



CSIRO Submission 08/291

Garnaut Review – Emissions Trading Scheme  
Discussion Paper

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## Introduction

CSIRO notes that the purpose of the Garnaut Emissions Trading Scheme Discussion Paper is to outline the Review's views on the role and design features of an emissions trading scheme.

CSIRO's submission in response to this Paper includes comments on the Emissions Trading Scheme (ETS) model in the discussion paper, and considerations relating to the inclusion of agriculture and forestry in an ETS.

These comments should be taken in the context of CSIRO's previous advice to the Garnaut Review secretariat on current and potential future emission scenarios, potential impacts on Australia, and issues in analysing the economic impacts of climate change in using economic models. These specific inputs and advice will be documented where relevant in the draft and final reports of the Review, particularly in relation to the methods and assumptions used in modelling the impacts of various national and global emissions trajectories.

Summaries of previous advice from CSIRO on emissions trading, and of CSIRO's relevant research are included in appendices.

## CSIRO response to the ETS model in the Discussion Paper

CSIRO considers that the broad approach to emissions trading set out in the Discussion Paper is consistent with design principles and insights from economics and the wider climate science context. We consider, however, that the definition of allowable emissions should take account of the demand for 'beyond trajectory' emissions reductions and that the signalling of different potential trajectories to 2050 should provide clarity rather than certainty to avoid undermining incentives for the best possible economy-wide risk management.

### *Accommodating voluntary or 'beyond trajectory' abatement*

A first issue is that some actors within Australia will want to take action that goes beyond whatever target Australia has set for itself. This may reflect personal beliefs or values, brand positioning, or represent a mechanism for hedging 'trajectory risk' for emissions exposed firms or activities. It is important that the design of the ETS and accompanying policy measures enable 'beyond trajectory' abatement, such as by firms who wish to claim – with substance and accreditation – that their products or services are carbon neutral.

### *Promoting efficient adjustment through and providing business clarity*

The principal rationale for signalling multiple trajectories is to reflect the pervasive uncertainties around the choice of Australia's allowable emissions over time. Providing clarity about the processes, conditions and considerations involved in changing from one trajectory to another helps businesses make informed investment decisions and manage associated risks. This contributes to efficient resource allocation over time (Hatfield-Dodds 2007a).

The multiple trajectory approach set out in the discussion paper would specify long run trajectories based primarily on the nature of the prevailing international agreement, and essentially envisages that Australia would switch from Trajectory C (interpreted as our commitment with a 'business as usual' evolution of international commitments) to Trajectory D in the event of more decisive global action. This is a very useful advance on previous approaches (such as a 'single trajectory' or more short term 'gateway' approach), but does not address some issues.

This is because the scope of International commitments is only one source of uncertainty impacting on the choice of an optimal emission trajectory. Changes in the scientific understanding of climate processes and risks, including through surprise events, may also impact on the choice of trajectory. These issues, in general, are likely to affect the choice of Australia's trajectory through effecting international commitments, but there may be issues where Australia evaluation of specific climate risks differs from the evaluation of others. The national and global economic impacts of achieving emissions reductions are also subject to increasing uncertainties over time, especially in relation to the effects of innovation across low carbon energy generation, potential step changes in energy efficiency, and the development of unforeseen technologies (particularly in transport and non-energy emissions,

such as in agriculture). Some economic modelling finds, for example, that pursuit of deep global emissions reductions boosts world gross product relative to the base case (before taking account of avoided climate impacts) because of the economy-wide productivity benefits of higher levels of research and development and innovation more generally (Edenhofer 2006). Again, these effects may be expressed through changes in international agreements, but this will take time and may not perfectly reflect Australia's national interests. Finally, it is unlikely that the range of potential international agreements could be distilled into two classes, each associated with one unique optimal Australian emissions trajectory.

The scale of these uncertainties imply that it would be difficult or impossible to define a single 'Trajectory D' that Australia could commit to in 2010 and be confident that it would represent the best national contribution to decisive global action on climate change. Over-specifying or mis-specifying the trajectory risks reducing efficiency by unnecessarily distorting decision making across the economy. Given inherent uncertainties, providing long run business certainty implicitly or explicitly shifts risks from private decision makers to government (and taxpayers), which may exacerbate distortions and inefficiencies.

This suggests that policy should provide clear guidance to business and others about the issues and considerations that will be taken into account in deciding whether to change trajectory, clearly specify adjustment arrangements for permits that are already issued, and provide illustrative information on the government's current view of the range of potential long run emissions trajectories.

The issue of long run future dated permits should seek to avoid excessive potential future fiscal obligations that would reduce the flexibility of future governments in adjusting trajectories. This argues in favour of issuing only modest volumes of long run permits. Future price visibility and information on current expectations about future carbon prices could be achieved through issuing government-backed medium and long run options (Hatfield-Dodds 2007a).

### ***Considerations relating to the inclusion of agriculture and forestry in an ETS***

The following comments relate to inclusion of agriculture and forestry in an emission trading scheme. They focus on (i) scope, (ii) science challenges, and (iii) the issues of integration and tradeoffs.

#### **Scope**

It would be useful to define the elements of "agriculture" and "forestry" as these are subject to different interpretation.

- Does agriculture include extensive grazing such as of savannah where there may be significant opportunities to mitigate GHG emissions, and increase C-storage, through judicious management of fires and grazing?
- Does "forestry" pertain to both plantations and managed native forest? Where would environmental plantings of trees for non-commercial biodiversity and carbon sequestration purposes, such as in the Gondwana Link Project and the Alps to Atherton Project, sit with respect to ETS and definition of forestry?

#### **Science challenges**

- Enabling the approaches used in National Carbon Accounting System and National Greenhouse Gas Inventory to operate effectively and creditably at fine scale in time and space appropriate to emissions trading:
  - Time, being annual estimations rather than long term predictions of carbon sequestration
  - Space, being "paddock" scaleErrors and uncertainties that to some extent cancel out at national accounting scale are significant at the scale at which emissions trading will be conducted. While model calculations will be used to deem greenhouse gas emission reduction associated with certain management activities, there is a clear need for strict conformation protocols to be developed for checking that the deeming is working for each trading project.
- Inclusion of forestry in emissions trading needs to account for measurement of carbon sequestered in long-lived timber products. In addition, inclusion of both forestry and agriculture

needs to account for substitution of hydrocarbon based products with natural materials, e.g. replacements for fossil fuels, plastics and bulk chemicals.

### **Integration and tradeoffs**

Individual land use systems do not operate in isolation or impact on a single outcome. Land use change on a particular area of land can impact: (i) on multiple benefits, and (ii) beyond that area, water and biodiversity being prime examples. To avoid unintentional consequences of land use change that might be driven by emissions trading consideration needs to be given to how the outcome of development of carbon sequestration and greenhouse gas mitigation can be integrated at landscape scale alongside other economic and environmental outcomes (e.g. water and biodiversity).

## **Appendix 1 - Previous advice from CSIRO on emissions trading**

CSIRO provided the attached submission to the Prime Ministerial Task Group on Emissions Trading in March 2007 (see Attachment A). This submission noted, among other issues, that the international literature suggests that developed countries, such as Australia, are likely to need to reduce emission by 60 to 90 percent by 2050 to have a reasonable prospect of avoiding dangerous levels of climate change. This implies that it will be important to position Australia to adopt more ambitious emission targets without including unnecessary economic costs – if desired – such as in response to improved scientific understanding of climate impacts, the development of new low carbon technologies, or evolving international circumstances. Research noted below suggests that making deeper cuts in emissions would involve modest and manageable economic impacts in relation to the potential impacts of unmitigated climate change, and that sharp unanticipated ‘tightening’ of Australia’s emissions trajectory would risk unnecessary economic costs.

The previous submission covered four main issues:

- greenhouse gasses and climate change
- a workable emissions trading system
- economic impacts of emissions trading systems
- emissions trading and policy innovation

## Appendix 2 – Relevant CSIRO research

### CSIRO research into policy impacts, incentive design, and adaptive governance

CSIRO conducts research into design and assessment of incentive based policy approaches. A number of projects have researched issues directly related to emissions trading and are summarised below.

#### ***Economic analysis of impacts and opportunities associated with emissions trading***

In addition to the economy-wide and energy sector modelling undertaken through the Energy Futures Forum (2006), CSIRO has been involved in analysing specific dimensions of the national and regional impacts of emissions reductions for various bodies. Key findings include:

- Achieving emissions reductions of 60% or more is projected to reduce annual GDP and GNP growth by up to 0.1% (lowering projected growth from 2.2% pa to 2.1% pa or from 2.9%pa to 2.8% pa), with cumulative impacts equivalent to 2% to 6% of the base case by 2050 depending on scenario and modelling assumptions (ABRCC 2006, Hatfield Dodds, Jackson et al 2007);
- Steady early action to reduce emissions would involve significantly smaller economic impacts than delayed action to achieve the same cumulative emissions (ABRCC 2006);
- Early commitment to deeper cuts of 80-100% by 2050 would involve relatively modest additional economic impacts, and would provide valuable 'insurance' or risk management advantages in light of international uncertainties associated with potential pressures to adopt more ambitious emissions targets before 2050 (Hatfield Dodds, Jackson et al 2007);
- The transition to a low carbon economy will involve significant increases in employment from current in sectors with high energy use and potential environmental impacts (such as heavy industry, construction and transport), requiring significant skills and work practice implications (Hatfield-Dodds, Schandl et al 2008);
- Rural Australia and the agricultural sector has much to gain from emissions trading, especially at higher carbon prices, including access to new business and income streams from renewable energy and creation of vegetation based sinks – assuming that any future policy moves to include direct agricultural emissions in emissions trading addresses potential trade distortions for export commodities (Hatfield-Dodds, Carwardine et al 2007).

