

Australia's 21st Century Carbon Budget

How much have we consumed?

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Summary

A national carbon dioxide (CO₂) budget is a set amount of CO₂ that can be emitted by human sources in a country over a given period. This paper determines five potential 21st century CO₂ budgets for Australia based on targets of stabilising the atmospheric concentration of CO₂ at 450, 550, 650, 800 and 1,000 parts per million (ppm).

The 450 ppm budget is consistent with the objective of keeping the increase in the global average surface temperature below 3°C above pre-industrial levels in order to minimise the risks associated with human-induced climate change. As the atmospheric CO₂ stabilisation targets increase, so do the climate-related risks. With a 550 ppm CO₂ target, there is a significant risk that the increase in the global average surface temperature will exceed 3°C. The 650, 800 and 1,000 ppm targets are well above the levels necessary to prevent dangerous anthropogenic interference with the climate system.

If the global CO₂ budget is allocated on a per capita basis, the 450 ppm budget provides Australia with 6,894 million tons (Mt) of CO₂ for the 21st century. In the first five years of the century, Australia consumed approximately 27 per cent of this budget. By 2010, approximately 54 per cent of the 450 ppm budget will be consumed and, if emissions remain at 2005 levels, the entire budget will be exhausted by 2019. To stay within the 450 ppm budget, Australia's CO₂ emissions would have to be reduced by 55 per cent by 2015 and 95 per cent by 2020.

Although the science suggests the atmospheric concentration of CO₂ should be stabilised at around 450 ppm, for political and economic reasons it has been argued that a 550 ppm CO₂ target should be set. Yet by 2010, Australia is likely to have consumed at least 46 per cent of the 550 ppm budget, leaving 54 per cent to be distributed over 90 years. To stay within the 550 ppm budget, CO₂ emissions would have to be approximately 42 per cent below 2005 levels by 2015 and more than 90 per cent below by 2021.

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The extent to which Australia's current emission levels are unsustainable is illustrated by the 650, 800 and 1,000 ppm budgets. By 2010, approximately 39 per cent of the 650 ppm budget, 32 per cent of the 800 ppm budget and 26 per cent of the 1,000 ppm budget are likely to have been consumed. To stay within the 650 and 800 ppm budgets, emissions would have to be reduced significantly between now and 2020. For the 650 ppm budget, emissions would have to be approximately 31 per cent below 2005 levels by 2015, 63 per cent below by 2020 and 90 per cent below by 2025. To stay within the 800 ppm budget, emissions would have to be approximately 34 per cent below 2005 levels by 2020, 68 per cent below by 2030 and 90 per cent below by 2037. Even remaining within the 1,000 ppm budget would require emission cuts in the order of 22 per cent on 2005 levels by 2020, 44 per cent by 2030, 65 per cent by 2040 and 90 per cent by 2052. According to the Intergovernmental Panel on Climate Change (IPCC), if the atmospheric concentration of CO₂ reaches 1,000 ppm we can expect the global average surface temperature to rise by more than 5°C above pre-industrial levels, a situation most climate scientists believe would lead to serious adverse impacts.

The greenhouse debate in Australia currently appears to be detached from the realities of the climate science. Greater attention will have to be paid to the science in decision-making processes if Australia is going to actively pursue the objective of minimising the risks associated with global warming.

1. Introduction

It is widely accepted that in order to minimise the risks associated with human-induced climate change, global greenhouse gas emissions will have to be significantly reduced over this century (IPCC 2007a). One way to plan for and facilitate emission reductions is through the use of national carbon budgets.

A national carbon budget is a measure that sets a limit on the amount of carbon that can be emitted by human sources in a country over a given period. The notion of long-term national carbon budgets (i.e. over more than 50 years) has been the subject of considerable research and debate overseas, including by the United Kingdom's Tyndall Centre on Climate Change Research.² A recent article published in *Science* by Wallace Broecker of the Lamont-Doherty Earth Observatory of Columbia University in New York also called for the use of long-term carbon budgets (Broecker 2007a).

Carbon budgets are appealing because they can take into account the cumulative nature of greenhouse gas pollution. The most important greenhouse gases have long atmospheric lifetimes. As a result, these gases will accumulate in the atmosphere if the quantity of emissions exceeds the rate at which they are naturally absorbed or removed. This is what is currently occurring and it is the primary cause of the climate change the Earth has experienced over the past century (IPCC 2007a).

Targets that are based on reducing annual emissions by a specific amount by a certain date in the future may not adequately constrain emissions in the period prior to the target date. This could result in the cumulative emissions exceeding the bounds that are necessary to minimise the risks associated with global warming. Carbon budgets address this issue by setting a limit on the total emissions over a given period of time rather than merely providing a target at a specific date.

