Submission to Senate Select Committee on Climate Policy

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The submission is structured in five parts: (1) scientific findings on climate change; (2) implications for *dangerous* climate change; (3) global emissions reductions needed to avoid *dangerous* climate change; (4) sharing of emissions reduction efforts, and (5) characteristics of a response strategy.

The relationship to the Terms of Reference (ToRs) is that the first three parts address ToR (c), and the fourth part addresses ToR (d), and the fifth part is relevant to ToR (b). The submission does not address the remaining ToRs.

Summary

1. Included in and since the completion of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4), many scientific findings confirm the major risks from climate change that are likely to be *dangerous* if allowed to develop unchecked. Fourteen such findings are highlighted.
2. A benchmark for avoiding major risks from climate change is a long-term global temperature rise of 2°C above preindustrial temperatures. This needs to be treated not as an "ambit claim" for climate protection but rather a firm goal. Above this level, the risks of *dangerous* climate change increase rapidly.
3. Stabilisation of greenhouse gas concentrations at 450 ppm CO_2eq (CO_2 equivalents) gives only a 50% chance of staying below the 2°C benchmark. Therefore the target must be lower.
4. Global emissions trajectories consistent with climate stabilisation involve a cap on future cumulative global CO_2 emissions, which are a finite, non-renewable resource. The cap is largely independent of particular emission pathways. To stabilise at 450 ppm CO_2eq, the cap is about 1000–1200 billion tonnes of CO_2 from 2000 on. This cap will be exhausted by 2030–2035 under current emission rates without growth, and earlier with growth.
5. Global emissions trajectories to achieve stabilisation at 450 ppm CO_2eq require emissions reductions below 2000 levels of approximately 5–10% by 2020, and 70–80% by 2050. A lower global target (such as 400 ppm CO_2eq) requires lower cumulative emissions.
6. Present Australian targets will *not* achieve even the limited degree of climate protection conferred by 450 ppm CO_2eq stabilisation, because they are weaker than the global average requirement, and much weaker than reductions required of developed nations given the need for differentiation between developed and developing nations.
7. Australian targets need to be framed within a global target consistent with climate protection, and need to include scope for differentiation between developed and developing nations. Without such targets, Australia is at high risk of permanent major damage from climate change.
8. We believe that Australia should embrace mitigation challenge in a way that is consistent with the need for climate protection, and offer emissions trajectories to achieve this. These involve stronger mitigation than currently proposed.

1 Scientific findings on climate change

This submission takes as its starting point the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) as reflected in its Synthesis Report (IPCC 2007a) and Working Group Reports. The cutoff date for incorporation of new material into the IPCC AR4 occurred in 2005. Since then, several new scientific findings have emerged which together with the IPCC findings confirm that the danger from climate change is likely to be greater than stated in the IPCC AR4. This is evident both in currently observed climate change (Section 1.1) and in predicted future climate change (Section 1.2).

1.1 Current climate change

Many new (post IPCC AR4) pieces of evidence strengthen findings of rapid current climate change. Six of the most important are as follows.

1. *Rapid observed temperature and sea level rise:* Observed global temperature and sea level rise over the last several decades are both tracking near the upper edge of the predictions of the IPCC AR4 (Rahmstorf *et al.* 2007). Claims of a slowdown in temperature rise since 2000 are unfounded: when the effects of Pacific ocean oscillations are considered, the post-2000 temperature rise is just as strong as before (Fawcett 2008).
2. *Loss of land based ice:* Loss of ice from the Greenland ice sheet has accelerated sharply in recent years, mainly as a result of increased ice discharge from glaciers to the ocean (Rignot *et al.* 2008b).
3. *Loss of sea ice:* There has been a multi-decadal decline in Arctic sea ice at about 2.8% per decade, as monitored by the National Snow and Ice Data Center of the USA (http://nsidc.org/).
4. *Antarctic Warming:* In the Antarctic, warming trends (from which Antarctica had been thought to be relatively immune) have recently been detected (Steig *et al.* 2009).
5. *Accelerating CO_2 emissions:* Fossil-fuel CO_2 emissions rose at 3.5% per year for 2000-2007 compared with a historic average (over 100 years) of 2% per year, and 1.1% per year through the 1990s (Raupach *et al.* 2007). The 2000-2007 emissions growth rate is faster than forecast by almost all emissions scenarios used in the IPCC AR4.
6. *CO_2 sinks are "losing the race" with emissions:* The natural uptake of CO_2 to land and ocean reservoirs currently removes more than half of all CO_2 emissions from the atmosphere, thereby reducing the climate impact of emissions, but these land and ocean CO_2 sinks have not increased as rapidly as emissions over the last 50 years (Canadell *et al.* 2007, Raupach *et al.* 2008). Hence their attenuating effect on climate change is weakening.

