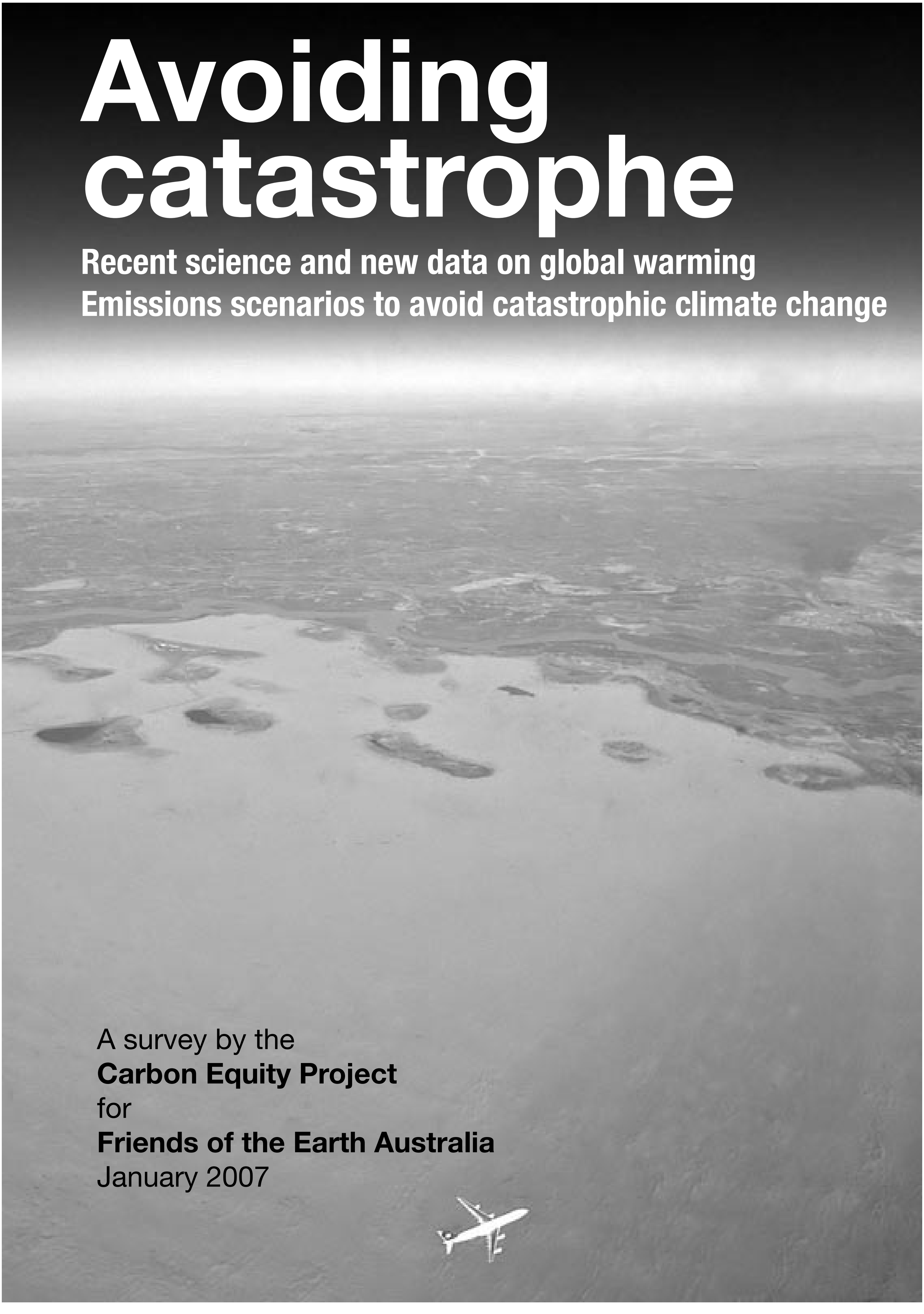
Avoiding catastrophe

Recent science and new data on global warming
Emissions scenarios to avoid catastrophic climate change



A survey by the
Carbon Equity Project
for
Friends of the Earth Australia
January 2007

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EXECUTIVE SUMMARY

The global mean temperature rise has been 0.8℃ since the late 1880s, but due to "thermal imbalance" there is a latent temperature rise still to come of about 0.6℃, which will result in a rise of 1.4℃ for the present level of atmospheric greenhouse gases.

This rise is sufficient to destroy most of the world's coral reefs, including the Great Barrier Reef, and the destruction of the Arctic floating ice is considered inevitable, with dramatic consequences for the stability of the Greenland ice sheet, which is likely to begin irreversible melting at less than 2°C of warming and is almost certain at less than 3°C, resulting in an eventual sea level rise of seven metres.

Recent research on feedback mechanisms suggests that the greatest effect may be changes in the long-term functioning of the carbon cycle: diminishing carbon sinks (both soil and ocean) and the release of long-stored greenhouse gases (permafrost methane) may combine to increase global temperatures at a rising rate.

It is widely considered that warming should be kept below 2°C to avoid triggering irreversible, dangerous climate change, but that figure is now very difficult to avoid. At 450 ppm CO2e, which will be achieved in less than ten years, there is an 26-78% chance of exceeding 2°C and a minimum 3% chance of triggering runaway greenhouse heating. At 550 ppm CO2e, which is the Stern review target, there is a minimum 24% chance of triggering runaway greenhouse heating.

The world has only a decade to take strong measures to avoid triggering irreversible, dangerous climate change. New research is increasingly sombre; many key climate change events are happening more rapidly or sooner than expected; atmospheric carbon level rises are higher than expected and emissions rising at an increasing rate.

The world is now annually producing double the atmospheric carbon that the earth's carbon sinks can absorb. If emissions continue on their present path, by 2030 the world will be producing five times the biosphere's carbon sinks capacity and catastrophic climate change will be unavoidable.

The current greenhouse gas levels pose an unacceptably high risk of damage to nature and an unacceptably high risk of triggering runaway heating and must be reduced from their current level of 430 ppm. This requires carbon emissions to be substantially less that the earth's carbon sink capacity, so that atmospheric carbon dioxide levels can be drawn down substantially. This report shows that Australia needs to:

- immediately stabilize emissions at their current level;
- set a target of reducing total emissions by over 90% by 2030; and
- set an annual and enforceable reduction target of 4–5%.

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Cover photo: desertification, Mongolia

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First published January 2007

INTRODUCTION

"The science of climate change has never been clearer... Without further action, scientists now estimate we may be heading for temperature rises of at least three to four degrees above pre-industrial levels.. We have a window of only 10 to 15 years to avoid crossing catastrophic tipping points…" Letter to European leaders by the British and Dutch prime ministers, Tony Blair and Jan Peter Balkenende, October 2006.

*"**Global warming appears to be pushing vast reservoirs of ice on Greenland and Antarctica toward a significant, long-term meltdown. The world may have as little as a decade to take the steps to avoid this scenario. Those are the implications of new studies*** (published in *Science* on 24 March 2006) ***that looked to climate history for clues about how the planet's major ice sheets might respond to human-triggered climate change**.*" (Spotts 2006)

Leading climate scientists and political figures including Sir Nicholas Stern, Dutch prime minister Jan Peter Balkenende, former US vice-president Al Gore, NASA atmospheric research chief Professor James Hansen and the eminent British climatologist Sir John Houghton all warn that unless decisive action to halt global carbon emissions is taken in the next decade, it may simply be too late and the trigger point for irreversible, dangerous climate change will have passed. Even stringent actions after that time will not be able to stop a climate system charged with strong feedback mechanisms running away from our capacity to control it.

Anthropogenic greenhouse gas emissions, particularly over the last fifty years, have made us the masters of climate change, but if we go on as we are there will be a swift inversion in which climate change becomes the master of our destiny.

A recent report by Christian Aid and EcoEquity concludes that: "the pace of our response has been profoundly inadequate... and the science now tells us that we’re pushing beyond mere ‘*dangerous* anthropogenic interference with the climate system,’ and are rather on the verge of committing to *catastrophic* interference. Given the slow progress to date, a heroic effort will now be required to have a high likelihood of averting a climate catastrophe" (Athanasiou et. al. 2006).

James Hansen, Director of NASA's Goddard Institute for Space Studies, and one of the world's most eminent climate scientists, says that "we must close that gap (between the science and the policy-makers) and begin to move our energy systems in a fundamentally different direction within about a decade, or we will have pushed the planet past a tipping point beyond which it will be impossible to avoid far-ranging undesirable consequences". Global warming of two to three degrees, he warns, would produce a planet without Arctic sea ice, a catastrophic sea level rise in the pipeline of around 25 metres, and a super-drought in the American west, southern Europe, the Middle East and parts of Africa. "Such a scenario threatens even greater calamity, because it could unleash positive feedbacks such as melting of frozen methane in the Arctic, as occurred 55 million years ago, when more than ninety per cent of species on Earth went extinct" (Hansen 2006b).

