further emissions of greenhouse gases if global temperatures are to be kept "well below 2°C" – much less below 1.5°C. Exactly how much room is available depends on several factors. These include how strictly or leniently we choose to define those somewhat ambiguous temperature objectives, our technical assumptions, and fundamental uncertainties that remain in scientists' understanding of the inherently complex and non-linear climate system. Nonetheless, the Intergovernmental Panel on Climate Change (IPCC) has provided helpful guidance on the question, including, for the first time, explicit statements about the available carbon budget for various temperature targets. The importance of this information and its political implications have been widely appreciated (Grantham Institute and Carbon Tracker Initiative 2013; McGlade and Ekins 2015; Rogelj et al. 2016).

The IPCC presents the available budget in a probabilistic way. The existing climate system uncertainties make it impossible to precisely state a specific budget corresponding to any given temperature threshold. Rather, it is necessary to specify a temperature threshold and a desired probability of keeping below the temperature (or, equivalently, risk of exceeding the specified temperature), and then the corresponding budget can be given. Table 1 below provides the remaining carbon budgets given by the IPCC (2014a)[1] for various temperature limits and various probabilities of keeping warming below each of those limits.

Some key caveats must be highlighted. First, while the choice of temperature limits (1.5°C, 2°C, and 3°C) included in the IPCC table clearly responds to policy concerns (the two lower temperature limits are explicitly referenced in UNFCCC decisions going back at least to the 2009 negotiations in Copenhagen and regularly thereafter), the choice of probabilities (66%, 50%, and 33%) was not informed by policy considerations. Their history lies rather in the somewhat arbitrary choices made by the IPCC (Mastrandrea et al. 2010) when selecting quantitative thresholds to correspond to qualitative terms such as "likely" and "very likely". From the perspective of public welfare, if a danger is deemed an "urgent and irreversible threat to human society" (UNFCCC 2015a), then a policy course that imposes a two-in-three, one-in-two, or even one-in-three risk of failing to avoid that danger would not warrant serious consideration. Responses with these high probabilities of failure would almost certainly be deemed inadequate under a risk management framework aimed at avoiding such severe consequences.

Consequently, these have become the probabilities that are typically used for calculating and reporting budgets in the climate science literature, and pathways consistent with a 66% chance of keeping warming below 2°C (and sometimes even those with a 50% chance) are often referred to as "2°C pathways". Thus, we need to bear in mind that by conventional usage, such pathways would not be deemed consistent with the Paris commitment of "holding the increase in global average temperature to well below 2°C".

Table 1: Carbon budgets for specified probabilities of keeping warming below the specified temperature limits

Cumulative CO_2 emissions (in Gt) from 2015 to when specified temperature limit is reached			
Probability	**66%**	**50%**	**33%**
1.5°C	250	400	700
2°C	850	1,150	1,700
3°C	2,250	2,650	3,100

References: Le Quéré et al. (2015); IPCC (2014a); see footnote 1 for details.

Second, it is important to note that these are generous estimates of the available budgets. They reflect cumulative emissions up to the point in time that warming reaches the specified temperature limit. However, the climate system responds slowly to change (in science terms, it is "inertial"), so warming lags cumulative emissions by years, even decades. Therefore, warming will continue beyond a specified temperature even if emissions were instantaneously halted once the corresponding budget was reached. Or, put differently, if the specified temperature is to be altogether avoided, then the budget actually available is even lower than that shown above, a point stressed by Rogelj et al. (2016).

Third, these budgets might be further overestimated because they are calculated by earth system models that are not yet able to fully account for the full range of feedbacks that likely affect the climate system's response to rising greenhouse gas concentrations (Torn and Harte 2006). Among those that may be very significant impacts are biospheric feedbacks (such as the dieback

[1] These figures are taken from Table 2.2 of the IPCC Synthesis Report, updated to account for the last four years (2011–2014) carbon emissions, which are reported by the Global Carbon Project (Le Quéré et al. 2015) as equal to ~150 Gt CO_2. The figures, in Gt CO_2, thus correspond to available budgets for the period from 2015 forward.