This paper calculates five 21st century carbon dioxide (CO₂) budgets for Australia based on targets of stabilising the atmospheric concentration of CO₂ at 450, 550, 650, 800 and 1,000 parts per million (ppm) (the 450, 550, 650, 800 and 1,000 ppm budgets respectively). The purpose of this paper is to analyse the rate at which these budgets are being consumed and the trajectory that Australia's emissions would have to take in order to stay within the budgets.

The paper is set out as follows. Section 2 provides an overview on the notion of dangerous climate change and discusses possible atmospheric CO₂ stabilisation targets that could be used to guide greenhouse policy. Section 3 uses five different stabilisation targets to calculate five separate CO₂ budgets and analyses the rate at which these budgets are currently being consumed. Section 4 discusses the implications of the analysis.

² See, for example, Bows *et al.* (2006), Gilbert and Reece (2006) and Preston and Jones (2006).

2. Avoiding dangerous climate change

The objective of the United Nations Framework Convention on Climate Change (UNFCCC) is to achieve:

... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.³

Although the UNFCCC was adopted in 1992 and came into force in March 1994, there is still no international consensus on what constitutes dangerous anthropogenic climate interference.⁴ This is partly due to political factors and partly due to the scientific uncertainty surrounding the magnitude and nature of anthropogenic influences on the atmosphere.

Despite the uncertainty, many scientists and policy institutions have suggested that it may be necessary to limit the increase in the global average surface temperature to 2°C on pre-industrial levels in order to avoid serious adverse impacts.⁵ The EU endorsed this suggested target as far back as 1996.⁶ In February 2007, the European Parliament reiterated that the EU's strategy on climate change should be based on two objectives:

- limiting average global temperature increase to 2°C above pre-industrialisation levels; and
- reducing emissions from industrialised countries by 30 per cent on 1990 levels by 2020 'with a view to achieving a reduction in the order of 60 to 80% by 2050'.⁷

The 2001 third assessment report of the Intergovernmental Panel on Climate Change (IPCC) suggested that in order to limit the global average surface temperature increase to 2°C, it is likely to be necessary to restrict the atmospheric concentration of CO₂ to approximately 400 parts per million (ppm) (roughly 450 ppm carbon dioxide equivalent (CO₂-e)) (IPCC 2001).⁸ Although stabilisation at this level would reduce the risks

³ UNFCCC, Article 2.

⁴ See Preston and Jones (2006) for a more comprehensive literature review on the attempts to define the maximum temperature increases and/or atmospheric CO₂ levels that are consistent with preventing dangerous climate change.

⁵ See, for example, Schellnhuber *et al.* (2006), RCEP (2000) and Anderson *et al.* (2005). Hansen *et al.* (2007) suggest that it may even be necessary to limit the increase in the global average surface temperature to 1.7°C on pre-industrial levels to prevent dangerous climate change.

⁶ European Council, 1939th Meeting, Luxembourg, 25 June.

⁷ European Parliament, *Resolution on Climate Change*, 14 February 2007, Res. No. B6-0045/2007.

⁸ Carbon dioxide equivalent (CO₂-e) is a measure that compares the warming effect of emissions of the six major greenhouse gases (i.e. CO₂, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride). To calculate CO₂-e, global warming potentials (GWPs) are used, which measure the relative warming effect of a unit mass of the relative gas against the same mass of CO₂ over a specific period (typically 100 years). For details of the approximate ratios between atmospheric concentrations of CO₂ and CO₂-e, see Elzen and Meinshausen (2005) or Stern (2007).

associated with climate change, data from the report indicated there would still be a 40 per cent chance the average temperature increase would exceed 2°C (Meinshausen 2006).

More recent research suggests that the atmospheric concentration of CO₂ may have to be stabilised at levels significantly below 400 ppm (450 ppm CO₂-e) to meet the 2°C target. The Hadley Centre for Climate Change Prediction and Research in the United Kingdom has estimated that with stabilisation at 450 ppm CO₂-e, there is a 78 per cent chance that the average surface temperature increase will exceed 2°C on pre-industrial levels (Stern 2007). Similarly, the fourth assessment report of the IPCC states that:

[s]tabilisation of atmospheric greenhouse gases below about 400 ppm CO₂ equivalent is required to keep the global temperature increase likely less than 2°C above pre-industrial temperature (IPCC 2007a, p. 828).⁹

A stabilisation target of 400 ppm CO₂-e roughly equates to a CO₂ only target of 350 – 375 ppm. In 2005, the atmospheric concentration of CO₂ had already reached 379 ppm and it is growing at a rate of around 1.9 ppm per annum (IPCC 2007a). With each passing year, the probability of the average temperature increase being kept below 2°C declines.

Although there is a considerable amount of support for the notion that preventing dangerous climate change will necessitate limiting the increase in the global average surface temperature to 2°C on pre-industrial levels, a number of atmospheric stabilisation targets have been proposed that are inconsistent with this objective. For example, the Royal Commission on Environmental Pollution in the United Kingdom has recommended stabilising the atmospheric concentration of CO₂ at or below 550 ppm (RCEP 2000). Using this as its basis, the Government of the United Kingdom has adopted a target of reducing emissions by 60 per cent on 2000 levels by 2050.