#### ***Assessing the welfare significance of the economic and physical impacts of achieving deep cuts in greenhouse emissions through emissions trading***

CSIRO has also explored the welfare significance of the economic impacts suggested by economic modelling, in part because social perceptions of impacts are a key factor influencing the ability of government to enact worthwhile reforms (Syme and Hatfield-Dodds 2007). Key insights have included:

- Slower trend increases in real income resulting from the introduction of emissions trading are likely to have little or no impact on self reported well-being or observable indicators of well-being in high income nations, with diverse literatures indicating sharply diminishing returns from increased average income or per capita GDP above a threshold of around US\$10,000 (Hatfield-Dodds 2006).
- Achieving deep cuts in emissions is unlikely, of itself, to impact negatively on lifestyles or physical quality of life in Australia. Most analysis suggests that achieving deep cuts in greenhouse emissions would result in total Australian energy use stabilising at or slightly higher than current levels, with gradual reductions in per capita energy use. It is likely that such reductions in energy use would be offset by improved energy efficiency, so that 'energy services' are improved or at least maintained relative to current levels (Hatfield-Dodds 2007b, Hatfield-Dodds, Jackson et al 2007).
- Most Australian analysis suggests that reducing emissions will result in significant energy price increases, with the real price of electricity increasing by more than 50% over twenty years. Affordability is likely to improve over time, however, as incomes are overwhelmingly projected to increase more than energy prices, and so the share of income required to purchase a given amount of energy (or level of energy service) will decline even in the face of very deep cuts in emissions (Hatfield-Dodds and Adams 2007, Hatfield-Dodds, Jackson et al 2007).

This work has catalysed related research into how the framing and communication of the impacts of mitigation policy interacts with public attitudes towards policy action, described in more detail below.

### **Policy issues in signalling the emissions trajectory and issuing permits**

Commissioned research undertaken for the Prime Ministerial Task Group on Emissions Trading (Hatfield-Dodds 2007a) found that:

- Significant uncertainties in climate science, the costs and availability of low emissions technologies, and the development of international agreements and expectations imply that the design of the emissions trading system should give careful attention to allowing adjustment of the national emissions trajectory over time.
- Issuing future dated emissions entitlements would not, of itself, provide certainty about future emissions targets (a key influence on future carbon prices) but would influence the views of carbon market participants. For example, if permits are fully issued for an emissions trajectory markets would recognise that shifting to a more ambitious target would require repurchase of some permits – potentially requiring billions of dollars per year of adjustment – implying that tightening of emission targets would be less likely than loosening under these institutional arrangements. This would not be the case if permits embody rules that share the impact of changes in trajectory (such as a proportional increase or decrease in the quantity of emissions covered, or number of permits).
- These issues suggest that consideration should be given to issuing medium term price contingent options to supplement price visibility and communicate market expectations of future prices. These might take the form of a 'high' and 'low' priced option dated 10-15 years into the future.

### **CSIRO energy and transport futures research**

CSIRO's Energy Futures research program partners with industry, government and community groups to identify plausible scenarios and develop innovative modelling approaches to determine implications of alternative futures for the economy, energy prices, technology uptake, greenhouse gas emissions and other environmental indicators.

This research program included the Energy Future Forum, a unique [three year] participatory exercise involving 20 leading Australian energy organisations and stakeholders which culminated in the 2006 report *The Heat is On: The future of energy in Australia*. That report contributes to the literature on the expected costs and benefits should Australia become involved in global emission trading. This material can be accessed at <http://www.csiro.au/science/EnergyFuturesForum.html>.

CSIRO is building on the experience and insights from the Energy Futures Forum through a project called the Future Fuels Forum which is examining the future of the transport sector in more detail (<http://www.csiro.au/science/futurefuelsforum.html>). The Future Fuels Forum which brings together fuel suppliers, road users groups, environmental groups, vehicle manufactures and government to explore plausible futures, quantify their outcomes for cost of travel, explore the transport sectors role in greenhouse gas emissions abatement and project potential technology development paths.

The Forum is in the process of delivering a final report (Modelling of the Transport Sector and its Response to an Emissions Trading Scheme) to the Australian State and Territory Governments' National Emission Trading Taskforce. The report will summarise the key challenges in arriving at a secure and sustainable transport fuel future. The final report scheduled to be publicly available in June 2008.

### **CSIRO research into the communication of policy impacts and public attitudes towards policy action**

It must be emphasised that this research is currently under external review, and has not yet been published. (Hatfield-Dodds and Jollands 2006 provides an initial report on the New Zealand pilot survey.) CSIRO is happy to provide the Garnaut Review team with a copy of our working paper under embargo until formal publication.

Presentations and discussions of research into the welfare significance the mitigation policy impacts (outlined above) indicated a widespread misunderstanding that achieving deep cuts in emissions will involve reductions in living standards from current levels (Azar and Schneider 2002) despite economic analysis overwhelmingly indicating that emission reductions result in slower increases – not reductions

– in economic living standards (Edenhofer et al 2006, Energy Futures Forum 2006, IPCC 2007). A CSIRO research project hypothesised that this misunderstanding could have a material impact on public attitudes towards policy action, and associated political support.

CSIRO explored this issue through split sample phone and internet surveys that applied insights from studies of individual choice (Tversky and Kahneman 1981, Kahneman et al 1991) to the communication of the impacts of policy action and associated public attitudes. These surveys had a total sample of 4596 and were implemented in Australia and New Zealand over the period from March to December 2006. Research design and implementation was led by Steve Hatfield-Dodds (CSIRO) and Mark Morrison (CSU).

A finding is that the communication biases identified significantly reduce support for mitigation policy. This negative effect on support is equivalent to the effect of overstating policy impacts by up to four times, and is considered large enough to be politically salient. The research also indicates that this communication bias can be avoided or corrected by describing mitigation policy outcomes relative to current living standards, as well as relative to projected future living standards without mitigation policy.

The study results suggest that political pessimism about gaining public support for deep cuts in global emissions may be profoundly misplaced. Rather, commonplace – and easily corrected – biases in the communication of the impacts of mitigation policy may be preventing effective national and global action.

## **CSIRO research on reducing greenhouse gas emissions from Australia's agricultural, forested, and managed rangelands, and increasing carbon storage in Australian landscapes**

### **Scope**

CSIRO has a research focus on the integration of substantive scientific effort in key aspects of soil, plant, animal systems and new work in the interaction of current and potential management systems which leads to "best management practice" systems operating at an integrated landscape scale with sequestration and greenhouse gas mitigation as an outcome.

The scope of the research activity includes:

- a) Reducing net GHG emissions (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) from Australia's agricultural, forested, and managed rangelands.
- b) Increasing long-term C storage (biosequestration) in these landscapes:
  - (i) The capture of atmospheric carbon dioxide and the storage of carbon in plants and soil.
  - (ii) Storage of carbon in long lived biological materials (e.g. Biochar, wood products)
- c) Developing robust measurement and monitoring systems (in space and time) to support verification / trading.
- d) Substitution of hydrocarbon based products with natural materials (e.g. replacements for fossil fuels, charcoal replacement of coke and coal in a range of metallurgical processes)

### **Research**

Current and planned research activity is outlined below.

#### *Livestock (links to grazing and rangeland)*

Short term:

- More accurate estimates of emissions especially CH<sub>4</sub>
- CH<sub>4</sub> and N<sub>2</sub>O into NCAS
- Management options to reduce livestock emissions

Long term

- Technical solution to address enteric methane emissions
- Lifecycle research into rangeland livestock production systems and temperate production systems

#### *Forests – planted, native, long-lived products*

New forests

- Regional and local suitability assessments for plantations that quantify new income streams for farmers and consider, water, biodiversity and social impacts.
- Improved predictions of growth and carbon sequestration, and methods to better estimate and verify sequestration.
- New species for biosequestration
- Vulnerability of new plantings

#### Protection and management of existing native forests

- Management impacts on woody thickening
- Fire impacts on direct emissions of CO<sub>2</sub>, non-CO<sub>2</sub> GHGs, and charcoal production and turnover
- Methods to better estimate and verify biosequestration
- Vulnerability of the large existing stocks of carbon in land systems to the direct and indirect effects of climate variability and change.

#### Storage in long lived wood products

- The amount of wood harvested, fate of the wood harvested (into various products or waste streams)
- The life-time of the carbon in various product and waste streams

#### *Rangeland/grassland*

- Rates of carbon storage in the absence of land clearing
- Management impacts on woody thickening
- Fire impacts on direct emissions of CO<sub>2</sub>, non-CO<sub>2</sub> GHGs, and charcoal production and turnover
- Methods to better estimate and verify biosequestration
- Vulnerability of the large existing stocks of carbon in land systems to the direct and indirect effects of climate variability and change.

#### *Cropping systems*

- Impacts of changed agricultural practice on soil carbon stocks
- Methods to better estimate and verify biosequestration.
- Dealing with C-stock decreases as well as increases as paddocks go through crop pasture rotations
- Including and verifying sources and sinks of non-CO<sub>2</sub> GHGs that are produced by agricultural practices (nitrous oxide and methane)

#### *Soil*

- Robust assessment of potential for including soil C in an emissions trading framework. Requiring:
  - Realistic potential and options for increasing C storage in Australian soils, underpinned by understanding of resilience and dynamics of key soil carbon pools.
  - Capacity to monitor change in soil C spatially, temporally, and cost-effectively.
- Dynamics of N<sub>2</sub>O emissions, the processes responsible for its generation, and strategies for reduction.