1.2 Future climate change

Climate change can be accelerated beyond current predictions by increased "positive climate feedbacks", meaning processes which both contribute to climate change and are accelerated as climate change occurs, thus causing climate change to feed on itself. When these feedbacks are sufficiently strong they become "climate tipping points" which can flip the climate into a new state with essentially no way to recover. Among the most important feedbacks and consequences are:

7. *Carbon-climate feedbacks:* Carbon-climate feedbacks act to accelerate climate change if sinks do not keep pace with emissions (point 6) and/or if previously inert carbon reservoirs (such as peatland carbon) are released to the atmosphere under climate change. There is increasing evidence that these feedbacks influence both ocean and land CO_2 sinks, and will indeed accelerate climate change. A conservative estimate is that the CO_2 increase from its preindustrial level (280 ppm) will be at least 20% larger because of carbon-climate feedbacks than it would have otherwise been, though it could be much more if tipping points are crossed which lead to collapse of sinks. Most of these feedbacks are not included in IPCC AR4 predictions of climate change.

8. *Methane release from melting permafrost:* A new assessment (Schuur *et al.* 2008) shows that there is more than twice the amount of organic soil carbon in permafrost than previously thought. This carbon is presently inert but will be mobilised to the atmosphere as the permafrost inevitably melts under warming (Lawrence and Slater 2005, Lawrence *et al.* 2008). The organic carbon in permafrost will be released both as CO_2 and as methane, a more potent greenhouse gas. There is already evidence of increased methane levels in arctic regions (Rigby *et al.* 2008), a sign that this amplifying feedback on climate change is starting to occur.

9. *Ice-albedo feedback:* Accelerated warming in polar regions (Lawrence and Slater 2005, Lawrence *et al.* 2008) will cause loss of ice and a consequent darkening of the surface, causing more heat absorption and faster warming. While this effect is accounted for in IPCC AR4 climate models, the present high rate of arctic ice loss suggest that its consequences may have been underestimated.

10. *Acceleration of global warming from release of the "aerosol brake":* Aerosols currently exert a net cooling effect on the Earth, offsetting the warming due to greenhouse gases. The cooling effect is presently enough to reduce long-term warming by around 0.5 to 1 degree, if it is maintained into the future. However, atmospheric aerosol loads are likely to decrease in future as nations improve air quality, especially in Asia. The effect will be accelerated warming (Ramanathan and Feng 2008) as the "aerosol brake" on warming is loosened.

11. *Ocean acidification:* A particular issue of concern is ocean acidification, which is a direct consequence of increased CO_2 concentrations in the atmosphere. New work (McNeil and Matear 2008, Hofmann and Schellnhuber 2009) shows that severe disruption of marine ecosystems through ocean acidification occurs above CO_2 concentrations of 450 ppm, to be reached by 2035 under business-as-usual CO_2 emission scenarios. One consequence for Australia is the near certainty of the loss of the Great Barrier Reef under all business-as-usual scenarios (Hoegh-Guldberg *et al.* 2003; Hoegh-Guldberg *et al.* 2007).