Table 1 shows data from the IPCC's third assessment report concerning the increase in the global average surface temperature above pre-industrial levels that is likely to be associated with atmospheric CO₂ stabilisation levels ranging between 450 and 1,000 ppm.¹⁰ The evidence suggests that if the atmospheric concentration of CO₂ is stabilised at 550 ppm, there is a significant risk the global average surface temperature will increase by more than 3°C above pre-industrial levels by the end of the 21st century and by more than 4°C in the long-term. Preston and Jones (2006) note that if the atmospheric concentration of CO₂ reaches 550 ppm, there is even a 10 – 20 per cent chance the global average surface temperature will increase by 5°C above pre-industrial levels at equilibrium.

⁹ 'Likely' in this context refers to a greater than 66 per cent chance of occurring.

¹⁰ Table 1 is based on the IPCC (2001) estimates, which evaluate the likely increase in the global average surface temperature above 1990 levels. These estimates were adjusted to provide an approximation of the likely increase on pre-industrial levels by assuming a global mean temperature increase to 1990 of 0.5°C.

Table 1 Temperature increase at 2100, 2300 and equilibrium associated with different CO₂ stabilisation levels

Stabilisation level (ppm CO ₂)	Change by 2100 (°C)	Change by 2300 (°C)	Change at equilibrium (°C)
450	1.7 – 2.8	2.0 – 3.4	2.0 – 4.4
550	2.0 – 3.4	2.3 – 4.3	2.5 – 5.7
650	2.2 – 3.7	2.7 – 5.1	2.9 – 6.6
750	2.3 – 3.8	3.1 – 5.7	3.3 – 7.5
1,000	2.5 – 4.0	3.6 – 6.8	4.0 – 9.2

Source: IPCC (2001).

The Stern Review on the Economics of Climate Change (Stern 2007) proposed a target of limiting the atmospheric concentration of greenhouse gases to between 450 and 550 ppm CO₂-e (roughly 400 to 475 ppm CO₂). Table 2 shows the IPCC's most recent assessment of the increase in the global average surface temperature at equilibrium that is likely to be associated with different CO₂-e stabilisation levels ranging from 350 to 1,200 ppm.

Table 2 Temperature increase at equilibrium associated with different CO₂-e stabilisation levels

Stabilisation level (ppm CO ₂ -e)	Best guess (°C)	Very likely above (°C)	Likely in the range (°C)
350	1.0	0.5	0.6 – 1.4
450	2.1	1.0	1.4 – 3.1
550	2.9	1.5	1.9 – 4.4
650	3.6	1.8	2.4 – 5.5
750	4.3	2.1	2.8 – 6.4
1,000	5.5	2.8	3.7 – 8.3
1,200	6.3	3.1	4.2 – 9.4

Source: IPCC (2007a).

If the atmospheric concentration of greenhouse gases is stabilised at 450 ppm CO₂-e, which is at the bottom of the range suggested in the Stern Review, the IPCC's 'best guess' is that the global average surface temperature will rise by around 2.1°C, with a likely range of between 1.4 – 3.1°C. At 550 ppm CO₂-e, the best guess is an average temperature rise of 2.9°C (range 1.9 – 4.4°C). At 1,200 ppm CO₂-e, the best guess is an average temperature rise of 6.3°C (range 4.2 – 9.4°C).

The evidence suggests that if the global average surface temperature increases by more than 2°C on pre-industrial levels, there are likely to be significant adverse impacts,

including a reduction in water availability and increased drought in mid-latitude and semi-arid low latitude regions, hundreds of millions of people exposed to increased water stress, the loss of species and unique ecosystems (for example, most coral reefs are expected to be bleached), increased bushfire risk, reduced agricultural productivity in some regions, increased extreme weather events and increased risks to human health (IPCC 2007b). If the global average surface temperature increases by more than 3°C, the grounds for concern rise substantially, particularly due to the risk of the terrestrial biosphere switching from a sink to a net source of carbon and the potential for large-scale, high impact events like the collapse of icesheets leading to dramatic increases in sea-levels (IPCC 2001; 2007b; Hansen *et al.* 2007).

Given this situation, it seems that preventing dangerous anthropogenic interference with the climate system is becoming increasingly unlikely. However, in order to minimise the risks associated with human-induced climate change, the evidence indicates that the atmospheric concentration of CO₂ should be stabilised at or below 450 ppm CO₂ (500 ppm CO₂-e). This was confirmed in a recent study published in *Atmospheric Chemistry and Physics*, which states that ‘a CO₂ level exceeding ~ 450 ppm is almost surely dangerous’ (Hansen *et al.* 2007, p. 2306). Stabilisation targets above 450 ppm CO₂ are not only likely to result in higher costs, but there is also a greater range of uncertainty associated with the likely impacts. Notwithstanding these issues, it may be necessary for a higher global stabilisation target to be adopted to account for economic and political factors. If there is widespread opposition to a 450 ppm CO₂ target, the Royal Commission on Environmental Pollution’s recommendation of an upper limit of 550 ppm CO₂ may be the best alternative.