#### *Integrating/over-arching research*

- Integrated modelling frameworks in the cropping (e.g. APSIM), grazing (e.g. GRAZFEED) forestry (e.g. CABALA) and soil-C domains to enable the integrated assessments that are needed to look at whole-systems emission budgets, trade-offs with other factors, enterprise-scale economics etc. Emission-calculating modules for the main greenhouse gases (e.g. GreenCalc) should be part of this platform.
- More effective monitoring and verification across systems
- Options to increase C-storage in cost-effective ways across systems, across scales

## References

- Australian Business Roundtable on Climate Change, 2006, *The Business Case for Early Action*, April 2006
- Azar, C. and S.H. Schneider, 2002, 'Are the economic costs of stabilising the atmosphere prohibitive?' *Ecological Economics* 42 (2002) 73-80
- Edenhofer, O., K. Lessmann, C. Kemfert, M. Grubb and J. Köhler, 2006, Induced Technological Change: Exploring its implications for the Economics of Atmospheric Stabilisation: Synthesis Report for the Innovation Modelling Comparison Project, *Energy Journal* (Endogenous Technological change and the Economics of Atmospheric Stabilization Special Edition) pp.57-108
- Energy Futures Forum, 2006, *The Heat is On: The Future of Energy in Australia*. A report by the Energy Futures Forum. CSIRO Canberra
- Hatfield-Dodds, S. and P. Adams, 2007, *Beyond the Double Dividend: Modelling the impacts of achieving deep cuts in Australian greenhouse gas emissions*. Paper presented to Australian Agricultural and Resource Economics Society Conference, February 2007, Queenstown, New Zealand
- Hatfield-Dodds, S., 2006, 'Reducing Greenhouse Emissions: Interpreting the economic impacts', in R. Chapman, J. Boston, and M. Schwass (eds) (2006) *Confronting Climate Change: Critical issues for New Zealand*, Victoria University Press, Wellington, New Zealand
- Hatfield-Dodds, S., 2007a, *Policy Issues in choosing forward commitments of emissions entitlements*. A discussion paper prepared for the Prime Minister's Task Group on Emissions Trading. CSIRO Sustainable Ecosystems, Canberra.
- Hatfield-Dodds, S., 2007b, 'The Economics of Climate Change and Climate Policy: Contributions and Distractions' in J. Boston (ed), 2007, *Towards a New Global Climate Treaty: Looking Beyond 2012*, Institute of Policy Studies, Wellington, New Zealand
- Hatfield-Dodds, S., and N. Jollands, 2006, *Issues in Communicating the Impacts of Climate Change Policy Options*, Consultancy report to the NZ Ministry for the Environment, NZCEE / CSIRO, July 2006
- Hatfield-Dodds, S., E.K. Jackson, P.D. Adams, and W. Gerardi, 2007, *Leader, follower or free rider? The economic impacts of different Australian emission targets*, The Climate Institute, Sydney, Australia.
- Hatfield-Dodds, S., H. Schandl, T. Doss and G. Turner, 2008, *Skills and labour challenges in moving to a low carbon economy: Summary of the DSF green collar jobs project*. Submission to the Garnaut Review prepared for the Dusseldorp Skills Forum, April 2008. CSIRO Sustainable Ecosystems, Canberra.
- Hatfield-Dodds, S., J. Carwardine, M. Dunlop, P. Graham, and C. Klein, 2007, *Rural Australia Providing Solutions for Australia*. A discussion paper prepared for the Australian Agribusiness Alliance on Climate Change, CSIRO Sustainable Ecosystems / The Climate Institute, Canberra
- IPCC WGIII, 2007, *Climate Change 2007: Impacts, adaptation and vulnerability – Summary for Policymakers*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge, UK: Cambridge University Press, pp 7–22
- Kahneman, D., J.L. Knetsch and R.H. Thaler, 1991. 'Anomalies: The endowment effect, loss aversion and status quo bias', *Journal of Economic Perspectives* 5(1) 193-206
- Syme, G.J and S. Hatfield-Dodds, 2007, 'The role of communication and attitudes research in the evolution of effective resource management arrangements', in S. Dovers, K. Hussey and D. Connell (eds) *Delivering the National Water Initiative: Understanding the social and industry dimensions*, CSIRO Press, Melbourne.
- Tversky, A and D. Kahneman, 1981, 'The Framing of Decisions and the Psychology of Choice' *Science* 211 (30 January 1981) 451-458



## Response to Issues Paper

Prime Minister's Task Group on Emissions Trading

**CSIRO submission**

March 2007

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## Executive Summary

- CSIRO has a strong multidisciplinary research background and knowledge base that it has developed in areas relevant to the Terms of Reference.
- Climate change is one of the most significant issues that Australia is currently facing. Global greenhouse gas (GHG) emissions are accelerating rapidly and are currently above the highest previous estimates of emissions growth. Of major importance is how we can mitigate further anthropogenic interference with the global climate system and develop ways of adapting to new situations, including carbon-restrained economies.
- A particular challenge is how we can reduce our domestic GHG emissions. An emissions trading system provides a prospective option.
- In designing an emissions trading system it will be important to consider what an appropriate long term emissions trajectory might be and consider that:
  - Current scientific understanding cannot precisely predict either the maximum temperature increase necessary to avoid unacceptable damage or the levels at which global GHG emissions need to be stabilised in order to avoid dangerous interference with the climate system. The best scientific estimates are that emissions should be stabilised at a level consistent with avoiding temperature increases of 0.9 – 2.9° above pre-industrial levels.
  - Research suggests that to have a reasonable chance of avoiding temperature increase above these levels, the trend increase in global emissions would require reversing within the next two decades.
  - These scientific findings point to the desirability of near term policy settings ensuring that Australia maintains maximum flexibility for achieving the more stringent reduction targets.

Consideration also needs to be given to:

- The potential social, economic and environmental impacts of climate change on the country;
- The level of reduction in emissions for which Australia is prepared to take responsibility;
- The near term targets that Australia might set to reduce its own GHG emissions from existing levels; and
- The timing and magnitude of reductions that might be undertaken by other nations.
- In designing an emissions trading system, it is important to consider that:
  - An effective response to climate change must be global;
  - A workable system for Australia needs to reflect Australian conditions;
  - The system should allow for easy integration with emerging international emissions trading systems;
  - Emissions will need to accurately measured, monitored and reported;
  - The system will need to build on decisions on the timing, extent of, attitudes to and judgements to potential global emissions targets and respond to them; and
  - The nature and duration of permits and processes for issuing them will impact on incentives and market behaviour.
- It will also be important to consider the impact of potential policy action to reduce GHG emissions, taking into account that:
  - The more flexible the policy approach, the lower are the expected abatement costs.
  - The best available modelling suggests that deep cuts in emissions are compatible with continuing strong economic growth and improvements to living standards.
  - Technological advance will play a key role in determining marginal abatement options and costs, but economic models currently struggle to incorporate technological innovation over decadal time scales.
  - An emissions trading system could have an important role in providing market signals that will encourage the development of relevant technologies and facilitate their use.

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## Introduction

CSIRO, the Commonwealth Scientific and Industrial Research Organisation, is Australia's national science agency and one of the largest and most diverse research agencies in the world. CSIRO's research aims to help create innovative and competitive industries, ensure the growth of a technologically advanced society and maintain healthy environments and lifestyles.

One of the ways that CSIRO operates is to employ its multidisciplinary capabilities (which span 17 Divisions and six National Research Flagships) to help Australia address the major challenges that it is facing. One of these significant domestic and international issues is clearly climate change. Governments around the world, including our own, are investigating ways of mitigating further anthropogenic interference with the global climate system and developing ways of adapting to new situations, including carbon-restrained economies. Of major importance is how we can further reduce our greenhouse gas emissions.

CSIRO research effort in climate change is multifaceted and includes research aimed at: understanding the environmental, economic and social implications of climate change; developing new technologies to reduce greenhouse gas emissions (GHG) and improve energy efficiency; and modelling possible policy approaches, one of which is the development of a workable global emissions trading system.

Specific areas of activity include:

- Exploring the nature and drivers of climate change.
- Modelling scenarios of climate-related impacts on Australia, including regional projections of temperatures, water availability, bushfire risk and coastal inundation.
- Investigating and assessing strategies and options for the mitigation of climate change using a variety of approaches, including economic modelling of policy scenarios.
- Investigating and assessing strategies and options for adapting to climate change, including to increases in climate variability that might occur.
- Surveillance of all greenhouse gases; observation and verification of claimed greenhouse gas emissions and concentrations in the atmosphere.
- Developing integrated risk assessment capacity to weigh the risks of climate policy against the benefits of avoided damages
- Investigating synergies between adaptation and mitigation options to identify multiple benefits and potential conflicts.
- Developing damage functions as a property of regional and global climate change and testing of alternative models for their benefits in avoided damages within a risk framework.
- Developing clean coal technologies and both the capture and storage of carbon dioxide (CO<sub>2</sub>).
- Developing cost-effective renewable energy technologies.
- Utilising Australia's large natural gas resources many of which are economically stranded under present conditions.
- Capturing and storing carbon dioxide using biosequestration
- Exploring attitudes and behavioural issues, such as the determinants of technology adoption at different scales and their implications for the design of effective and acceptable interventions by different sectors and levels of government.

CSIRO's interest in the issues identified by the Prime Minister's Task Group on Emissions Trading arises from the strong research background and knowledge base that it has developed. The purpose of our response is to provide the Task Group with information that can help inform the nature and

design of a workable emissions trading system for Australia within the context of the Group's Terms of Reference.

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## Greenhouse gases and climate change

Research has shown that climate change is the direct result of worldwide increases in the anthropogenic emissions of greenhouse gases (GHG). A global emissions trading system could help reduce these emissions and mitigate future changes.

To be most effective, an emissions trading system should include all greenhouse gases (GHGs). The GHGs listed in the Kyoto Protocol are carbon dioxide (CO<sub>2</sub>); methane (CH<sub>4</sub>); nitrous oxide (N<sub>2</sub>O); sulfur hexafluoride (SF<sub>6</sub>); hydrofluorocarbons (HFCs); and perfluorocarbons (PFCs). This list does not include chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) which are controlled by the Montreal Protocol. However, given the considerable potential impact of HCFCs on radiative forcing over the next twenty years, and the timescale for their control under the Montreal Protocol, the Task Group may wish to consider whether there is a need to include this group of gases in any global emissions reduction strategy.

