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5 St Vincent Place, Albert Park, VIC 3206 • tel: (03) 9645 7977 • email: enquiries@tya.org.au • www.australiancollaboration.com.au

Intergovernmental Panel on Climate Change: Fourth Assessment reports

In 2007, the *Intergovernmental Panel on Climate Change* (IPCC), the world's leading scientific body on climate change, released the *Summary for Policymakers* of each of the three Working Group reports, together with the Synthesis Report. These reports form part of the IPCC's Fourth Assessment. This fact sheet summarises their key conclusions.

In brief, the reports state with high confidence that climate change is happening and the warming of the world over the last several decades, is largely due to human emissions of greenhouse gases (GHGs). Climate change is already having noticeable effects, which are likely to increase to potentially dangerous dimensions by or earlier than 2100, unless greenhouse gas emissions are greatly reduced. Moreover, the IPCC says that impacts are very likely to cause costs that will increase as global warming increases, but that there is substantial potential for reductions in emissions at little cost to the economy, with many examples given. It reports that global costs of emission reductions to achieve stabilisation of GHG concentrations at levels between 445 and 710 ppm CO_2 equivalent[1] would range between a 5% loss and a 1% gain in global Gross Domestic Product (GDP) in 2050. This is less than a tenth of one percent of the growth in GDP by 2050.

In agreement with the Stern Report issued in the UK during 2006, the IPCC Working Group III report confirms that potential costs of the impacts of unabated climate change and sea level rise would far exceed the costs of reducing greenhouse gas emissions to avoid the impacts.

Background

Scientists chosen to write IPCC reports are appointed on the basis of their relevant expertise. Exhaustive processes of peer and government review are followed, with responses to all comments documented and archived for transparency. More than 2000 scientists from many countries are directly involved.

The final documents are the responsibility of the scientist authors, but the Summaries for Policymakers are subject to agreement, line-by-line by government representatives, including countries as disparate in their views and interests as the UK, Germany, Russia, the United States, China, India and Australia. As this final "plenary review" is based on consensus and the agreement of the scientist authors, no single extremist position is possible.

This does not mean that political influence is entirely absent: compromises are reached on some issues, but these have to be agreed to by the scientist authors. Changes are invariably matters of emphasis or expression rather than of facts.

IPCC is charged with preparing reports that are relevant to policy but do not tell governments or people what to do. Three factors have tended to create difficulties in providing the best advice:

- A tendency for many scientists involved in these Assessments to concentrate on "best estimates" in which they have most confidence, rather than on less certain possibilities that may be more serious in their impacts. The latter are important in risk management, since they identify and hopefully quantify more extreme possible outcomes that should be avoided by policy actions.
- A tendency for many scientists to only state numerical conclusions that come from processes explicitly included in numerical models of climate and sea-level rise. Other processes may be known to be occurring, with possibly large impacts, but if these are not already in the numerical models the magnitude and likelihood of their impacts cannot be confidently stated. How these unquantified possibilities are dealt with in reports can be critical.
- The cut-off date for publications considered in any report is set so that any statements based on recent work have been reviewed by relevant experts apart from those

drafting the Assessments. Thus in some details the reports become out of date before they appear in print.

The IPCC Assessments are very different to the day-to-day work of a "normal" scientist. In her/his day-to-day work, a scientist is looking for cutting edge results and theories. In IPCC Assessments the same scientist is looking for what is generally agreed across the field and is well-supported by multiple lines of evidence and by multiple publications in the scientific, peer-reviewed literature. IPCC aims to identify the "gold standard" science, rather than the "leading edge" science.

Conclusions from the IPCC reports have to be considered in the light of these factors.