3. Australia’s carbon dioxide budget for the 21st century

As explained, carbon budgets are an appealing method of determining national emission allowances because they set limits on the total quantity of emissions over a specific period. The emission limitations that are prescribed for the Annex B countries under the Kyoto Protocol are a type of carbon budget. An obvious deficiency of these budgets is that they only constrain emissions over the period 2008 – 2012; there are no limits on Annex B country emissions prior to this date. More comprehensive carbon budgets would restrict emissions from the time they are set through to the end of the relevant commitment period.

The benefits of comprehensive, long-term carbon budgets are not confined to their capacity to provide greater certainty in relation to environmental outcomes. They could also help reduce economic uncertainty and facilitate long-term planning and investment.¹¹ Further, a comprehensive network of national carbon budgets could work in conjunction with an international emissions trading scheme, which would allow emission abatement to be achieved in an efficient manner.

¹¹ Flexibility concerns could be accommodated by devising a process for adding or withdrawing allocations from the national budgets in accordance with scientific recommendations.

Five illustrative Australian CO₂ budgets for the 21st century have been calculated for this paper on the basis of atmospheric CO₂ stabilisation targets of 450, 550, 650, 800 and 1,000 ppm. The 450 ppm budget is based on the assumption that Australia and the rest of the international community remain committed to the objective of preventing dangerous climate change, or at least minimising the risks associated with global warming. The 550 ppm budget assumes that the international community has accepted a higher target because of political and economic factors, but that it still wants to keep climate-related risks at the lower end of the spectrum. The 650, 800 and 1,000 ppm budgets are included to enable a comparison if these prevention and risk minimisation objectives are abandoned.

There are many different approaches that the international community could take to stabilise the atmospheric concentration of greenhouse gases at any given level. The approach that is adopted internationally, and in particular the way in which emission allowances are allocated between countries, will determine the quantity of greenhouse gases (including CO₂) that Australia should aim to emit over the coming century.

The method used to determine the budgets involved three steps:

- (a) determine the cumulative global CO₂ emissions over the 21st century that are likely to be necessary to stabilise the atmospheric concentration of CO₂ at 450, 550, 650, 800 and 1,000 ppm;
- (b) divide the results in (a) by the world population in 2000 to provide global per capita CO₂ allocations for the 450, 550, 650, 800 and 1,000 ppm targets; and
- (c) multiply the results in (b) by Australia's population in 2000 to provide the 450, 550, 650, 800 and 1,000 ppm budgets.¹²

This approach was adopted because it is transparent, does not rely on projections of future population levels and takes into account equity considerations.¹³ Developing countries could object to this approach on the grounds that it does not account for the large quantity of emissions from developed countries prior to 2001. Another possible objection is that a significant number of developing countries are still experiencing rapid population growth and they will be disadvantaged if allocations are made on the basis of 2000 population levels. These are valid points. However, several developed countries, including the United States and Australia, are currently strongly opposed to schemes that would compromise the competitiveness of their trade-exposed industries. Any scheme that provides significant preferential treatment to developing countries is therefore likely to face considerable opposition. Given the competing claims of developed and developing countries, the method that was chosen, which determines emission allowances

¹² This method is consistent with that suggested by Broecker (2007).

¹³ The determination of national budgets on this basis is likely to be consistent with the so-called 'contraction and convergence' method of allocating emission allowances. Global emission levels would be reduced (contraction) and per capita emission levels should gradually be equalised amongst developed and developing countries (convergence) over the 21st century.

on per capita basis, represents a fair and reasonable approach to estimating Australia's 21st century CO₂ budget.

There is considerable uncertainty regarding the emission constraints that are necessary to ensure the atmospheric concentration of CO₂ is stabilised at any particular level.¹⁴ Data in the IPCC's fourth assessment report indicate that to stabilise the atmospheric concentration of CO₂ at 450 ppm, cumulative global emissions over the 21st century should be kept to approximately 490 billion tons of carbon (Gt C) (with a range of 375 to 600 Gt C) (1,800 [1,370 to 2,200] Gt CO₂).¹⁵ In order to stabilise at 1,000 ppm CO₂, the data suggest cumulative 21st century emissions should be 1,100 Gt C (980 to 1,250 Gt C) (4030 [3590 to 4580] Gt CO₂).¹⁶ The high range estimates in the fourth assessment report were derived using the BERN2.5CC carbon cycle EMIC¹⁷ and they indicate that cumulative global emissions for the 21st century should be kept to between 596 Gt C (2,187 Gt CO₂) and 1,236 Gt C (4,536 Gt CO₂) for CO₂ stabilisation targets ranging from 450 to 1,000 ppm.¹⁸ Unlike some other estimates, these approximations from the fourth assessment report take into account land and ocean carbon cycles and the potential for natural carbon sinks to weaken with climate change.