Although a trading system should include all GHGs, when an organisation calculates its greenhouse emissions it reports them as though they were equivalent to a given volume of CO<sub>2</sub>. This is called the *carbon dioxide equivalent* or CO<sub>2</sub>e. Calculating CO<sub>2</sub>e takes into account that each of the GHGs has a different capacity to heat the atmosphere. This is called their global warming potential (GWP). Carbon dioxide is the least potent of the GHG in terms of GWP. However because CO<sub>2</sub> is produced and released in such huge quantities, its effect on climate change is much more significant than all of the other GHGs combined.

The increase in CO<sub>2</sub> has contributed approximately 60% of the additional heat that is trapped in the atmosphere. This additional heat is known as *enhanced radiative forcing* and it has driven climate change over the past 250 years (Ramaswamy *et al.*, 2001; referenced and quoted in Beer *et al.*, 2006). The underlying long term global CO<sub>2</sub> growth rate has increased since the mid 1970s in response to increases in international fossil fuel emissions, despite global attempts to increase the efficiency of fossil fuel use.

It is important to note that climate change occurs largely as a result of changes in the accumulated stock of GHGs in the atmosphere. This means that some future changes to the climate are inevitable. Even if we stopped emitting all GHGs now, so that atmospheric GHGs remained constant at current levels, the gases that we have already released will continue to have an effect for some time to come. This committed warming effect is estimated at between 0.2 – 1.0°C, and is in addition to the temperature increase of 0.7°C that has already occurred (Wigley, 2005).

Fossil fuels are likely to remain a significant component of the world energy mix for many decades to come. This means that CO<sub>2</sub> from fossil fuels will continue to be the dominant factor in climate change due to GHGs.

Global CO<sub>2</sub> emissions from fossil fuel burning and industrial processes are accelerating. There has been a rise from an annual average growth rate of 1.1% per annum from 1990-1999 to over 3% per annum from 2000-2004 (Raupach *et al.*, 2007). This acceleration in emissions has been driven by a cessation or reversal of earlier declining trends in *carbon intensity* (which is the ratio of emissions to Gross Domestic Product (GDP) or World Gross Product). This reversal is largely driven by GHG emissions in key developing countries, particularly China, growing even faster than their rate of economic growth. As shown in **Appendix 1**, the net result is that global emissions are rising more rapidly than the highest of the Intergovernmental Panel on Climate Change (IPCC) emissions scenarios developed in the late 1990s.

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## A Workable Emissions Trading System

### **Setting an emissions reduction target**

In designing an emissions trading system in which Australia could participate, it is important to consider:

- The likely effects of climate change on the country;

- The level of reduction in emissions that Australia is prepared to take responsibility for through domestic or offshore mitigation; and
- The targets that Australia might set to reduce its own GHG emissions.

The extent of the desired reduction from existing levels will be important in setting some of the parameters of the trading system, including the level of emissions for which the trading system will issue permits and corresponding emissions price measures.

Global warming will directly affect most segments of the economy and all aspects of our lives. A number of recent studies have reviewed likely climate pressures and their impacts on industry, the natural environment, health and infrastructure (refer to Allen Consulting 2005; Jones and Preston, 2006). Some of the expected impacts include less water for cities such as Perth; an increased fire risk in SE Australia and Tasmania; and the southward spread of mosquito-borne diseases in SE Queensland (CSIRO and the Australian Greenhouse Office, 2002; referenced and quoted in Beer *et al.*, 2006). Rainfall is also likely to decrease in south western Australia and in parts of the south east and in Queensland (CSIRO 2001; referenced and quoted in Beer *et al.*, 2006).

In setting a national emissions target it is also important to consider the timing and magnitude of reductions that might be undertaken by other nations. Much of the scientific analysis of the merits of different mitigation targets begins with the ultimate aim of the United Nation's Framework Convention on Climate Change (UNFCCC). This is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCC,1992).

Interpreting what is 'dangerous' in this context requires scientific understanding of climate and earth system processes and an understanding of the potential social, economic and environmental impacts of climate change.

Current understanding of these complex parameters is not sufficient to precisely identify the maximum level of global mean temperature change required to avoid dangerous levels of climate interference or the at what level it is necessary to stabilise GHG concentrations to ensure that we do not exceed these levels.

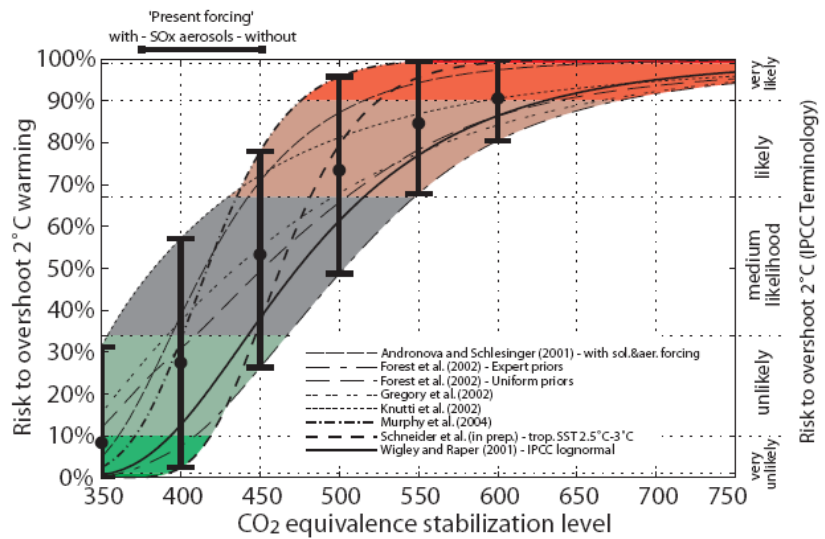
Recent studies suggest temperature targets to avoid dangerous levels of climate interference range from 0.9 – 2.9°C above pre-industrial levels (summarised in Table 1 from Preston and Jones, 2006; see Schellnhuber 2006). As noted above, the earth is already committed to temperature increases of 0.9-1.7°C, even if anthropogenic emissions stopped immediately (Wigley, 2005). The best available models suggest that without substantial action to reduce emissions, temperature could rise by up to 6°C (refer to **Appendix 1**). This suggests that there will need to be very significant changes in energy use and other emissions-generating activities if we are to avoid dangerous levels of climate interference.

Related studies suggest that to avoid overshooting these temperature targets it will be necessary to stabilise GHG concentrations at between 375 – 550 parts per million by volume (ppmv) CO<sub>2</sub>e. The current concentration of atmospheric CO<sub>2</sub> is already at approximately 377 ppmv (Blasing and Smith, 2006).

Consistent with these studies, the European Union's Environment Council has recommended that policy action seek to prevent a global mean temperature increase of more than 2°C (European Council, 2005), and the Stern Report (2006) recommends greenhouse gas stabilisation in the range 450-550 ppmv.

**Figure 1** summarises a number of studies which have modelled the possible effects on warming of various CO<sub>2</sub>e stabilisation levels. The figure shows that according to our best available estimate, GHG stabilisation at 450ppmv would have a 54% chance of exceeding 2°C warming at equilibrium (Hare and Meinshausen, 2004; Meinshausen 2006), with the range of estimates for the risk of exceeding 2°C warming being from 26% to 78% (Meinshausen 2006). With GHG stabilisation at 550 ppmv, the chance of exceeding a 2°C warming is estimated at between 63 - 99%. Therefore, GHG stabilisation at or below 450 ppmv is necessary in order to ensure a reasonable likelihood of warming remaining at or below 2°C.

**Figure 1:** The probability of exceeding 2°C global mean equilibrium warming for different CO<sub>2</sub> equivalent stabilization levels (from Meinshausen, 2006).



Related studies indicate that relatively short delays in implementing comprehensive global action (as reflected in the date that global emissions are expected to peak) would require significantly greater subsequent reductions in annual emissions to achieve a comparable stabilisation target. This implies that it would be desirable to implement comprehensive global reductions in emissions from 2015 – 2020. This is illustrated in **Table 1**.

**Table 1:** Emissions paths to stabilisation

Stabilisation level CO <sub>2</sub> e	Date of global emissions peak	Global emissions reduction rate (% per year)	Reduction in emissions relative to 2005 levels (%)	
			2050	2100
450 ppm	2010	7.0	70	75
500 ppm (falling to 450 ppm in 2150)	2010	3.0	50	75
	2020	4.0-6.0	60-70	75
	2030	5.0 <sup>b</sup> -5.5 <sup>c</sup>	50-60	75-80
550 ppm	2015	1.0	25	50
	2020	1.5-2.5	25-30	50-55
	2030	2.5-4.0	25-30	50-55

Source: Stern 2006 pg.200

Overall, these studies suggest that if the objective is to ensure no more than 2°C warming, national emissions trajectories that are consistent with stabilising global GHG concentrations at 400-500 ppmv CO<sub>2</sub>e may be necessary. For this reason, near term policy settings should preferably ensure that Australia maintains maximum flexibility for achieving these more stringent targets. Policy that presumes stabilisation targets of 500-550 ppmv (and no lower) as the required reduction in emissions would present risks. This is because if it became clear that stabilising atmospheric GHGs at these levels would lead to warming beyond the target level, further and urgent action would become necessary. This would be more costly and have more dramatic economic and social costs than action taken earlier and might prove ineffective.

## ***Designing and effective and efficient emissions trading system***

The development of a workable emissions trading system would provide an opportunity for Australia to show leadership in the global reduction of GHG emissions. It would also help position Australia to take advantage of the new opportunities that a trading system and transition to a low emissions economy could generate. These are likely to include stronger markets for new low emission technologies and methods for dealing with existing emissions.

It is important to consider a number of key issues in the design of any system designed to reduce anthropogenic GHG emissions.