In 2006, predictions on the final demise of the Arctic's floating ice were brought forward from 2080-2100 to 2030-40. The melting of the floating ice around the north pole is now considered unstoppable. The polar bear's only habitant will be the zoo. Data presented at the American Geophysical Union in December 2006 suggests that the Arctic may be free of all summer ice by as early as 2030, "a positive feedback loop with dramatic implications for the entire Arctic region" according to Dr Marika Holland, because the Earth would lose a major reflective surface and so absorb more solar energy, potentially accelerating climatic change across the world (Amos 2006). "Our hypothesis is that we've reached the tipping point," says Ron Lindsay of the University of Washington in Seattle. "For sea ice, the positive feedback is that increased summer melt means decreased winter growth and then even more melting the next summer, and so on" (Connor and McCarthy 2006). With no ice, the Arctic region will rapidly begin heating, perhaps by as much as 12 degrees, putting further pressure on the Greenland icecap (Flannery 2006). Global warming so far has been greatest in the high latitudes of the northern hemisphere, particularly in the sub-Arctic boreal forests of Siberia and North America (Pearce 2006a), with severe implications for the rate at which vast quantities of methane held in the Siberian permafrost will be released into the atmosphere, driving the level of greenhouse upwards.

New research and analysis, in part motivated by the preparatory phase of the 2007 report of the International Panel on Climate Change, is increasingly sombre. Events are happening more rapidly or sooner than expected, atmospheric carbon level rises are higher than expected, and deeper understanding of positive feedback mechanisms is leading some climate change scientists to ring alarm bells more urgently.

This report is a survey of some recent climate change research and data, and the implications for emissions scenarios. It has been prepared by the Carbon Equity Project for Friends of the Earth Australia as part of a wider study looking at Australia's policy responses to climate change.

"The calm before the storm" (Part 1) is an overview of atmospheric carbon emissions and projections, outcomes and impacts and enquiries: when does "dangerous" climate change become catastrophic?

"Small or very large" (Part 2) surveys the impacts of positive feedback mechanisms in triggering runaway climate change in order to pose the question: adopting the precautionary principle, what is the temperature below which we should constrain global warming and what are the implications for emission levels in "Safety First" (Part 3).

"The heat is on" (Part 4) explores implications for Australia of a "safety-first" target.

Part 1: THE CALM BEFORE THE STORM

Abbreviations
ghg: greenhouse gases
ppm: parts per million
CO_2: carbon dioxide
CO_2e: Measure of all ghg in equivalent amount of CO_2
GtC gigatonne of carbon.
gigatonne = billion tonnes
1 tonne of carbon = 3.65 tonnes carbon dioxide (so X tonnes of CO_2 = X/3.65 tonnes of carbon)

"BAU involves very high risks; it is likely to imply a rise of 4-5°C or more above pre-industrial levels within the next 100 or 150 years. This is way outside human experience. At high levels of warming, less is known about how the climate will respond – very large events might happen. The last Ice Age was 5C below where we are today – such differences are transformative. Redrawing physical geography would redraw human geography; where we live, and how we can live our lives." Sir Nicholas Stern (Stern 2006a).

EMISSIONS AND PROJECTIONS

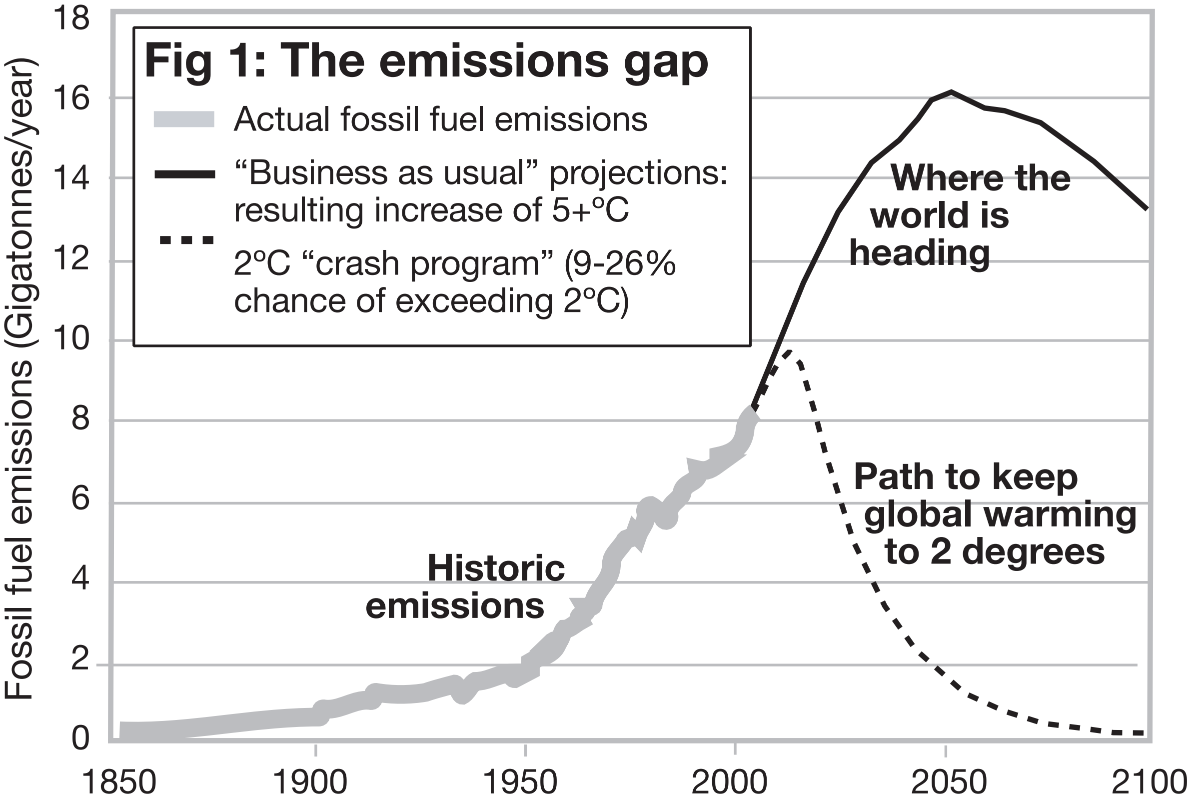
Greenhouse gases

Greenhouse gases comprise principally carbon dioxide (CO_2), but also methane, ozone and nitrous oxide. Their rate of occurrence in the atmosphere is measured in parts per million (ppm) and the effect of the different components is calculated as a carbon dioxide equivalent (CO_2e). The pre-industrial level was 280 ppm CO_2e and the anthropogenic impact (emissions as a consequence of human activity) has pushed this level now to 430 ppm CO_2e.

The measure of how much increasing levels of greenhouse gases affect temperature is known as "climate sensitivity", and this is now well-estimated at 2.8–3℃ (Jones and Preston: 36). That is, a doubling of atmospheric carbon dioxide from the the pre-industrial level of 280 ppm to 560 ppm will produce an increase of around 3℃. Each year the level of level of greenhouse gases increases about 2–2.5 ppm, so that every four–five years the temperature is being pushed up 0.1℃, but but this may rise to 3-4 ppm by mid-century if the world continues produces emissions "business as usual" (Hansen 2005a), ultimately resulting in a one degree temperature increase every 25 years.