Based on the latest IPCC data, it is assumed that the global CO₂ emission budgets for the 450, 550, 650, 800 and 1,000 ppm scenarios are 2,200, 2,600, 3,050, 3,700 and 4,500 Gt CO₂ respectively. These estimates are conservative as there is evidence suggesting the global 100-year CO₂ budgets may have to be significantly lower to stabilise the atmospheric concentration of CO₂ at these levels.¹⁹ It is also assumed that the international community does not intend to overshoot the stabilisation targets (i.e. exceed

¹⁴ For debate about this issue in the context of carbon budgets, see Broecker (2007a; 2007b) and Wigley (2007). See also IPCC (2007a).

¹⁵ One Gt C corresponds to 3.67 Gt CO₂.

¹⁶ See IPCC (2007a, pp. 16 and 789 – 793).

¹⁷ See Joos *et al.* (2001) and Plattner *et al.* (2001) for details of the BERN2.5CC carbon cycle EMIC.

¹⁸ See IPCC (2007a, pp. 789 – 793). Total cumulative emissions could continue to increase beyond 2100 while still stabilising CO₂ concentrations at levels between 450 and 1,000 ppm (even assuming no overshoot). However, annual global emissions would have to be reduced or at the very least stabilised, depending on the atmospheric stabilisation target. For example, data in the IPCC's fourth assessment report that were derived using the BERN2.5CC carbon cycle EMIC indicate that for stabilisation at 450 ppm CO₂, cumulative emissions over the period 2000 – 2300 should be 933 Gt C. If global emissions remain within the budget for the 21st century, this suggests that average global emissions for the following 200 years would have to be approximately 1.6 Gt C per annum (6.2 Gt CO₂). Current global emissions are approximately 9 Gt C per annum. For stabilisation at 1,000 ppm, the IPCC report suggests that cumulative emissions between 2000 – 2300 should be 3,052 Gt C. This implies that average global emissions would have to be 9.08 Gt C per annum (33 Gt CO₂) over the period 2100 – 2300.

¹⁹ The Stern Review (2007) discusses modelling undertaken by the Hadley Centre that suggests the 100-year CO₂ budget may have to be significantly lower (around 1,600 Gt CO₂) to be compatible with stabilisation at 450 ppm CO₂. The modelling by the Hadley Centre and similar research by other institutions is discussed in the IPCC's fourth assessment report (IPCC 2007a, pp. 16 and 789 – 793). See also Broecker (2007a; 2007b) and Wigley (2007). Although the BERN2.5CC carbon cycle EMIC estimates are higher than those found in a number of other studies, they were adopted to ensure conservative outputs.

the stabilisation targets for a short period before reducing the atmospheric concentration of CO₂ to the desired level).

The United Nations Statistics Division's *National Accounts Main Aggregates Database* (UNSD 2007) indicates that in 2000 the world population was 6,085,801,318 and the population of Australia was 19,071,458.

Using these data provides the estimates outlined in Table 3.

Table 3 Australia's 450, 550, 650, 800 and 1,000 ppm budgets for the 21st century

Stabilisation target	Global CO ₂ budget (Gt CO ₂)	Global per capita CO ₂ allocation (t CO ₂)	Australian CO ₂ budget (Mt CO ₂)*
450 ppm	2,200	361.5	6,894
550 ppm	2,600	427.2	8,148
650 ppm	3,050	501.2	9,558
800 ppm	3,700	608.0	11,595
1,000 ppm	4,500	739.4	14,101

* Mt = million tons

Australia's CO₂ emissions over the five year period 2001 – 2005 and the proportion of the budgets consumed over this period are shown in Table 4.²⁰

Table 4 Australia's CO₂ emissions from 2001 to 2005 and the annual rate of consumption of the 450, 550, 650, 800 and 1,000 ppm budgets (per cent)

Year	CO ₂ emissions (Mt)	450 ppm budget (per cent)	550 ppm budget (per cent)	650 ppm budget (per cent)	800 ppm budget (per cent)	1,000 ppm budget (per cent)
2001	363.3	5.27	4.46	3.80	3.13	2.58
2002	369.0	5.35	4.53	3.86	3.18	2.62
2003	356.2	5.17	4.37	3.73	3.07	2.53
2004	374.5	5.43	4.60	3.92	3.23	2.66
2005	377.4	5.47	4.63	3.95	3.25	2.68
Total	1,840.4	26.70	22.59	19.26	15.87	13.05

Source: DEWR (2007).