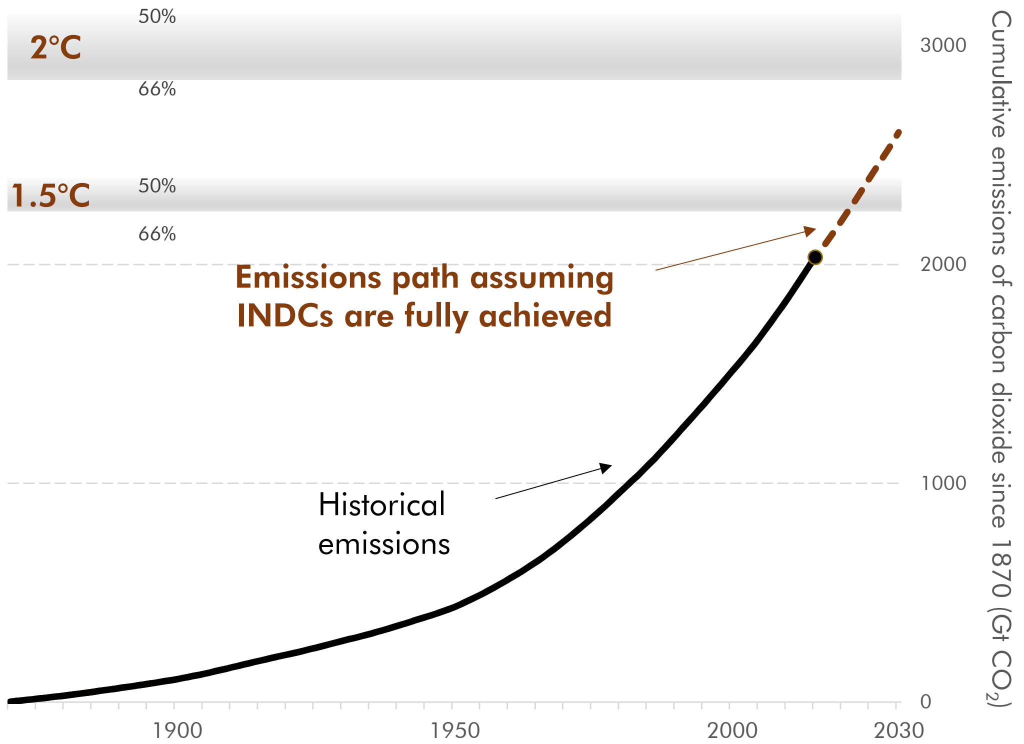
of forests due to warming or drought), methane feedbacks (such as release of methane from warming permafrost or ocean clathrates), and ice dynamics feedback (such as the destabilisation of ice sheets) (Flato et al. 2013).

The exact implications of the Paris temperature objectives are to some degree a matter of interpretation. However, the science strongly indicates that "holding warming well below 2°C", and trying earnestly to keep warming below 1.5°C, requires that emissions are kept within an *extremely* limited budget. Preserving a high likelihood of success (as opposed to, say, accepting a one-in-three risk of failing) in holding warming below 2°C (to say nothing about "well below" 2°C) clearly requires a budget of significantly less than 850 Gt CO_2. To have a *reasonable* likelihood of limiting warming to below 1.5°C arguably implies a budget of less than (and perhaps significantly less than) 250 Gt CO_2. Despite the implied risk, we use those budgets for reference in the rest of this report since they are what is available in the scientific literature.

3. ARE WE ON TRACK TO KEEP WITHIN THE NECESSARY BUDGET?

By 2015, about 2,000 billion tonnes of carbon dioxide (Gt CO_2) had been emitted by human activities since pre-industrial times, roughly three-quarters of which is from fossil fuels, and one-quarter from deforestation and other land use changes. As a result, the earth's average surface temperature has already risen by about 1°C relative to pre-industrial times (World Meteorological Organization 2016). Figure 1 shows how close we have come to reaching and exceeding the budgets corresponding to the 1.5°C and 2°C limits.