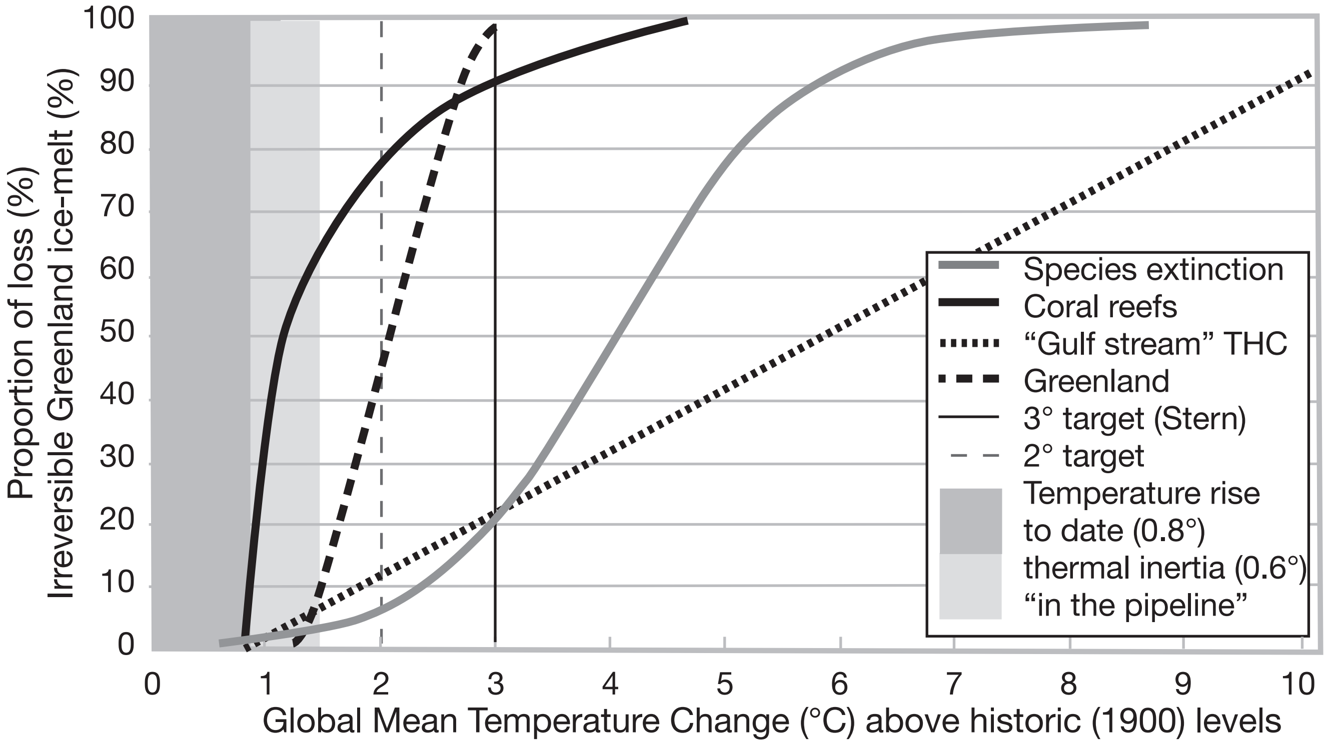
Emissions

The world is now annually producing double the atmospheric carbon that the biosphere's carbon sinks can absorb: production of 7.9 GtC (Black 2006) compared to the earth's total land and ocean carbon sink capacity (capacity to absorb carbon) of 4 GtC (Jones 2003). Emission since 1900 are charted in Figure 1.



Source: *Historic emissions/BAU path:* GCP Report No 5/2006 www.globalcarbonproject.org. BAU based on 2001 IPCC report scenario. *2ºC “crash program” path:* Athanasiou, T, S Kartha, P Baer, 2006. “Greenhouse Development Rights”, EcoEquity/Christian Aid (www.ecoequity.org)

Fig 2: Damage curves as the heat rises



Damage curves for fourkey biophysical vulnerabilities: risk of species extinction, proportion of loss of coral reefs due to thermal bleaching, slowdown in North Atlantic thermohaline circulation and the probability of commencement of irreversible melting of the Greenland ice-sheet.

Source: Adapted from Jones, R.N. and Preston, B. L. 2006: “Climate Chang Impacts, Risk and the Benefits of Mitigation: A report for the Energy Futures Forum (CSIRO Marine and Atmospheric Research)

In other words, to stabilise atmospheric CO_2 at its present levels, which are already dangerous, would require an immediate average global 50 per cent reduction in emissions.

Anthropogenic CO_2 emissions are rising at an increasing rate. Between 2000 and 2005, global emissions grew two-and-a-half times faster than in the preceding 10 years, according to the Global Carbon Project (Black 2006). Others suggest a four-fold rate of increase: from growth rates of 0.8% for 1990–1999 to 3.2% for 2000–2005 (Brahi 2006). Half of all anthropogenic emissions have been in the last 30 years, as has three-quarters of the temperature rise so far (Hansen 2006a).

Concentrations of CO_2 rose by 2.6 ppm during 2006, giving an average rise of 2.2 ppm since 2001, compared to about 1.5 ppm for 1970-2000. In a worrying development, "The spike in the last five years does not appear to match the pattern of steady increases in human emissions… the finding could indicate that global temperatures are making forests, soils and oceans less able to absorb carbon dioxide – a shift that would make it harder to tackle global warming" (Adam 2007).

With a current world population of 6.2 billion people, global atmospheric carbon emissions average 1.27 tonnes per capita; in **Australia the rate is 5.63 tonnes per capita**. In comparison, the earth's current capacity to absorb carbon is 0.62 tonnes per capita, decreasing to 0.32 by 2030**. The maths is simple and devastating: emissions need to be reduced to well below the earth's carbon sink capacity to reduce the already dangerous levels of atmospheric carbon, but just to get current emissions in Australia down to the level of the earth's current carbon sink capacity requires a cut of 90% of the current level of emissions.

[** Australian Government "National Greenhouse Gas Inventory 2004": total emissions 564.7 $MtCO_2e$, of which 73.5% were CO_2; total population 20.2 million; 1 tonne carbon = 3.65 tonnes CO_2. So 564.7m X 73.5%/20.2 X 3.65 = 5.63 tonnes of carbon emissions per head.]

Future emissions

Global CO_2 emissions, the principal component of greenhouses gases, are increasing at an average of about two per cent per year, in accordance with the worst-case "business-as-usual" (BAU) scenarios described in the third report of the International Panel on Climate Change (IPCC). This is illustrated in Figure 1. "Business as usual" is the most pessimistic of the various "scenarios" considered by the IPCC and implies that little is done to prevent increasing emissions.

CO_2 emissions are predicted to increase by 63% over 2002 levels by 2030 (IEA; DEFRA 2005) to 13–14 GtC annually; Asia's greenhouse gas emissions will treble over the next 25 years, according to a report commissioned by the Asian Development Bank (ADB 2006).

The earth's carbon sink capacity is expected to fall to 2.7 GtC by 2030 (Jones 2003) due to deceased capacity of the earth's carbon sinks due to both human activity and as a consequence of higher temperatures, so that if we continue as we are, **in another 25 years we will globally be producing five times the amount of atmospheric carbon that the earth can absorb**. This is a path to uncontrollable, runaway climate change.

The Greenhouse Office predicts Australia's emissions by 2020 will have swollen 22 per cent from their 1990 levels. Transport would be emitting 78 per cent more gases than in 1990, power generation 70 per cent more, industry 75 per cent more. ABARE predicts energy emissions will be more than 50-60 per cent higher over the next 25 years if we continue with "business as usual".

Temperature increases

The global means temperature rise has been 0.8℃ (Hansen 2006a) since the late 1880s; in Australia "annual mean temperatures have increased by approximately 0.9°C since 1910" (BOM 2007) . But some of the effects of increasing greenhouses gases on temperature are delayed and take time to work their way through the climate system; this process presently results in a "thermal imbalance" ** of about 0.6℃, so there is latent temperature rise still to come for the present level of greenhouse gases. That is, **our present level of greenhouse gases will produce a temperature rise of 1.4℃**.

[** Currently the earth has a thermal imbalance of approx 0.85 W/m2 (Watts per sq. metre) ± .15 W/m2 (Hansen 2005a:1). The forcing is approx 0.75℃ per W/m2 ± 0.25℃ (Hansen 2005b), so the imbalance is 0.85 X 0.75 = 0.6℃]

On current trends and if emissions increase as predicted, by 2025 the implied (actual plus thermal imbalance "in the system") rise will be around 2℃, comprising 1.4℃ now and "in the pipeline" plus at least another 0.4℃ (0.1℃ for every four–five years atmospheric levels increase at the current annual rate of 2–2.5 ppm, and more if that rate rises as predicted).

As a point of reference, China on 27 December 2006 released its first comprehensive scientific review on global warming, predicting rises of 1.3–2.1°C by 2020, 1.5–2.8°C by 2030 and 2.3–3.3°C by 2050. Leaks from the IPCC 2007 summary report say it is likely to foresee a rise in temperatures of 2 to 4.5°C this century, with about 3°C most likely.

The calm before the storm

Since the 1880s our greenhouse gas emissions have produced an actual rise of 0.8℃. The impacts have been significant, including the widespread changes in global climate patterns being felt around the globe and the imminent end of the Arctic floating ice, but the day-by-day impact in the developed nations has not been perceived as dangerous in the way that an approaching bush fire would. It is the calm before the storm, because in another 20 years the implied rise will be around 2℃and the consequences will be all around us as the impacts hit home, and catastrophic climate change triggered.

IMPACTS

Global warming impacts reported in the popular press in 2006 included Britain's average temperature for the year being higher than at any time since records began in 1659, little winter snow in the Alpine ski resorts, bears not hibernating, wild weather patterns, continuing droughts in Africa, mountain glaciers melting faster than at any time in the past 5000 years, algae destruction in the mid-Pacific, disappearing Arctic sea ice, ice sheet loss in Canada, and Greenland's ice sheet sliding into the sea.

Today the melting of the floating ice around the north pole is now considered unstoppable, coral reefs are under stress, glaciers are retreating, fish stocks decreasing, climate change is devastating parts of central Africa.

Amongst many impacts, at the implied total temperature rise to date of 1.4°C, two-thirds of the world's coral reefs will be lost to thermal bleaching, and there will already be a 10 per cent chance that the irreversible melting of the Greenland ice sheet (eventual seal level rise of 7 metres) will have been triggered. The likely impact of further global heating on a number of key vulnerabilities has been surveyed by the CSIRO for the Australian Energy Futures Forum (Jones and Preston 2006: 12). An annotated representation of their findings is reproduced as Figure 2.

The summary of impacts of Sir Nicholas Stern's Review on the Economics of Climate Change, is reproduced as Figure 3.