²⁰ The UNFCCC emission figures were used rather than those calculated in accordance with the Kyoto Protocol requirements. The UNFCCC figures were preferred because they provide a more comprehensive account of Australia's contribution to the accumulation of CO₂ in the atmosphere. The Federal Government has not yet released the emission estimates for 2006 or 2007.

The 450 ppm budget

In the first five years of the 21st century, Australia consumed approximately 27 per cent of the 450 ppm budget. Each year, a further five per cent of the 450 ppm budget is being consumed. If annual CO₂ emissions remain at 2005 levels (approximately 377 Mt CO₂), the entire 450 ppm budget will be exhausted by 2019. Further, approximately 54 per cent of the 450 ppm budget will be consumed by 2010, which appears to be the earliest possible date for the commencement of the proposed national emissions trading scheme.²¹ This would leave 46 per cent of the budget to be spread over 90 years. To remain within the budget over this 90-year period, average annual CO₂ emissions will have to fall to approximately 35 Mt CO₂, 91 per cent below 2005 levels.

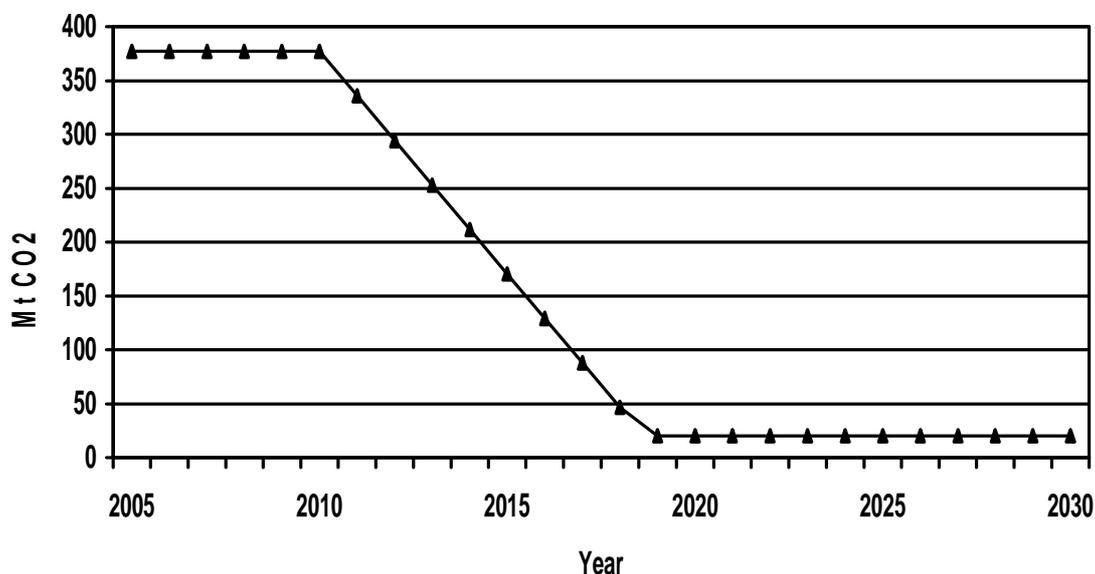
Figure 1 shows the type of trajectory that CO₂ emissions would have to follow between now and 2030 in order to stay within the 450 ppm budget if nothing is done to reduce emissions until 2010. This trajectory assumes annual emissions over the period 2006 – 2010 of 377 Mt CO₂ and that emissions follow a linear path towards stabilisation at 20 Mt CO₂ per annum (five per cent of 2005 levels) at the latest possible date while staying within the budget.

By 2015, CO₂ emissions would have to be approximately 55 per cent below 2005 levels. From 2019 to the end of the century, CO₂ emissions would have to be 95 per cent below 2005 levels.²²

²¹ See Howard (2007).

²² It may be possible for Australia to meet any international obligations based on a national carbon budget by acquiring surplus emission credits from other countries. Whether this is viable will depend upon the availability and price of surplus emission credits. The international community may also give developed countries like Australia a greater proportion of the global CO₂ budget than would be allocated under a per capita system.

Figure 1 Trajectory of CO₂ emissions between now and 2030 to stay within the 450 ppm budget