1. An effective response to climate change must be global. This means that it must involve key developing nations and limit the growth of their future emissions while meeting the national interest of key high income nations.
  - It is important to note that six jurisdictions (United States; European Union; Japan; China; India; and Russia) are now responsible for more than 75% of emissions. This simplifies the political challenge of negotiating an effective international agreement.
  - Research on the potential impacts of climate change suggests that developing nations have a strong incentive to support effective action to take action. For example, uncontrolled climate change would;
    - Threaten Chinese food security, with reductions in glacier fed summer flows, trend reductions in precipitation in inland continental regions and increased drought risk;
    - Threaten border security and stability in India and its neighbours, as well as increased drought and extreme weather events; and
    - Disrupt inland and coastal fisheries and access to protein.
2. A workable system for Australia needs to reflect Australian conditions, our economic and social structures, resource endowments and political and market systems.
  - The system should encompass all practical forms and sources of anthropogenic GHG emissions, where this can be achieved with low transaction costs.
  - The system needs to have wide application, and preferably reflect the importance of carbon sinks as well as emissions. For example, biosinks provide an important means of reducing carbon emissions, as discussed in **Appendix 2**. A trading system that does not acknowledge this might lead to the neglect of an important means of mitigating GHG emissions.
3. The system needs to be easily integrated with emerging international emissions trading systems. Given that the problem of GHG emissions is a global one, being able to operate across international boundaries will significantly increase the options available for reducing emissions and lead to lower cost solutions.
4. The system needs clarity as to how it will measure, monitor, and report on emissions. This should have a firm scientific foundation and be acceptable to other countries, to prevent arguments about data accuracy and relevance.
  - Policing of emissions to ensure system integrity while balancing measurement and compliance effort against the risks of misreporting will become a significant global issue. The National Greenhouse Gas Inventory for Industry relies on self reporting using emissions coefficients. Incentives for misreporting will increase as the emissions price rises. CSIRO has the technology necessary to measure industry emissions directly (usually by atmospheric measurements).
  - The development by the Australian Greenhouse Office (in conjunction with science providers) of the National Carbon Accounting System (NCAS) and the National Carbon Accounting Toolbox (NCAT) provides a useful approach to estimating carbon stocks and uncertainties associated with land use, land use change and forestry (LULUCF). It should be possible to use these in an emissions trading system, particularly since

afforestation and reforestation activities have been developed under the administration of Standards Australia (see **Appendix 2**).

- Verification of both industrial and LULUCF emission claims is especially important if Australia wants to operate globally, not just domestically. Scientific surveillance can play a role in monitoring whole-of-region for all sources, down to fleet-average emissions from motor vehicles. CSIRO research in this area has been applied to reducing the uncertainty of emissions inventories for Victoria using remote monitoring data from Cape Grim in north western Tasmania, and for the motor vehicle fleet in Melbourne, Sydney, Hong Kong and Bangkok (refers to references and quotes in Manins *et al.*, 2001).
5. The system will need to build on and respond to decisions made nationally and globally on the timing and extent of potential global emissions reductions and evolving international attitudes and judgements on desirable targets. This will set the context for setting a firm near term emission target (such as an x% reduction in GHG emissions by 2020), perhaps in conjunction with a longer term, quantitative goal.
    - While the national implications of global reductions necessary to stabilise GHG emissions at 400 – 500 ppmv CO<sub>2</sub>e depend crucially on the distribution of the emissions task between nations or groups of nations, most of the literature suggests the need for reductions in annual GHG emissions of 60-90% from 1990 or 2000 levels by 2050 for countries listed under Annex 1 in the Kyoto Protocol (Preston and Jones, 2006).
  6. The Task Group may also wish to consider how the nature and duration of permits and processes for issuing them will impact on incentives and market behaviour, especially as permit markets mature in Australia and around the world.

In considering the development of future international arrangements, an important issue for Australia is the Kyoto Protocol emphasis on accounting and controlling emissions in emitting jurisdictions. This gives rise to the potential for ‘emissions leakage’, which is a problem that becomes more important with higher implicit or explicit emissions prices. If uncorrected, this may give an ‘artificial’ policy-based advantage to emissions-intensive industries in unconstrained nations (including middle and low income nations). This undermines incentives for participation and reduces the environmental effectiveness of the agreement. Avoiding this problem will require a cross-broader approach, such as ‘border tax adjustments’ or global ‘sectoral approaches’ that encourage best emissions practice regardless of jurisdiction. Securing global action will also require clear signals by key developing countries that they are prepared to limit their future emissions growth.

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## Economic impacts of emissions trading systems

The economic impact of policy action to reduce GHG emissions, including emission trading systems, is a function of five broad factors.

1. The nature of the policy constraint (such as mandated technology standards versus tradable emissions permits), including the scope and coverage of the policy option in terms of GHGs; sources and sinks; sectors and nations; and associated administrative and compliance costs;
2. The extent and nature of emissions obligations across different countries and the nature of any flexibility mechanisms (such as international trade in emissions credits) which largely determines how the burden of emission reductions is distributed across nations and sectors;
3. The rate at which emissions are required to diverge from the “business as usual case”, which in turn depends on the outlook for emissions growth and the stringency of the emissions reductions sought through policy action;
4. The incremental cost of lower emission technologies over the period examined (which usually extends to at least 2050, raising issues about modelling technological change); and
5. The extent to which it is possible to reduce energy demand through:
  - Improvements in energy efficiency at the end-user stage;

- Changes in lifestyles; and
- Structural change in the economy towards a lower share of the more energy intensive industries.

In general terms, the more flexible the policy approaches the lower are the expected abatement costs (a tradable permits scheme covering the widest range of GHGs, sources and sinks provides an example of a flexible system). Technological advance will play a key role in determining marginal abatement options and costs, but the current economic models in Australia and abroad struggle to incorporate technological innovation over decadal time scales and this is still an area of active research.

A number of recent reports have estimated the economic impacts of achieving substantial reductions in emissions. Recent international modelling (Endenhofer *et al.*, 2006 and Grubb *et al.*, 2006) explores stabilisation scenarios for atmospheric concentrations of CO<sub>2</sub> at 450ppm and 550 ppm CO<sub>2</sub> using eight comprehensive global economic models and a further three global energy sector models.

- All of the models show positive but slower economic growth, with nine of the eleven models suggesting that world gross product in the 450 ppm scenario would be no more than 1% lower than the level achieved without emissions reductions by 2050.
- A second important insight from this modelling is that representing the development of new technologies in response to policy action in the model (referred to as endogenous technological change) typically reduces estimated global impact by 0.5% to 1.5% of world product. The authors argue that earlier modelling work overstates the economic impact of achieving substantial reductions in emissions because it paid less attention to endogenous technological change.

More detailed Australian modelling exercises (Allen Consulting Group report to the Australian Business Roundtable on Climate Change (2006); Energy Futures Forum report (2006); Hatfield-Dodds and Adams, 2007) report larger economic impacts from emissions reductions, reflecting both differences in modelling approach (including less attention to technological change processes) and Australia's specific economic circumstances. Key results include:

- Australia and the world continue to experience strong trend economic growth under all policy scenarios modelled, with Australian gross domestic product (GDP) more than doubling by 2040 in all scenarios.
- Australian emissions reductions in the order of 40-60% from current levels by 2050 are associated with trend annual GDP growth 0.10-0.25% below business as usual (that is, for example, 2.2% per annum rather than 2.4% per annum).
- Macroeconomic impacts are very small in the first 10 – 15 years, where uncertainty about the extent of global action is the greatest.
- The GDP gap between the base case and emission reduction scenarios in 2050 varies from 1.7% to 10.7% in the Energy Future Forum scenarios and from 5.1% to 6.0% in the early action scenarios modelled by Monash University. These reflect differences in both the specification of the scenarios and the models used.
- Electricity and other energy prices increase, but affordability improves as real incomes rise more than real prices (with both adjusted for inflation).
- Policy action can substantially decouple energy and emissions from the value of economic activity.

It is important to note that these estimates take into account only the economic costs of mitigation. They do not include any economic impacts of climate change itself. The studies thus do not account for costs or benefits of avoided climate change impacts (such as reduced storm and flood damage across Australia or avoided loss of tourism around the Great Barrier Reef).

More detail on the Australian modelling, particularly the results from the Energy Futures Forum, is provided at **Appendix 3**.

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## Emissions trading and policy innovation

An important benefit of an emissions trading system is that it can provide market signals that will encourage the development of low or no emission technologies and facilitate the use of such technologies. This is important because improved technologies can help decrease the global costs of reducing GHG emissions.

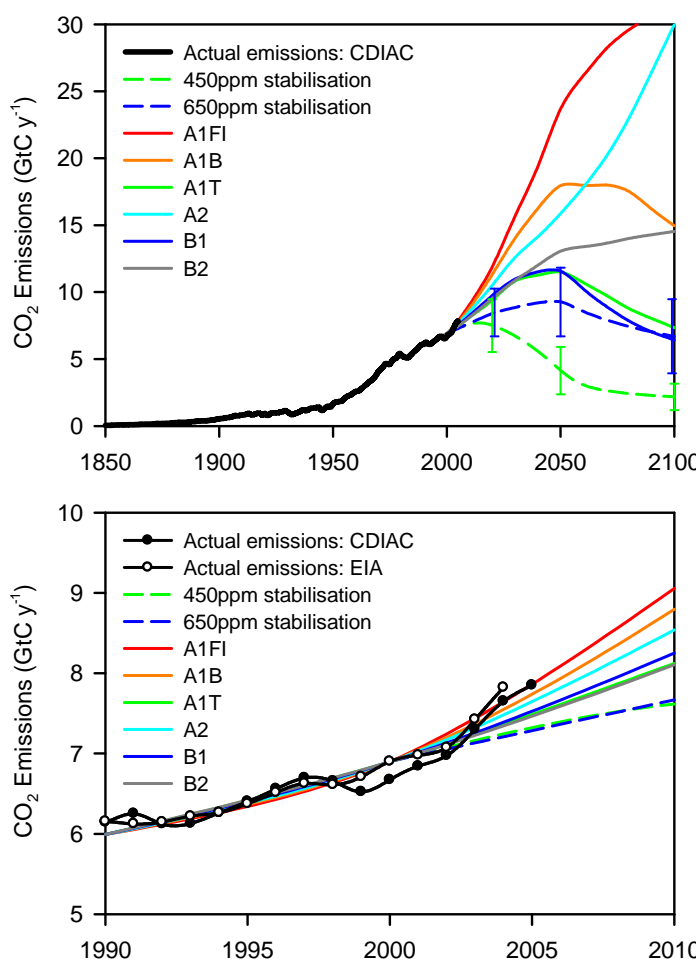
The introduction of an effective emissions price signal (such as through tradable emissions permits) gives market value to emissions and provides a crucial near term incentive to develop and deploy low emissions technologies by providing a financial return to improved emissions performance (including through improved energy efficiency, which provides indirect emissions savings). This price signal is particularly important for established technologies with scope for incremental improvement and for near-to-market technologies requiring demonstration and field testing.