Sir Nicholas Stern's key messages on impacts in his October 2006 report are:

"Climate change threatens the basic elements of life for people around the world – access to water, food, health, and use of land and the environment. On current trends, average global temperatures could rise by 2–3°C within the next fifty years or so, leading to many severe impacts, often mediated by water, including more frequent droughts and floods.

• Melting glaciers will increase flood risk during the wet season and strongly reduce dry-season water supplies to one-sixth of the world’s population, predominantly in the Indian sub-continent, parts of China, and the Andes in South America.

• Declining crop yields, especially in Africa, are likely to leave hundreds of millions without the ability to produce or purchase sufficient food – particularly if the carbon fertilisation effect is weaker than previously thought, as some recent studies suggest. At mid to high latitudes, crop yields may increase for moderate temperature rises (2 – 3°C), but then decline with greater amounts of warming.

• Ocean acidification, a direct result of rising carbon dioxide levels, will have major effects on marine ecosystems, with possible adverse consequences on fish stocks.

• Rising sea levels will result in tens to hundreds of millions more people flooded each year with a warming of 3 or 4°C. There will be serious risks and increasing pressures for

Figure 3: Impacts of climate change on growth and development

Table 3.1 Highlights of possible climate impacts discussed in this chapter

Temp rise (°C)	Water	Food	Health	Land	Environment	Abrupt and Large-Scale Impacts
1°C	Small glaciers in the Andes disappear completely, threatening water supplies for 50 million people	Modest increases in cereal yields in temperate regions	At least 300,000 people each year die from climate-related diseases (predominantly diarrhoea, malaria, and malnutrition) Reduction in winter mortality in higher latitudes (Northern Europe, USA)	Permafrost thawing damages buildings and roads in parts of Canada and Russia	At least 10% of land species facing extinction (according to one estimate) 80% bleaching of coral reefs, including Great Barrier Reef	Atlantic Thermohaline Circulation starts to weaken
2°C	Potentially 20 - 30% decrease in water availability in some vulnerable regions, e.g. Southern Africa and Mediterranean	Sharp declines in crop yield in tropical regions (5 - 10% in Africa)	40 – 60 million more people exposed to malaria in Africa	Up to 10 million more people affected by coastal flooding each year	15 – 40% of species facing extinction (according to one estimate) High risk of extinction of Arctic species, including polar bear and caribou	Potential for Greenland ice sheet to begin melting irreversibly, accelerating sea level rise and committing world to an eventual 7 m sea level rise Rising risk of abrupt changes to atmospheric circulations, e.g. the monsoon Rising risk of collapse of West Antarctic Ice Sheet Rising risk of collapse of Atlantic Thermohaline Circulation
3°C	In Southern Europe, serious droughts occur once every 10 years 1 - 4 billion more people suffer water shortages, while 1 – 5 billion gain water, which may increase flood risk	150 - 550 additional millions at risk of hunger (if carbon fertilisation weak) Agricultural yields in higher latitudes likely to peak	1 – 3 million more people die from malnutrition (if carbon fertilisation weak)	1 – 170 million more people affected by coastal flooding each year	20 – 50% of species facing extinction (according to one estimate), including 25 – 60% mammals, 30 – 40% birds and 15 – 70% butterflies in South Africa Onset of Amazon forest collapse (some models only)	
4°C	Potentially 30 – 50% decrease in water availability in Southern Africa and Mediterranean	Agricultural yields decline by 15 – 35% in Africa, and entire regions out of production (e.g. parts of Australia)	Up to 80 million more people exposed to malaria in Africa	7 – 300 million more people affected by coastal flooding each year	Loss of around half Arctic tundra Around half of all the world's nature reserves cannot fulfill objectives	
5°C	Possible disappearance of large glaciers in Himalayas, affecting one-quarter of China's population and hundreds of millions in India	Continued increase in ocean acidity seriously disrupting marine ecosystems and possibly fish stocks		Sea level rise threatens small islands, low-lying coastal areas (Florida) and major world cities such as New York, London, and Tokyo		
More than 5°C	The latest science suggests that the Earth's average temperature will rise by even more than 5 or 6 C if emissions continue to grow and positive feedbacks amplify the warming effect of greenhouse gases (e.g. release of carbon dioxide from soils or methane from permafrost). This level of global temperature rise would be equivalent to the amount of warming that occurred between the last age and today – and is likely to lead to major disruption and large-scale movement of population. Such "socially contingent" effects could be catastrophic, but are currently very hard to capture with current models as temperatures would be so far outside human experience.					

Note: This table shows illustrative impacts at different degrees of warming. Some of the uncertainty is captured in the ranges shown, but there will be additional uncertainties about the exact size of impacts (more detail in Box 3.2). Temperatures represent increases relative to pre-industrial levels. At each temperature, the impacts are expressed for a 1°C band around the central temperature, e.g. 1°C represents the range 0.5 – 1.5°C etc. Numbers of people affected at different temperatures assume population and GDP scenarios for the 2080s from the Intergovernmental Panel on Climate Change (IPCC). Figures generally assume adaptation at the level of an individual or firm, but not economy-wide adaptations due to policy intervention (covered in Part V).

Source: Stern Review on the Economics of Climate Change, table 3.1, page 57

coastal protection in South East Asia (Bangladesh and Vietnam), small islands in the Caribbean and the Pacific, and large coastal cities, such as Tokyo, Shanghai, Hong Kong, Mumbai, Calcutta, Karachi, Buenos Aires, St Petersburg, New York, Miami and London.
• Climate change will increase worldwide deaths from malnutrition and heat stress. Vector-borne diseases such as malaria and dengue fever could become more widespread if effective control measures are not in place. In higher latitudes, cold-related deaths will decrease.
• By the middle of the century, 200 million more people may become permanently displaced due to rising sea levels, heavier floods, and more intense droughts, according to one estimate.
• Ecosystems will be particularly vulnerable to climate change, with one study estimating that around 15 – 40% of species face extinction with 2°C of warming. Strong drying over the Amazon, as predicted by some climate models, would result in dieback of the forest with the highest biodiversity on the planet.
The consequences of climate change will become disproportionately more damaging with increased warming. Higher temperatures will increase the chance of triggering abrupt and large-scale changes that lead to regional disruption, migration and conflict.
• Warming may induce sudden shifts in regional weather patterns like the monsoons or the El Niño. Such changes would have severe consequences for water availability and flooding in tropical regions and threaten the livelihoods of billions.
• Melting or collapse of ice sheets would raise sea levels and eventually threaten at least 4 million Km2 of land, which today is home to 5% of the world's population."

These impact assessments appear to be conservative. More recent research on positive feedback mechanisms (Part 3) suggests that the greatest effect may be changes in the long-term functioning of the carbon cycle: diminishing carbon sinks (both soil and ocean), increased CO_2 production and the release of long-stored greenhouse gases (permafrost methane) may combine to increase global temperatures at a rising rate.

More detailed surveys of the scientific literature on the impacts so far of global warming, and of the anticipated impacts of further increases in temperature, were compiled for the "Avoiding dangerous Climate Change" Scientific Symposium on Stabilisation of Greenhouse Gases, held on 1–3 February 2005 by the United Kingdom Met Office. The three surveys are:
1. Impacts of level/rate of temperature change on ecosystems
2. Impacts on human systems due to temperature rise, precipitation change, increases in extreme events and sea level rise
3. Major impacts of climate change on the earth system
(http://www.stabilisation2005.com)

WHEN DOES CLIMATE CHANGE BECOME DANGEROUS?

The United Nations Framework Convention on Climate Change urges stabilization of greenhouse gas emissions… "at a level that would prevent dangerous anthropogenic interference with the climate system."

So what is "dangerous"? Dangerous to the planet, to other species, to us?

It's an odd question, what is a "reasonable" definition of "dangerous". If we say 2°C, does this imply that events happening at less than 1.5°C are not dangerous? That the loss of the Arctic floating ice and its implications is not already dangerous? That the destruction of the Great Barrier Reef is not dangerous in all sorts of ways, including maritime species diversity? That a 30% chance of starting the irretrievable melting of the Greenland ice sheet is not dangerous? Its consequences would be catastrophic.

In 2004 two researchers neatly summarised the absurdity of the dilemma: "We'd all vote to stop climate change immediately, if we only believed that doing so would be so cheap that no country or bloc of countries could effectively object. But we do not so believe. Thus we're forced to start trading away lives and species in order to advocate a "reasonable" definition of "dangerous." ... So it's no surprise that... the advocates of precautionary temperature targets strain to soft-pedal their messages, typically by linking 2ºC of warming to CO2 concentration targets that can be straight-forwardly shown to actually imply a larger, and sometimes much larger, probable warming... Climate activists soft-pedal the truth because they think it will help, and perhaps they are even right. Who are we to know? Nevertheless, we also believe that the waffling is becoming dangerous, that it threatens, if continued, to critically undermine the coherence of our emerging understanding. That it delays difficult, but necessary, conclusions... " (Baer and Athanasiou 2004)

Yet the question as to what would constitute "dangerous anthropogenic interference with the climate system" is commonly answered as a temperature rise of 2°C. This is the target set by the European Union, the IPCC (2001) and the International Climate Change Taskforce.