12. *Sea level rise of metres:* Business-as-usual emissions scenarios carry a high risk of crossing temperature levels which would lead to an essentially irreversible melting of the Greenland ice sheet. A global average warming (relative to pre-industrial values) in excess of 1.9 to 4.6°C is estimated to lead to virtually complete elimination of the Greenland Ice Sheet and a resulting contribution to sea level rise of about 7 m from Greenland alone (IPCC 2007b). Under these condition and when combined with ongoing thermal expansion, a sea-level rise of metres would occur over centuries.

13. *Stability of the West Antarctic Ice Sheet:* There is also major concern over the potential for global warming to affect the stability of the West Antarctic Ice Sheet, leading to a sea-level rise of up to an additional five metres. While recent observations are indicating an acceleration in

ice loss from the West Antarctic Ice Sheet (Rignot *et al.* 2008a), current understanding is insufficient to quantify the timing or rate of future decay.

14. *Irreversibility of climate change:* Both past and recent work (Solomon *et al.* 2009) have found that current anthropogenic climate change is effectively irreversible in time frames less than 1000 years, because of the large thermal inertia of the ocean and the fact that about 20% of present anthropogenic emissions of CO_2 will remain in the atmosphere for this long, even after all emissions have been brought to zero.

2 Implications for *dangerous* climate change

The above recent findings (and others) have led to a revision in the climate science community of thresholds for what might be considered *dangerous* climate change. The concept of *dangerous* climate change is necessarily a value judgement; the italicisation of *dangerous* is a continuing reminder in this submission of the importance of this value judgement. Its significance can be appreciated from a simple causal chain:

$$\begin{bmatrix}\text{greenhouse gas}\\ \text{emissions}\end{bmatrix} \rightarrow \begin{bmatrix}\text{greenhouse gas}\\ \text{concentrations}\end{bmatrix} \rightarrow \begin{bmatrix}\text{climate}\\ \text{change}\end{bmatrix} \rightarrow \begin{bmatrix}\text{climate}\\ \text{impacts}\end{bmatrix}$$

It is logical to work backwards through the chain to determine what conditions lead to *dangerous* climate change. At the fourth and last link (impacts), the direct physical consequences of climate change include (1) heat stress on many agricultural, human and natural systems; (2) increased droughts (mainly in mid-latitude regions); (3) increased storminess and flooding (especially in tropical regions); (4) sea level rise; and (5) ocean acidification. These in turn lead to societal impacts including (6) stress on food and water supplies; (7) stress on natural ecosystems, both terrestrial and marine; (8) threats to ecosystem functions (including CO_2 sinks and other earth-system maintenance functions, feeding back to accelerate climate change itself); (9) displacement of populations and associated risks to wellbeing and security for both the displaced peoples and at their destinations; and (10) increased disease of many kinds.

The impacts of climate change affect different parts of the world in quite different ways. For Australia, likely impacts of particular concern (under business-as-usual climate scenarios) include:

- decreases in rainfall (by up to 20%) and much greater decreases in streamflow (by up to 60% or more) in southern Australia, placing unrecoverable stress on many agricultural and natural systems in areas such as the Murray-Darling Basin;
- consequent stresses on food production and urban water systems;
- the effects of sea level rise on coastal communities in both Australia and neighbouring low-lying Pacific and Asian countries;
- the near-certain loss of much of the Great Barrier Reef (Hoegh-Guldberg *et al.* 2003, Hoegh-Guldberg *et al.* 2007).

At the third link in the chain (climate change), a widely used benchmark for avoiding major risks from climate change is a long-term global temperature rise of 2^{o}C above preindustrial temperatures (or 1.4^{o}C above present temperatures). This figure was affirmed by a 2005 conference in the UK on “Avoiding Dangerous Climate Change” (Schellnhuber *et al.* 2006, Schneider and Lane 2006). The figure is a value judgement because impacts vary strongly from region to region and because impact assessments are statements of risk (the higher the temperature rise, the greater the risk) rather than absolute assertions. However, for many climate impacts, recent evidence indicates an increase in the risk associated with a given temperature rise such as 2^oC (Smith *et al.* 2009; see the above discussion of sea-level rise for one example). Even more importantly, the risk of crossing climate tipping points increases rapidly with greater warming. It is therefore important regard the 2^oC benchmark not as an "ambit claim" for climate protection but rather as a firm goal for avoiding major risks from *dangerous* climate change. Risks rise rapidly above this 2^oC value.

