Submission to the Climate Change Authority

Caps and Targets Review

Response to Issues Paper

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1. INTRODUCTION AND SUMMARY OF RECOMMENDATIONS

WWF-Australia welcomes the opportunity to make this submission to the Climate Change Authority's Caps and Targets Review.

WWF-Australia is part of the WWF International Network, the world's largest and most experienced independent conservation organisation. We have 80,000 supporters in Australia, five million supporters worldwide and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural resources and to build a future in which humans live in harmony with nature. WWF has been an advocate for national and international action to avoid dangerous climate change for more than two decades.

This submission is divided into the following sections:

- The need for greater ambition;
- Australia's emission reduction efforts to date;
- Australia's carbon budget and targets; and
- Economic costs and benefits for Australia.

As indicated in the body of the submission, we have also included separate reports by consulting firms, Ecofys and Vivid Economics as annexes to our submission.

1.1. Summary of recommendations

In this submission we make the following recommendations:

Issue	Recommendation
Assessing progress to date	*The CCA should take a sectoral approach to its assessment of Australia's emissions trends.*
Forestry-related emissions	*In the interests of increasing ambition, the CCA should assess options for accounting for forestry-related emissions in Australia's emissions caps between 2015 and 2020.* *The CCA should prepare a robust and independent assessment of how emissions in the land sector may change in the coming years and decades and how this should be taken into account when recommending targets and caps.* *The CCA should assess and make recommendations on options for reducing forestry related emissions. This should also consider the broader ecological benefits that could be derived.*
Dealing with surplus permits	*The CCA should assess options for accounting for surplus permits from the first commitment period in the caps for the period 2015-2020, with the goal of maximising Australia's contribution to the pre-2020*

	global mitigation effort.
2020 target	*The current target range of 5-25 per cent should not constrain the CCA's assessment or recommendations of what is required from Australia. The analysis presented here implies that a 25 per cent target should be considered Australia's minimum level of ambition.*
Post-2020 targets	*The CCA should shift away from using the current 2050 target (80 per cent) as a reference point for its analysis and instead base its recommendations on the findings of the carbon budget analysis.* *The CCA should make recommendations on an emissions target for 2030 that is consistent with the long-term budget.*
International abatement	*The CCA should assess options for using overseas abatement to balance Australia's carbon budget. This should include the option of the Government purchasing international abatement as well as the option of liable entities being responsible for these purchases.*

2. THE NEED FOR GREATER AMBITION

It is widely accepted that amongst developed countries Australia has the most to lose from ongoing climate change[1], particularly our unique wildlife and places. Indeed, already endangered species and ecosystems in Australia – such as marine turtles, Carnaby's black cockatoo and the Great Barrier Reef – are suffering the impacts of climate change, especially from extreme weather events.

Scientists predict that a 1.5°C global temperature rise may see 25 per cent of the Earth's animals and plants disappear; a 3°C rise may see 30 per cent disappear.[2] This would be a significant loss to the world and Australia. There is no way to put a dollar figure on this type of loss.

Australia's 2012-13 summer was defined by extreme weather events across much of the continent, including record-breaking heat, severe bushfires, extreme rainfall and damaging flooding. In just 90 days, 123 weather records were broken. According to the Climate Commission extreme heatwaves and catastrophic bushfire conditions during the summer were made worse by climate change.[15]

According to a recent report by the World Meteorological Organization (WMO), "the world experienced unprecedented high-impact climate extremes during the 2001-2010 decade, which was the warmest since the start of modern measurements in 1850 and continued an

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[1] Garnaut (2011) Carbon Pricing and Reducing Australia's Emissions. Climate Change Review Update 2011:Update paper 6, pg.6. http://www.garnautreview.org.au/update-2011/update-papers/up6-carbon-pricing-and-reducing-australias-emissions.pdf

[2] IPCC (2007) Fourth Assessment Report. Working Group II: Impacts, Adaptation and Vulnerability http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch19s19-3-4.html

extended period of pronounced global warming. More national temperature records were reported broken than in any previous decade."[3]

These impacts are occurring in a system where the annual average daily maximum temperature for Australia has increased by only 0.75°C since 1910.[4]

WWF-Australia supports the view of the Australian Government and the federal opposition that it is in Australia's national interest to keep global warming *below* 2°C, relative to pre-industrial levels. The goal of limiting warming to 2°C has also been agreed by all countries at the international climate change conference in Cancun in 2010. However, it is WWF's view Australia's interests would be best served if global warming could be limited to no more than 1.5°C. Aiming for no more than 1.5°C would also bring us into step with the view of the many countries around the world who are concerned that 2°C of warming would have unacceptable consequences to their economic, social and environmental wellbeing.