Figure 1: How emissions under the INDCs compare with a 1.5°C and 2°C budgets



Note: The figure shows the 50% and 66% likelihood budgets (IPCC 2014a) for 1.5°C and 2°C (shaded ranges), historical cumulative emissions (black line), and projected cumulative emissions (UNFCCC Secretariat 2016) consistent with achieving the mitigation actions of the Intended Nationally Determined Contributions (INDCs) submitted under the Paris Agreement.

The backbone of the Paris Agreement is the set of voluntary emission reduction pledges (Intended Nationally Determined Contributions, or INDCs) that nations have put forward, generally with targets for the years 2025 or 2030. However, even if all countries fulfil their pledges, the level of effort would be incompatible with the 1.5°C and 2°C benchmarks set by the Paris Agreement.

Indeed, the Paris decision notes that actions taken so far and pledges made for the future (in the INDCs) are not commensurate with the Agreement's underlying objectives. It says that the Conference of Parties:

> Notes with concern that the estimated aggregate greenhouse gas emission levels in 2025 and 2030 resulting from the intended nationally determined contributions do not fall within least-cost 2°C scenarios but rather lead to a projected level of 55 gigatonnes in 2030, and also notes that much greater emission reduction efforts will be required than those associated with the intended nationally determined contributions in order to hold the increase in the global average temperature to below 2°C above pre-industrial levels by reducing emissions to 40 gigatonnes or to 1.5°C above pre-industrial levels by reducing to a level to be identified in the special report referred to in paragraph 21 below;
>
> (UNFCCC 2015a, Para. 17)

Assessing the pledges in detail, the United Nations Environment Programme (UNEP 2015) has concluded that mitigation efforts would need to increase threefold compared with the existing pledges, if emission reductions are to be consistent with a pathway that gives a two-in-three chance of keeping warming below 2°C. The UNFCCC Secretariat – which did its own detailed analysis – soberly noted that under the Paris pledges, global emissions would continue to grow through this coming decade, rather than sharply decline, as would be needed to meet the 2°C goal. In fact, by 2025, the world will have used up half of the remaining 2°C emissions budget (again, for a 2-in-3 chance). By 2030, three-quarters of that emissions budget will have been used up. With emissions still rising, the remainder of the budget is due to be depleted within another five or so years. A carbon budget that holds warming below 1.5°C will have been exceeded soon after 2020 (UNFCCC 2016).

There is thus no question that the Paris pledges represent a manifestly inadequate level of effort. To actually meet the global temperature goals agreed in Paris will require rapid decarbonisation around the world, at a far more rapid rate than nations have yet committed to.

4. SHOULD WE JUST LET GO OF THE 1.5°C AND 2°C LIMITS?

It is very tempting to just let go of the 1.5°C and 2°C targets. Indeed, some may say we have no choice, given how late the hour and how little space we have left ourselves. What's the point in sticking with such a stringent goal, especially if every year of tepid action makes it that much harder to achieve? Is such an intense effort really necessary, just to prevent a few more degrees of warming? After all, in a typical day, temperatures routinely swing by 10°C or 15°C between the early morning and high afternoon. How bad can a few degrees of global warming be?

It's helpful to consider it this way. In the depths of the last ice age, about 20,000 years ago, the oceans were more than 100 metres lower, and coastlines were far from where they are now. That volume of water was instead frozen in massive ice sheets that covered huge swathes of the land, as much as four kilometres thick over areas that today feature major cities.

That ice age came to an end as the earth warmed by only around 5°–6°C (Masson-Delmotte et al. 2013). That amount of warming was enough to radically transform the surface of the earth, making it hospitable for the emergence of human civilisation. And, as it turns out, if we were to do nothing about curbing our greenhouse gas emissions to avoid climate change, that's how much warmer again we could expect it to get: 5°–6°C (IPCC 2014c), enough to kick the earth into the "opposite of an ice age".