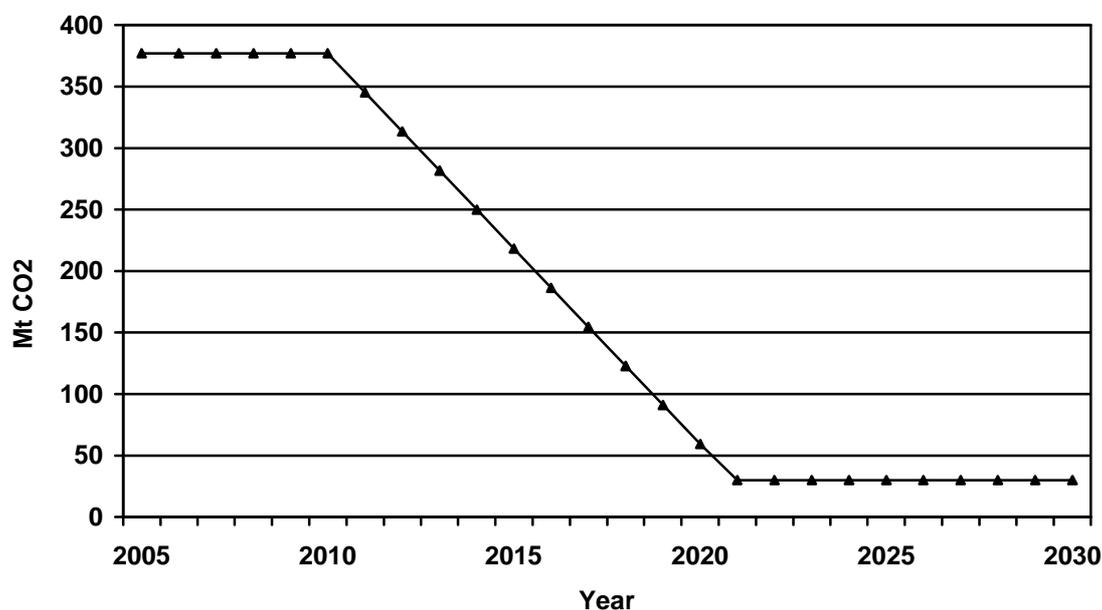
The 550 ppm budget

Between 2001 and 2005, Australia consumed 23 per cent of the 550 ppm budget. If emissions remain at 2005 levels, 46 per cent of the budget will be consumed by 2010 and the entire budget will be exhausted by 2022. To remain within the budget after 2010, annual emissions would have to average 49 Mt CO₂ for the remainder of the 21st century, approximately 87 per cent below 2005 levels.

Figure 2 shows the type of trajectory that CO₂ emissions would have to follow between now and 2030 in order to stay within the 550 ppm budget if nothing is done to reduce emissions until 2010. This trajectory assumes annual emissions over the period 2006 – 2010 of 377 Mt CO₂ and that emissions follow a linear path towards stabilisation at 30 Mt CO₂ per annum (eight per cent of 2005 levels) at the latest possible date while staying within the budget.

By 2015, CO₂ emissions would have to be approximately 42 per cent below 2005 levels. From 2021 to the end of the century, CO₂ emissions would have to be more than 90 per cent below 2005 levels.

Figure 2 Trajectory of CO₂ emissions between now and 2030 to stay within the 550 ppm budget



The 650, 800 and 1,000 ppm budgets

Between 2001 and 2005, Australia consumed approximately 19 per cent of the 650 ppm budget, 16 per cent of the 800 ppm budget and 13 per cent of the 1,000 ppm budget. At 2005 emission levels, between 2.5 – 4 per cent of these budgets is being consumed each year. If emissions remain at 2005 levels until 2010, 39 per cent of the 650 ppm budget, 32 per cent of the 800 ppm budget and 26 per cent of the 1,000 ppm budget will be consumed. Further, if annual emissions remain at 377 Mt CO₂, the 650, 800 and 1,000 ppm budgets will be exhausted by 2026, 2031 and 2038 respectively.

