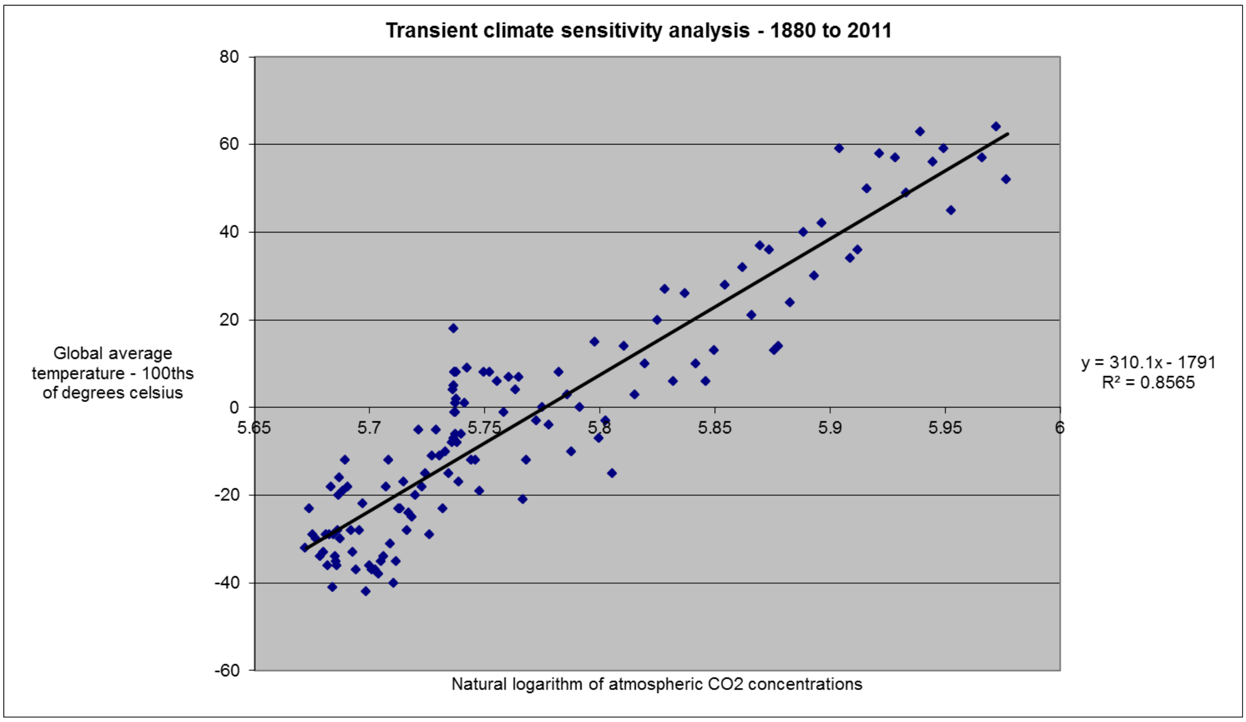
The only real adaptation strategy



Clear evidence of the problem we face

Submission to the Senate Environment and Communications References Committee

inquiry into: *Recent trends in and preparedness for extreme weather events*

David Colin Gould, private capacity

“Australian average temperatures are projected to rise by 0.6 to 1.5 °C by 2030 when compared with the climate of 1980 to 1999. The warming is projected to be in the range of 1.0 to 5.0 °C by 2070 if global greenhouse gas emissions are within the range of projected future emission scenarios considered by the Intergovernmental Panel on Climate Change.”

http://www.csiro.au/en/Outcomes/Climate/Understanding/State-of-the-Climate-2012/Future-Changes.aspx

Thinking through the implications of 4C of warming shows that the impacts are so significant that the only real adaptation strategy is to avoid that at all cost …

Professor Neil Adger, leader of the Adaptation Theme within the Tyndall Centre for Climate Change Research.

http://www.guardian.co.uk/environment/2008/aug/06/climatechange.scienceofclimatechange

Section topics

Who I am

I am someone who became extremely interested in the issue of climate change in 2007 after reading about the decline in Arctic summer sea ice in that year. Since that time, I have built up my knowledge of climate change by reading a broad range of material on the topic, including: scientific papers; reports from academia, industry and government; newspaper and magazine articles; and internet blogs. The CSIRO and the Bureau of Meteorology have been prime sources. Over the same period, I completed my mathematics teaching degree, which included a statistics component. I have since expanded on that knowledge and applied it to my examination of the climate. I am currently working at Parliament House in Hansard while studying for my master of scientific studies. In 2014, I will change careers and become a high school maths teacher.

Why I have made this submission

I have studied the issue of climate change for over five years. Everything I have learned in that time has made me more and more concerned about the climate change problem. I have been looking for ways for this concern to manifest into constructive action, and committees like this one offer me one way of making my concern heard.

I understand that Senator Milne intends for the committee to serve a particular purpose, having stated:

> *Those who hide their heads in the sand and pretend nothing is happening will not be able to say they weren't warned after this inquiry.*

http://christine-milne.greensmps.org.au/content/media-releases/greens-secure-senate-inquiry-extreme-weather-frequency-and-preparedness

That is fair enough, and my submission is indeed intended to be a warning. I have, however, taken the terms of reference of this committee at face value and reading them has made me even more concerned, particularly the start of term of reference (b), which says:

> *(b) based on global warming scenarios outlined by the Intergovernmental Panel on Climate Change and the Commonwealth Scientific and Industrial Research Organisation of 1 to 5 degrees by 2070: ...*

This term of reference appears to be ignoring or at best glossing over the policy and scientific realities at both ends of that temperature spectrum. The low end of that temperature range, a one degree temperature rise for Australia by 2070 above the baseline climate between 1980 and 1999, approximately maps to a global temperature increase of two degrees above preindustrial temperatures over the same timeframe (this is complicated a little by the fact that temperature over land increases faster than global average temperature and by the fact that the southern hemisphere will warm slower than the northern hemisphere, but it roughly holds).

My concern issue here is that a cursory analysis of the most recent scientific data and the policy positions of the major emitters makes it clear that we are not going to hold global temperature to that level—we are going to blow past that. Thus, looking at projections for extreme weather event frequency, intensity and cost and regional social and economic impacts based on such a temperature rise is not a constructive use of limited resources.

At the high end of that temperature range, a five degree rise for Australia approximately maps to a six degree rise for the globe above preindustrial temperatures. Yet just a four degree rise in global average temperature above preindustrial—which is approximately a three degree rise for Australia above the baseline climate between 1980 and 1999—in such a short timeframe is projected to be catastrophic for the environment and for humanity. Indeed, some have said that it would not be compatible with organised human society in the form in which it exists today. One key point is that a four degree rise would likely not be stable: the world would warm further even if human greenhouse gas emissions stabilised. It is not sensible to be discussing how to prepare for the impacts of such a temperature rise—let alone something like the availability of insurance—when the impacts are likely going to be unmanageable and will continue to get worse. These impacts are outlined on pages 21 to 23 of this submission.

While I do not like the phrase 'at all cost'—in any situation, the cost of a particular outcome, no matter how desirable, can be too high—the only real adaptation strategy for four degrees of warming is as Professor Neil Adger outlines in the quote on page two: to avoid it.

In this submission, I present data and information from many different organisations and individuals, much of which the committee has likely already seen. Using that material, I make the argument that the only rational thing to discuss is how to prepare for the best scenario that is still on the table, which is still pretty bad: a temperature rise of three degrees globally, approximately equating to a temperature increase in Australia of two degrees above the baseline climate between 1980 and 1999.

I also argue that the current discussion on what to do about the problem ignores its scale and, as such, the scale of what needs to be done—what needs to be sacrificed—in order to solve it. And by ‘solve it’, I mean ‘keep global temperature rise to something around three degrees above preindustrial temperatures’. It is my hope that an honest conversation about the drastic steps required can begin.