Society could choose to stop trying to keep warming below 1.5°C or 2°C warming, and allow the world to slip closer to "the opposite of an ice age", but it is not at all clear what humankind would be bringing upon itself. We cannot be confident that such a world will remain hospitable to human civilisation. In the words of climate scientist James Hansen and several co-authors in a recent peer-reviewed article:

> "Social disruption and economic consequences of such large sea level rise, and the attendant increases in storms and climate extremes, could be devastating. It is not difficult to imagine that conflicts arising from forced migrations and economic collapse might make the planet ungovernable, threatening the fabric of civilization." (Hansen et al. 2016)

5. ISN'T THERE SOME WAY TO STRETCH THE AVAILABLE BUDGET?

In principle, we could. We could simply overshoot the budget, with the intention of later removing the excess carbon dioxide from the atmosphere through various "negative emissions" technologies and processes. Indeed, many "2°C" and "1.5°C" pathways in recent scientific literature and policy-oriented reports actually assume an "overshoot" of climate goals, and then negative emissions that reduce atmospheric CO_2 levels in the second half of the century, to bring warming back below the target at a later date.

Some negative emissions technologies are still considered speculative – such as direct air capture, which a U.S. National Research Council study called an "immature" technology "with high technical and environmental risk") and ocean-fertilization, which the study called "immature", "energy-intensive" and "cost-prohibitive" (National Research Council 2015). Others are more developed, and already figure strongly in discussions of strategies for meeting the 2°C – and especially 1.5°C – limits. These measures involve drawing carbon dioxide out of the atmosphere through photosynthesis and sequestering it in plants and other organic material in land-based sinks, or in geological storage. The key options being widely considered are large-scale afforestation, and bioenergy in combination with carbon capture and storage (BECCS). Less commonly assessed is landscape restoration – both restoration of closed canopy forests and "mosaic" restoration of more intensively used landscapes as a potential negative-emissions strategies.

In the idealised world of techno-economic models with perfect foresight and confident projections of costs and potentials, a negative-emissions strategy appears eminently sensible. It buys time and allows for a slower, more orderly transition to a low-carbon energy system. It also avoid near-term mitigation costs, deferring the expense to a comfortably distant future, when negative-emissions options are implemented. And it takes the pressure off sectors such as aviation, in which mitigation is still quite challenging.

Tavoni and Socolow (2013), noting that negative emissions have increasingly been incorporated into modelled assessments of mitigation pathways, point out the irony: "Thus, paradoxically, despite little progress in international climate policy and increasing emissions, long-term climate stabilization through the lens of IAM [integrated assessment modelling] appears easier and less expensive." The underlying concerns have been reiterated by others (Anderson 2015; Geden 2015; Fuss et al. 2014; Peters 2016; Smith et al. 2015; Williamson 2016).

However, it is necessary to highlight three risks associated with strategies based on future deployment of negative emissions options (Kartha and Dooley 2016). First, the measures on which negative emission strategies tend to rely most heavily are as yet unproven. What happens if the necessary negative emission measures – such as large-scale centralised biomass-fuelled power plants coupled with carbon capture and sequestration – ultimately prove technologically infeasible, or cannot be deployed at the necessary scale because of fundamental limits related to land availability and photosynthetic productivity, that are not currently well understood?

Second, even if the necessary negative emission options ultimately prove to be technically feasible, society may find the ecological and social costs to be unacceptably high. Negative emissions options, insofar as they rely on photosynthesis, are inherently land-intensive, requiring large amounts of agriculturally productive land. This means they may not be deployable at a large enough scale without major adverse impacts on biodiversity, food security, water resources, and human rights. From this perspective, the feasibility of such strategies depends on whether several conditions align favourably: agricultural yields continue to rise steadily, limiting the amount of land needed to produce food; water, fertiliser and other necessary resources are available in sufficient quantities in the locations they are needed; ecological damage such as anoxic dead zones caused by fertiliser run-off are avoided; and institutions are put in place to avoid food price shocks or land grabs that dispossess indigenous peoples and local communities.

A third risk is that even if negative emission options prove technically feasible, and can be undertaken at large scale without adverse ecological and social consequences, they ultimately prove less effective than expected at reducing climate change impacts. Land-based carbon stocks are inherently insecure, and can easily be released either through human action (e.g. land clearing) or natural forces outside of human control (drought, fire, pests, and other factors). Climate change itself compounds the risk that land-based carbon will be released – for instance, through forest dieback due to drought, heat, or pests. Evidence suggests that a weakening of the land-based sink has already started in some regions, such as the Arctic (Rawlins et al. 2015).