Key findings of the IPCC reports

Working Group 1: The Physical Science Basis

- **Concentrations of GHGs now far exceed pre-industrial values** and the increases are due primarily to fossil fuel usage and land-use change and agriculture.
- There is now very high confidence that the global average effect of human activities since 1750 has been one of warming of about 0.8°C. **Global warming is unequivocal**, and is now evident in air and ocean temperatures, widespread melting of snow and ice, and rising global sea levels due to thermal expansion and ice melt.
- **Numerous long-term changes in regional climate have been observed** including higher temperatures and reduced sea ice in the Arctic, changes in precipitation, ocean salinity, wind patterns and weather extremes including drought, heavy rains, heat waves and intensity of tropical cyclones.
- For a doubling of atmospheric carbon dioxide, stabilised warming is likely to be in the range 2 to 4.5°C. It is very unlikely to be less than 1.5°C but warmings substantially higher than 4.5°C cannot be excluded.
- **For the next 20 years warming of about another 0.4°C is inevitable for the IPCC range of emissions,** due to past emissions and lags in the climate system. Continued greenhouse gas emissions at or above current rates would cause further warming during the 21st century. For the full range of the IPCC emissions scenarios, the lowest plausible warming by 2100 is about 1.1°C relative to the 1990s and the highest is about 6.4°C.
- **Projected sea level rises** by 2100 are estimated to be in the range 18 to 59 cm, but this does not include uncertainties in climate-carbon cycle feedbacks, nor the full effects of changes in ice dynamics, because these are not yet included in the models. If ice flow rates continue to increase in Greenland and Antarctica significantly higher sea level rise might occur. 125,000 years ago, when polar regions were warmer than now, sea level was 4 to 6 metres higher.
- Increased atmospheric carbon dioxide concentrations have led to **increased acidity in the oceans**. Further acidification is likely to occur over the 21st century, sufficient to inhibit coral growth and shell-formation in many oceanic species.
- **There is now higher confidence in projected patterns of warming**, changes in wind patterns, precipitation, some aspects of extreme events and ice. Even if greenhouse gas concentrations are stabilised, warming and sea level rise would continue for centuries, due to the long timescales of climate processes and feedbacks,
- **In Australia**, tropical cyclones are likely to be more intense, heat waves and heavy precipitation events more frequent, and extra-tropical storm tracks and wind and precipitation patterns will move further poleward.

In March 2009, the International Alliance of Research Universities (IARU) held an International Scientific Congress in Copenhagen, entitled "Climate Change: Global Risks, Challenges and Decisions". The Synthesis Report stemming from the Congress summarised the most recent knowledge from the research community in preparation for the United Nations Climate Change Conference to be held in December 2009.

Recent research cited in the Synthesis Report shows that some climate indicators are changing at the upper level of the range indicated in the IPCC's 2007 reports. Significantly, sea level rise is changing at levels greater than IPCC projections, and ocean warming is occurring at a rate 50% higher than previously reported.

The IARU Synthesis Report also noted that the 2°C rise in temperature above pre-industrial levels remains the most often quoted guardrail for avoiding dangerous climate change, but a 2°C rise is now considered to carry significant risks of deleterious impacts for society and the environment.

Working Group 2: Impacts, Adaptation and Vulnerability

- **Observations from all continents and most oceans show natural systems are being affected by regional climate changes, especially warming**. This includes snow, ice and permafrost, land and ocean species and ecosystems and ocean acidity. 89% of 75 studies involving 29,000 data series of physical and biological systems and species, show changes consistent with a response to warming. Effects of regional climate changes on human and managed systems are emerging, but are complicated by adaptation and non-climatic stresses (e.g., land-use change, population growth).
- **Future impacts can now be projected for many sectors**, e.g., increased runoff at high latitudes, decreased runoff and drought in some mid-latitudes, loss of seasonal water storage in snow and glaciers, loss of species and ecosystems, reduced crop productivity at low latitudes and at mid-latitudes with larger warmings, increased coastal erosion and flooding, displacement of many coastal populations, increased vulnerability of many settlements and industries, and increased threats to health especially in poor countries.
- Specific information is available for many regions. **Impacts on Australia** will include: water problems in southern and eastern Australia, and significant losses of biodiversity in the Great Barrier Reef, the Queensland Wet Tropics, Kakadu, south-western Australia, alpine areas and the sub-Antarctic islands. Coastal development and population growth in many coastal areas will amplify losses from sea-level rise and increased severity of storms and coastal flooding. Productivity from agriculture and forestry is expected to decline by 2030 over much of southern and eastern Australia due to increased drought and fire. While substantial adaptive capacity is available, there will be increasing costs associated with adaptation and from failure to fully adapt.
- **Regions other than Australia will also experience significant problems**, with increasing malnutrition in Africa, displacement of many coastal people from large deltas and small islands in many countries, low adaptive capacity in many poor countries and increasing financial expense and losses even in rich countries, especially from impacts of extreme events.
- **Key impacts are expected to increase with increasing global warming, becoming very widespread and serious at warmings of only 2 or 3°C above temperatures of the 1990s.** This is especially true of impacts from extreme events. **Climate change impacts are very likely to impose net annual costs that will increase over time as global warming increases.**
- **Some large-scale climate events have the potential to cause very large global impacts**, especially beyond 2100. Sea-level rise of up to 7 m from melting of the Greenland Ice Sheet, and 5 m from melting of the West Antarctic Ice Sheet is possible over timescales of centuries to millennia, possibly triggered by warming in the 21st century. Slowing of the rate of sinking of cold saline water in the North Atlantic is very likely during the 21st century, with widespread impacts on marine ecosystems, fisheries, ocean uptake of carbon dioxide, oceanic oxygen concentrations and terrestrial vegetation.
- **Adaptation is necessary to address impacts** resulting from the warming that is already unavoidable due to past (and continuing) emissions. A wide array of adaptation options is available, but more is required. There are barriers, limits and costs to adaptation, but these are not fully understood.
- Other stresses such as pollution, poverty, and inappropriate development (e.g., rapid population growth) increase vulnerability to climate change. **Sustainable development can reduce vulnerability to climate change**, while climate change can impede sustainable development.
- **Many impacts can be avoided, reduced or delayed by reducing GHG emissions**