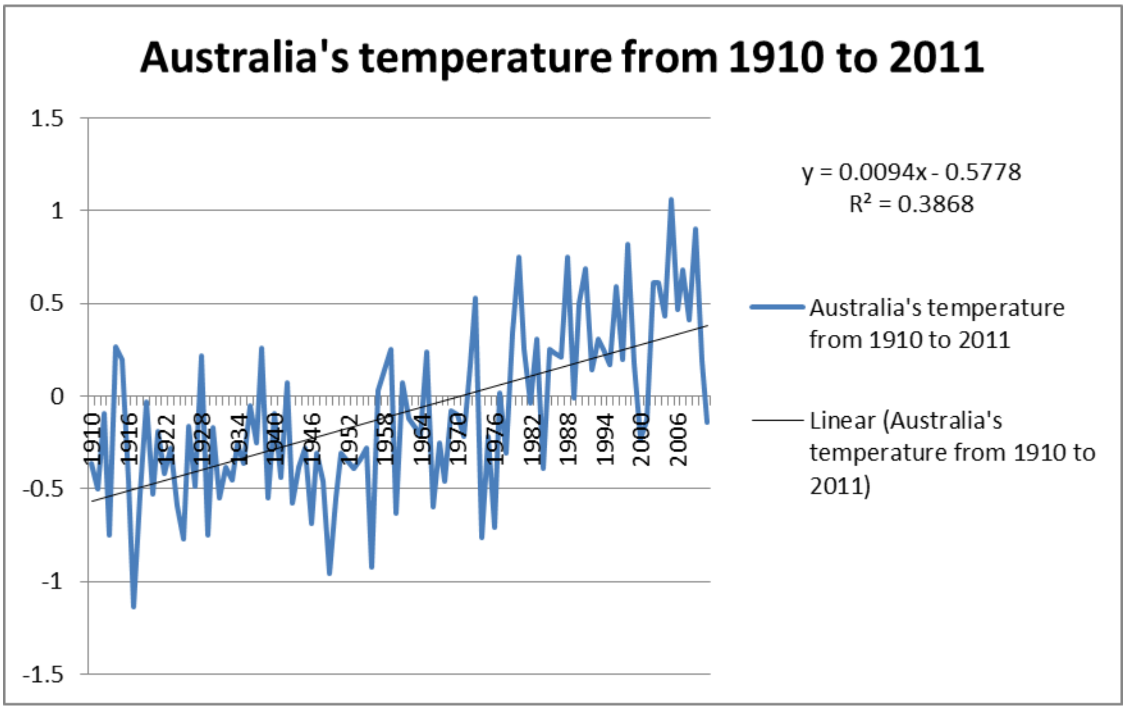
I would welcome the opportunity to appear as a witness before the committee to highlight the important points in my submission and to answer any questions.

Sincerely

David Colin Gould

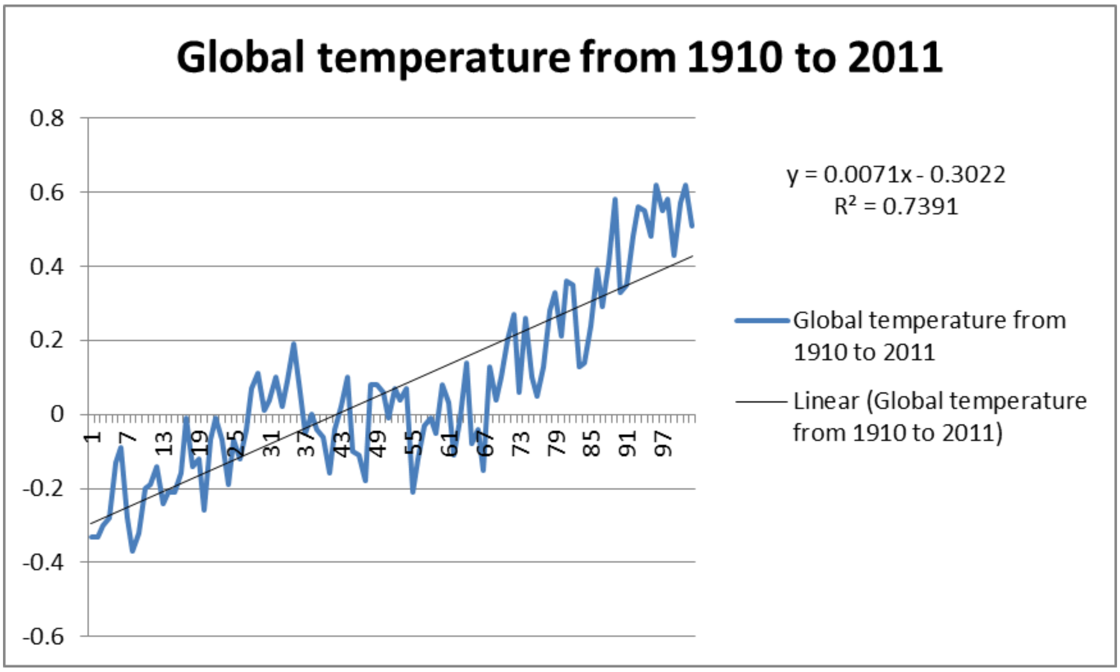
Australia’s temperature is rising alongside that of the Earth’s temperature and at roughly the same rate

The key point to take from this section is that the amount that Australia’s temperature will rise between now and 2070 will depend on the global temperature rise over that period. As the Earth warms, Australia also warms. Australia’s temperature rise is messier than the global temperature rise. This is because Australia is only around 1.5 per cent of the surface area of the planet (Earth: 510,072,000 km squared; Australia: 7,618,000 km squared) and is affected by events that drive temperature in one direction more often and more sharply. Over the entire earth, these events tend to average out a lot more.



Note that the temperature ranges from below -1 to above 1 in this graph, with significant fluctuations. This data is taken from the Bureau of Meteorology, here:

http://www.bom.gov.au/web01/ncc/www/cli_chg/timeseries/tmean/0112/aus/latest.txt



Note that the temperature range is from close to -0.4 to just above 0.6, a much narrower range than the Australian temperature data. This data is taken from the Goddard Institute for Space Studies, here:

http://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts+dSST.txt

The R^2 value for the linear trend line is around double for global temperature than for Australia's temperature. This reflects the same fact: that Australia's temperature is noisier than the globe's. Both temperature trends are statistically significant.

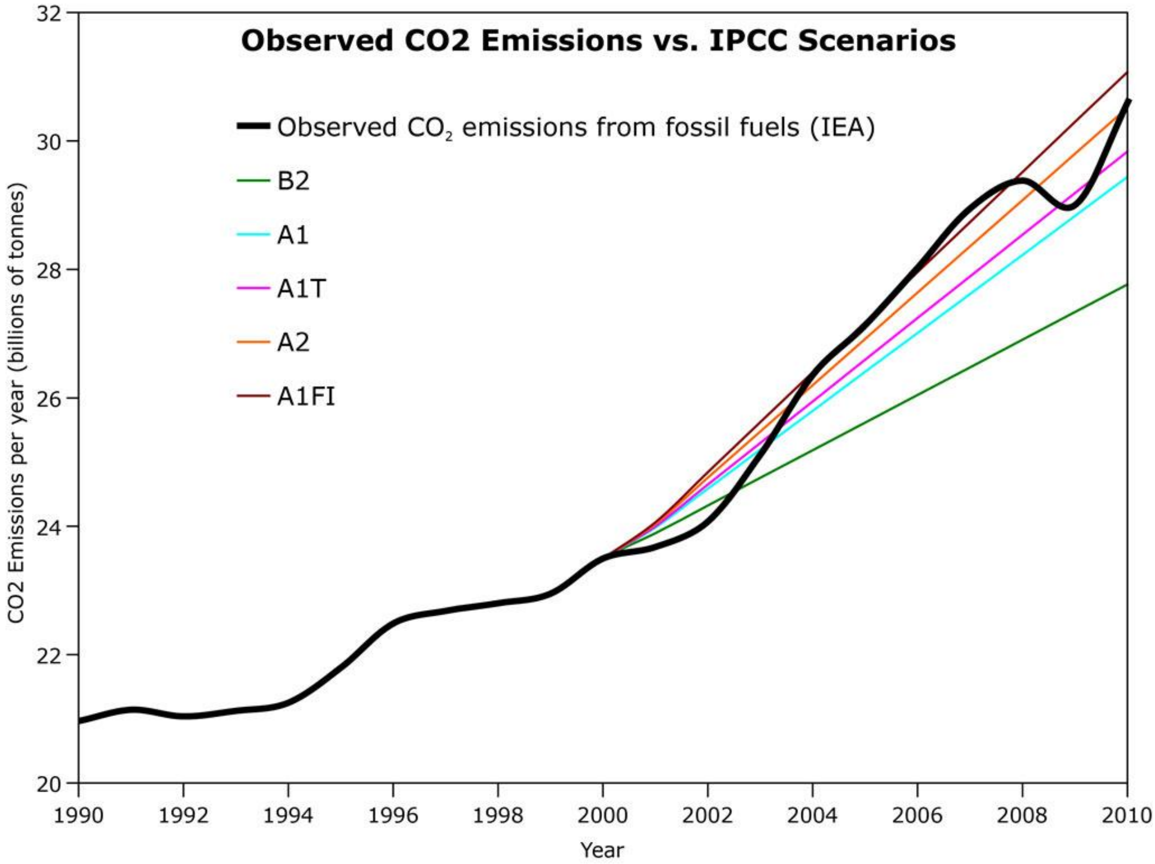
For some periods, Australia's temperature rises faster than the global average; for some periods, it rises at the same rate. Since 1910, Australia's overall temperature rise has been greater than the global average, but not much greater. The likely reason for this is that land warms faster than the global average.

