Close to the edge

ENVIRONMENT 1

DAVID SPRATT discusses the consequences of climate change and the impact of controls on carbon

JAMES HANSEN IS A NASA SCIENTIST ON A mission, but it is not directed to the moon or to Mars, but to the heart of American politics.

Hansen is convinced that we are on the edge of precipitating ecological disaster and '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).

And Hansen is no crazy. The Director of NASA's Goddard Institute for Space Studies, and one of the world's most eminent climate scientists for three decades, his budget has been slashed by the Bush administration as punishment for speaking out on climate change and he has been officially gagged. So now he regularly takes days off work and as a private citizen talks passionately to scientific organisations and community audiences around the country, claiming his right to free speech under the protection of the first amendment of the American Constitution.

Hansen is one of many scientists concerned that the 2007 reports of the International Panel on Climate Change (IPCC) will not tell the whole story; that the IPCC process is bogged down in line-by-line negotiations by government representatives from around the world that produces a lowest-common-demoninator, conservative report on climate change.

Of particular concern is the failure of the IPCC to focus on the likely impacts on the polar regions, such that 'it fails to stress that climate change is already

Carbon taxes or a carbon ration?

THE GLOBAL MEAN temperature has risen 0.8º since the late 1880s, but due to 'thermal imbalance' there is a latent temperature rise still to come of about 0.6º, which will result in a rise of 1.4ºC for the present level of atmospheric greenhouse gases.

It is widely considered that warming should be kept well below 2°C to avoid triggering irreversible, dangerous climate change. NASA's James Hansen says that 'global warming of more than ~1°C, (above the 2000 temperature of 0.7°C to 1.7°C) 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. Time is very short.

Today global atmospheric carbon emissions average around 1.27 tonnes per person; in Australia the rate is 5.63 tonnes. In comparison, the earth's current capacity to absorb carbon is 0.62 tonnes per capita, estimated to decrease to 0.32 tonnes by 2030. That is, Australia's present per capita emissions are eighteen times the earth's carbon sink capacity of 2030.

Modelling in the recently released 'High Stakes' report (Baer and Mastrandrea 2006) provides a '2ºC crash program' scenario which shows carbon 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' (see Figure 1).

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

- immediately stabilise emissions at

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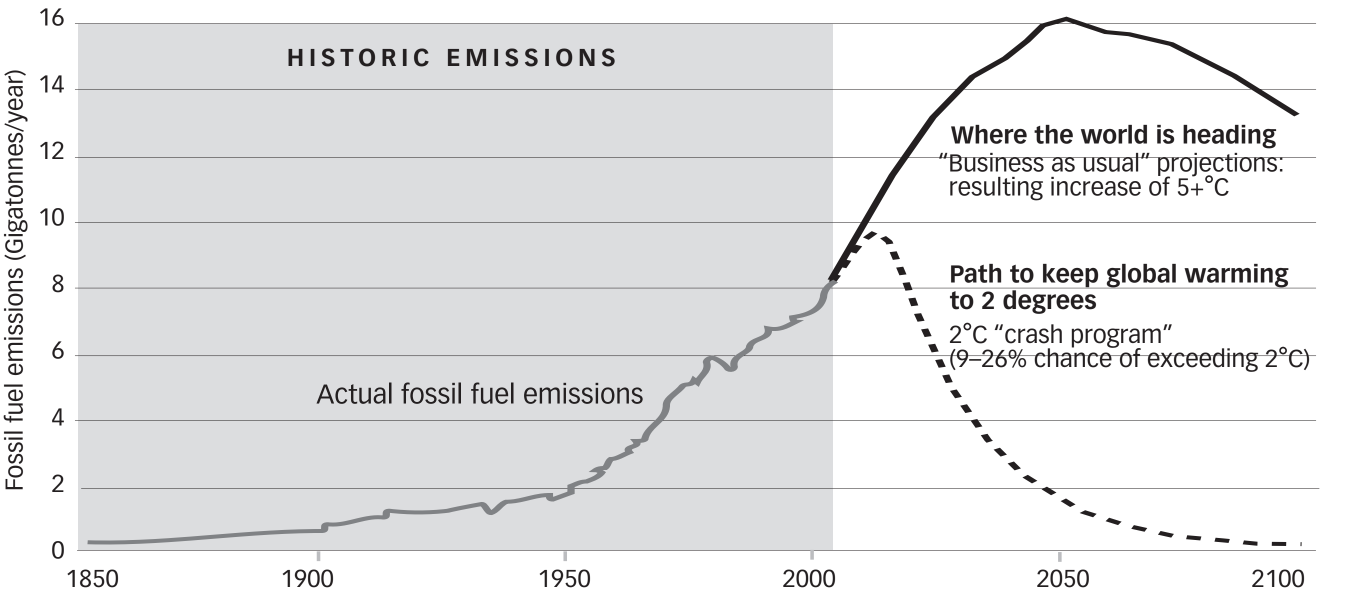
emissions.