Taken together, these risks suggest that it is wrong to assume that future "negative emissions" can truly substitute for avoided emissions, particularly when the latter keep carbon stocks in permanent, secure underground fossil reserves. Moreover, even if carbon is sequestered successfully, irreversible climatic changes could occur due to the period of concentration overshoot. It is known that, for a given amount of total cumulative emissions, peak warming is higher for a pathway that overshoots before negative emissions begin to reduce concentrations. It is also known that higher peak warming causes greater climate impacts, and "increases the likelihood of crossing thresholds for 'dangerous' warming" (Tokarska and Zickfeld 2015). Impacts that could be wholly or partially irreversible include species extinction, coral reef death, and loss of sea or land ice, some of which themselves contribute to positive feedbacks. The likelihood of irreversible impacts increases with the amount and duration of concentration overshoot – that is, with the amount of negative emissions (International Cryosphere Climate Initiative 2015).

So, with respect to long-term strategies that rely on large amounts of negative emissions, we have to take these risks seriously. Any nominal "1.5°C" or "2°C" pathway that relies on large amounts of future negative emissions involves a real possibility that we will be lock into much higher temperature rise than planned if the relevant measures do not ultimately prove technically feasible, ecologically and socially acceptable, and reliably permanent and effective.

Thus, policy-makers would be well advised to be sceptical of any "1.5°C" or "2°C" pathway labelled as "likely" if it relies on negative emissions options that themselves do not have a "likely" chance of proving feasible and effective at the needed scale.

Scientists recognise the risks and have highlighted the urgency of addressing them. Fuss et al. (2014), for example, note: "Determining how safe it is to bet on negative emissions in the second half of this century to avoid dangerous climate change should be among our top priorities." The need is especially great given that policy-oriented documents (for example, UNEP 2015) and policy decisions (for example, UNFCCC 2015b) increasingly seem to assume the availability of negative emissions. Such assumptions are premature and unwise, and they could lead policy-makers to greatly underestimate the near-term mitigation efforts needed. If large-scale deployment of negative emissions options later proves infeasible, compensating for decades of inadequate effort could be immensely costly and disruptive, if it is even possible. In the words of the Australian Climate Change Authority (2014): "If net negative emissions prove to be infeasible, a radical shift in mitigation options may come too late to stay below 2 degrees."

To the extent that negative emissions options become feasible at significant scales and are proven reliable, we can make use of them then – after carefully choosing how and where to deploy them, to avoid any negative social or ecological impacts. But first, we will have done everything in our power to reduce emissions, promptly and aggressively, and to build low-carbon, more sustainable economies.

6. WHAT DOES THIS ALL THIS MEAN FOR AUSTRALIA?

What this means for the world is clear. There is an exceedingly small carbon budget remaining if we truly aim to keep warming below 1.5°C or "well below 2.0°C", to do so with high probability, and without greatly exceeding the budget in the uncertain hope that those excess emissions can be undone in later years.

What this means for Australia may seem more ambiguous. After all, it is a relatively small country, and given its relatively minor contribution to global emissions, some might argue that the climate ambitions of other, larger countries are what matters most. Of course, the same claim can be made by most other countries, and certainly by any individual on a planet of more than 7 billion people, no matter which country, province, or city they live in. However, the climate problem will not be solved if we each excuse our emissions as inconsequential to causing the problem and our participation as irrelevant to solving it.

Ultimately, the climate problem is a *commons* problem – a *global commons* problem. No country can solve its own climate problem by itself. Even if a country forced its greenhouse gas emissions to plummet to zero, instantaneously, this alone could not stop climate change from happening on its territory. That's because each country's climate problem is being caused primarily by emissions from *other* countries. This is true even for the largest emitters, even the United States, even China, and certainly of Australia.

What this means is that if countries take action to reduce their emissions, it is not for the sake of protecting "their" climate, at least not directly. Rather, it is for the sake of getting *everyone* to do the same: to get their negotiating partners, their trading partners, to reduce *their* emissions as well.