The introduction of a credible emissions constraint or price signal would also have an important signalling effect about the likely long term future demand for low emissions technologies. This is a key factor influencing expected returns on investment in low emissions research. An example of the effectiveness of such a signalling effect is the impact of air quality and vehicle emissions standards in the European Union and California. Stringent standards in these jurisdictions have promoted research into cleaner vehicle technologies at laboratories around the world.

To be effective, the price signal provided by an emissions trading system should operate in as comprehensive a way as possible. The system should not exclude any technological or other options (existing or potential) for reducing or mitigating GHG emissions. This means that any trading system should take into account the importance of sinks, noting that Australia is largely on track to meet its notional Kyoto Protocol commitment because of biosinks (see **Appendix 2**). In addition, if the system is to produce the most cost-effective outcome and allow GHG emitters to draw on the broadest possible range of available options, it must operate across the widest possible range of jurisdictions and environments. One reason for this is that the market signals operating in different countries, regions and environments will depend very much on local conditions – including resource endowments, economic and industrial structure, population dispersion, urban structures, available technologies and a whole range of other factors. Moreover, the countries with the greatest need to apply clean technologies may not always be the ones where the market signals for doing so are strongest.

One consequence of this is that an efficient trading system should recognise the benefits that can arise from technology deployment beyond Australia, noting that the countries with the greatest potential to apply clean technologies may not always be the ones with the strongest market signals or capabilities. For example, there would be a very significant additional incentive to further the development of more effective technologies if those developing the technology in Australia were confident that there was a growing market for these technologies in countries such as China or India, either through international financial support for low emissions technologies or arrangements that effectively give ‘sponsoring’ firms or nations credit for the emissions reductions achieved.

Figure 1: Actual versus projected global GHG emissions (Source: Rapauch *et al.*, 2007)



**Notes:** Observed global CO<sub>2</sub> emissions data from Energy Information Administration (EIA) (<http://www.eia.doe.gov/emeu/international/energyconsumption.html>) and Carbon Dioxide Information Analysis Center (CDIAC) ([http://cdiac.esd.ornl.gov/trends/emis/tre\\_coun.htm](http://cdiac.esd.ornl.gov/trends/emis/tre_coun.htm); Marland, Boden and Andres, 2006), compared with emissions scenarios (Nakicenovic *et al.*, 2000) and stabilisation trajectories (IPCC 2001, Wigley, Richels and Edmonds, 1996, Joos *et al.*, 1999). EIA emissions data are normalised to same mean as CDIAC data for 1990-1999, to account for omission of cement production in EIA data. IPCC scenarios are spline fits to projections (initialised with observations for 1990) of possible future emissions for four scenario families, A1, A2, B1 and B2, which emphasise globalised versus regionalised development on the A,B axis and economic growth versus environmental stewardship on the 1,2 axis. Three variants of the A1 (globalised, economically oriented) scenario lead to different emissions trajectories: A1FI (intensive dependence on fossil fuels), A1T (alternative technologies largely replace fossil fuels) and A1B (balanced energy supply between fossil fuels and alternatives). The stabilisation trajectories (IPCC 2001) are spline fits approximating the average from two models (Wigley, Richels and Edmonds, 1996, Joos *et al.*, 1999) which give similar results. They include uncertainty because the emissions pathway to a given stabilisation target is not unique.

**References:** IPCC (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York; Joos F. *et al.* (1999). Global warming and marine carbon cycle feedbacks on future atmospheric CO<sub>2</sub>. *Science* 284: 464-467; Marland G., *et al.* (2006). Global, regional, and national CO<sub>2</sub> emissions. Trends: A

Compendium of Data on Global Change, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA; Nakicenovic N., *et al.* (2000). IPCC Special Report on Emissions Scenarios. Cambridge University Press, Cambridge, U.K. and New York; Wigley, T *et al.*, (1996). Economic and environmental choices in the stabilization of atmospheric CO<sub>2</sub> concentrations. *Nature* 379: 240-243.

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## Appendix 2: Biosequestration – A Key Element of a Workable Global Emissions Trading System

Australia is largely on track to meet its notional Kyoto Protocol GHG emissions commitment, almost entirely due to trees. Reducing the clearing of forests and woodlands for agriculture is offsetting most of the increases in emissions arising from stationary power, while increases in plantation growth are largely offsetting increases in emissions due to transport (AGO 2006).

Land use changes, mainly as a result of deforestation in the tropics, continue to account for about 15% to 25% of anthropogenic carbon dioxide emissions at the global scale (UN-Sigma XI Scientific Expert Group on Climate Change 2007), so reducing deforestation and encouraging tree planting should be an important part of any future global emissions trading system.

Reducing net emissions through biological sinks is particularly important as an immediate measure because other technologies such as clean coal geosequestration, nuclear or geothermal power will take 20 years or more to reduce emissions. In contrast, reducing deforestation and increasing tree planting are relatively cheap options and they can be scaled up almost immediately. Afforestation and reforestation (A/R) schemes can be implemented by unskilled people in developing countries. These are ‘no regrets’ actions that can be undertaken now and can make a major contribution to reducing CO<sub>2</sub> emissions, particularly in the next 20 years while high technology solutions are developed. Australia with its large area of marginal agricultural land has the potential to create significant new carbon sinks in woody biomass, and to produce large amounts of biofuels that can substitute for fossil fuel use.

In addition to afforestation and reforestation, other land management practices that increase stored carbon could become in scope for an emissions trading system. These activities include better fire management in northern Australia to reduce high intensity fires which are creating a net source of GHG in some savanna environments. One example of actively reducing emissions in response to this issue has been the recent implementation of fire management and abatement scheme in West Arnhem Land. The West Arnhem Fire Management Agreement (WAFMA) is a partnership between Darwin Liquefied Natural Gas (DLNG), the Northern Territory Government, the Northern Land Council and relevant Aboriginal Traditional Owners and indigenous representative organisations, formed to implement strategic fire management in the 28 000 km<sup>2</sup> Western Arnhem Land Fire Abatement project area for the purposes of offsetting greenhouse gas emissions from the Liquefied Natural Gas plant at Wickham Point in Darwin Harbour.

For any biosequestration program to function effectively in an emissions trading framework it must:

- Recognise and quantify the carbon sequestered with robust and practical approaches that are consistent with international frameworks; and
- Minimise transaction costs.

Australia has been at the forefront of developing regulatory and measurement approaches to meet these two criteria. The Greenhouse Gas Abatement Scheme has been implemented in NSW and ACT and is rigorous in meeting UNFCCC standards and Australian Standards around land eligibility, record keeping, risk management, permanency of carbon stocks, baselines, additionality and administration arrangements. More details on key issues associated with forest sinks can be found in a recent working group report (Afforestation and Reforestation Sub-group 2006).

The development of the National Carbon Accounting System (NCAS) and the National Carbon Accounting Toolbox (NCAT) by the Australian Greenhouse Office in conjunction with science providers provides a robust approach to verifying carbon stocks and carbon stock change and their uncertainties that can be effectively utilized in an emissions trading system. Afforestation and Reforestation activities have also been developed under the administration of Standards Australia so that there should be few impediments to afforestation and reforestation activities being included in an emissions trading framework.

Encouraging implementation of NCAS-like systems in developing countries should be an important part of implementing a workable global emissions trading system. Providing the ability to track land use, land use change and forestry at sub-hectare levels would allow reductions in deforestation rates, as well as increases in afforestation and reforestation to be assessed reliably.

## Appendix 3: Energy Future Forum Report – December 2006

In December 2006, the Energy Futures Forum released a report called *The Heat Is On: The Future of Energy in Australia*. The report examined several scenarios that mimic a global emissions trading scheme for their economic and environmental impacts. The following text summarises the economic impacts that were found by examining six GHG mitigation scenarios using emissions trading<sup>1</sup>. The scenarios that were modelled and the particular assumptions relating to the global carbon pricing system are shown in **Figure 1**.

**Figure 1:** The scenarios examined by the Energy Futures Forum

	Reference case	High oil price	Mitigation scenarios					
			1	2a	2b	2c	2d	3
Targeted global abatement of CO <sub>2</sub> at 2050	NA	NA	35%	40%	40%	40%	40%	40%
Introduction of climate change policy action	NA	NA	Late action: global participation commencing in 2030	Early action: global participation commencing in 2010	Early action: global participation commencing in 2010	Early action: global participation commencing in 2010	Early action: global participation commencing in 2010	Early action: for developed countries 2010; delayed action for developing countries 2020
Differentiated abatement target for Australia	NA	NA	No	No	No	No	Yes: 50% below 1990 levels of CO <sub>2e</sub> emissions by 2050	No
Availability of CCS, globally	NA	NA	Yes	Yes	No	No	Yes	Yes
Nuclear power in Australia	NA	NA	No	No	No	Yes	Yes	No
Temporary oil price peak (\$100/bbl)	No	Yes	No	No	No	No	No	No

Each of the mitigation scenarios imposes a carbon price to reduce emissions to achieve the stabilisation of CO<sub>2</sub> concentration at 575 ppm by 2100. Emission reduction is driven by investment in generally higher-cost technologies in the sectors most responsible for greenhouse gas emissions, namely electricity generation, agriculture and transport. Such investment is underpinned by research, diffusion of information, and other efforts aimed at improving the competitiveness of these technologies. Mitigation can also be achieved via structural change within the Australian economy, away from high-energy intensive industries to low-energy intensive industries. Energy efficiency also plays a role, with improvements in energy conversion in the supply of energy and energy end-use.