One important implication from Australia's noisier climate, by the way, is that we can expect greater year-to- year fluctuations, so that even if Australia warms on average by a particular temperature any year may be around a full degree different from that average. But, in general, as the Earth warms so too will Australia.

Australia's temperature is rising alongside that of the Earth's temperature and at roughly the same rate.

Greenhouse gas emissions are matching the IPCC's worst case scenarios

The key point to take from this section is that the global temperature rise between now and 2070 depends upon the concentration of greenhouse gas emissions in the atmosphere, itself dependent upon cumulative emissions. Between 2000 and 2009, greenhouse gas emissions exceeded 35 of the 40 scenarios outlined by the IPCC. While the global financial crisis put a large dent in global emissions, in 2010 global emissions spiked by a record six per cent, heading back to the worst case scenario.



Source: http://www.skepticalscience.com/pics/1_IEAvsSRES_2011.jpg

In 2011, emissions rose by 3.2 per cent to 31.6 gigatonnes. In 2012, emissions rose by 2.6 per cent. Note that there is some uncertainty in the absolute emissions numbers, with different organisations calculating them differently. However, they all tell the same story.

Greenhouse gas emissions are matching the IPCC's worst case scenarios, A2 and A1F1

Sources for emissions numbers and percentage increases:

International Energy Agency:

http://www.iea.org/newsroomandevents/news/2012/may/name,27216,en.html

Global Carbon Project:

http://www.sciencedaily.com/releases/2012/12/121202164059.htm

Restricting temperature rise to two degrees above preindustrial temperatures—the supposed safe limit agreed to at Copenhagen and subsequently—is no longer possible

The key point to take from this section is that it is going to warm by more than two degrees. The most likely warming and the range of warming from the 1980-1999 average by 2090-2099 for the two worst case scenario families in the 2007 IPCC report are below:

	Most likely warming	Range
A2 scenario	3.4	2.0 – 5.4
A1FI scenario	4.0	2.4 – 6.4

In the five years since the publication of that report, the picture has become clearer—and grimmer. The above projected temperature rise under the two scenarios is now expected by 2070 or perhaps 2060 if feedbacks are worse than we think.

Professor Kevin Anderson, Deputy Director of the Tyndall Centre for Climate Research, says that all analyses that talk about us having any hope of holding to the two degree target global have emissions peaking in around 2015 and then decline by about four per cent per year. This is not possible without a planned global recession that lasts for a decade or more. Further, for global emissions to decline by four per cent per year, emissions in Annex 1 nations [1] must fall by considerably more. The Stern report, along with some other economic analyses, states that economic growth is compatible with cuts in greenhouse emissions of no greater than three per cent per year in the first decades of emissions reductions. All talk of 'green jobs' or 'green growth' are fig leaves that disguise the enormity of the task and the huge sacrifices it will take to succeed. Very soon it will take just as much effort to prevent a three degree rise.

[1] Annex 1 nations are defined in the first annex to the United Nations Framework Convention on Climate Change. Australia is an Annex 1 nation.

I encourage anyone who reads this to watch the video presentation by Professor Anderson found here: http://www.bristol.ac.uk/cabot/events/2012/194.html

Below are the key findings from the United Nations Environment Programme *The Emissions Gap Report,* which was written in November 2010 after the Copenhagen climate change conference:

> *— that emission levels of approximately 44 gigatonnes of carbon dioxide equivalent ($GtCO_2e$) (range: 39-44 $GtCO_2e$*) in 2020 would be consistent with a "likely" chance of limiting global warming to 2° C.*
>
> *— Under business-as-usual projections, global emissions could reach 56 $GtCO_2e$ (range: 54-60 $GtCO_2e$) in 2020, leaving a gap of 12 $GtCO_2e$.*
>
> *— If the lowest-ambition pledges were implemented in a "lenient" fashion**, emissions could be lowered slightly to 53 $GtCO_2e$ (range: 52-57 $GtCO_2e$), leaving a significant gap of 9 $GtCO_2e$.*
>
> *— The gap could be reduced substantially by policy options being discussed in the negotiations:*
> *»» By countries moving to higher ambition, conditional pledges*
> *»» By the negotiations adopting rules that avoid a net increase in emissions from (a) "lenient" accounting of land use, land-use change and forestry activities and (b) the use of surplus emission units.*
>
> *— If the above policy options were to be implemented, emissions in 2020 could be lowered to 49 $GtCO_2e$ (range: 47-51 $GtCO_2e$), reducing the size of the gap to 5 $GtCO_2e$. This is approximately equal to the annual global emissions from all the world's cars, buses and transport in 2005—But this is also almost 60 per cent of the way towards reaching the 2°C target.*
>
> *— It will also be important to avoid increasing the gap by "double-counting" of offsets.*
>
> *— Studies show that it is feasible to bridge the remaining gap through more ambitious domestic actions, some of which could be supported by international climate finance.*
>
> *— With or without a gap, current studies indicate that steep emission reductions are needed post 2020 in order to keep our chances of limiting warming to 2° C or 1.5° C.*
>
> ** Range here refers to the "majority of results", i.e. their 20th and 80th percentile.*
> *** "Lenient" in this report is used to refer to the situation in which LULUCF accounting rules and the use of surplus emission units result in a net increase in emissions*

http://www.unep.org/publications/ebooks/emissionsgapreport/pdfs/EMISSIONS_GAP_TECHNICAL_SUMMARY.pdf

It is clear that a significant gap is going to exist by 2020.