For this to work, a country has to be seen to be *doing its fair share*. Nobody likes to be taken for a fool. If people in one country see that other countries are not doing their fair share, that they are "free-riding", they will think twice before putting any real effort into reducing their own emissions. Even if they are in fact deeply worried about climate change, they may well decide their best bet is to invest in adaptation to prepare for the increasingly unavoidable impacts of climate disruption.

The IPCC stressed this fundamental, structural feature of climate change in its most recent report. The *Summary for Policymakers* from Working Group III notes that an agreement that is “seen as equitable can lead to more effective cooperation” (IPCC 2014b). This viewpoint was echoed clearly by the Australian Climate Change Authority (2014): “It is clearly in Australia’s interest to persuade and encourage other nations to strengthen their contributions to international action. Australia is likely to be more persuasive and encouraging if its own goals are viewed as a fair contribution by others.”

So what would be a “fair contribution” by Australia? Below we consider two different perspectives on that question. The first is the approach developed by the Australian Climate Change Authority (2014; Annex C), which is combination of a grandfathered allocation and an equal per capita allocation, with some adjustment for income, to make more space available for developing countries. In effect, in the early years, when annual global emissions are higher, it allocates more emissions to those countries that have historically emitted more. In the latter years, as global emission approach zero, it allocates to countries on an equal per capita basis. (The income adjustment amounts to roughly a 20% downward adjustment to Australia’s overall budget.) This approach finds that Australia’s fair share of the remaining budget is approximately 1% of the total global budget.

The second approach is that adopted for the Civil Society Equity Review (ActionAid et al. 2015), a comprehensive review of the INDCs published by a broad coalition of global and regional environment and development NGOs as input to the Paris negotiations. This approach, developed by the Climate Equity Reference Project,2 is based on sharing the globally required mitigation among countries in proportion to a simple indicator reflecting each country’s responsibility for causing GHG emissions and its capacity to contribute to solving the problem. Each country’s responsibility is defined as its a share of the total global cumulative emissions, and its capacity is defined as its share of global income, calculated in a manner that takes income distributions within nations into account (so that a dollar earned by a wealthy person counts for more than a dollar earned by a poor person, analogous to the standard approach used in virtually all countries to implement progressive income tax schedules). This approach would allocate a rapidly declining share of annual global emissions to Australia, that reaches zero (i.e., a 100% reduction target) by roughly 2025 and becomes negative afterward. This implies that Australia has a significantly negative allocation cumulatively over the course of the coming decades.[3]

Both approaches acknowledge that a country’s fair contribution requires efforts both domestically, through emission reductions within the country, and internationally, by providing support to other (developing) countries whose fair contribution is less than the reductions needed to fully shift those countries onto a 1.5°C/2°C pathway.

The Climate Change Authority approach arrives at a more lenient expectation of Australia’s fair contribution than the Civil Society Equity Review approach. This arises for two main reasons: First, the Climate Change Authority approach is based to a large degree on grandfathering, a political concession that benefits high-emitting countries such as Australia,

[2] See http://www.climateequityreference.org.

[3] It is important to note that a “negative” share of the remaining emissions budget does not mean that Australia must therefore deploy negative-emissions technologies, but rather that, through a combination of mitigation at home and support for mitigation abroad in poorer countries, its future contribution to future global emissions is effectively negative.

despite being the opposite of what might be desirable based on ethical considerations. Second, the Civil Society Equity Review approach takes account progressively of global and national income disparities.

There are other reasons to believe that the Climate Change Authority approach is somewhat charitable toward Australia. It grants to Australia a significantly greater share of the world's budget (1%) than Australia's population comprises (less than one-third of 1%). This is despite the fact that Australia is responsible for among the highest greenhouse gas emissions on a per capita basis (exceeds 25 tonnes CO_2-equivalent in 2012, versus a global average of 6.5 tonnes). In terms of cumulative emissions released into the atmosphere, Australia is responsible for four times the global average relative to its population. The country also has a far greater than average capacity to address the climate problem (nearly six times the global average income).