<sup>1</sup> In the economic modelling a price on carbon dioxide and other greenhouse gases was the policy instrument used to deliver the required emissions outcomes, subject to the underlying modelling assumptions. With the exception of two scenarios, the carbon tax is considered to be globally harmonised. The modelling also does not take into account tax policy design issues or issues relating to compliance costs and revenue constraints. This approach was the simplest to apply for modelling purposes, as via the modelling process, the carbon tax adjusts automatically to ensure that the world economy achieves the designated emission paths. This automatic adjusting is an important feature of a dynamic model, such as the Global Trade and Environment model (GTEM), as in other modelling contexts a carbon tax may be set to achieve an unknown level of emission reduction. Because the carbon tax applied in GTEM automatically adjusts to ensure the emission path is achieved, it can also be interpreted as closely approximating the price of a permit (for an equivalent amount of emissions) under a tradeable emissions permit scheme. In other words, the carbon tax is equivalent to emissions trading for the purposes of economic modelling.

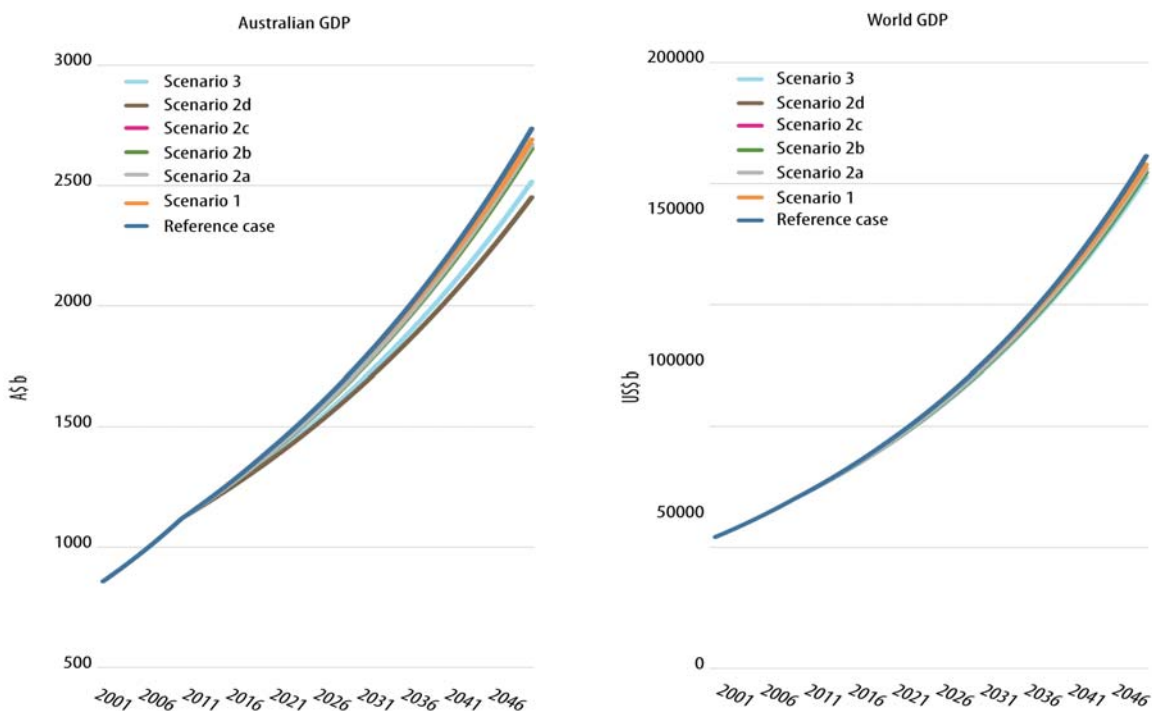
### Impact on gross domestic product

The economic cost of mitigating climate change can be measured by the impact on gross domestic product (GDP). When viewed as a time path for the period 2001 to 2050 (**Figure 2**), it is projected that both the Australian and world economies will continue to experience strong economic growth under all modelled scenarios, including scenario 2d (where Australia makes unilateral emission cuts) and scenario 3 (where Australia forms part of a coalition of developed countries in making emission cuts).

The delay experienced across the scenarios in achieving the GDP level projected in the reference case for 2050 is less than 18 months, with two exceptions. The exceptions are scenarios 2d and 3, where Australia experiences the largest relative impact to GDP due to its voluntary scenario decision to impose a higher carbon price than the rest of the world in order to achieve a deep cut in greenhouse gas emissions (50 per cent below 1990 levels by 2050) and its inclusion in the coalition of developed countries. In these cases, the delay in achieving the GDP level projected in the reference case is around five years.

Note that these estimates of GDP only take into account the cost of mitigation. The benefits of avoided climate change impacts (such as loss of tourism around the Great Barrier Reef) are not taken into account in estimating GDP. For indicative world economic and biophysical impacts of climate change see the full *The Heat is On* report.

**Figure 2:** Time path of projected economic growth by scenario



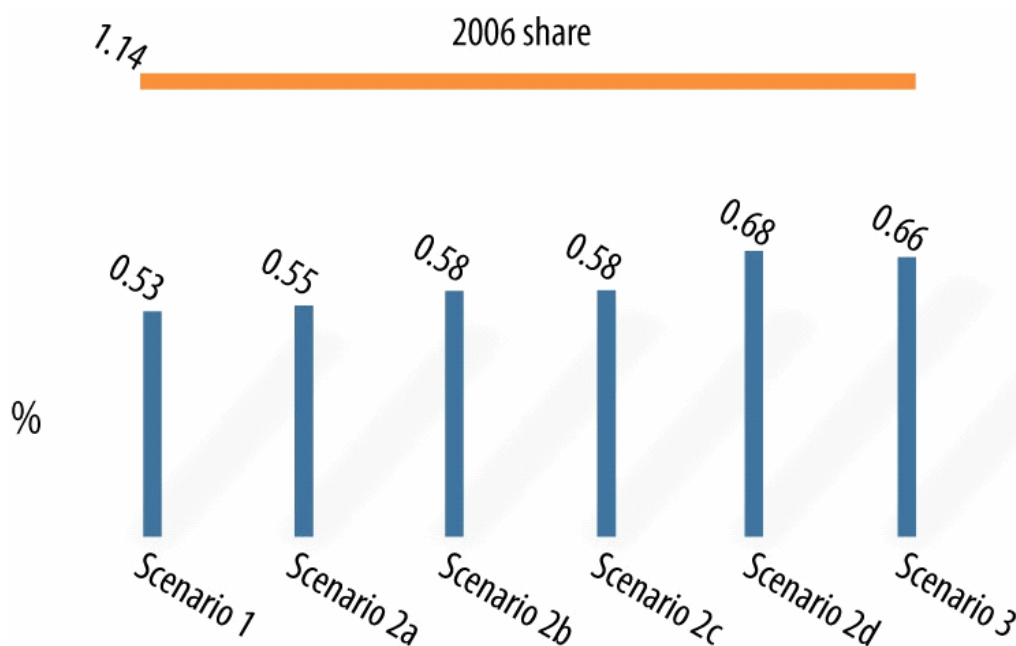
### Impact on consumer energy prices

The economic cost of greenhouse gas abatement via an emissions trading scheme can also be measured by the impact of a carbon price on consumer energy prices. Even with a carbon price in place, Australians are projected to be spending a lower proportion of their income on electricity in 2050 than in 2006 (**Figure 3**). While retail electricity prices will increase by 2050 by between 7 and 20 per cent, those increases will be below the change in real income per capita in Australia which is expected to rise by over 100 per cent by 2050 as GDP increases. By 2050 the share of average full-time wages spent on electricity is expected to decline from around 1.1 per cent in 2006 to between

0.5 and 0.7 per cent<sup>2</sup>. This is inclusive of carbon prices imposed in the scenarios. These findings are consistent with preliminary results presented in Hatfield-Dodds and Adams (2007), which suggests that the share of average income required to purchase the average 2005 household energy bundle would fall from 7% to 6% by 2050.

When considering changes in income and energy costs, the opportunity exists to recycle any potential carbon tax or permit revenues through the tax system, to either reduce personal income tax or reduce the impacts on the expense side of the household budget. It is also important to consider how various income groups would be impacted by the whole package of policy changes. It was assumed in the scenarios that there would be some offsetting tax changes to reduce the impact of the carbon tax on vulnerable groups. However, it was not possible to model the various options in detail in the context of the Energy Futures Forum. Preliminary results from Hatfield-Dodds and Adams (2007) suggest that aggressively targeting existing distortions in the tax system, such as high effective marginal tax rates, could significantly reduce the net impact of emissions reductions.

**Figure 3:** Household electricity consumption share of real average full-time wages in 2050 under the mitigation scenarios compared to 2006 levels



### *Impact on industry*

The economic cost of greenhouse gas abatement via emissions trading can also be measured by the impact on industry sectors. The Australian economy is dominated by its services sector (68 per cent of GDP in 2005-06). However the sectors most likely to be affected by the introduction of a carbon price are aluminium and iron and steel because they are highly energy intensive, and agriculture because it emits large volumes of greenhouse gases. In 2006, aluminium and iron and steel comprised about 4.5 per cent of the value of exports, while the agricultural sector accounts for about 3 per cent of GDP and 16 per cent of the value of exports. Australia is among the world's lowest cost producers of minerals and metals and, combined with abundant mineral resources and low sovereign risk, low cost energy is at the heart of this competitive position.