How likely is it that the steep emission reductions needed post 2020 are not going to occur? Well, global emissions are not expected to peak around 2015. BP had this to say in its 2010 energy outlook:

> *Strong growth in non-OECD energy consumption, especially of coal, translates into continued growth of global CO2 emissions. The growth of global CO2 emissions from energy averages 1.2% p.a over the next twenty years (compared to 1.9% p.a. 1990-2010), leaving emissions in 2030 27% higher than today.*
>
> ... ...
>
> *The implementation of carbon abatement policies in the OECD reduces the level of emissions in 2030, but only by 10% relative to current levels.*

http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2010_downloads/2030_energy_outlook_booklet.pdf

Exxon Mobile said this in its 2008 energy outlook:

> *Global CO2 emissions are projected to rise by close to 30 percent between 2005 and 2030, even with improved energy efficiency and growth in nuclear and renewable energies. Although CO2 emissions are expected to begin declining in the United States and Europe over the period to 2030, these declines will be more than offset by increases in developing countries. For example, by 2030 China is expected to have CO2 emissions comparable to those in the U.S. and EU combined.*

http://www.exxonmobil.com.au/corporate/files/news_pub_2008_energyoutlook.pdf

In its most recent energy outlook, released in December of 2012, Exxon had this to say:

> *Greenhouse gas emissions related to energy use are projected to plateau by 2030*

According to this report, annual emissions from energy use will rise from 30.5 gigatonnes in 2010 to close to 36.7 gigatonnes, a 20 per cent increase, by 2030. By 2040, annual emissions will still be over 36 gigatonnes.

http://exxonmobil.com/corporate/files/news_pub_eo2013.pdf

India is projected to quadruple coal consumption by 2030 to close to current US levels:

> *While environmental groups in developed nations talk of a coming world based on solar, wind and other forms of renewable energy, India's 8 percent economic growth rate is powered by coal. Its consumption is projected to increase by at least 400 percent by the year 2030, according to the government's 2005 Integrated Energy Policy report.*
>
> *This means that in the next 20 years, India will extract, transport, import and burn coal at record rates. It could emit between 4 billion and 6 billion tons of carbon dioxide per year and approach the United States' current emission levels, according to the report.*

http://www.nytimes.com/cwire/2010/02/04/04climatewire-indias-roaring-economy-is-hitched-to-a-gallo-20341.html

Most mining companies and investors believe that coal consumption will continue to increase until at least 2030.

http://www.miningreview.com/node/16492

The World Bank believes that even if all current pledges were met the world is looking at a 20 per cent chance of a four degree temperature rise by the end of the century:

http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

However, their projection is considered optimistic by other organisations. The IEA projects that on our current path emissions will keep rising until at least 2030 when they will be about 25 per cent greater than today, putting us on track for warming of six degrees:

> *The chief economist for the International Energy Agency said Monday that current global energy consumption levels put the Earth on a trajectory to warm by 6 degrees Celsius (10.8 degrees Fahrenheit) above pre-industrial levels by 2100, an outcome he called "a catastrophe for all of us." Fatih Birol spoke as as delegates from nearly 200 countries convened the opening day of annual U.N. climate talks in Durban, South Africa. "Everybody, even the schoolchildren, knows this is a catastrophe for all of us," he said at the Carnegie Endowment for International Peace.* 26 November 2011

http://www.iea.org/publications/worldenergyoutlook/pressmedia/quotes/7/

Further, in their World Energy Review, they stated the following:

> ***No more than one-third of proven reserves of fossil fuels can be consumed prior to 2050 if the world is to achieve the 2 °C goal, unless carbon capture and storage (CCS) technology is widely deployed****. This finding is based on our assessment of global "carbon reserves", measured as the potential CO2 emissions from proven fossil-fuel reserves. Almost two-thirds of these carbon reserves are related to coal, 22% to oil and 15% to gas.*

They also noted that:

> *Coal has met nearly half of the rise in global energy demand over the last decade, growing faster even than total renewables.*

http://www.iea.org/publications/freepublications/publication/English.pdf

Deployment of CCS technology on a sufficient scale to make a difference within the next two decades is impossible, even assuming that it works. Indeed, Shell has stated:

> *Reaching an annual storage capacity of 6 gigatonnes of CO2 – a substantial contribution to efforts to lower emissions – would require an enormous transportation and storage site infrastructure twice the scale of today's global natural gas infrastructure.*

http://s08.static-shell.com/content/dam/shell/static/future-energy/downloads/shell-scenarios/shell-energy-scenarios2050.pdf

The IEA released its *Medium-Term Coal Market Report* on 17 December 2012. It outlines a stark picture in the immediate future.

> *… the world will burn around 1.2 billion more tonnes of coal per year by 2017 compared to today – equivalent to the current coal consumption of Russia and the United States combined.*

http://www.iea.org/newsroomandevents/pressreleases/2012/december/name,34441,en.html

Australia's role in this is clear. While briefly being surpassed as the world's largest coal exporter by Indonesia, the IEA projects:

> ***Australia will recover its throne as the biggest coal exporter.*** *Despite some issues such as rising labour costs and domestic currency rate, which give Indonesia competitive advantages, Australia will concentrate a great share on infrastructure and mine expansion investments to become the largest exporter, with 356 mtce by 2017, well above Indonesia's total exports then of 309 mtce.*

http://www.iea.org/newsroomandevents/news/2012/december/name,34467,en.html

It also said this:

> ***Even though coal demand growth is slowing, coal's share of the global energy mix is still rising**, and by 2017 coal will come close to surpassing oil as the world's top energy source.*

Much of the economic issues facing the achievement of a two degree target can be summed up by some quotes in an article by Bill McGibbon, founder of 350.org, published in *Rolling Stone* magazine:

> *Yes, this coal and gas and oil is still technically in the soil. But it's already economically aboveground – it's figured into share prices, companies are borrowing money against it, nations are basing their budgets on the presumed returns from their patrimony.*

It is already factored into superannuation and pensions, yours and mine.

> *If you told Exxon or Lukoil that, in order to avoid wrecking the climate, they couldn't pump out their reserves, the value of their companies would plummet. John Fullerton, a former managing director at JP Morgan who now runs the Capital Institute, calculates that at today's market value, those 2,795 gigatons of carbon emissions are worth about $27 trillion. Which is to say, if you paid attention to the scientists and kept 80 percent of it underground, you'd be writing off $20 trillion in assets.*

http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719#ixzz2Ek5E68Nh

Bill McGibbon is using one-fifth as his maximum figure; the International Energy Agency talk about one-third. This is because Bill McGibbon wants to avoid a one-in-five chance of hitting two degrees while the IEA is looking at a 50-50 bet. In any case: to avoid two degrees of warming, trillions of dollars must be wiped from the stock market and from national economies.

Further explanation is needed on this point: why, for example, are the above expressed as chances of avoiding two degrees of warming? The answer is that at this point it is not clear precisely how sensitive earth's climate system is to a change in radiative forcing. The best estimate is that for each doubling of greenhouse gases in the atmosphere the earth's average temperature will rise by three degrees. However, there is a spread of possible values: we might get only 2.5 degrees warming; we might get four degrees warming. This is discussed further in the appendices.

Additional information on carbon budgets and the two degree target can be found here:
http://www.nature.com/nature/journal/v458/n7242/full/nature08017.html

PricewaterhouseCoopers agrees that the task of limiting temperature rise to two degrees is impossible:

> *The new reality is a much more challenging future in terms of planning, financing and predictability. Even doubling our current annual rates of decarbonisation globally every year to 2050, would still lead to 6C, making governments' ambitions to limit warming to 2C appear highly unrealistic.*

http://press.pwc.com/GLOBAL/News-releases/current-rates-of-decarbonisation-pointing-to-6oc-of-warming/s/47302a6d-efb5-478f-b0e4-19d8801da855

Restricting temperature rise to two degrees above preindustrial—the supposedly 'safe limit' agreed to at Copenhagen and subsequently—is no longer possible.

<u>Successful cost-effective adaptation depends upon two things:</u>

> **1.) regional predictions with low uncertainty; and**
>
> **2.) the stabilisation of the climate system occurring at a point correctly projected before adaptation efforts start.**

(It should be noted that here I am mainly talking about the high-cost larger scale adaptation measures.)

The key point to take from this section is that the two necessary conditions for cost-effective adaptation do not exist.

It is possible to take some reactive measures to observed changes in the system without having certainty about the future or stabilisation. Such measures might include spending more money on fire-fighting services because of the increase in the number and severity of fires. There are also going to be some infrastructure measures that will be scalable with temperature rise. These might include things like sea defences in some areas. But the vast majority of adaptation measures are not going to fall into this category.

Firstly, let us look at regional predictions. As the earth warms, the climate of particular regions responds in different ways and at different rates. Because climate models necessarily work with averages, as the regions for which they make predictions becomes smaller, the uncertainty becomes larger. (As an aside, we can see this general mathematical effect if we compare the temperature graph of the globe to that of Australia—the variation is significantly greater for Australia.) However, adaptation works on a regional level, not on a global one. So what are the uncertainties?