At the second link the chain (greenhouse gas concentrations), the question is: what maximum level of greenhouse gases in the atmosphere is necessary to stay below the 2^oC benchmark? In preindustrial times (before 1800), the CO_2 concentration was about 280 ppm. The present (2008) CO_2 concentration is 385 ppm, and the concentration including all major greenhouse gases is about 440–450 pp CO_2eq (short for "CO_2 equivalents", a measure of total greenhouse gas concentration including not only CO_2 but also methane, nitrous oxide, CFCs, HFCs and other gases, but not the effects of aerosols).

Stabilisation of greenhouse gas concentrations at 450 ppm CO_2eq or lower is necessary to have a 50% chance of limiting long-term warming to the 2^oC benchmark. A level of 400 ppm CO_2eq or lower is needed to have an 80% or better chance of staying below the benchmark (Meinshausen 2006). An even lower CO_2 target of 350 ppm has been advocated by James Hansen of NASA (Hansen *et al.* 2007, Hansen *et al.* 2009) on the basis of the paleo observations of the earth's climate history and its relationship with atmospheric CO_2 concentration.

At this time, the Hansen target, whilst scientifically justifiable, is unreachable in practice because it would require immediate cessation of all emissions. Even 450 ppm CO_2eq (giving only a 50% chance of staying below the 2^oC benchmark) requires that greenhouse gas concentrations be stabilised at essentially their present level, an enormous challenge. This is a *minimum* definition of the challenge of avoiding *dangerous* climate change, and still carries major risks. To reduce these risks the long-term concentration target needs to be lower, a still greater challenge.

The rest of this submission considers the first link in the chain, exploring the steps needed to stabilise greenhouse gas concentrations at 450 ppm CO_2eq or lower. A 450 ppm CO_2eq target is a very imperfect compromise between what is necessary from the point of view of climate science and what is possible from the point of view of current emissions trajectories, so the actual target must be lower. We note that an imperfect compromise may be all that is available, as there is now essentially no common ground between the necessary and the possible.

3 Global emissions reductions needed to avoid *dangerous* climate change

This section considers the global emissions reduction requirement (the question of sharing this requirement, and the Australian target, is considered in the next section).

Figure 1 (from the IPCC AR4 Synthesis Report, with the caption quoted in full) shows a set of future CO_2 emissions pathways as coloured bands in the left panel, with corresponding long-term temperature outcomes as matching coloured bars in the right panel. The shaded range of these bars corresponds to a "climate sensitivity" of 2 to 4.5^oC. (The climate sensitivity is the long-term increase in global temperature under a doubling of CO_2eq). The best estimate of the IPCC AR4, a climate sensitivity of 3^oC, shown as the central black line. Consistent with the above discussion, the right panel of Figure 1 confirms that to stay below a 2^oC benchmark for long-term warming with 50% or better probability, concentration stabilisation must occur at or below 450 ppm CO_2eq.