Putting aside the debate over what is an acceptable level of global warming, the fact is at this point in time we are heading towards global warming well in excess of 2°C. Indeed according to the International Energy Agency (IEA) we are currently on track to global warming of 3.5 – 5.3°C above pre-industrial levels. In other words, there is a gap between the international community's desire to keep global warming below 2°C and the strength of the policies to which they are prepared to commit. According to the United Nations Environment Program (UNEP) under current and planned policies global emissions in 2020 are projected to be 8 - 13 gigatonnes higher than they need to be give a 50 per cent chance of staying below 2°C (Figure 1).

The CCA's Caps and Targets Review provides an opportunity for an independent assessment of the role Australia can play in closing the gap between ambition and reality. The CCA can and should make the case for bold and ambitious action from Australia to not only reduce emissions at home, but also to send a powerful signal to the rest of the world, that Australia will contribute its fair share to reducing global emissions.

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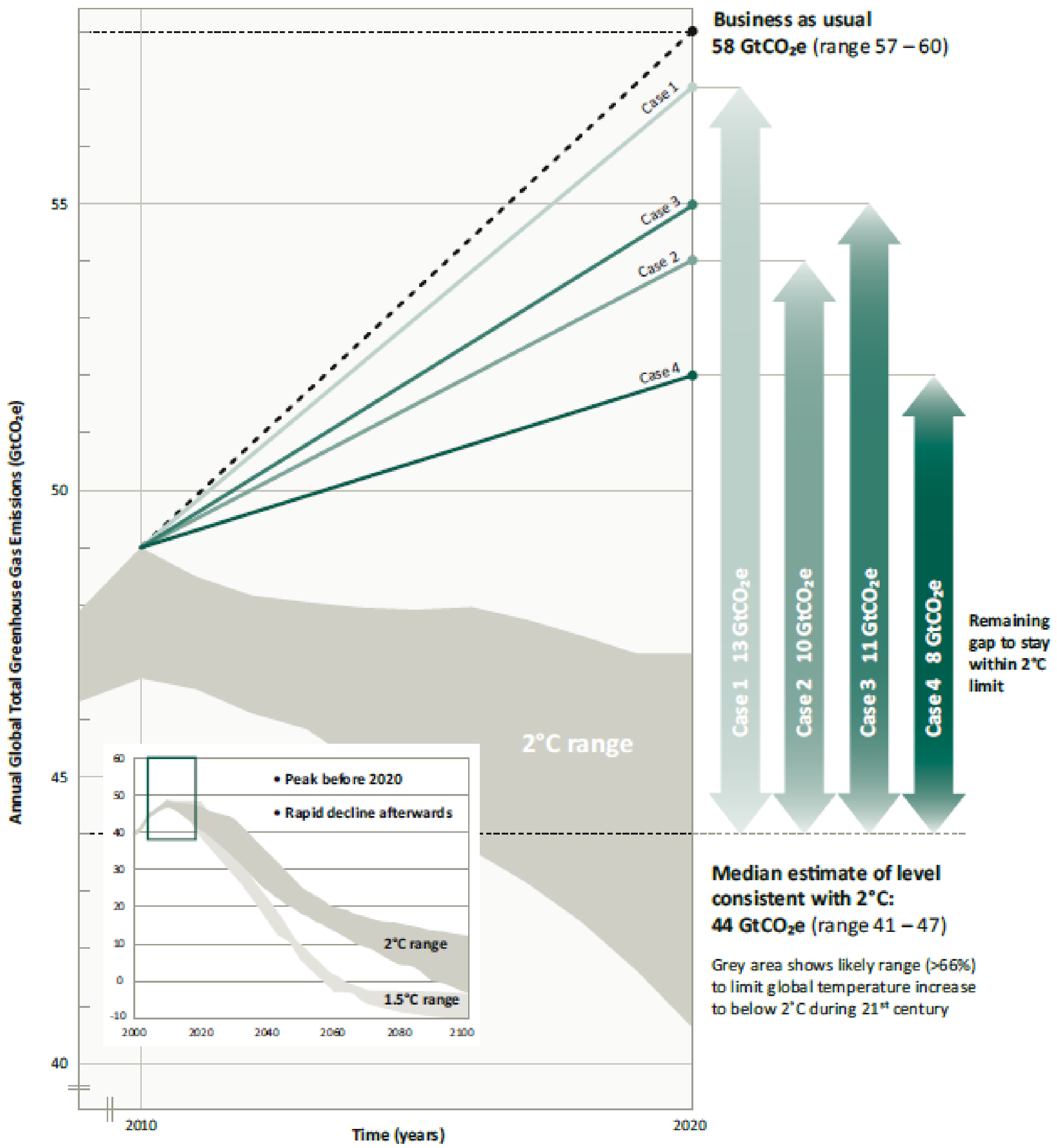
[3] http://www.wmo.int/pages/mediacentre/press_releases/pr_976_en.html

[4] CSIRO and BoM (2012) *State of the Climate 2012*, http://www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2012.aspx

Figure 1: The global emissions gap as estimated by UNEP.[5]



Case 1 – Unconditional pledges, lenient rules
If countries implement their lower-ambition pledges and are subject to "lenient" accounting rules, then the median estimate of annual GHG emissions in 2020 is 57 $GtCO_2e$, within a range of 56 – 57 $GtCO_2e$.