Looking at New South Wales and the ACT, in a high emissions scenario, the predictions range from a 20 per cent increase in annual rainfall to a 40 per cent decrease in rainfall by 2070. It is very difficult to put in place cost-effective adaption measures in the face of such uncertainty.

What if we decide not to attempt to look so far into the future, but simply look at 2030? Here the uncertainty narrows to somewhere between a 10 per cent increase in rainfall to a 20 per cent decrease in rainfall. Which end of the range do we pick? If we build dams because we are worried about the decrease end of that uncertainty band, we could be wasting our money; if we don't build them, we could be wrecking our agriculture and be facing major water shortages in Australia's largest city. And going the other way and choosing to build floodways and water diversion systems could well be a waste of money, too. Yet doing nothing is hardly a good idea, either.

The good news is that we can take some steps that have benefits in a broad range of scenarios, such as water efficiency measures. However, large-scale infrastructure decisions—for example, about dams or the location of new suburbs—will necessarily involve preparing for a number of possibilities, which will make those preparations less than optimal as well as significantly more expensive.

Without regional predictions with low uncertainty, adaptation is going to be a case of throwing away a large proportion of the money spent.

Source for regional predictions:

http://www.climatechangeinaustralia.gov.au/nswactrain15.php

The second problem is that, if we do not know ahead of time the point at which climate is likely to stabilise, adaptation efforts run the risk of costing us lots of money for little long-term gain. As an example, moving agriculture from one region of the country to another would take significant money, time and effort. Assuming that we had regional predictions with low uncertainty, there may well be value in doing so. But if the climate continues to change then it is highly likely that the result of that cost-benefit analysis will change also. A region that is optimal for agriculture in a two-degree world may not be so in a three-degree world. If we knew in advance that we were going to stabilise at around two degrees—or three degrees—we could make that decision. But if the temperature was increasing for the foreseeable future, many choices would become foolish. A one metre rise in sea level might be able to be dealt with by coastal defence systems such as sea walls. But a two metre rise might require significant relocation of population and infrastructure. If we spend the money on sea walls, we might not have the resources to carry out the relocation effectively, so it might be better to relocate early. But if we relocate early, we impose costs that may be unnecessary if temperature stabilises early.

Without knowing the likely stabilisation point, adaptation is going to be a case of throwing away a large proportion of the money spent.

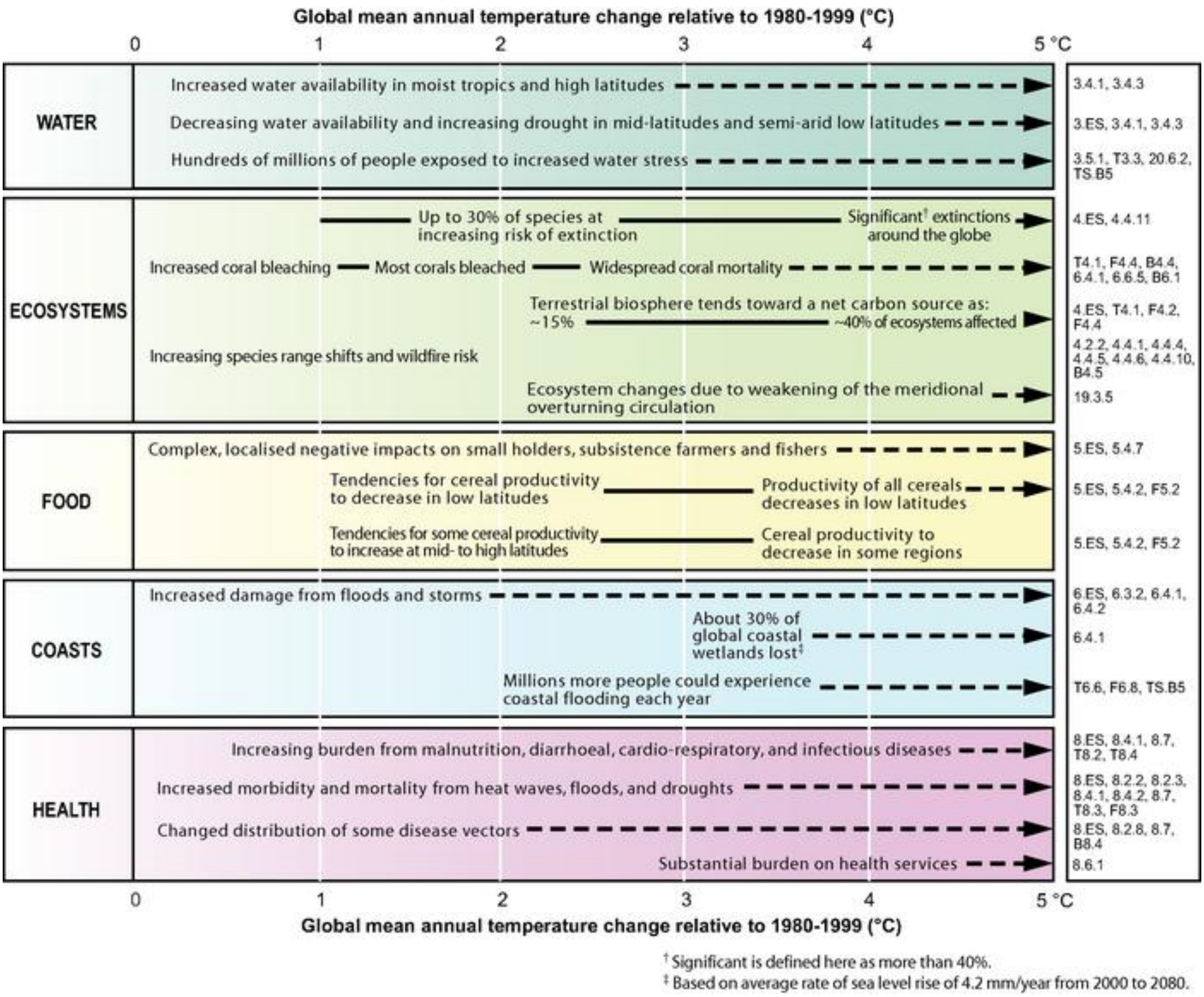
Successful cost-effective adaptation depends upon two things:

1.) **regional predictions with low uncertainty; and**
2.) **the stabilisation of the climate system at a point known before adaptation efforts start.**

Without these two things, much of the money spent on adaptation will be money wasted; money that could have and should have been spent on mitigation measures.