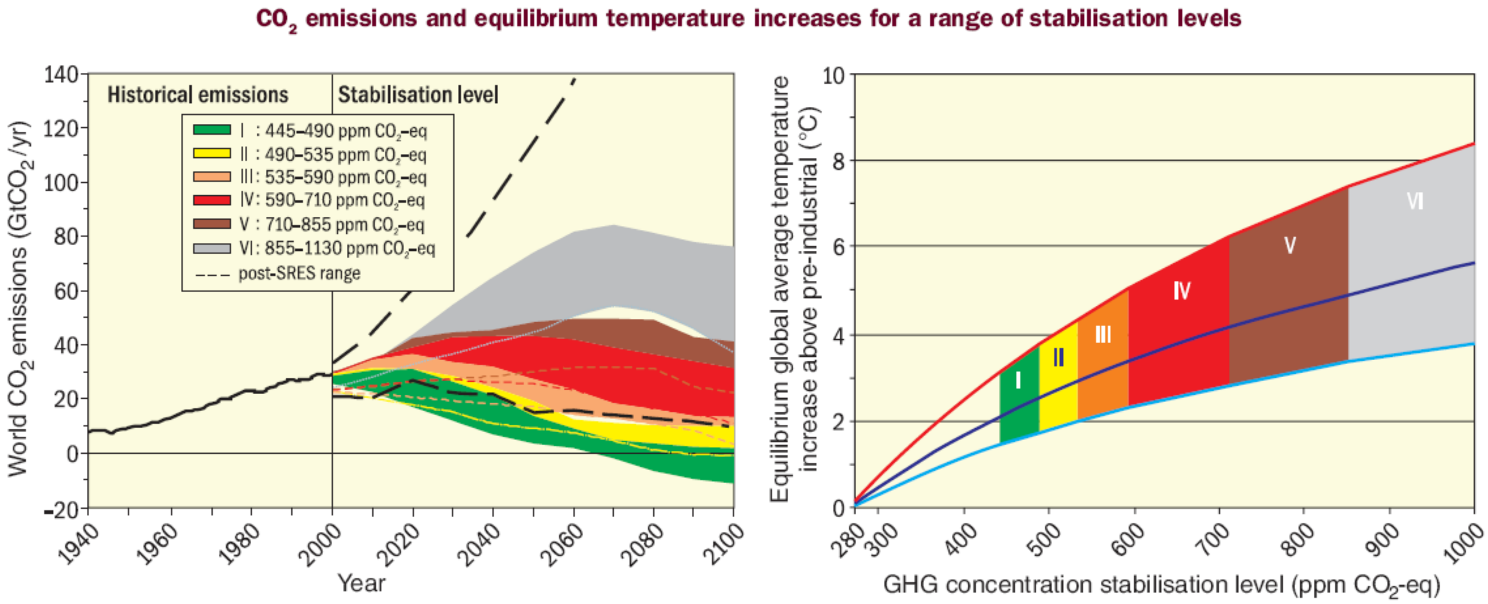

Figure 1 (IPCC 2007a, Fig 5.1): Global CO2 emissions for 1940 to 2000 and emissions ranges for categories of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the likely equilibrium global average temperature increase above pre-industrial (righthand panel). Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilisation. Coloured shadings show stabilisation scenarios grouped according to different targets (stabilisation category I to VI). The right-hand panel shows ranges of global average temperature change above pre-industrial, using (i) 'best estimate' climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2°C (blue line at bottom of shaded area). Black dashed lines in the left panel give the emissions range of recent baseline scenarios published since the SRES (2000). Emissions ranges of the stabilisation scenarios comprise CO2-only and multigas scenarios and correspond to the 10th to 90th percentile of the full scenario distribution. Note: CO2 emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from peat fires and drained peat soils.

The green band in the left panel of Figure 1 shows the emissions pathways needed to achieve concentration stabilisation levels of 445–490 ppm CO_2eq. Emissions pathways required to achieve 450 ppm CO_2eq are represented by the lower boundary of this green band and even then there is still a significant risk of rises above 2^{o}C. This broadly defines the *minimum* global requirement for emissions reductions to avoid *dangerous* climate change.

Inescapable characteristics of this emissions pathway are as follows.