Case 2 – Unconditional pledges, strict rules
This case occurs if countries keep to their lower-ambition pledges, but are subject to "strict" accounting rules. In this case, the median estimate of emissions in 2020 is 54 $GtCO_2e$, within a range of 54 – 55 $GtCO_2e$.

Case 3 – Conditional pledges, lenient rules
Some countries offered to be more ambitious with their pledges, but link that to conditions. If the more ambitious conditional pledges are taken into account, but accounting rules are "lenient", median estimates of emissions in 2020 are 55 $GtCO_2e$ within a range of 54 – 56 $GtCO_2e$.

Case 4 – Conditional pledges, strict rules
If countries adopt higher-ambition pledges and are also subject to "strict" accounting rules, the median estimate of emissions in 2020 is 52 $GtCO_2e$, within a range of 51 – 52 $GtCO_2e$.

Please note: All emission values shown in the text are rounded to the nearest gigatonne.

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5 UNEP (2012), *The Emissions Gap Report 2012*. http://www.unep.org/publications/ebooks/emissionsgap2012/

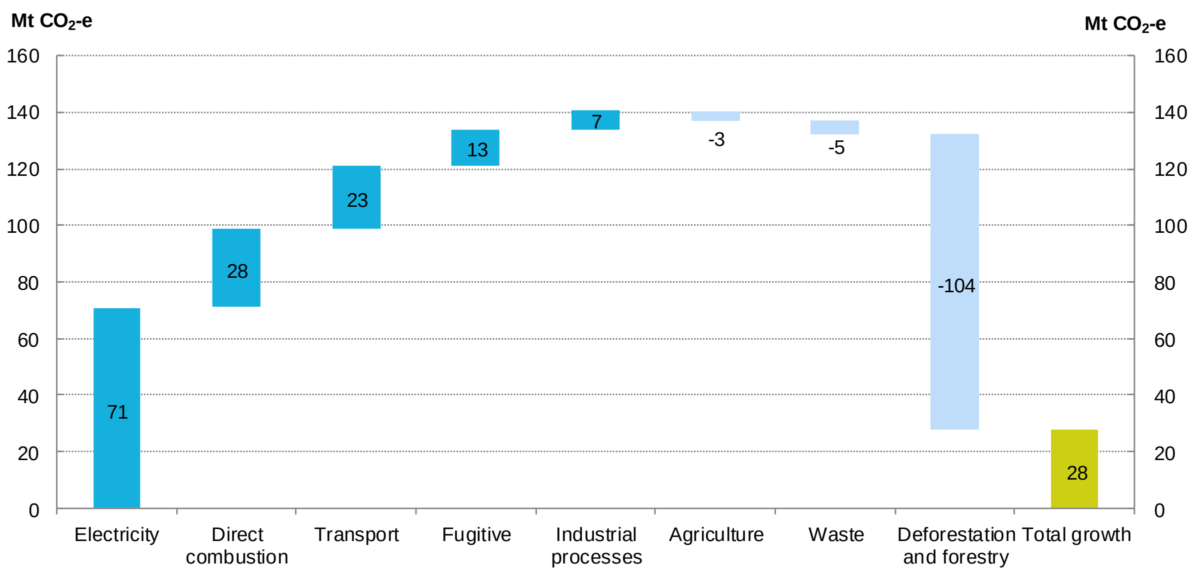
3. AUSTRALIA'S EMISSION REDUCTION EFFORTS TO DATE

3.1. Approach to assessing progress

WWF-Australia welcomes the CCA's intention to examine the drivers of change in Australia's emissions since 1990. As illustrated in Figure 2, while national emissions may have only increased to 105 per cent of 1990 levels, this masks a much more alarming rate of growth at the sectoral level. For this reason it is crucial that the CCA take a sector by sector approach to its analysis of emissions trends.

Recommendation: The CCA should take a sectoral approach to its assessment of Australia's emissions trends.