A four degree rise in temperature would be both catastrophic and unstable

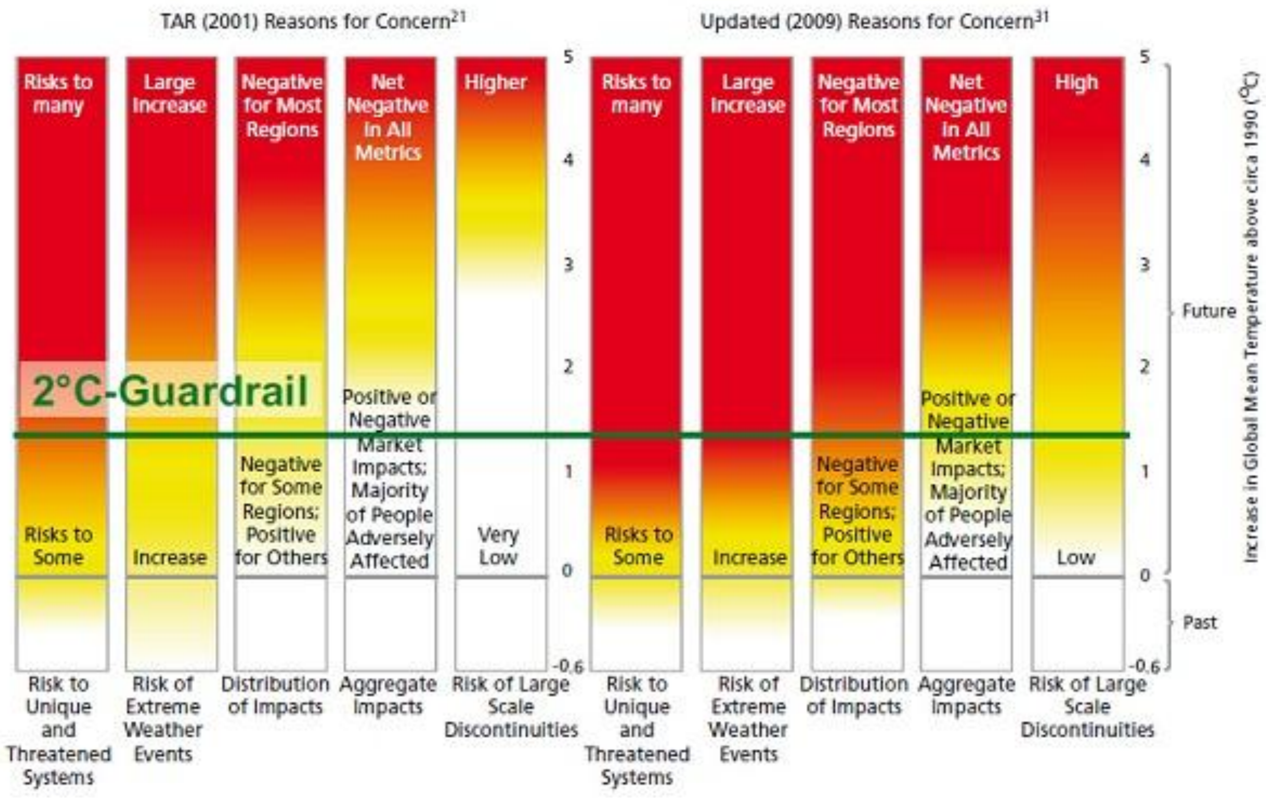
The key point to take from this section is that a four degree rise would be catastrophic and unstable. Such a rise would be devastating to the environment, to agriculture and to coastal infrastructure. However, some argue that it might be possible to take sufficient precautions so that the impact was reduced, provided governments were prepared to spend the vast amounts of money required to do so while reducing greenhouse gas emissions rapidly to zero to prevent temperature rising above four degrees. First of all, I do not agree with the notion that we could be able to successfully manage the impacts at four degrees. Below is a table outlining the projected impacts in the five areas of concern defined by the IPCC:



http://www.ipcc.ch/publications_and_data/ar4/wg2/en/figure-spm-2.html

Note that a four degree global temperature rise above preindustrial equates to roughly a 3.2 degree temperature change relative to the average temperature between 1980 and 1999. The image is taken from the *IPCC Fourth Assessment Report: Climate Change 2007* and specifically *Working Group II: Impacts, Adaptation and Vulnerability*.

The below image is the 'Burning Embers' diagram from the *IPCC Third Assessment Report: Climate Change 2001* alongside the same diagram updated in 2009.



http://www.pnas.org/content/early/2009/02/25/0812355106.full.pdf+html

At 3.2 degrees (4 degrees above preindustrial temperatures) in the updated version all five areas of concern are in the dangerous red zone. What is most alarming is that the risk of large scale discontinuities is significantly elevated. What is a large scale discontinuity? Examples include:

- disruption of the south- or east-Asian monsoons;

- a repeat of historic droughts in the Sahel region of Africa; or
- a widespread dieback of the Amazon rainforest.

These are events that cannot be predicted through simply extrapolating a linear increase in temperature.

The Department of Climate Change and Energy Efficiency has also looked at this issue. At a temperature increase of more than three degrees above the 1980 to 1999 baseline (which is around four degrees above preindustrial temperature) the impacts are massive, with—for example—a third of species around the globe at risk of extinction.

Extreme climate response or impact	**450 ppm**	**550 ppm**	**No mitigation**
Temperature outcomes	**1.6 (0.8–2.1)°C**	**2 (1.1–2.7)°C**	**5.1 (3.0–6.6)°C**
Species at risk of extinction	7 (3–13)%	12 (4–25)%	88 (33–98)%
Likelihood of initiating large-scale melt of the Greenland ice sheet	10 (1–31)%	26 (3–59)%	100 (71–100)%
Area of reefs above critical limits for coral bleaching	34 (0–68)%	65 (0–81)%	99 (85–100)%
Estimated lower threshold exceeded by 2100			
Threshold for initiating accelerated disintegration of the west Antarctic ice sheet	No	No	Yes
Threshold for changes to the variability of the El Niño—Southern Oscillation	No	No	Yes
Threshold at which terrestrial sinks could become carbon sources	Possibly	Possibly	Yes

http://pandora.nla.gov.au/pan/102841/20090728-0000/www.climatechange.gov.au/whitepaper/report/pubs/pdf/V1002Chapter.pdf

In 2008, the Garnaut report starkly outlined what would face Australia with such a temperature increase. The impacts included:

- a 92 per cent decline in irrigated agricultural production in the Murray-Darling Basin;
- the catastrophic destruction of the Great Barrier Reef;
- an up to 34 per cent increase in the cost of urban water supplies; and
- significant risk to coastal buildings from storm events and sea-level rise.

It is not possible to adapt in any meaningful sense to those kinds of impacts.

http://www.garnautreview.org.au/pdf/Garnaut_Chapter6.pdf

A study of the impact of temperature on wheat yields by Asseng, Foster and Turner found that a temperature increase of just two degrees could cut wheat yields by 50 per cent.

http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2486.2010.02262.x/abstract

Feeding the world after a four degree rise in temperature is going to be a massive challenge at best and impossible at worst.

The second problem with the scenario of a four degree temperature rise is that it is highly likely to be unstable, because it will trigger significant positive feedbacks not under human control, such as the shrinking of the Amazon rainforest through drought and fire and the rapid melting of permafrost. Note that the Department of Climate Change and Energy Efficiency already has it possible that terrestrial sinks (carbon sinks) could become carbon sources. This would leave us in the position of having expended those vast resources and yet still be facing the necessity to spend even more money and effort to adapt to a continually and rapidly warming climate.

As outlined in section three of this document, making cost-effective adaptation decisions in such a situation would be extremely difficult. There would be no expected point of future stabilisation, at least not in the short term.

In a recent report, the World Bank stated:

> *Even with the current mitigation commitments and pledges fully implemented, there is roughly a 20 percent likelihood of exceeding 4°C by 2100. If they are not met, a warming of 4°C could occur as early as the 2060s. Such a warming level and associated sea-level rise of 0.5 to 1 meter, or more, by 2100* ***would not be the end point****: a further warming to levels over 6°C, with several meters of sea-level rise, would likely occur over the following centuries.*

http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

It should be noted that there is disagreement with the 20 per cent likelihood. Participants in the 'Four Degrees Or More? Australia in a Hot World' conference, held in 2011, said:

> *... the Copenhagen pledges to cut emissions will, if honoured collectively, result in average warming of 4 degrees or more.*

Professor Kevin Anderson, in a presentation in 2011, said this:

> *There is a widespread view that a 4°C future is incompatible with an organised global community, is likely to be beyond 'adaptation', is devastating to the majority of eco-systems & **has a high probability of not being stable** (i.e 4° C would be an interim temperature on the way to a much higher equilibrium level).*

http://www.slideshare.net/DFID/professor-kevin-anderson-climate-change-going-beyond-dangerous

As outlined previously, the major changes in weather patterns, extreme weather events, ocean acidification, and sea level rise that are likely under a 4° C increase in global average temperature would have severe negative impacts including extensive loss of life and assets. In situations where there is no known way to adapt to a potential climate impact, addressing the source of the threat by controlling greenhouse gas emissions is the only feasible option. It is the only real adaptation strategy.

A four degree rise in temperature would be both catastrophic and unstable.

Conclusion: the only rational strategy is to take the necessary measures to prevent a temperature rise of four degrees while preparing for a rise of around three degrees

As it is no longer possible to constrain temperature rise to two degrees, and four degrees is a threshold that we cannot afford to cross, both because of the threats associated with doing so and the fact that it is likely that once reached climate will not stabilise at that temperature, then—assuming we act rationally—we should be taking all necessary measures to limit temperature rise to somewhere close to three degrees through mitigation of greenhouse gas emissions. Therefore, all our adaptation measures should be focusing on dealing with what we would face at such a temperature rise.