NASA's James Hansen says that "further global warming of 1°C (above the 2000 temperature of 0.7°C to 1.7°C) defines a critical threshold. Beyond that we will likely see changes that make Earth a different planet than the one we know" (Pearce 2006a). **"We conclude that global warming of more than ~1°C, relative to 2000, will constitute "dangerous" climate change as judged from likely effects on sea level and extermination of species"** (Hansen et al, 2006). Taking thermal inertia into consideration, we are now effectively just 0.3°C from 1.7°C.

Others have named 1.5°C as the danger mark: "Based on our current understanding of responses of species and ecosystems, we propose that efforts be made to limit the increase in global means surface temperatures to maximally 1.5C above pre-industrial levels" (van Vlliet and Leemans).

As noted previously, Christian Aid and EcoEquity concludes that: "the pace of our response has been profoundly inadequate ... and the science now tells us that we're pushing beyond mere ‘*dangerous* anthropogenic interference with the climate system,’ and are rather on the verge of committing to *catastrophic* interference" (Athanasiou et al 2006).

It is clear that we are already moving into the zone of dangerous climate change, and there is evidence, such as the increasing seismic activity in the Greenland ice sheet as it starts to crack and move at a much-increased rate (Hansen 2006a), that **we are already on the edge of triggering catastrophic events** such as the melting of that ice sheet. If that goes we are facing sea level rises of 7 metres from Greenland (as quickly as a metre every 20 years) let alone the consequences for Antarctica and climate more generally.

For our part, the evidence is that climate change so far is already serious, and "in the system" rises to 1.4°C will, from the Arctic evidence, reflect "dangerous anthropogenic interference with the climate system". Above 2°C degrees there is a reasonable chance that it is catastrophic. The impact of positive feedback mechanisms helps explain why.

Part 2: SMALL OR QUITE LARGE?

"We live on a planet whose climate is dominated by positive feedbacks, which are capable of taking us to dramatically different conditions. The problem that we face now is that many feedbacks that came into play slowly in the past, driven by slowly changing forcings, will come into play rapidly now, at the pace of our human-made forcings, tempered a few decades by the oceans thermal response time." (Hansen 2006)

In some of the less-informed public discussion about global warming, there is casual, seemingly unconcerned, talk of rises of three or four degrees, as if these are small nuisances to which we can easily adapt. The assumption is that there is a simple linear relationship between temperature rise and impact: that going from two to three degrees will require a measure of adaption similar to going from zero to one degree.

But the review of global warming in 2006 by the "Independent" newspaper reported that: "During the past year, scientific findings emerged that made even the most doom-laden predictions about climate change seem a little on the optimistic side. And at the heart of the issue is the idea of climate feedbacks -- when the effects of global warming begin to feed into the causes of global warming. Feedbacks can either make things better, or they can make things worse. The trouble is, everywhere scientists looked in 2006, they encountered feedbacks that will make things worse -- a lot worse". Things are worse because in part the 2001 report of the IPCC had little to say about positive feedbacks; it tended "to regard the Earth's climate as something that will change gradually and smoothly, as carbon dioxide and global temperatures continue their lock-step rise. But there is a growing consensus among many climate scientists that this may be giving a false sense of security. **They fear that feedback reactions may begin to kick in and suddenly tip the climate beyond a critical threshold from which it cannot easily recover**" (Connor and McCarthy 2006).

Positive feedback occurs when a change (a rise) in one component (global temperatures) of a system (the climate) leads to other changes (such as the melting on the Arctic floating ice) which then "feed back" to amplify it (increased water temperature as the white ice which reflects heat is replaced by dark water which absorbs heat). The result of the first feedback (increased water temperatures) may trigger another change (the beginning of the melting if the Greenland ice sheet) which will itself produce further feedback (rising sea levels with destabilize further parts of the ice sheets) and so on. An unstoppable chain reaction may be set off (runaway global warming), but this far from inevitable: the system may re-stabilize at higher global temperature.

We must prevent that chain reaction from starting. As James Hansen notes, positive feedbacks will be "moderate" but if "global warming becomes larger than that, all bets are off... there seems to be a dichotomy. We either keep the warming small or it is likely to be quite large." (Hansen 2006b)

The example given above is the **Albedo effect**. It is occurring in the Arctic basin where the summer melting of the floating ice around the north pole is now considered unstoppable. Arctic temperatures will rise much more quickly than the global average: for a global warming of 2°C, the area-mean annual temperature increase over the Arctic (60-90°N) is likely to be between 3.2° and 6.6°C (0.45° to 0.75°C per decade, and possibly even as large as 1.55°C per decade) (New 2006).

Events in the Arctic are already staring to destablize the **Greenland ice sheet**. At less than a global average 2°C rise there is more than a one-in-three chance that its irreversible melting will have started; at 3°C it is almost certain (see Figure 2). Rising Arctic temperatures flowing from floating ice loss are already at "the threshold beyond which glaciologists think the (Greenland) ice sheet may be doomed"; this accelerated melting "is caused by meltwater penetrating crevasses and lubricating the glaciers' flow... The ice is in effect sliding into the ocean on rivers of water", an effect not included in models of the effect of global warming on the Arctic (NS 2006). A recent study found that the Greenland ice cap "may be melting three times faster than indicated by previous measurements" and that "the mass loss is increasing with time" (Young 2006). James Hansen notes that "Ice sheet disintegration starts slowly but multiple positive feedbacks can lead to rapid non-linear collapse" and than "equilibrium sea level rise for ~3°C warming (25±10 m = 80 feet) implies the potential for us to lose control" because "we cannot tie a rope around a collapsing ice sheet" (Hansen 2006a, 2006d).

In a draft paper for publication in 2007, Hansen and fellow researchers warn: **"We foresee the gravest threat from the possibility of surface melt on West Antarctica, and interaction among positive feedbacks leading to catastrophic ice loss**. Warming in West Antarctica in recent decades has been limited by effects of stratospheric ozone depletion. However, climate projections find warming of nearby ocean at depths that may attack buttressing ice shelves as well as surface warming in the region of West Antarctica. Loss of ice shelves allows more rapid discharge from ice streams, in turn a lowering and warming of the ice sheet surface, and increased surface melt. Rising sea level helps unhinge the ice from pinning points. With GHGs [greenhouse gases] continuing to increase, the planetary energy imbalance provides ample energy to melt ice corresponding to several meters of sea level per century.... Our concern that BAU GHG scenarios would cause large sea level rise this century differs from estimates of IPCC (2001), which foresees little or no contribution to 21st century sea level rise from Greenland and Antarctica. However, the IPCC analyses and projections do not well account for the nonlinear physics of wet ice sheet disintegration, ice streams, and eroding ice shelves, nor are they consistent with the paleoclimate evidence we have presented for the absence of discernable lag between ice sheet forcing and sea level rise." (Hansen et. al 2007).

Loss of the Greenland ice sheet would not only bring a seven metre rise in sea levels, but would start to float the Antarctic ice sheets off their base. Even a one metre of sea level rise from Greenland melt would be devastating. The 2006 Conference of the International Association of Hydrogeologists concluded that rising sea levels will also lead to the inundation by salt water of the aquifers used by cities such as Shanghai, Manila, Jakarta, Bangkok, Kolkata, Mumbai, Karachi, Lagos, Buenos Aires and Lima. "The water supplies of dozens of major cities around the world are at risk from a previously ignored aspect of global warming. Within the next few decades rising sea levels will pollute underground water reserves with salt... Long before the rising tides flood coastal cities, salt water will invade the porous rocks that hold fresh water... The problem will be compounded by sinking water tables due to low rainfall, also caused by climate change, and rising water usage by the world's growing and increasingly urbanised population." (Pearce 2006b)

As the Arctic warms, **melting permafrost** in the boreal forests and further north in the Arctic tundra is now starting to melt, triggering the release of methane, a greenhouse gas twenty times more powerful than CO_2, from thick layers of thawing peat. The West Siberian bog is estimated to contain 70 gigatonnes of CO_2, about twice the world's annual total CO_2 emissions. The methane is bubbling free into the atmosphere from growing lakes of liquid methane as permafrost underneath liquifies. Prof. Sergei Kirpotin, a botanist at Russia's Tomsk State University, says patches of white lichen on high Siberian ground reflect the sun's rays and help to keep the ground underneath cold, but as the dark lakes expand, more heat is absorbed and more permafrost melts: "As we predicted in the early 1990s, there's a critical barrier... Once global warming pushes the melting process past that line, it begins to perpetuate itself." Some estimates put this methane release in 2006 as high as 100,000 tons a day, "which means a warming effect greater than America's man-made emissions of carbon dioxide." (Connor and McCarthy 2006).

This chain of events will rapidly drive up the temperature, triggering and reinforcing further feedbacks.