1. To avoid *dangerous* climate change, there is a limit on cumulative global CO_2 emissions into the future; in other words, our ability to emit CO_2 into the atmosphere is a finite, non-renewable resource. For stabilisation at 450 ppm CO_2eq, this limit is about 1000–1200 billion tonnes of CO_2 between 2000 and the later part of the 21st century (around 2070), after which emissions must reach zero and then go negative. If we emit more than the limit, there is less than 50% chance of avoiding 2^{o}C warming.
2. The implication of the limit can be gauged by noting that current total emissions (including both fossil fuels and land use change) are about 35 billion tonnes per year, growing at over 3% per year. This means that:
    - A global cumulative emission limit of 1200 billion tonnes of CO_2 will be entirely used up by 2030–2035 under current emission rates without growth, and earlier with growth;
    - In 8 years since 2000, global CO_2 emissions used up about a fifth of the total available.
3. A limit on cumulative emissions of CO_2 is a robust feature of emissions pathways to achieve stabilisation; that is, the limit is largely independent of details of the path. Therefore, delay in starting global emissions reductions can only be made up by steeper reductions later. There quickly comes a point beyond which later emissions reduction requirements become impossible.
4. For stabilisation at 450 ppm CO_2eq, the required average emission reduction (negative growth) rate is about −1.5% to −2% of current global emissions per year, in contrast with a current positive growth rate of about +3% per year over 2000–2007 (Raupach *et al.* 2008).
5. To meet these constraints, the necessary *minimum* global emissions reductions below 2000 levels are approximately 5–10% by 2020, and 70–80% by 2050. Stronger reductions are highly desirable to reduce the danger from crossing climate tipping points.
6. In the later part of the 21st century, a period of negative emission is necessary. It is still possible that natural CO_2 sinks may achieve this, though this possibility is uncertain and is closing fast (that is, continued climate change will remove the ability of natural sinks to absorb enough CO_2). If natural sinks cannot cope, large-scale CO_2 sequestration from the atmosphere will be needed to bring long-term concentrations back to below 450 ppm CO_2eq.
7. Not shown in Figure 1 is the future trajectory of greenhouse gas concentrations (either of CO_2 or CO_2 equivalents including other gases). This trajectory inevitably involves overshoot above the long-term stabilisation level of 450 ppm CO_2eq or lower, by at least 50 ppm CO_2eq. (This is clear because concentrations are already at this level and rising by over 2 ppm CO_2eq per year on average). The greater the delay in bringing about emissions reductions, the greater the overshoot and the more difficult it will be to return concentrations to the stabilisation level.

4 Sharing of emissions reduction effort

The last section concludes that *global* emissions reductions below 2000 levels must be *at least* 5–10% by 2020, and 70–80% by 2050. The *Australian* targets are 5% by 2020 (up to 15% if other nations make significant commitments), and 60% by 2050.

The Australian targets will not achieve climate protection. Even if every nation on earth adopts and succeeds in meeting Australian targets, global emissions would still be above a pathway consistent with long-term climate protection.

Further, not all nations can meet the same targets. In particular, differentiation is needed between developed nations (USA, Europe, Japan, Canada, Australia and others) and developing nations (China, India, Brazil and many others). Equal emissions reduction targets across both developed and developing nations cannot be applied, for sheer practical reasons as well as reasons of equity. Australia currently has a per-capita CO_2 emission about twice that of Europe, about four times that of China, and about twenty times that of India and the African continent as a whole. Consequently, emissions growth rates in many developing nations are high (10% per year for China, 5% per year for India and many others) because of rapid development which is presently powered largely by fossil fuels. It is not possible for developing nations to reduce these growth rates immediately to below zero, both because of development pathways which are locked in for time frames of a decade or more, and because of constraints on technological and economic capacity. Such rapid changes in emissions trajectories in developing economies would cause major economic and social dislocation, with immediate adverse consequences in developed nations as well. For these reasons, the principle of differentiated emissions targets between developed and developing nations is recognised in international negotiations[1].