The only rational strategy is to take the necessary measures to prevent a temperature rise of four degrees while preparing for a rise of around three degrees.

Where to from here?

Holding temperature rise to less than three degrees will take gargantuan efforts over many decades. The idea that we can achieve this relatively painlessly is a fantasy that governments all around the world need to set aside today. An honest conversation between elected representatives and citizens about the scale of the challenge in front of us is urgently needed. The fact is that economic growth is at present directly correlated with growth in CO2 emissions. That will change over time, but it will not change fast enough. The terrible truth is that without a deliberately engineered decades-long economic contraction—a recession that will cause significant suffering for many people—we are not going to prevent climate catastrophe. And this recession needs to be global, although its impacts will differ from country to country.

During this damaging world recession, the Australian government is also going to have to take the lead in preparing our nation for the damaging impacts of a three degree global temperature rise. This will need flexibility—as I have stated previously, without regional predictions with narrow uncertainty, adaptation is going to be challenging. Water management is going to be key, as droughts, floods and sea level rise threaten food security, regional economies and coastal infrastructure.

How are we going to do these two things—massively reduce our consumption of fossil fuels and take the necessary adaptation measures—simultaneously? Our economy will be in decline and yet we will need to be spending billions of dollars on coastal defences, river protection measures, irrigation systems and research into crop resilience and improved regional projections. And there will need to be greater expenditure on social security.

The other problem is this: because we have taken so long to act, the level that atmospheric greenhouse gas concentrations will reach is no longer in the hands of annex 1 nations. Even if we in the wealthy west cut our emissions to zero tomorrow, developing nations, and specifically India and China, hold the key to preventing global average temperature from reaching four degrees above preindustrial temperature. However, if the wealthy nations fail to reduce our emissions significantly it is highly unlikely that India and China will take the required action, reasoning that our emissions will cause climate to change dramatically and that they need to have economies strong enough to deal with that change.

If we do not break out of thinking that it is the other who has the power and that thus we are excused, we accept defeat and the massive suffering that will go alongside that. To act is to create the opportunity for the other to do so. And, yes, it is a risk—we could endure a crippling recession and still face a four degree temperature rise. But that would be like a person contracting AIDS while dying from incurable cancer: terrible, but ultimately irrelevant.

So what do we need to do? Australia's total emissions in 2010 were around 580 million tonnes. Passenger vehicle transport accounted for about 40 million tonnes. Air travel accounted for about 15 million tonnes. Meat production, through enteric fermentation and manure disposal, accounted for 55 million tonnes. Note that this does not include the impact of land use changes such as deforestation and controlled burning of savannah, which would add somewhere between 20 and 40 million tonnes to the emissions from the meat industry. Stationary power generation and the direct burning of fuel accounted for close to 300 million tonnes, by far the largest component. The rest comes from other transportation, crop production, waste disposal, industrial processes and other land use impacts.

Sources:

http://www.carbonneutral.com.au/climate-change/australian-emissions.html

http://www.climatechange.gov.au/publications/projections/~/media/publications/projections/cie-agriculture-modelling-pdf.pdf

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To tackle Australia's stationary power generation, something unpalatable to environmentalists must at least be examined objectively: the scale of the problem is such that solar, wind, tidal and geothermal energy sources may not be able to solve it by themselves. The advanced economies with the lowest per capita emissions are France and Sweden. That is mainly because they use nuclear power for a large portion of their energy needs, with nuclear power producing 80 per cent of French and around 35 per cent of Swedish electricity. The Japanese, a people who understand the risks of nuclear power, are moving back towards nuclear power. Since the tsunami, greenhouse gas emissions in Japan have risen because of their increased reliance on coal and gas, showing the positive impact of nuclear energy. Germany, after shutting down its fleet of nuclear power stations, is expanding its use of renewable energy. But it will also be expanding its use of coal, which will lock in coal use for 20 to 30 years. Australia needs to look closely at nuclear power. Even more importantly, Australia must help other nations do so, India particularly. Remember: India is projected to be using more coal by 2030 than the US is now. We have huge reserves of uranium. Those reserves may well need to be deployed in the fight against climate change, even if that is at the cost of other negative environmental effects and the deeply held principles of some. We only have a few decades to deal with the problem of climate change. We have no time for the luxury of a perfect environmental solution.

It should be noted that without the use of nuclear energy in Australia, the CSIRO projects that CO2 emissions will be significantly larger in 2050 than they otherwise would be. Further, the reduction in emissions depends upon the wide deployment of carbon capture and storage for gas and coal power stations. You can use the CSRIO efuture tool to examine these scenarios here: http://efuture.csiro.au/#scenarios

I would encourage everyone to examine the work of Professor Barry Brook, the holder of the University of Adelaide Sir Hubert Wilkins Chair of Climate Change. He has examined the issue of nuclear power and climate change in great detail and has much to contribute to this debate. His web site is: http://bravenewclimate.com/

The other thing that we must do is reduce coal exports to zero as rapidly as possible—within the next decade or so. Some will argue that China and India will simply get their coal elsewhere. That may be true, but they will do so at a much higher price with Australian coal not on the market. Further, the loss of the largest coal exporter will send shockwaves through the global energy market, putting the expansion of coal power stations at risk. This will help renewable energy become more competitive, which, combined with an expansion in nuclear energy—propelled by Australian uranium—could see the two economies we most need to do so make a massive shift away from coal. It is a similar story for gas, although we can afford a slightly longer lead time for the closure of this industry. The disquieting truth is that if we are to have a 50 per cent chance—and we surely cannot allow it to get to that high a likelihood—of preventing a global temperature rise of four degrees we must keep atmospheric greenhouse gas concentrations below 700 parts per million. If we burn all our current known reserves of fossil fuels, we will get to somewhere between 570 and 750 parts per million, depending on what happens with natural sinks and feedbacks for CO2. A lot of those fossil fuels reserves are in the form of coal and gas in Australia—indeed, Australia has around eight per cent of global coal reserves. We have the responsibility of ensuring that most of it remains in the ground. By the way: if climate sensitivity is four degrees or more, 550 parts per million will see us exceed the four degree limit. And there is recent evidence in a study by Professor Trenberth that climate sensitivity may well be that high.

http://www.newscientist.com/article/mg21628914.700-estimates-for-future-global-warming-narrowed-down.html

http://www.sciencemag.org/content/338/6108/792

Australians must move towards a diet with much less meat and dairy, as the production of those foods contribute more CO2 emissions to the atmosphere than passenger vehicle transport and air transport combined. And our meat and dairy industries must reduce their exports. The globe cannot afford the Indians or the Chinese to become consumers of lamb, beef and cheese at anywhere near current Australian consumption levels. And we must drive and fly much less, which will cause immense damage to our tourism industry. We certainly can no longer encourage large numbers of international visitors to come to our shores knowing as we do what that will cost us—and them—in the end.

Incredibly important industries to the Australian economy and to the hundreds of thousands of Australians who work in them need to be shut down. We must by choice enter a recession that will last for decades. And this recession needs to spread to the entire Western world and beyond. It is a very bad choice. But that is where 25 years of inaction, climate change 'scepticism', politicians trying to sell fantasies of green growth, the mindless pursuit of economic growth and a whole host of other things have left us.

Thinking through the implications of 4C of warming shows that the impacts are so significant that ***the only real adaptation strategy is to avoid that at all cost*** *…*

Will we make the right choice? Will we pay the price? Will we set aside our dreams for a better life now to safeguard the future?

As David Roberts, senior staff writer for Grist, says, this seems implausible; indeed, it seems impossible. Indeed we are stuck between the impossible and the unthinkable. He goes on to say:

> *Anyone who hears this: your job for the rest of your life is to make the impossible possible.*

http://www.youtube.com/watch?feature=player_embedded&v=pznsPkJy2x8#!