Increased mobilisation of organic carbon: Soils and the oceans have historically contributed equally to absorbing atmospheric carbon dioxide. The soil also releases carbon as plant and organic matter decompose. Professor Guy Kirk of the National Soil Resources Institute at Cranfield University has calculated that the increase in carbon lost by UK soil each year since 1978 of 13 million tons of carbon dioxide a year is more than the 12.7 million tons a year Britain saved by cleaning up its industrial emissions as part of its commitment to Kyoto. The loss is likely to be due to plant matter and organic material decomposing at a faster rate as temperatures rise. Soil sinks are predicted to release their carbon at an even faster rate as temperatures increase: "It's a feedback loop," says Kirk. "The warmer it gets, the faster it is happening." (Pickrell 2005, Connor and McCarthy 2006). It is thought that at 2-3°C, the conversion will begin of the terestrial carbon sink to a carbon source due to temperature-enhanced soil and plant respiration overcoming CO_2-enhanced photosynthesis, resulting in widespread desertification and enhanced feedback (Sarmiento and Gruber 2003).

Ocean acidity: As more carbon dioxide dissolves in seawater to form carbonic acid, the acidity of the ocean increases. Ken Caldeira of the Carnegie Institution’s

Department of Global Ecology says that increased carbon dioxide emissions are rapidly making the world's oceans more acidic and, if unabated, could cause a mass extinction of marine life similar to one that occurred 65 million years ago when the dinosaurs disappeared. **"What we're doing in the next decade will affect our oceans for millions of years... CO2 levels are going up extremely rapidly, and it's overwhelming our marine systems"** (Eilperin 2006). Caldeira says "The geologic record tells us the chemical effects of ocean acidification would last tens of thousands of years... But biological recovery could take millions of years. Ocean acidification has the potential to cause extinction of many marine species" (NASA 2006).

Algae extinction: In 2006, Nasa satellites showed earlier that phytoplankton – which absorb carbon dioxide – are finding it harder to live in the more stratified layers of the warmer ocean, which restrict the mixing of vital nutrients. Since 2000, when the sea surface temperatures began to rise more noticeably, the photosynthetic productivity of phytoplankton have decreased in some ocean regions by 30 per cent. James Lovelock points out that as the ocean surface temperature warms to over 12℃, "a stable layer of warm water forms on the surface that stays unmixed with the cooler, nutrient-rich waters below. This purely physical property of ocean water denies nutrients to the life in the warm layer, and soon the upper sunlit ocean water becomes a desert", recognized by the clear azure blue, dead water of 80 per cent of today's ocean surface. In such nutrient-deprived water, ocean life cannot prosper and soon "the surface layer is empty of all but a limited and starving population of algae". Algae, which comprise most of the ocean's plant life, are the world's greatest CO2 sink, pumping down carbon dioxide, as well as contributing to cloud cover by releasing dimethyl sulphide into the atmosphere, gas "connected with the formation of clouds and with climate" (Lovelock 2006: 23), so that warmer seas and less algae will likely reduce cloud formation and further enhance positive feedback. Severe disruption of the algae/DMS relation would signal spiralling and irreversible climate change.

Algae prosper in waters below 10℃, so as the climate warms, the algae population reduces. In computer modelling of climate warming and regulation carried out by James Lovelock and Lee Kump (Lovelock 2006:31-33), it was found that "as the carbon dioxide abundance approached 500 ppm (or a rise of about 3℃), regulation began to fail and there was a sudden upward jump in temperature. The cause was the failure of the ocean ecosystem. As the world grew warmer, the algae were denied nutrients by the expanding warms surface of the oceans, until eventually they became extinct. As the area of ocean covered by algae grew smaller, their cooling effect diminished and the temperature surged upwards." The end result was a temperature rise of 8℃ above pre-industrial levels, which would result in the planet being habitable only from the latitude of Melbourne south to the south pole, and northern Europe, Asia and Canada to the north pole. Everything in between would be desert and uninhabitable, billions of people would not be able to survive.

It is fatuous to talk about a 3℃ rise as if it were a stable state: more than likely two-to-three degrees means 8℃. Climate change will be either small or quite large.

Part 3: SAFETY FIRST

THE PRECAUTIONARY PRINCIPLE

How big a risk is acceptable when considering irreversible climate change? The precautionary principle states that if an action or policy might cause severe or irreversible harm to the public, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action. It is applied widely in everyday life: the manufacturers of new pharmaceutical drugs seeking registration must demonstrate by clinical trials that the product will do no harm.

What is our risk philosophy? For nuclear power stations in the USA, the regulatory standard is no more that one-in-a-million risk of serious accident. In 2004, the chances of being killed in a commercial air crash was about one in four million. We think that is acceptable. If it was one in hundred (a 1% chance) or one in a thousand (0.1% chance) would we fly?

In considering a maximum target, the precautionary principle must apply. It implores us to stay on the risk-averse side of triggering an irreversible chain of temperature rise events. This is not a bet where losing means we are simply out of pocket; it is Russian roulette where a lack of suitable precaution is deadly. We cannot gamble on how far we can push the system till in breaks, and then try and unscramble the eggs. We need a level of safety in setting a ceiling for acceptable temperatures increases as we do for air travel: should it be more than a one-in-a-million chance?

For example, if the science suggests that a 3ºC rise implies a 50% chance of triggering runaway climate change, that is unacceptable. So would the proposition that a 2ºC rise implied a 10 per cent of runaway climate change. We would, as we do with aircraft or nuclear facilities, demand only a one-in-a-million chance of catastrophic failure and death.

Because biodiversity, our lives and that of succeeding generations are at stake, we cannot accept a level of warming that creates an unacceptable risk (possibility) of unacceptable impacts.

EMISSION TARGETS and SCENARIOS

With targets ranging from 1.5ºC to 4ºC on offer, what should we choose? Principally, we want to sustain people and other species, and to protect them the target has to actually do the job.

Reflecting on the evidence so far examined:

1. We have to choose a prudent risk level. You wouldn't fly in a plane that had a 1% (one in a 100) or even a 0.1% (one in a 1000) chance of crashing. We should be at least as careful with the planet.

2. Even with present level of greenhouse gases, ice sheets and glaciers are melting globally, there is serious drought, and extreme weather events have been triggered. The most vulnerable – other species and poor people in developing countries – are struggling with the impacts with a warming of "only" 0.8ºC over pre-industrial. Even if no more CO_2 is emitted, the current gases will cause at least a further 0.6ºC warming and most of the Great Barrier Reef and the Arctic floating ice will be gone, and positive feedbacks will be increasing. A 1.5ºC warming will be very damaging for nature.

3. The big impacts from climate change and CO_2 acidification of the oceans come from impact on ecosystems, extensive desertification and sea-level rise (possibly as fast as one metre per 20 years if Greenland, then the West Antarctic ice sheets, are destabilised). Climate systems are surprisingly unstable and the world is on the brink of runaway heating because of positive feedbacks. 3ºC plus warming is likely to trigger runaway greenhouse heating, perhaps until the globe is 8ºC warmer; under these conditions most species become extinct and most people die.

4. The earth system is complex and it often doesn't respond in simple ways, and despite growing knowledge, there is still uncertainty. In this situation it is necessary to consider the probabilities of an event occurring rather than establishing a simple correspondence, for example, between a particular level of greenhouse gases and a specific temperature increase.

The evidence is that climate change so far is already serious, and "in the system" rises to 1.4°C will, from the Arctic observations, reflect "dangerous anthropogenic interference with the climate system". Above 2°C there is a reasonable chance that it will become catastrophic.

Figure 4 illustrates a number of levels of CO_2e against the probability of certain temperature levels being exceeded. In many of the cells there are four probabilities, taken from the 2006 UK government's Stern Review. The four probabilities, running from left to right illustrate the range of results from different computer models, from the highest to the lowest risk of exceeding a certain level of warming.

From this data, we can identify the safe zone within which the things we value can be sustained. Atmospheric greenhouse gas levels are currently around 430 ppm CO_2e, and will reach 450 ppm CO_2e within ten years.

Figure 4 demonstrates:
* There is a 100% likelihood of the rise exceeding 1.5°C.
* At the 1990 level of 400 ppm CO_2e, there is an 8–57% chance of exceeding 2°C.
* Within a decade, at 450 ppm CO_2e, there is an 26-78% chance of exceeding 2°C.