Working Group 3: Mitigation of climate change (reducing emissions and mitigating impacts)

- **Global GHG emissions have increased by 70% between 1970 and 2004**, and will continue to grow under current policies. The March 2009 IARU Synthesis Report noted that fossil fuel emissions have accelerated to grow at around 3.4% per year, an observed growth rate that is in the upper edge of the range of growth rates in IPCC scenarios.
- **There is substantial economic potential for limiting or reducing GHG emissions over the coming decades, even below current levels**. Key technologies for reducing emission of GHGs are available in all relevant sectors including energy supply, transport, buildings, industry,

agriculture, forestry and waste, and also through non-technological means such as life-style changes and management practices.

- **These technologies will often have other benefits.** For example, improvements in energy facilities can create opportunities to reduce GHG emissions, and at the same time reduce air pollution, improve the balance of trade, and provide better services in rural areas and increased employment.
- **Geo-engineering options** such as ocean fertilisation to remove atmospheric CO2, or blocking sunlight in the upper atmosphere remain largely speculative and unproven, with unknown side effects and costs.
- **In order to stabilise GHG concentrations in the atmosphere and thus eventually the climate, emissions must peak and then decline**. The lower the needed stabilisation level the sooner the peak and decline must occur. Emissions reductions over the next two or three decades will have a large impact on opportunities to reach lower levels. Research presented in Copenhagen in March 2009 confirmed that immediate and dramatic reductions in emissions are necessary if the 2°C guardrail is to be respected, with a peak in emissions occurring in the near future. If peak greenhouse gas emissions are not reached until after 2020, the emission reduction rates required thereafter would have to exceed 5% per annum. This is a daunting challenge when compared to a long-term average annual increase of 2% in emissions.
- **Stabilisation of atmospheric GHG concentrations in the low range of 445-490 ppm CO2 equivalent would still lead to eventual global warming in the range of about 1° to 3°C** (which entails a risk of causing "widespread and serious" climate change).[2] To reach the lower stabilisation levels some scenarios depend upon removal of CO2 from the atmosphere (negative emissions).
- The range of stabilisation levels assessed by IPCC can be achieved with a portfolio of technologies, assuming appropriate incentives are in place for their development and deployment. **Global costs of emission reductions** to achieve stabilisation of GHG concentrations at levels between 445 and 710 ppm CO2 equivalent would range between a 5% loss and a 1% gain in GDP in 2050. This **is less than a tenth of one percent of the growth in GDP by 2050.**
- **Choosing an appropriate level of global emissions reductions over time is a risk management process.** It involves balancing the costs of more rapid emission reductions now against the longer-term risks from climate change.
- **Many national policies and instruments are available to governments** to create the incentives for reducing emissions. Each of these has advantages and disadvantages. All approaches (such as regulations and standards, taxes and charges, tradeable permits and other incentives) can be designed well or poorly, and be stringent or lax.
- **Polices that provide a price on carbon emissions could create incentives for producers and consumers to invest in low-GHG products, technologies and processes.** However, many barriers to implementation of emission reduction policies, exist.
- **Government support through financial contributions, tax credits, standard setting and market creation is important for effective technology development, innovation and deployment, and for transfer to developing countries.**
- The United Nations Framework Convention on Climate Change and its Kyoto Protocol stimulated an array of national policies, created an international carbon market and established new mechanisms that may provide the foundation of future emissions reduction efforts. **There are many options for reducing GHG emissions globally through international cooperation**.
- **Changing the pattern of development to make it more sustainable can make a major contribution to emissions reductions** but extra resources may be needed to overcome barriers.