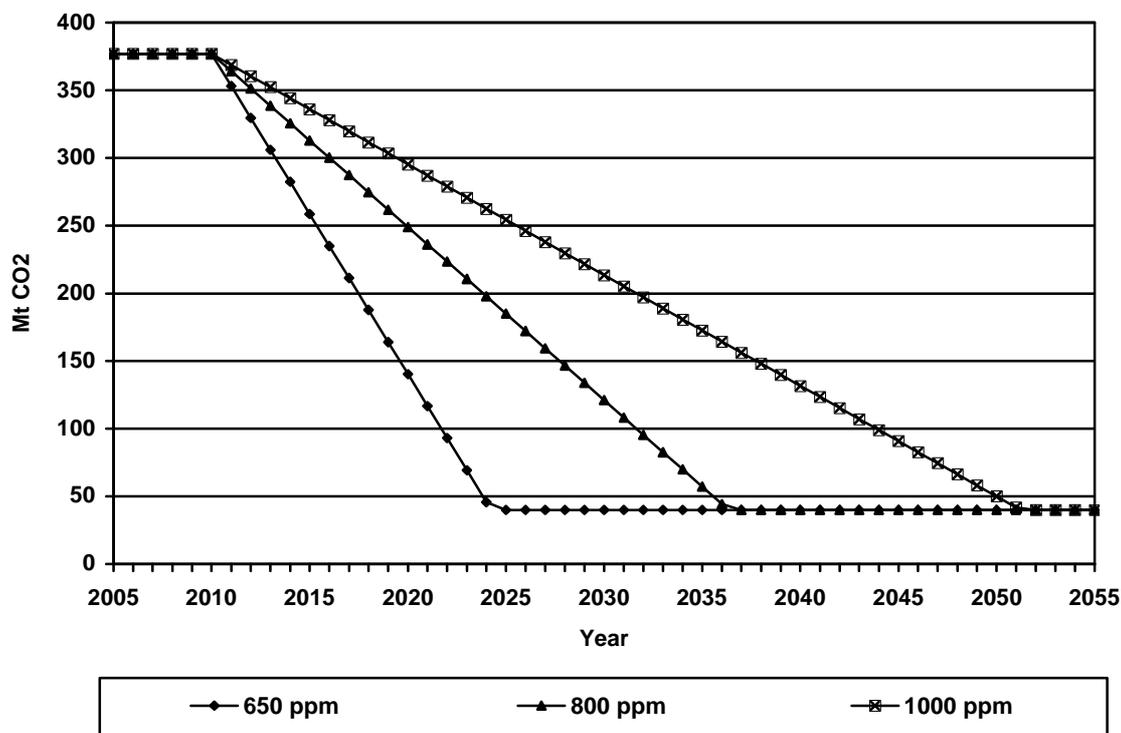
Figure 3 shows the type of trajectory that CO₂ emissions would have to follow between now and 2055 in order to stay within the 650, 800 and 1,000 ppm budgets if nothing is done to reduce emissions until 2010. These trajectories assume annual emissions over the period 2006 – 2010 of 377 Mt CO₂ and that emissions follow a linear path towards stabilisation at 40 Mt CO₂ per annum (approximately 10 per cent of 2005 levels) at the latest possible date while staying within the budget.

Deep cuts are necessary in the short-term to stay within the 650 and 800 ppm budgets. For the 650 ppm budget, emissions would have to be 31 per cent below 2005 levels by 2015, 63 per cent below by 2020 and 90 per cent below by 2025. To stay within the 800 ppm budget, emissions would have to be 34 per cent below 2005 levels by 2020, 68 per cent below by 2030 and 90 per cent below by 2037.

The 1,000 ppm budget provides greater leeway in the short-term, but emissions would still have to be reduced significantly prior to 2050. To stay within the budget, emissions

would have to be 22 per cent below 2005 levels in 2020, 44 per cent below in 2030, 65 per cent below in 2040 and 90 per cent below by 2052.

Figure 3 Trajectory of CO₂ emissions between now and 2030 to stay within the 1,000 ppm budget



4. Implications

The five budgets illustrate the magnitude of the task facing Australia if it is to meaningfully address the risks associated with climate change.

The evidence suggests that the atmospheric concentration of CO₂ should be stabilised at around 450 ppm in order to minimise the risks associated with global warming. However, in just five years, Australia has consumed approximately 27 per cent of the 450 ppm budget. By 2010, approximately 54 per cent of the 450 ppm budget will be consumed and, if emissions remain at current levels, the entire budget will be exhausted by 2019. To stay within the 450 ppm budget, Australia's CO₂ emissions would have to be reduced by approximately 55 per cent on 2005 levels by 2015 and 95 per cent by 2020.

Although the science suggests the atmospheric concentration of CO₂ should be stabilised at around 450 ppm to minimise the risks associated with climate change, for political and economic reasons it has been argued that a 550 ppm CO₂ target should be pursued. Yet by 2010, Australia is likely to have consumed at least 46 per cent of the 550 ppm budget,

leaving 54 per cent to be distributed over 90 years. To stay within the 550 ppm budget, CO₂ emissions would have to be approximately 42 per cent below 2005 levels by 2015. From 2021 to the end of the century, CO₂ emissions would have to be more than 90 per cent below 2005 levels.

The extent to which Australia's current emission levels are unsustainable is demonstrated by the 650, 800 and 1,000 ppm budgets. By 2010, approximately 39 per cent of the 650 ppm budget, 32 per cent of the 800 ppm budget and 26 per cent of the 1,000 ppm budget are likely to have been consumed. To stay within the 650 and 800 ppm budgets, emissions would have to be reduced significantly between now and 2020. Remaining within the 1,000 ppm budget would require emission cuts in the order of 22 per cent on 2005 levels by 2020, 44 per cent by 2030, 65 per cent by 2040 and 90 per cent by 2052.

The greenhouse debate in Australia currently appears to be detached from the realities of the climate science. The Federal Government has accused the Opposition of being fanatical for proposing a target of reducing emissions by 60 per cent by 2050 on 2000 levels (ABC 2007). It also accused the Opposition spokesperson on the environment, Peter Garrett, of being economically irresponsible for discussing an aspirational target of reducing emissions by 20 per cent by 2020 (Howard 2007). When measured against the science, these types of targets appear extremely conservative. Greater attention will have to be paid to the science in decision-making processes if Australia is going to actively pursue the objective of minimising the risks associated with climate change.

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