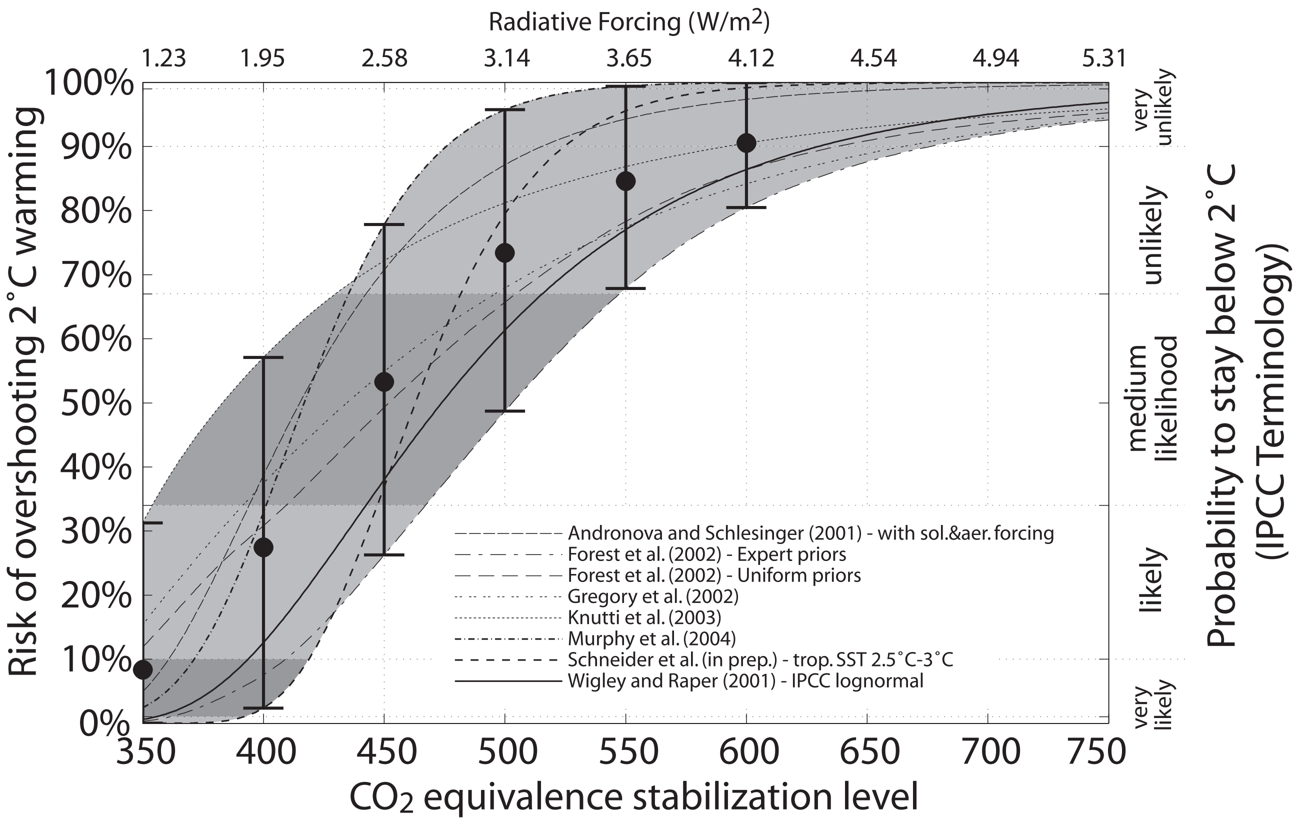
Figure 4: Risk of overshooting temperature level for different CO2e levels

PPM CO_2e	Acid	1.5°C	2°C	3°C	4°C	5°C	8+°C
300			?	(most likely 0%)	(most likely 0%)	(most likely 0%)	0%
350		?	?	?	?	?	?
400		50%	57%-33%-13%-8%	34%-3%-1%-1%	17%-1%-0%-0%	3%-0%-0%-0%	?
430		We are here	We are here - according to Stern Review		We are here - according to Stern Review		
450		100%	78%-78%-38%-26%	50%-18%-6%-4%	34%-3%-1%-0%	21%-1%-0%-0%	?
500		100%	96%-96%- 61%-48%	61%-44%-18%-11%	45%-11%-4%-2%	32%-3%-1%-0%	?
550		100%	99%-99%-77%-63%	69%-69%-32%-21%	53%-24%-9%-6%	41%-7%-2%-1%	?
Species loss		?	15-40%	60%	90%	90%	90%
Runaway warming to ~8+°C		No	No	Maybe	Yes	Yes	Yes
Mode of climate change		Serious	Dangerous	Catastrophic			

Figure prepared by Philip Sutton, Greenleap Strategic Institute

Sources: Temperature probability data for range 400–550ppm and 2–5 degrees: Stern review, box 8.1, page 195 Clusters of percentages (left to right): highest estimate; Hadley Centre ensemble (more recent data); IPCC TAR 2001 ensemble; lowest probabilities. Prbability for 1.5 degrees at 400ppm from Azar and Rodhe (1997)

Figure 5: Risk of overshooting 2 degrees mean equililibrium warming for different CO2e stabilization levels



Meinshausen.M., Februrary 2005, “On the risk of overshooting 2 degrees Celsius”, www.stabilisation2005.con

In other words it is certain that we will pass 1.5°C and into the zone of "dangerous anthropogenic interference with the climate system", and a high and unacceptable risk of exceeding 2°C and moving towards catastrophic territory.

Runaway greenhouse heating is the planetary equivalent of crashing a plane. It simply has to be avoided. The risk must be kept well below 0.1%. Using the risk data featured by the Stern Review, sourced from the UK Defence Department's Hadley Centre and focusing at the 4ºC warming column, figure 4 demonstrates that there is, at a minimum:

* a 24% chance of triggering runaway greenhouse heating at 550 ppm CO2e
* a 11% chance of triggering runaway greenhouse heating at 500 ppm CO2e
* a 3 % chance of triggering runaway greenhouse heating at 450 ppm CO2e
* a 1 % chance of triggering runaway greenhouse heating at 400 ppm CO2e

So right now, with levels half way between 400 and 450 ppm CO2ewe have an unacceptably high risk of causing runaway heating, of "crashing" the planet.

Another study (figure 5) showed that "at 550 ppm CO2 equivalence (corresponding approximately to a stabilization at 475 ppm CO2 only), the risk of overshooting 2°C is very high, ranging between 68% and 99% for the different climate sensitivity PDFs with a mean of 85%. In other words, the probability that warming will stay below 2°C could be categorized as 'unlikely' .... If greenhouse gas concentrations were to be stabilized at 450 ppm CO2e then the risk of exceeding 2°C would be lower, in the range of 26% to 78% (mean 47%), but still significant. In other words, 7 out of the 8 studies analyzed suggest that there is either a "medium likelihood" or "unlikely" chance to stay below 2°C. Only for a stabilization level of 400 ppm CO2eq and below can warming below 2°C be roughly classified as 'likely' (risk of overshooting between 2% and 57% with mean 27%). The risk of exceeding 2°C at equilibrium is further reduced, 0% to 31% (mean 8%), if greenhouse gases are stabilized at 350 ppm CO2e" (Meinshausen 2005).

Taken together:
* The greenhouse gas levels in the air now pose an unacceptably high risk of damage to nature and an unacceptably high risk of triggering runaway heating, and therefore:
* The levels of greenhouse gases must be reduced below their current level of 430ppm.
* This requires carbon emissions to be substantially less that the earth's carbon sink capacity, its capacity to absorb carbon dioxide, so that atmospheric carbon dioxide levels can be drawn down substantially.
* Global emissions are now double the earth's carbon sink capacity, its capacity to absorb carbon dioxide. By 2030 we will be producing five times the amount of atmospheric carbon that the earth can absorb.
* There must a radical and rapid decrease in total global emissions, with particular implications for Australia.

Part 4: THE HEAT IS ON

EMISSION IMPLICATIONS FOR AUSTRALIA

Modelling in the recently released "High Stakes" report (Baer and Mastrandrea 2006) provides a "2ºC crash program" scenario (see figure 1) which shows emissions "peaking in 2010 and dropping off at a resolute 4% per year, thus keeping atmospheric carbon concentrations below 420ppm. Yet, even with this almost inconceivable effort, we would still be exposed to an alarming 9-26% risk of exceeding 2ºC" . Accepting that 2ºC is too high and a 9-26% risk of exceeding the target temperature is far too high, "High Stakes" implies that global emissions must be reduced annually at more than the 4%.

The "High Stakes" model is an average for all countries. Australia's emission are about five times the global average, so our reductions must be more severe than those nations whose emissions are less. Indeed, some poor nations have every right to argue that they should be able to increase emissions up to a sustainable global standard.

In Australia total carbon emissions are rising towards 6 tonnes per person, by 2030 on current projections they will be a lot, perhaps 50%, more; the biosphere's capacity to absorb carbon will be around 0.32 tonnes per person by 2030. Thus for Australia:

1. Emissions need to be reduced from more than 6 to 0.32 tonnes per person by 2030 just to ensure that on a per capita basis Australia is not contributing to atmospheric carbon levels rising after 2030.
2. Further reduce emissions are required to start the process of taking the excess CO2 out of the atmosphere as fast as possible to reduce the already unacceptably high chance of triggering catastrophic climate change.

The harsh truth is that there can be no reasonable argument that Australians have any right to emit more carbon that any other person on this earth. In fact, development equity arguments suggest we have less right.