The IPCC's Synthesis Report

In November 2007, the IPCC released the AR4 Synthesis Report. Although the report is essentially a summary of the previous three reports (on the science of climate change, on likely impacts and adaptation and on paths to mitigation) there are some significant shifts in emphasis. The messages are strengthened. The generally conservative assessments of the earlier reports are exposed rather than hidden. The report acknowledges openly that the numerical estimates given for sea-level rise do not include recent evidence for more rapid discharge of ice from Green-

land and Antarctica that could lead to faster sea-level rise. The links between mitigation strategies and climate impacts are made explicit.

Most relevant to impacts on Australia, the Report confirms that mid-latitude storm tracks in the Southern Hemisphere are expected to move further polewards, leading to reduced rainfall in southern Australia. This is already happening, resulting in the prolonged "droughts" in the southwest and more recently in southeastern Australia. The present water crisis in southern Australia is a combination of natural variability and climate change. We are moving into a more arid climate and are unlikely to pull out of the present 'drought'.

The Report highlights four major areas of adverse impacts on Australia:

- Significant loss of biodiversity in some important sites such as the Great Barrier Reef and Queensland Wet Tropics;
- Water supply problems likely to get worse in southern and eastern Australia;
- Agricultural and forestry production likely to decline over much of southern and eastern Australia; and
- Ongoing coastal development and growth in population likely to increase risks from sea level rise and increases in storms and coastal flooding.

This should motivate Australians to insist that we do something to reduce greenhouse gas emissions. Projected impacts in many other countries, including those of Asia and North America should motivate other key countries to act as well, notably China, India and the United States. The report thus provides a basis for international action arising out of the common threat to all major countries. Global greenhouse emissions and sea-level rise are already tracking at the highest levels of the range of uncertainty reported by IPCC. Based on this new evidence sea-level rise by 2100 is unlikely to be under 1 metre, and could be considerably larger. This will have enormous implications for present coastal infrastructure and coastal development.

The Report finishes with the statement that "balancing the economic costs of more rapid emissions reductions now against the corresponding medium-term and long-term climate risks of delay" is at the centre of the policy debate regarding emissions reduction. The Report provides evidence that reducing global greenhouse gas emissions can be done at quite moderate costs, far less than the costs of failing to do so. To date, we in Australia, and indeed the world community, do not have policies in place to do what is necessary.

Comments and updates on these findings will be contained in other Fact Sheets.

Endnotes

1 CO_2 equivalent if a measure of the combined effect of all greenhouse gases, as if they were all CO_2. It is calculated based on the effectiveness of each gas as a greenhouse gas.

2 This is actually a WGI result, but does not appear in the WGI SPM Summary despite its critical importance for policy. It is in the WGIII Figure SPM 8. What is "dangerous" is a subjective judgement.

Useful Sources

Intergovernmental Panel on Climate Change
http://www.ipcc.ch/
The AR4 Synthesis Report and the reports from the three working groups are all available on the IPCC site.

The Stern Review on the Economics of Climate Change **http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm**. In this report for the UK government, distinguished economist Sir Nicholas Stern assesses the alternative global economic costs for early action to respond to climate change versus non-action.

The Garnaut Climate Change Review:
http://www.garnautreview.org.au/domino/Web_Notes/Garnaut/garnautweb.nsf
The Garnaut Climate Change Review was commissioned by Australia's state and territory governments on 30 April 2007. On taking office, Prime Minister Kevin Rudd confirmed the Commonwealth Government's involvement in the Review. It was conducted by Professor Ross Garnaut, and dealt with the economic impact of climate change on Australia. The Review presented its Final Report to the Prime Minister of Australia and the eight states and territories on 30 September 2008.

Author

This fact sheet was written by Dr Barrie Pittock, leading climate scientist and author. Last revised July 2009.