Figure 2: Sectoral emissions change, 1990 to Kyoto period average 2008-2012 (DCCEE[6])



3.2. Forestry emissions and removals

As shown in Figure 2, a major reason why Australia has been able to constrain its overall emissions growth is due to the major decline in deforestation emissions since 1990. From our perspective, the role of forestry-related emissions and removals deserves more detailed interrogation by the CCA, with a focus on three key issues:

i. The extent to which the decline in deforestation emissions should be considered additional and therefore count towards Australia's past and future abatement efforts;

ii. The likely 'business as usual' trends in forestry emissions and removals for the coming years and how this should be factored into Australia's future emission reduction targets; and

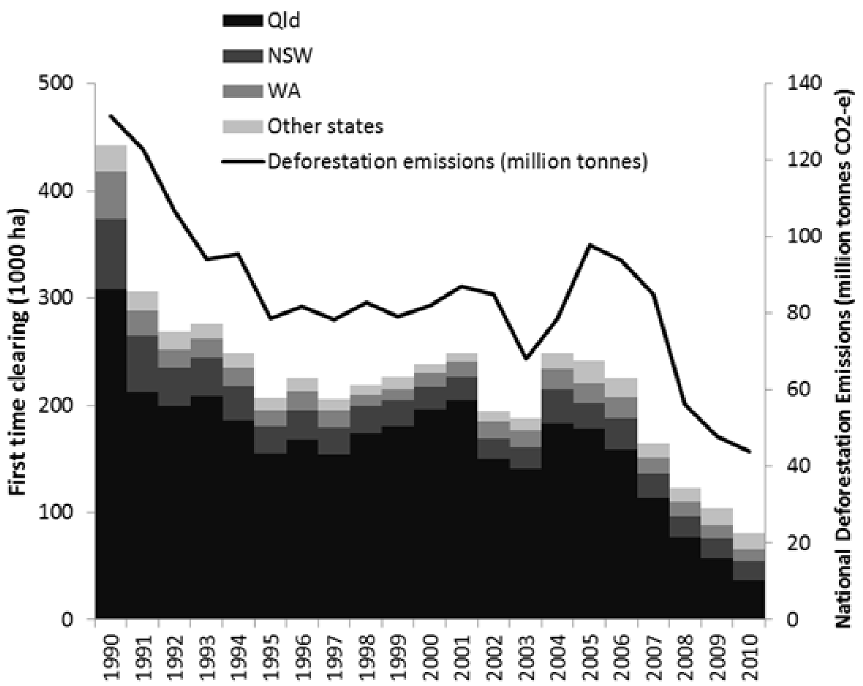
[6] DCCEE (2012), *Australia's emissions projections*, http://www.climatechange.gov.au/reducing-carbon/reducing-australias-emissions/australias-emissions-projections

iii. The potential of new policies to drive additional abatement in the land sector, including those which can deliver a range of other environmental co-benefits.

Additionality in the forestry sector

While on paper (and according to the Kyoto rules) Australia reduced forestry related emissions by approximately 104 Mt between 1990 and the first commitment period (ending in 2012), our view is that not all of this should be considered additional abatement. Using 1990 as the reference point for deforestation emissions inflated Australia's allocation of international carbon permits for the first commitment period. This is because 1990 was an unusually bad year for deforestation (Figure 3), with over 440,000 hectares of forest cleared for the first time in just twelve months (compared to 282,000 hectares pa on average over the period 1990 to 1996 – the year prior to when the Kyoto Protocol was adopted).

Figure 3: Annual land clearing rates by state, 1990-2010[7]



Our calculations suggest that using 1990 as the reference point gave Australia access to at least an extra 159 Mt of international carbon permits that would not have otherwise been available if a more appropriate reference point had been used (e.g. the average net emissions from deforestation and reforestation over the period 1990-1996). This abatement had already occurred at the time of negotiating Australia's final target under the first commitment period of the Kyoto Protocol, and in hindsight should not have been allowed to be counted towards the target.

The already achieved declined in forestry emissions allowed Australia to increase emissions from non-forestry sources by at least an additional 31 Mt CO2-e per year across the first

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[7] Taylor, M (2013) *Bushland at Risk of Renewed Land Clearing in Queensland*, WWF-Australia, http://awsassets.wwf.org.au/downloads/fl012_bushland_at_risk_of_renewed_clearing_in_queensland_9may13.pdf; and DCCEE (2012), Emission Projections data set: http://www.climatechange.gov.au/sites/climatechange/files/files/climate-change/projections/aep-data.xlsx

commitment period. To put this into perspective, this is approximately 44 per cent of the emissions growth seen in the electricity sector since 1990.

Recommendation: In the interests of increasing ambition (as opposed to exploiting accounting loopholes), the CCA should assess options for accounting for deforestation emissions in Australia's emissions caps between 2015 and 2020. One option would be for Australia to take on tighter caps during this period to ensure the full climate benefits of Australia's first commitment period target are realised.