Soft-pedalling climate change impact will lead the likes of Australia's major political parties to point to 3ºC and 550ppm as a stabilization target, or even worse. The Stern review focused on ways to keep the rise to under 3ºC, but as "High Stakes" notes: "3ºC includes an increase in the number of people affected by water scarcity to two billion; agricultural losses extending to the world's largest exporters of food; the loss of the world's most biodiverse ecosystems including most of the coral reefs, and irreversible damage to the Amazon rainforest, which could result in its collapse. Particularly worrying is the likely transformation of the planet's soils and forests into a net source of carbon, causing an additional 2 to 3ºC rise in temperature, and an increase in the likelihood of other abrupt changes in climate, such as the slowing-down of the Gulf Stream and the loss of the Greenland and West Antarctic ice sheets, which together would raise sea levels by 12 metres." Stern's bet on 3ºC is calamitous and a death warrant for the biosphere as we know it, even if the execution takes some time.

So the 550ppm trajectory, which is still put forward as “precautionary,” can no longer be taken seriously, at least not as a mitigation trajectory. It poses a 63-99% risk of exceeding 2ºC and a 21-69% risk of exceeding 3ºC, **making it difficult to argue that 550ppm is anything other than a reckless flirtation with catastrophe**.

Yet for Prime Minister John Howard even Stern was too much: "Whether the doomsday scenarios painted in the Stern report are right or wrong I don’t think anybody can assert with great confidence... We mustn’t by over-reaction and panicky reaction impose burdens on industries that give Australia enormous advantage," he told Sky News on 2 November. Pressed as to whether he doubted the main findings of the Stern report, Howard said he was "a little sceptical or reserved about the dimension of the disaster that’s being spelt out" and that "We rely very heavily on coal, not only to generate our own electricity but as a major export earner and people have to understand that if major immediate measures were taken to change the situation we’d run the risk, a huge risk, of burdening those industries with additional costs…" (Howard 2006).

Taken together, Australia must aim to:
* immediately stop any further increase from the current level of emissions;
* set a target of reducing total emissions by over 90% by 2030; and
* set an annual and mandated reduction target of 4–5%.

Not to do so would be unconscionable.

POLICY IMPLICATIONS

The European Union has put climate change at the centre of its foreign policy. In the United Kingdom there has been much public discussion on the need for a state of emergency and the focus of all national efforts on defeating the looming threat, just as that country did in response to the rise of fascism. Former British Labour minister Michael Meacher has called for a war on global warming, where the nation's resources are as focussed on the one big threat as they were in 1939, including the rationing of carbon.

Whilst the war analogy has its limits, it at least suggests that an extraordinary effort must be made that will require the active support of the whole community, a mobilisation to avoid catastrophic climate change. In will not means that things go on as they are. As in any emergency, the normal workings of some aspects of the nation will need to be modified or curtailed, especially those aspects of the market which encourage an unconstrained demand for high-carbon commodities.

We cannot wait decades for promised new solutions such as clean coal, and measures adopted at the Kyoto rate are simply too little, too late. Painless voluntary reductions, the drip-by-drip implementation of more efficient and renewable technologies and carbon trading will not do enough, soon enough. **Constraining carbon emissions requires major economic structural adjustment**: state regulation for low-carbon policies and practices, the virtual elimination of high-carbon luxury goods, and wholesale redevelopment of housing and transport.

The issue of systematically reducing total demand, year-by-year, is very challenging. Given the huge scale of reductions required, demand must be cut across the board; any sector with a capacity to escape from the parameters of the climate action plan can derail the outcome. For example, take air travel emissions, the fastest growing sector of global carbon emissions, for which there is no available low-carbon substitute, short of a bus or a train at ground level.

The federal transport department projects air travel emissions for domestic and international (fuel uplifted in Australia) flights to increase to 21849 Gg CO2 or 5.98 million tonnes carbon by 2020. At that time the estimated population will be 24 million, so that average air travel emissions for fuel uplifted in Australia will be around 0.25 tonnes carbon per capita. Aircraft emissions have a radiative forcing effect of 2.7 (that is the total warming effect of aircraft emissions is 2.7 times as great as the effect of the carbon dioxide alone) so effective total air travel emissions by 2020 will 0.67 tonnes carbon per person. This compares to, as previously noted, a carbon sink capacity that by 2030 will be about 0.32 tonnes carbon per capita.

That is, even the failure to control just one small sector can produce carbon emissions greater than our overall target. Emissions for stationery energy and road transport for all domestic, commercial and industrial needs could be zero, yet air travel emissions alone would exceed our carbon budget in another two decades.

Whilst measures to reduce particular sectoral demand and make aspects of supply low-carbon are absolutely necessary, they are not in themselves sufficient. A key factor must be the capacity to control total demand.

The notion of establishing a maximum permissible amount of emissions (an emissions budget) and dividing a right to a portion of that budget to each citizen (a ration or carbon quota) is under serious study by the British government.

The ideas was developed by David Fleming in "Energy and the Common purpose: Descending the Energy Staircase with Tradable Energy Quotas" (Fleming 2005) and subsequently studied by the Tyndall Centre in "Domestic Tradable Quotas: A policy instrument for reducing greenhouse gas emissions from energy use" (Starkey and Anderson 2005).

In December 2006 a new report for the British environment department was released, "A Rough Guide to Individual Carbon Trading: The ideas, the issues and the next steps: Report to Defra" (Roberts and Thumim 2006). It is also the focus of George Monbiot's book, "Heat: how to stop the planet burning".

The British Environment minister David Miliband says "the challenge we face is not about the science or the economic ... it is about politics". Carbon credits, he says, "limit the carbon emissions by end users based on the science, and then use financial incentives to drive efficiency and innovation" and are necessary because "essentially, by 2050 we need all activities outside agriculture to be near zero carbon emitting if we are to stop carbon dioxide levels in the atmosphere growing". Currently reports are being prepared for the British government on how carbon rationing might be implemented.

So will the general public accept rationing? Miliband, one of the few senior politicians who seems to "get it" on climate change, suggests they will, and floated the idea of carbon rationing at a major speech to the Audit Commission on 19 July (Miliband 2006). In part Miliband said:

"A variety of models of tradeable personal carbon allowances have been proposed. But the basic elements are easy to describe. It is a compelling thought experiment – limit the carbon emissions by end users based on the science, and then use financial incentives to drive efficiency and innovation. Imagine a country where carbon becomes a new currency. We carry bank cards that store both pounds and carbon points. When we buy electricity, gas and fuel, we use our carbon points, as well as pounds. To help reduce carbon emissions, the Government would set limits on the amount of carbon that could be used.

"Imagine your neighbourhood. Each neighbour receives the same free entitlement to a certain number of carbon points. The family next door has an SUV and realise they are going to have to buy more carbon points. So instead they decide to trade in the SUV for a hybrid car. They save 2.2 tonnes of carbon each year. They then sell their carbon points back to the bank and share the dividends of environmental growth. The granny next door doesn't drive and doesn't do much air travel. So she has spare carbon points that she can sell. But she doesn't want to be handling two currencies so she cashes in all her carbon permits as soon as she receives them. When she pays her electricity bill, her energy company builds in the price of carbon to her total bill. She simply pays carbon as she uses it. At the end of the year she finds herself better off.

"It is easy to dismiss the idea as too complex administratively, too utopian or too much of a burden for citizens. Do we really want another Government IT programme? Are there not simpler ways of achieving the same objective by focusing on business to change their behaviour not citizens? And will it ever be politically acceptable? But, as the Tyndall Centre's work shows, in the long term, there may be potential to make a system work, and in a way that is arguably more equitable, more empowering and more effective than the traditional tools of information, tax, and regulation.

"It could be more equitable because instead of tax increases which hit all consumers of products, personal carbon allowances provide free entitlements and only offer financial penalties for those who go above their entitlement. People on higher incomes tend to have higher carbon emissions due to higher car ownership and usage, air travel and tourism, and larger homes. People on low incomes are likely to benefit as they will be able to sell their excess allowances.

"It could be more empowering than many forms of regulation because instead of banning particular products, services or activities, or taxing them heavily, a personal carbon allowance enables citizens to make trade-offs. It is also empowering because many citizens want to be able to do their bit for the environment, but there is no measurable way of guiding their decisions.

"It could be more effective because unlike taxes or attempts to ban products, personal carbon allowances regulate the outcome to be achieved, not the means of achieving it. Carbon trading fixes the outcome to be achieved, and leaves the price of carbon to adjust to the necessary level to change behaviour. By intervening downstream, it enables each part of the supply chain to adapt – consumers change their preferences which has a domino effect throughout the system. By focusing on just the energy a citizen buys – their electricity, gas, petrol and air travel – not the energy used already to make food, cars or domestic appliances – the complexity is reduced. However, vast majority of individual emissions are captured which in turn make up 44 per cent of the economy's total emissions."

"This is no lunatic proposal from the eco-radical fringe," reported Gwynne Dyer in January 2007. "It is on the verge of becoming British government policy, and environment secretary David Miliband is behind it one hundred per cent. In fact, he is hoping to launch a pilot scheme quite soon, with the goal of moving to a comprehensive national scheme of carbon rationing within five years" (Dyer 2007).

It is an option that must also be considered in Australia.

It may appear an extraordinary idea, but we live in a moment when the science of climate change suggests we face an extraordinarily bleak future if we go on as we are, and out-of-the ordinary solutions may be the key to our survival.

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