Nevertheless, whether Australia's allocation of the remaining budget is 1% or significantly less or indeed negative, the implications are clear. In a situation where the global budget is extremely limited, perhaps to 250 Gt CO_2 or less, and where Australia's emissions are now disproportionately high, a rapid and comprehensive decarbonisation is crucial. Even a very generous 1% of the 250 Gt CO_2 budget is 2.5 Gt CO_2, which, given that Australia currently emits roughly 0.4 Gt of CO_2 per year from fossil fuel combustion alone, would be exhausted in merely six years.[4] A less risky global budget, or a less generous share for Australia, makes the task ahead for Australia all the more demanding.

7. CAN AUSTRALIA CONTINUE SUPPLYING FOSSIL FUELS TO THE WORLD?

Australia's role as fossil fuel supplier to the world is arguably incompatible with the urgent need to address the climate challenge, as fossil fuel use in other countries would need to sharply decline to keep within the available carbon budget. Globally, a 1.5°C or 2°C carbon budget is dramatically less than the carbon contained in the remaining fossil fuels. Comparing the figures in Table 2 with any plausible budget available for holding warming well below 2°C or 1.5°C leads to the immediate conclusion that a large fraction – if not the overwhelming majority – of proven reserves cannot be burnt and will ultimately need to remain in the ground. That is even more true of the vast fossil fuel resources that have yet to be developed, but are considered recoverable.

Some researchers have attempted to analyse which suppliers are likely to remain competitive in these final years of the fossil fuel market, as declining demand is increasingly focused on the least costly and least remote fossil fuel sources. McGlade and Ekins (2015), for example, have shown that even assuming a rather optimistic global carbon budget were available, market demand for fossil fuel production from Australia would be severely curtailed. (See also Climate Council of Australia 2016b.) That conclusion holds even with optimistic assumptions of the feasibility of carbon capture and sequestration.

[4] The budgets discussed here refer to carbon dioxide (CO_2) only. Comparably ambitious efforts would be needed in addition for other greenhouse gases, such as fugitive methane emissions from the fossil fuel extraction and processing and industrial process emissions.

Table 2: Carbon dioxide emissions resulting from combustion of proven reserves and remaining recoverable resources (BGR 2013)

Carbon emissions from combustion of fossil fuel resources (Gt CO_2)		
	Proven reserves	**Remaining recoverable**
Oil	660	2,390
Natural gas	410	2,080
Coal	2,150	48,500
Total	**3,220**	**52,970**

Given the rapidly depleting carbon budget, the rate of fossil fuel use to be reduced rapidly if the world is to act in line with the Paris Agreement. As a consequence, the market for Australia's fossil fuel exports would need to rapidly reduce and ultimately disappear. Action taken to increase Australia's capacity for fossil fuel production – such as increasing export capacity or commissioning new coal mines – is difficult to reconcile with the goals of the Paris Agreement.

8. CONCLUSIONS

The stakes, for Australia just as for every other country, are very high. The world has already warmed by about 1°C above pre-industrial levels, and unless we promptly and sharply reduce greenhouse gas emissions, we risk slipping toward the "opposite of an ice age", with whatever grave implications this holds for humankind.

An absolutely minimal carbon budget remains if we are to prevent this and preserve a climate similar to that which enabled human civilisation to emerge and grow prosperous. Only an excessively risky choice of our tolerable temperature threshold and our acceptable chance of failure would allow us to contrive a budget that permits a prolonged reliance on fossil fuels and a gradual shift to renewables.

The transformation must be rapid and comprehensive, and an equitable approach to the climate problem demands that Australia must be among the countries taking the lead. It has a high level of responsibility for the greenhouse gases that have caused the climate problem, and a high level of capacity to help solve it.

Ultimately, this implies that Australia will need to undertake an urgent energy transformation away from fossil fuels and toward renewables domestically. With all countries sharply reducing fossil fuel use, Australia will also need to diversify away from fossil extraction for export. In addition, it will need to provide support to those countries with less responsibility and capacity, to help them undergo a low-carbon transition as well.

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