Future changes in forestry emissions

Understanding how emissions and removals in the forestry sector are likely to change in the coming years is crucially important when setting Australia's emissions targets and caps. If the business as usual projections are for a further decline in net emissions from this sector, this will make it easier to achieve the 2020 target. Conversely, if net forestry emissions are projected to increase, this makes the overall abatement challenge more difficult. Unfortunately there is no consensus on what is likely to happen in the forestry sector over the coming years and how this will affect Australia's abatement challenge.

The Government's official view is that net emissions from afforestation, reforestation and deforestation are unlikely to significantly change over the coming decade. This view is disputed by others, who argue that net emissions are likely to decline significantly in the coming years.[8] As Ecofys and Climate Analytics have noted:

> If these [the Government's] projections are realised in practice Australia will need to increase its efforts to reduce industrial greenhouse gas emissions. On the other hand, if the trend continues, Australia would need to do less in the industrial sector to meet its international pledge than is suggested by Australia's current deforestation/ reforestation projections.[9]

The fact is that Australia's forestry sector is currently experiencing significant changes, driven by a range of market and policy drivers. For example, the Queensland Government's recent decision to weaken land clearing laws could potentially put at risk carbon stocks equivalent to around 369 Mt CO_2-e, whereas the Tasmanian forestry agreement is expected to see a decline in that state's forestry emissions.[10]

Recommendation: The CCA should prepare a robust and independent assessment of how emissions in the land sector may change in the coming years and decades and how this should be taken into account when recommending targets and caps.

Policy options for forestry emissions and removals

Unlocking low cost abatement opportunities in the land sector should allow Australia to adopt more ambitious emission reduction targets. Efforts to reduce land sector emissions could also deliver a range of other environmental co-benefits, including protecting ecologically important habitats.

[8] Ecofys and Climate Analytics (2011), *Climate Action Tracker Australia: Assessment of Australia's policies impacting its greenhouse gas emissions profile*, http://climateactiontracker.org/assets/publications/publications/CAT_Country_Report_Australia_2011.pdf

[9] Ibid.

[10] Martin Taylor – World Wildlife Fund (2013), *Bushland at Risk of Renewed Land Clearing in Queensland*, http://www.wwf.org.au/news_resources/?6800/Bushland-at-risk-of-renewed-clearing-in-Queensland

Recommendation: The CCA should assess and make recommendations on options for reducing forestry related emissions. This should also consider the broader ecological benefits that could be derived.

3.3. Surplus carry-over

According to the Government's own estimates, Australia is likely to have a surplus of permits of around 96 million tonnes from the first commitment period of the Kyoto Protocol.[11] Within the UN negotiations the Government has been arguing for the right to carry this surplus over to the second commitment period. In effect this would make it easier to achieve the target for the second commitment period by allowing Australia to release more pollution into the atmosphere than would be otherwise allowed. Given the urgent need to curb global emissions, WWF-Australia urges the CCA to assess options for accounting for this carry-over in the caps for the period 2015-2020. One option would be to recommend that the surplus permits should be retired. An alternative would be to recommend a tighter cap to account for these surplus permits.

Recommendation: The CCA should assess options for accounting for surplus permits from the first commitment period in the caps for the period 2015-2020, with the goal of maximising Australia's contribution to the pre-2020 global mitigation effort.

4. AUSTRALIA'S CARBON BUDGET AND TARGETS

4.1. Actions by other countries

The 5-25 per cent target range – supported by both the Government and the Opposition – is based on the 2008 advice of Professor Ross Garnaut. Drawing on detailed global modelling, Garnaut concluded that a 25 per cent target would represent Australia's fair share of the global effort required to provide at least a 50:50 chance of limiting global warming to 2°C.[12]

The minimum 5 per cent target was recommended by Garnaut in 2008 as a holding position until there was more certainty about the commitments from other countries. Since then, Garnaut[13] and others such as ANU Professor Frank Jotzo,[14] have argued that things have progressed sufficiently at the international level to warrant lifting Australia's minimum target.

Analysis by the Department of Climate Change and Energy Efficiency supports the view that, given the actions being taken other nations, Australia should be prepared to commit to at least a 10-15 per cent emissions reduction target. Significantly, the Department's analysis

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[11] Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (2013), *The impact of Kyoto accounting changes on the QELRO and targets*, http://climatechange.gov.au/sites/climatechange/files/documents/06_2013/impact-of-kyoto-accounting-changes-on-the-qelro-targets.pdf.
[12] Garnaut, R (2008), *Garnaut Climate Change Review*, http://www.garnautreview.org.au/
[13] Garnaut, R (2011), Australia in the Global Response to Climate Change: Summary, http://www.garnautreview.org.au/update-2011/garnaut-review-2011/summary-20June.pdf
[14] Jotzo, F. (2010), "Copenhagen targets and Australia's climate commitment", Polity Brief, Centre for Climate Economics & Policy, ANU,

also concluded that China's emissions target is consistent with the conditions for Australia's 25 per cent emissions target.[15]