I am sure that before each of you became a politician you had great dreams of making Australia and the world better places. You may well have thought about the legacies of great leaders such as Abraham Lincoln and Winston Churchill and imagined scenarios in which you too could show your mettle and write yourselves into history. Such leaders showed their greatness in the face of immense challenge. The challenge before you dwarfs what they faced and gives you the opportunity to demonstrate true greatness. I have confidence that people everywhere will rise to this challenge and make the sacrifices necessary. Generations before us have done this in war and in peace and we are not less than they were. But people need to know the truth about the choice in front of us. We—and you as our elected representatives—need to start talking about it now. And then we need to act. We need to make the impossible possible. We need to implement the only real adaptation strategy.

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'Climate change' is simple by David Grist:

Anyone who hears this: your job for the rest of your life is to make the impossible possible.

http://www.youtube.com/watch?feature=player_embedded&v=pznsPkJy2x8

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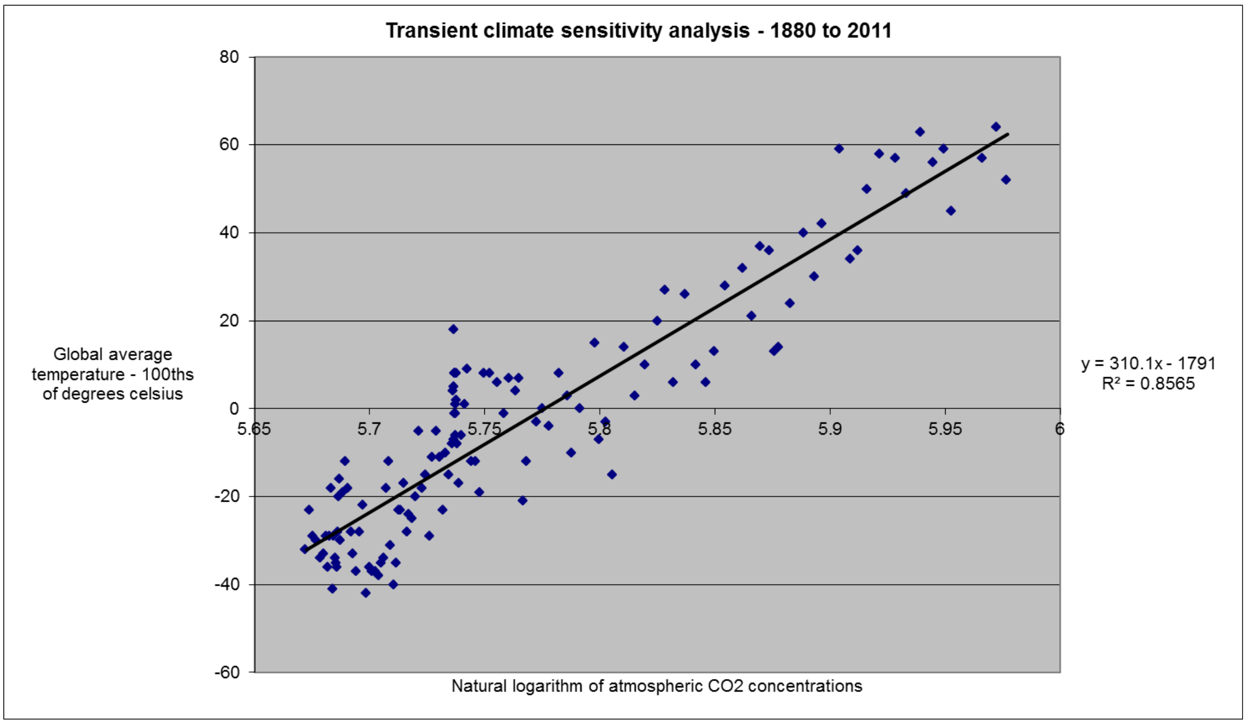
www.balestar.com/Excel_spreadsheets/Climate_Sensitivity_Analysis.xls

Appendix A

Climate sensitivity

The graph on the cover of this submission is an attempt to determine climate sensitivity from observations over the past 130 years or so. Climate sensitivity is the amount temperature will rise if greenhouse gas concentrations in the atmosphere double. There are two types of climate sensitivity, equilibrium sensitivity, which is the temperature rise expected after medium- and long-term feedbacks have run their course and temperature has stabilised, and transient sensitivity, which is the temperature rise expected to occur in the short term.



Clear evidence of the problem we face

The above graph plots the natural logarithm of CO2 atmospheric concentration versus global average temperature for the period between 1880 and 2011. From the graph of these observations, transient climate sensitivity can be determined by multiplying the slope—310.1—by 0.7, the natural logarithm of two (for a doubling). Note that the slope is statistically significant to at least the 99 per cent level. The answer is approximately 2.2 degrees.

Equilibrium sensitivity is estimated to be between 2.5 degrees and 4.5 degrees, but most likely close to three degrees.

The uncertainty in equilibrium climate sensitivity is due to it being significantly harder to observe directly, because through geological time temperature is rarely at equilibrium. As such, sensitivity must be inferred from past climate changes and from seeing how well models build with different equilibrium sensitivity capture other observed changes. My own limited work in this area suggests that climate sensitivity is likely to be somewhere around 3.3 degrees, which is in the same ballpark as the consensus.

One of the key problems that arise from the range of possible sensitivities is that this leads to a probability range for temperature rise with any given atmospheric concentration of greenhouse gases. That is what Bill McGibbon and the World Bank are talking about when they say something along the lines of, 'If we burn X amount of fossil fuels, there is a Y per cent change of a temperature rise of Z degrees.'

As a specific example, if atmospheric concentrations of greenhouse gases reach 450 ppm and go no higher, if climate sensitivity is three degrees then there will be a two degree rise in temperature after things have stabilised. However, if climate sensitivity is 2.5 degrees, there will be a temperature rise of 1.8 degrees when greenhouse gases reach that level. But if sensitivity is 4.5 degrees, there will be a temperature rise of 3.2 degrees. The probabilities of particular sensitivity have been estimated. From that, the probability of particular rises in temperature at particular greenhouse gas levels can be calculated.

The data used in creating the graph, along with an explanation of some of the statistical analysis is available here: www.balestar.com/Excel_spreadsheets/Climate_Sensitivity_Analysis.xls

Appendix B

Emissions scenarios

It is possible to build a simple model that provides rough projections of cumulative emissions under various scenarios. I have done this in Excel spread sheet format for the period from 2012. The spread sheet is available at this web address:

http://www.balestar.com/Excel_spreadsheets/Emissions_scenarios.xls

Various parameters can be adjusted to see what outcomes are likely and what would need to happen to keep cumulative emissions below particular targets.

Appendix C

Explanations of temperature comparisons

One of the complications in writing this submission—and indeed in looking at any work on climate change—is understanding the many different baselines used to measure temperature rise against. To further confuse things, there are differences between projected Australian temperature rise and projected global temperature rise, even though they are closely aligned.

Many discussions of projected temperature rise talk about the rise compared to preindustrial temperatures. The two degree target set at Copenhagen is calculated in that way.

However, recent analyses by the IPCC and CSIRO, for example, use the global and Australian 1980-1999 average temperature as the baseline against which future temperature rise is measured. And that average temperature is different for the globe and for Australia.

The *Burning Embers* image on page 26 of this submission provides a direct comparison between the two baselines, with at two degree rise above preindustrial temperatures equating to a 1.2 degree rise above the 1980-1999 baseline. Note that this is global temperature.

Australian temperature rise would be similar although not exactly the same, given that Australia's temperature rise has been slightly different than the globe's already. As stated in the body of the submission, temperature over land increases faster than global average temperature and the southern hemisphere in general will warm slower than the northern hemisphere.

According to the Bureau of Meteorology data, Australian 20-year average temperatures are already around 0.1 of a degree above the 1980 to 1999 baseline. For global temperature, the Goddard Institute of Space Studies data shows a rise of around 0.2 degrees in the 20-year average temperature above the average global temperature between 1980 and 1999. This shows how difficult it is to make direct comparisons. This should be kept in mind when looking at scenarios of future temperature rise.

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