A sense of the implications of differentiated emissions targets can be gained by noting that the world's greenhouse emissions are shared nearly 50-50 between developed and developing nations (though the shares of population are more like 17-83). This implies that if the global target is (say) a 5% reduction by 2020, any leeway given to developing nations must be numerically balanced by extra reductions in the developed world. For example, if developing nations increase their emissions by 10% from 2000 to 2020, thus exceeding the global target by 15%, then developed nations must set an aggregate target 15% in the other direction, reducing their emissions by 20%. Even a 10% increase for developing nations is a very substantial cut, as most developing-country emissions would increase from 2000 to 2020 under current growth rates by much more than this, typically by over 100%, and have already increased by nearly half this amount since 2000.

Targets for Australian emissions reductions in 2020 and 2050 (relative to 2000) need to be set to be consistent with:

- ~~1.~~ *minimum* global emissions reductions below 2000 levels of 5–10% by 2020 and 70–80% by 2050, which are necessary to stabilise greenhouse gas concentrations at or below 450 ppm CO_2eq and provide 50% or better chance of avoiding long-term warming of more than 2^{o}C above preindustrial temperatures; and

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[1] For example, the 13th Conference of Parties of the UN Framework Convention on Climate Change (UNFCCC) in Bali, December 2007, endorsed the Bali Action Plan, calling for *"a shared vision for long-term cooperative action, including a long-term global goal for emission reductions, …[and] in particular the principle of common but differentiated responsibilities and respective capabilities, and taking into account social and economic conditions and other relevant factors"*.

~~2.~~• the need for differentiation of targets between developed and developing nations, interpreted within a realistic assessment of possible emissions reductions for both developed and developing nations.

Without such targets, Australia is at high risk of permanent major damage from climate change.

5 Characteristics of a response strategy

This final section offers a few brief comments on characteristics of Australia's climate mitigation strategy that are appropriate from the perspective of climate and carbon-cycle science.

1. It is important to reduce emissions quickly in all sectors of the Australian National Greenhouse Gas Inventory (NGGI), particularly the sectors responsible for the largest emissions. Reductions in CO_2 emissions from stationary (mainly coal-fired) energy and the transport sector are very important. If reductions in these challenging sectors are not made soon and strategically, impossibly steep reduction rates will be required later to meet 2050 targets.
2. For the same reason, it is important to avoid the temptation to meet short-term (2020) targets by book-keeping methods involving large apparent reductions in sectors where these can be made easily, while allowing emissions from more challenging sectors to continue to grow. This requirement means that targets need to be set sector by sector, in addition to an overall target.
3. Reducing Emissions from Deforestation and Degradation (REDD) is an important strategy for the inclusion of tropical developing countries such as Indonesia and Malaysia into the overall global mitigation effort (Canadell and Raupach 2008). Therefore Australia's participation in REDD is highly desirable. However, it is critical that REDD and similar measures do not become major strategies for Australia to meet its domestic emissions reduction targets, because REDD alone can mitigate only a fraction of less than 15% (and decreasing) of the world's CO_2 emissions. Reduction of fossil-fuel CO_2 emissions must be the highest global and national priority because of their dominant share of total emissions.

Shown in Figure 2 are two trajectories for Australian emissions between 1990 and 2020, a "low mitigation" scenario consistent with present Australian Government targets and a "high mitigation" scenario consistent with requirements for climate protection. Each panel shows CO_2 emissions only (red line), total greenhouse gas emissions excluding land use change and forestry (blue line) and total greenhouse gas emissions including land use change and forestry (black line). Total emissions in the year 2000 are set to 1, so that emissions reductions in later years are easily read.

Important points about these trajectories are: both the low and high mitigation scenarios require significant structural changes (for example, decarbonisation of Australia's energy systems) but both scenarios are technically possible. The differences are in degree rather than in kind. The key difference is that one trajectory (low) is not consistent with global climate protection, whereas the other (high) confers a reasonable chance of climate protection. The high mitigation scenario achieves zero emissions in 2050 (100% net emissions reduction) by assuming that the Australian domestic land use change and forestry sector can create a sink of about 50 $MtCO_2eq$ per year.

We believe that Australia should embrace mitigation challenge in a way that is consistent with the need for climate protection, rather than partially as currently proposed.