Most recently, Garnaut has argued that Australia should be willing to at the very least match the US goal of reducing emissions by 17 per cent below 2005 levels by 2020 (equivalent to 21 per cent below 2000 levels).[16]

Indeed, contrary to popular belief that global action has stalled, the last two years have seen steady progress in the world's major economies. Highlights include:

- China is piloting emissions trading in seven key industrial regions, which together account for approximately a quarter of the nation's GDP. The Chinese legislature has also passed an ambitious Five Year Plan that will see the emissions intensity of China's economy reduced by 17 per cent by 2015.
- South Korea, Australia's third largest export market, has passed legislation to begin an emissions trading scheme from 2015.
- The US is making good on its pledge to reduce emissions by 17 per cent below 2005 levels, with series of new regulations under the Clean Air Act.
- California, the world's eighth largest economy, introduced and emissions trading scheme at the beginning of 2012.
- In April 2012, Mexico's parliament unanimously passed a national climate change law, including a legally binding target to reduce Mexico's emissions by 50 per cent by 2050.
- Japan has introduced a world leading renewable energy feed-in tariff, expected to deliver a six-fold increase in solar capacity by 2020.[17]

One of the key pillars of the Durban Platform is a commitment from all countries to increase the level of ambition of current emission pledges.[18] This is likely to occur in 2015 when the new international treaty is scheduled to be finalised. If the conditions are right, countries will be expecting Australia in 2015 to commit to at least a 25 per cent target if they haven't already done so.

4.2. Defining a safe global budget

WWF-Australia supports the CCA's proposal to base its recommendations for national emission targets and caps on the analysis of a global carbon budget. This approach should ensure there is a strong connection between the CCA's recommendations and what is required to achieve global goals.

As outlined above, WWF supports the goal of keeping global warming *well below* 2°C and believes we should in fact be aiming to limit global warming to no more than 1.5°C. Given that the international community has committed to reviewing the adequacy of the 2°C in

[15] The Climate Institute (2010), "Summary of Freedom of Information Request from The Climate Institute to the Department of Climate Change and Energy Efficiency: Documents regarding the influence of foreign emission reduction targets on Australia's emission reduction targets", Media Brief, November 2010, http://www.climateinstitute.org.au/verve/_resources/foi_request_summary.pdf

[16] Comments made during Grattan Institute event: http://www.climatechange.gov.au/reducing-carbon/reducing-australias-emissions/australias-emissions-projections

[17] http://reneweconomy.com.au/2012/iea-says-renewable-energy-growth-to-accelerate-76483

[18] 2 UNFCCC (2011), Decision 1/CP.17, http://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf 2 UNFCCC (2011), Decision 1/CP.17, http://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf

2015 and to consider moving to a 1.5°C, it seems inappropriate for the CCA to limit its analysis of the global carbon budget to 2°C only.

One option for the CCA is to use a global carbon budget that provides an 80 per cent probability of keeping global warming below 2°C. As indicated by Rapauch et al (2011), this is consistent with maintaining at least a 50 per cent change of limiting warming to 1.5°C.

Recommendation: The CCA should assess global carbon budgets for both 1.5°C and 2°C, for a range of probabilities.

4.3. Analysis of effort-sharing options

As noted by the CCA, defining a global carbon budget is just the first step in identifying a national carbon budget for Australia. The second and equally challenging step is to determine what share of this global budget should be allocated to Australia. As the Garnaut climate change review correctly stated, "[t]his is the question upon which the prospects of effective international agreement… will stand or fall."[19] Indeed, the allocation of the global carbon budget between countries remains a central stumbling block in the international negotiations.

While it would be naïve to believe that the international community will be able to agree on a single formula for sharing the global carbon budget, there is no doubt that countries will only accept international emission reduction targets if they believe these targets are fair. If a country believes the target they are being asked to adopt is too stringent in comparison to the target of its competitors, they are likely to resist and may even opt out.

Just as the CCA is currently assessing different options for sharing the global carbon budget, similar exercises are underway around the world. When negotiators meet to negotiate targets in 2014 and 2015 they will draw on their own government's analysis to determine if the targets on the table (both for their county and for other countries) represent a 'fair' share of the global carbon budget.

A number of different effort sharing approaches have been developed, including by academics, governments and non-government organisations. We encourage the CCA to critically assess a representative cross-section of these methodologies. Ultimately, however, the CCA will need to select an effort sharing methodology that will stand up to international scrutiny. There is no point recommending a carbon budget for Australia that is likely to be rejected by other countries. With this in mind, we believe the principles identified by the CCA in the Issues Paper are the right ones to assess the effort sharing options against.