having a severe impact on the (Antarctic) continent and will continue to do so for the rest of century. At least a quarter of the sea ice around Antarctica will disappear in that time... though this forecast is not mentioned in the study ... One expert denounced the February 2007 report as "misleading". Another accused the panel of "failing to give the right impression" about the impact that rising levels of carbon dioxide will have on Antarctica.' (McKie 2007)

Driving the alarm of climate scientists is recent and increasingly sombre research, and new data from the Arctic region. 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. 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).

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. Australian prime minister John Howard's response to the February 2007 IPPC summary report release was that life would be 'less comfortable for some' (sic) if average temperatures rose between four and six degrees by the end of the century! New environment minister Malcolm Turnbull suggested that tweaking Australia's planning laws to build houses further from the beach would be enough to

The emissions gap



Source: *Historic emissions/BAU path*: GCP Report No. 5/2006 www.globalcarbonproject.org BAU based on 2001 IPCC report scenario. 2°C *"Crash program" path*: Athanasiou, T, S Kartha, P Baer, 2006 "Greenhouse Development Rights", EcoEquity/Christian Aid (www.ecoequity.org) deal with a one-metre sea level rise. Their ignorant 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 adaptation 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 IPCC report 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 which destabilise further parts of the ice sheets) and so on. An unstoppable chain reaction may be set off (runaway global warming), but this is far from inevitable: the system may restabilise at higher global temperature.

The example given above is the **Albedo effect.** It is occurring in the Arctic basin. 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).

James Hansen says that up to a point 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)

Events in the Arctic are already starting to destabilise 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. 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).

their current level;

- set a target of reducing total emissions by over 90% by 2030-40; and
- set an annual and enforceable reduction target of at least 4%.

For a strategy to be effective, it must deal with reducing total demand for carbon emissions, either by placing a price (tax) on carbon emissions sufficient to drive down demand, or setting a total emissions target or budget that decreases over time and is enforced by a system of carbon rationing that sets a price by balancing supply and demand.

For a price or tax on carbon to be effective, it is essential that the tax apply to all carbon emissions. Any sector with a capacity to escape carbon pricing can derail the outcome. Carbon trading schemes that deal with emissions from only some sectors cannot, by definition, produce the emissions outcome that the science dictates.

For example, for air travel, the fastest growing sector of global carbon emissions, there are few available low-carbon substitutes. The federal transport department projects air travel emissions for domestic and international (fuel uplifted in Australia) flights to increase to 21849 Gg CO_2 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 emitted at ground level) so effective total air travel emissions by 2020 will be 0.67 tonnes carbon per person (compared to a carbon sink capacity in 2030 of around 0.32 tonnes carbon per capita). So, air emissions alone in Australia would exceed our total carbon budget well before 2030.

Carbon emissions

Global	Australia
1.27 tonnes per person	**5.63** tonnes per person

Put simply, a carbon tax increases the price of goods with carbon content to the point where:

- there is technological substitution because the no/low-carbon good has a lower end-price: for example, renewable for carbon-generated

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 an '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, 2006c).

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 2006)

As the Arctic warms, **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. Professor 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

electricity, different transport choices as the relative costs of transport modes change.

- more energy efficient technologies in the house, office and industry become a rational economic choice as the cost of stationary energy rises (solar hot water, natural ventilation for air conditioning, etc). The Energy Efficiency and Greenhouse Working Group noted in 2003 that 'Significant potential for energy efficiency to improve further... improvements of 15-35% are achievable under conservative assumptions of only existing technology being available, and that the change must pay for itself within four years.'

The incidence and social impact of a carbon tax is a key issue in considering how the socially regressive impact of a carbon tax might be alleviated by social policies or tax changes that redistribute some or all of the revenue from a carbon tax.