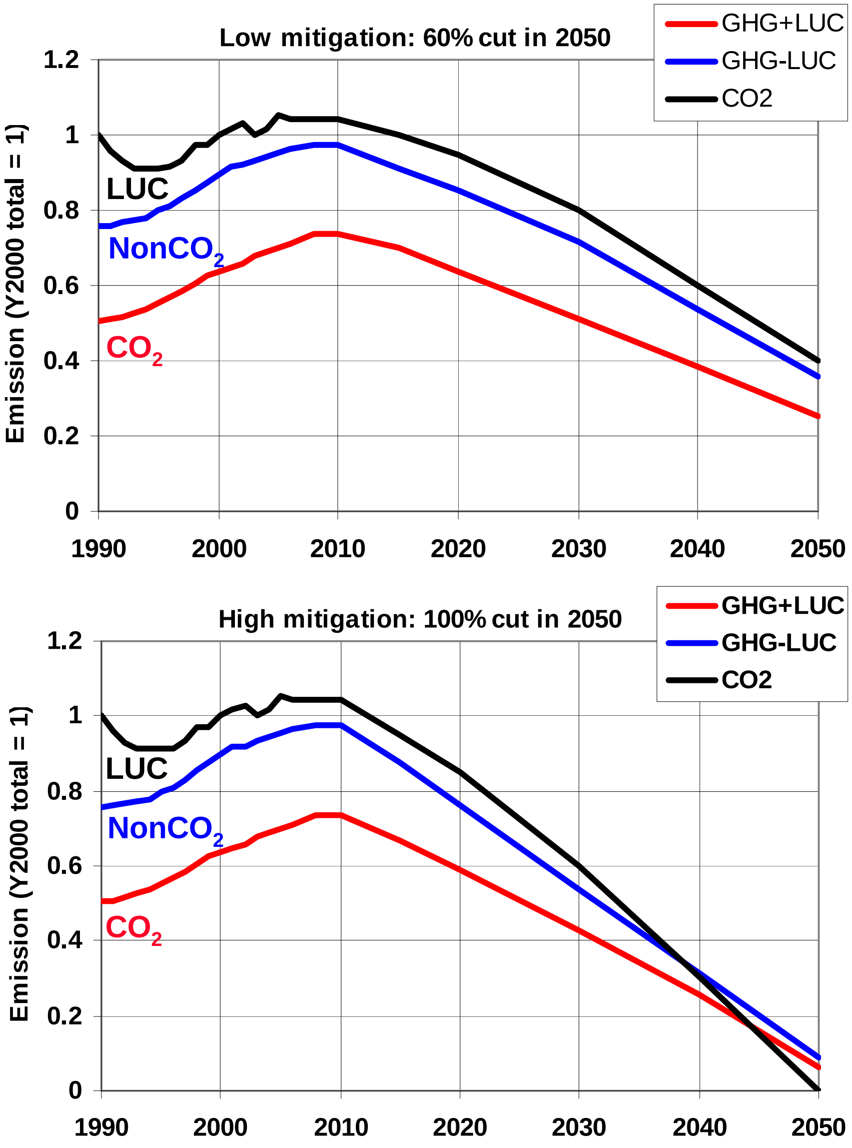

Figure 2: Two trajectories for Australian emissions between 1990 and 2020, a "low mitigation" scenario consistent with present Australian Government targets (top panel) and a "high mitigation" scenario consistent with requirements for climate protection (bottom panel). Each panel shows CO_2 emissions only (red line), total greenhouse gas emissions excluding land use change and forestry (blue line) and total greenhouse gas emissions including land use change and forestry (black line). Total emissions in the year 2000 are set to 1, so that emissions reductions in later years are easily read. The high mitigation scenario achieves zero emissions in 2050 (100% net emissions reduction) by assuming that the Australian domestic land use change and forestry sector can create a sink of about 50 $MtCO_2eq$ per year.

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