In the past some commentators have suggested that the marginal cost of abatement should be used as the basis for sharing the global carbon budget between countries. Under this approach, countries with higher costs of abatement would be required to take on less stringent budgets than countries where abatement is less costly. This approach is flawed on a number of different levels, including its failure to consider historical responsibility and capacity to implement abatement opportunities. However, it also fails to acknowledge that the differential costs of abatement between countries can be overcome through international emissions trading. As discussed in Section 5 of this submission, the fact that Australia will

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[19] Garnaut, R (2008), *Garnaut Climate Change* Review, p. 200.

have an internationally linked emissions trading scheme in place from 2015 (or possibly one year earlier),[20] means that the cost per tonne of achieving an emissions target should be the same as in Europe. Over time, as linkages to other schemes are established, there should be a trend towards a truly global carbon price.

In 2009 WWF International commissioned leading international consulting firm, Ecofys, to assess a range of options for sharing the global carbon budget between countries. WWF-Australia has commissioned Ecofys to update this analysis and to assess the implications for Australia. The key findings of the Ecofys analysis are presented below. A more detailed presentation of the Ecofys results has been provided as an appendix to this submission.

Background to Ecofys analysis

The Ecofys analysis uses a global carbon budget of 1,800 Gt CO2-e for the period 1990-2100, excluding land use, land use change and forestry (LULUCF). This global carbon budget is consistent with stabilising atmospheric greenhouse gas concentrations at around 450 parts per million (ppm) CO2-e. If LULUCF is included, the global budget is reduced to 1,600 Gt CO2-e over the period 1990-2100.[21]

The Ecofys analysis considered three approaches to distributing the global carbon budget between countries, which are briefly explained in Table 1. The three effort sharing approaches considered by Ecofys are not the only options that have been developed. However, we do believe these three approaches provide a useful contribution to the debate, because they place a strong emphasis on the issue of equity. Ensuring the global carbon budget is shared equitably between countries is the central challenge facing the UN climate negotiations.

While it was beyond WWF's resources to assess all of the options, we encourage the CCA to ensure its analysis considers a broad cross-section of options and to weigh up the various strength and weaknesses.

It is important to note that Ecofys' analysis focusses on carbon allocations, as opposed to actual domestic emissions. It is assumed that if Australia's domestic emissions exceed the allocation, this overshoot can be offset by purchasing abatement from overseas.

Table 1: Description of the effort sharing approaches assessed by Ecofys

Effort sharing approach	**Description provided by Ecofys**
Contraction and convergence	Under Contraction and convergence (C&C) (GCI 2005[22], Meyer 2000[23]), all countries participate in the regime with quantified emissions targets. As a first step, all countries agree on a path of future global emissions that leads to an agreed long-term stabilisation level for greenhouse gas concentrations ('contraction'). As a second step, the targets for individual countries are set in such a way that per capita emissions allowances converge from the countries' current levels to a level equal for all coun-tries within a given period ('convergence'). The convergence level is calculated at a level that result-ing global emissions follow the agreed global emissions path. It might be more difficult for some countries to reduce emissions compared to others, for example, due to climatic conditions or resource availability. Therefore, emissions trading could be allowed to level off differences between allowances and actual emissions. However, C&C does not explicitly

[20] Prime Minister Kevin Rudd announced on the 16th of July that the Governments policies to move to a floating price from 1 July 2014. Such a move will need the support of parliament.

[21] Ecofys (2009), *Sharing the effort under the a global carbon budget*, WWF, http://www.ecofys.com/en/publication/sharing-the-effort-under-a-global-carbon-budget/

[22] GCI (2005), *GCI Briefing: Contraction & Convergence*, Global Commons Institute.

[23] Meyer, A. (2000), *Contraction & convergence. The global solution to climate change*, Schumacher Briefings, No. 5. Bristol, UK.