The 2006 CSIRO report on energy, 'The heat is on', provided a number of scenarios aimed at stabilising CO_2 at 575 ppm by 2100 'through the introduction of a globally harmonised carbon tax from 2030'. This is aimed at producing a reduction of 35% in emissions compared to the 'business as usual' emission scenario. Whilst the targets are ludicrously high, the results are instructive. Scenario 2a which assumes carbon capture and storage (CCS) technology is available produces a carbon price by 2050 of 2005A\$99/tCO_2 or \$361 per tonne of carbon. Scenario 2b which assumes no CCS is available produces a carbon price by 2050 of 2005A\$157/tCO_2 or \$573 per tonne of carbon.

Global carbon absorbtion capacity

2007	2030
0.62 tonnes per person	0.32 tonnes per person

The Stern report introduces a cost/benefit analysis that compares the marginal cost of abatement with the social cost of carbon. That is, at what rate should a carbon tax be set so that the cost of the tax is lower than the future cost of abatement. It's an odd approach if you are talking about catastrophic climate change for which no abatement is possible, but Stern derives a figure of US\$85/tCO_2, or approx A\$397 per tonne of carbon (Stern 2006).

At present electricity from wind

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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 terrestrial 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... CO_2 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 has decreased in some ocean regions by 30 per cent. James Lovelock points out that as the ocean surface temperature warms to over 12ºC, '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', recognised 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 CO_2 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 10ºC, 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 3ºC), regulation began to fail and there was a sudden upward jump in temperature. The cause

power is 40-50% more expensive than conventional power. Averaging the emissions factors between existing and new capital stock for electricity generation, and assuming that the relative capital costs of conventional and renewable generation technologies stay at current levels, it can be demonstrated that the following rates are necessary to make green energy an equally rational economic choice to carbon-fired electricity: black coal $183 per tonne of carbon; brown coal $247 per tonne of carbon; natural gas $421 per tonne of carbon.

All of which suggests that for a carbon tax to have a significant impact on emissions, it would need to be multiples higher than the figures being talked about in Australia today for emissions trading: around $300-$400 per tonne of carbon, not the $20-35 being mooted. And in the end it seems very unlikely that such a tax could force down emissions by the 90% plus that is necessary.

The alternative is carbon rationing with 21st century technology. The British environment minister David Miliband says 'the challenge we face is not about the science or the economics ... it is about politics'. Carbon rationing would, he says, 'limit the carbon emissions by end users based on the science, and then use financial incentives to drive efficiency and innovation' and is 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' (Miliband 2006). Currently reports are being prepared for the British government on how carbon credits might be implemented.

Carbon rationing works as follows:

- An authority independent of government, like the Reserve Bank, sets a total carbon emissions budget for the country each year, which is decreased by three or four per cent each year in a series of downward steps; in a decade emissions have been cut by 30 or 40 per cent.
- Because households are responsible for about 34 per cent of emissions, 34 per cent of the carbon budget is made available free of charge as an equal 'carbon credit' (or ration) for each citizen on an electronic swipe 'carbon card' which would be used to draw on an individual carbon credit balance each time household gas and electricity, petrol and air tickets are paid for. Unused credits can be sold.
- For minor amounts of energy embedded in commodities purchased such as food and personal

was the failure of the ocean ecosystem. As the world grew warmer, the algae were denied nutrients by the expanding warm 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 8ºC 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.

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. It is fatuous to talk casually, as does the prime minister about a three or four of five degree rise as if it were a stable state: more than likely two-to-three degrees means 8ºC. Climate change will be either small or quite large, as James Hansen forebodes.

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. — James Hansen

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services, the carbon ration will already have been paid by the manufacturer, and its cost built into the end price for the consumer.

- If a person lacks the carbon credits to cover a purchase or is an overseas visitor without a carbon credit, he or she could buy on the 'spot' market at the point of sale.
- The balance of 66 per cent would be auctioned to business and government in a market where the price would rise and falls such that the business and government demand for carbon emissions would not exceed the budget target for business carbon emissions.

The change would be rapid and effective: suddenly renewable electricity would be cheaper than coal-fired power, everyone would want solar hot water and better insulated houses, the madness of excessive use of private cars would be rationalised, stores and offices would be lit by natural light and skylights rather than floods of lights. We might even slow down a little and reduce our madly stressed lives, planning our movements for the day before we leave home. We would be more likely to consume what we need, rather than what we want.

Because both individuals and businesses can trade their carbon credit within the overall national carbon emission target, there is a financial incentive to switch rapidly to low-carbon technologies and for low-carbon innovation. If a new technology needs less of your ration, it will become more attractive, and business has an incentive to make long-term, low-carbon investment decisions.

— *David Spratt*

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