Economic modelling suggests that industry output for agriculture and iron and steel will be reduced by 2050 (Figure 4) by between 1–3 and 4–9 per cent respectively compared to the reference scenario, where Australia acts in concert with the international community (under economic modelling scenarios 1 and 2a–c), but that output is reduced by between 32–34 and 53–54 per cent

<sup>2</sup> Assuming wages track income per capita. An estimate of average residential electricity prices across Australia in 2005-06 was 10.1c/kWh. There is significant variation, however, depending on the Australian state of residence. Fees are also typically a mix of fixed and usage-based rates.

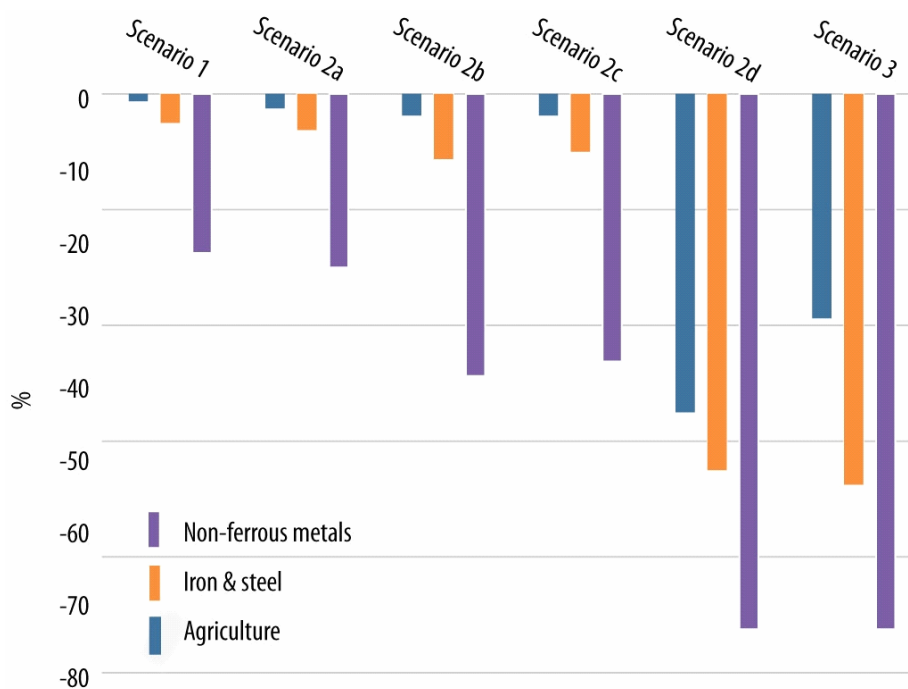
respectively compared to the reference scenario where Australia makes unilateral deep cuts (scenario 2d), or acts as part of a smaller international coalition (scenario 3). The reduction in non-ferrous metals output by 2050 is more significant under all scenarios – between 22 and 39 per cent compared to the reference scenario in scenarios 1 and 2a-c, and about 75 per cent in the case of the case of scenarios 2d and 3.

These reductions in output accumulate gradually from the time the carbon prices are introduced and the modelling also assumes that there is no protection provided to these energy intensive industries. By contrast, the impact of a carbon price on the services sector is projected to have only a minor impact, on the basis that energy is a relatively small input to their industry. While the economic modelling does not comment on how such impacts would be managed, it could be reasonably expected that such impacts would present challenges to regional employment and the balance of trade.

The impacts are projected to be the greatest in scenarios 2d and 3, where Australia makes a deeper cut in greenhouse gas emissions than other countries. Under such scenarios, it is plausible to expect carbon leakage to countries with lesser or no carbon constraints. Carbon leakage is a process whereby emission intensive production (and the associated employment and wealth creation opportunities) moves from regions or countries under a carbon constraint to regions or countries without such a constraint, or a lesser constraint. As a result, emissions abatement in one region is offset by increased emissions elsewhere. The economic modelling does not consider border adjustments to limit carbon leakage, or tradeable emission permits that would also reduce costs.

In the absence of a multilateral agreement, exempting selected industries that are carbon intensive and trade exposed would reduce the potential for carbon leakage. However, it would spread the same economic burden over a reduced portion of the economy.

**Figure 4:** Changes in industry output in 2050 across scenarios, relative to the reference case (selected industries only)



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## References

- Afforestation and Reforestation Sub-group (2006). Background paper for the National Emissions Trading Taskforce Forest Sinks Industry Consultation, 15<sup>th</sup> December 2006. Abatement Solutions – Asia Pacific, Matraville. Pg. 24.
- Allen Consulting Group, (2006). *Deep Cuts in Greenhouse Gas Emissions: Economic, Social and Environmental Impacts for Australia*. Report to the Australian Business Roundtable on Climate Change, ACG, Melbourne ([www.businessroundtable.com.au](http://www.businessroundtable.com.au)).
- Allen Consulting Group (2005), *Climate Change: Risk and Vulnerability. Promoting an Efficient Adaptation Response in Australia*. Report to the Australian Greenhouse Office, Department of the Environment and Heritage. The Allen Consulting Group, Melbourne.
- Australian Greenhouse Office (2006). Tracking to the Kyoto Target. Australian Greenhouse Office, Canberra. Pg. 20.
- Beer, T., Borgas, M., Bouma, W., Fraser, P., Holper, P. and S. Torok (2006). ‘Atmosphere’, theme commentary prepared for the 2006 Australia State of the Environment Committee, Department of Environment and Heritage, Canberra (Downloadable from <http://www.environment.gov.au/soe/2006/publications/commentaries/atmosphere/index.html>)
- Blasing, T.J., and Smith K. (2006). *Recent Greenhouse Gas Concentrations*. Carbon Dioxide Information and Analysis Center, Oakridge National Laboratory, Oakridge, TN, USA.
- CSIRO (2001). *Climate Change Projections for Australia*. CSIRO Atmospheric Research, Aspendale, VIC, Australia.
- Edenhofer, O., K. Lessmann, C. Kemfert, M. Grubb and J. Köhler (2006). Induced Technological Change: Exploring its implications for the Economics of Atmospheric Stabilisation: Synthesis Report for the Innovation Modelling Comparison Project, Energy Journal (Endogenous Technological change and the Economics of Atmospheric Stabilization Special Edition). Pgs pp. 57-108.
- Energy Futures Forum (2006). The Heat is On: The future of energy in Australia. A report by the Energy Futures Forum, CSIRO, Canberra.
- European Council (2005). *Provisional minutes of the European Council*, Brussels, Belgium, March 10.
- Grubb, M., C. Carraro, J. Schellnhuber (2006). ‘Technological Change for Atmospheric Stabilisation: Introductory Overview to the Innovation Modelling Comparison project’, Energy Journal (Endogenous Technological change and the Economics of Atmospheric Stabilization Special Edition). Pgs pp.1-16
- Hare, B., and Meinshausen, M. (2004). *How Much Warming Are We Committed To And How Much Can Be Avoided?* PIK Report, No. 93, Potsdam Institute for Climate Impact Research, Potsdam, Germany. Pg. 45. Downloadable from: [http://www.pik-potsdam.de/pik\\_web/publications/pik\\_reports/reports/pr.93/pr93.pdf](http://www.pik-potsdam.de/pik_web/publications/pik_reports/reports/pr.93/pr93.pdf)
- Hatfield-Dodds, S. and P. Adams (2007). Beyond the Double Dividend: Modelling the impacts of achieving deep cuts in Australian greenhouse gas emissions. Paper presented to Australian Agricultural and Resource Economics Society Conference, February 2007, Queenstown, New Zealand
- Jones, R.N. and Preston, B.L. 2006, *Climate Change Impacts, Risk and the Benefits of Mitigation*. A report for the Energy Futures Forum, CSIRO Marine and Atmospheric Research, Melbourne.
- Manins, P., Allan, R., Beer, T., Fraser, P., Holper, P., Suppiah, R. and K. Walsh. (2001). *Atmosphere, Australia State of the Environment Report 2001* (Theme Report), CSIRO Publishing on behalf of the Department of the Environment and Heritage, Canberra.

- Meinshausen, M. (2006). What does a 2°C target mean for greenhouse gas concentrations? A brief analysis based on multi-gas emission pathways and several climate sensitivity uncertainty estimates. In: *Avoiding Dangerous Climate Change*, H.J. Schellnhuber, W. Cramer, N. Nakicenovic, and T. Wigley [eds.], UK Department of Environment, Food, and Rural Affairs, Cambridge University Press, Cambridge, UK. Pgs. 265-279.
- Preston, B.L and Jones, R.N. (2006). *Climate Change Impacts on Australia and the Benefits of Early Action to Reduce Global Greenhouse Gas Emissions*. A consultancy report for the Australian Business Roundtable on Climate Change, CSIRO Marine and Atmospheric Research, Melbourne
- Raupach M. R., Marland G., Ciais P., Le Quere C., Canadell J. G., Klepper G., Field C. B. (2007). Global and regional drivers of accelerating CO<sub>2</sub> emissions. *Proc.Natl.Acad.Sci.U.S.A. submitted*.
- Schellnhuber H. J., Cramer W., Nakicenovic N., Wigley T. M. L., Yohe G. 2006. Avoiding dangerous climate change. Cambridge University Press, Cambridge, pg. 392.
- Stern, N. (2006). *The Economics of Climate Change: The Stern Review*. Cambridge University Press, Cambridge, UK. Pg. 712.
- UNFCCC (1992) *United Nations Framework Convention on Climate Change*, United Nations, New York, NY. Pg. 33.
- UN-Sigma XI Scientific Expert Group on Climate Change (2007). *Confronting Climate Change. Scientific Expert Group Report on Climate Change and Sustainable Development*. United Nations Foundation and Sigma Xi. Pg. 166 p. (Downloadable from <http://www.unfoundation.org/SEG/>)
- UNESCO-SCOPE (2006). *The Global Carbon Cycle*. UNESCO-SCOPE Policy Briefs, October 2006 – No 2. UNESCO-SCOPE, Paris.
- Wigley, T.M.L. (2005). The Climate Change Commitment. *Science* 307, 1766-1769.