	provide for emissions trading. As current per-capita emissions differ greatly between countries some developing countries with very low per capita emissions, (e.g. India, Indonesia or the Philippines) could be allocated more emissions allowances than necessary to cover their emissions ('hot air'). This would generate a flow of re-sources from developed to developing countries if these emissions allowances are traded.
Common but differentiated convergence	Common but differentiated convergence (CDC) is an approach presented by Höhne et al. (Höhne et al. 2006[24]). Annex I countries' per capita emissions allowances converge within, for example, 40 years (2010 to 2050) to an equal level for all countries. Individual non-Annex I countries' per capita emissions also converge within the same period to the same level but convergence starts from the date, when their per capita emissions reach a certain percentage threshold of the (gradually declining) global average. Non-Annex I countries that do not pass this percentage threshold do not have bind-ing emissions reduction requirements. Either they take part in the CDM or they voluntarily take on positively binding emissions reduction targets. Under the latter, emissions allowances may be sold if the target is overachieved, but no emissions allowances have to be bought if the target is not reached. The CDC approach, similarly to C&C, aims at equal per capita allowances in the long run. In contrast to C&C it considers more the historical responsibility of countries. Annex I countries would have to reduce emissions similarly to C&C, but many non-Annex I countries are likely to have more time to develop until they need to reduce emissions. Non-Annex I country participation is conditional to Annex I action through the gradually declining world average threshold. No excess emissions allowances ("hot air") would be granted to least developed countries.
Greenhouse development rights	The Greenhouse Development Rights (GDRs) approach to share the effort of global greenhouse gas emissions reduction was developed by Baer et al. (Baer et al. 2007[25]). It is based on three main pillars: • The right to develop; • Capacity (income); and • Responsibility (for emissions since 1990). The allocation of emissions reduction obligations and resulting emissions rights is based on each country's responsibility and capacity, combined in the Responsibility Capacity Index (RCI). This is defined as , where a and b are weighting factors. Baer et al. assume and equal weighting of 0.5 for a and 0.5 for b, which gives capacity and responsibility an equal weight. Two global emissions development paths are considered. First, the BAU case and second the reduction path necessary to reach the emissions level in order to stabilise global emissions. The difference of these two is the amount of emissions that need to be reduced globally. Each country's annual share of this reduction is determined by the relative share of its RCI compared to the sum of RCIs of all other countries.

Key findings

As shown in Table 2, Australia has already used between 65 per cent and 83 per cent of its 'fair share' of the global carbon budget, depending on the effort sharing approach applied. At current rates of emissions the remaining budget would be consumed within the next 4 to 11 years.

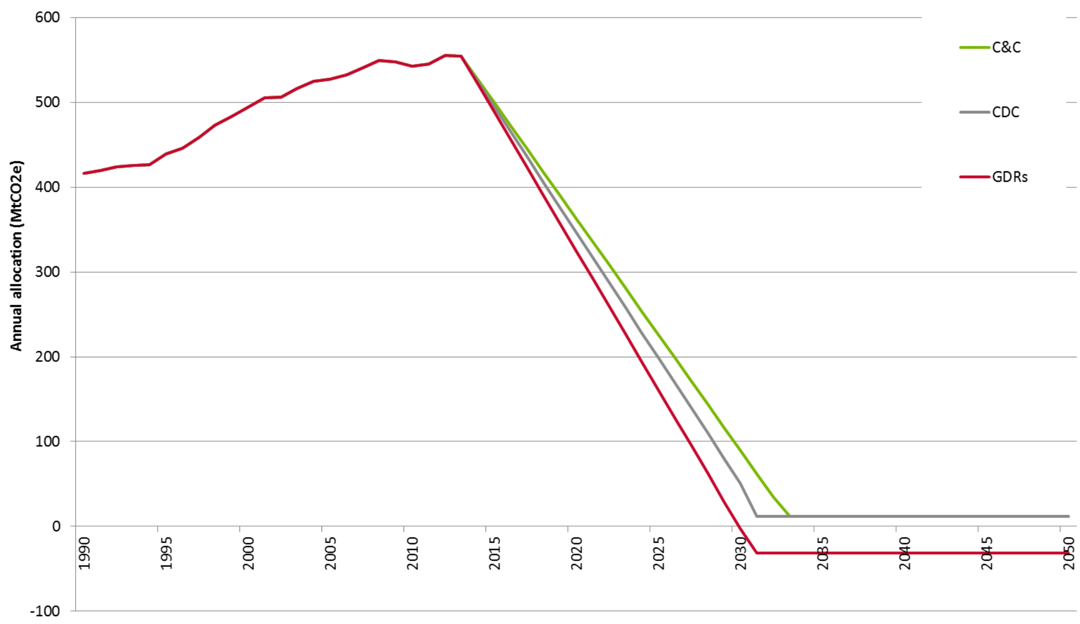
The Ecofys analysis highlights the challenge Australia faces in the coming decades in order to stay within a fair long-term carbon budget (Figure 4). Indeed, assuming a straight-line emissions trajectory and excluding forestry related emissions and removals (i.e. afforestation, reforestation and deforestation), the Ecofys analysis implies a carbon allocation in the range of 27 per cent to 34 per cent below 2000 levels by 2020. Even under the least stringent effort sharing approach, Australia's allocation of emissions falls to 82 per cent below 2000 levels by 2030, while the GDR methodology implies net negative emissions by 2030.

[24] Höhne, N., M. G. J. den Elzen, and M. Weiss. (2006), Common but differentiated convergence (CDC): A new conceptual approach to long-term climate policy. *Climate Policy*, *6*, 181-199.
[25] P. Baer, Athanasiou, T., and Kartha, S. (2007). *The right to development in a climate constrained world. The Greenhouse Development Rights framework*. Publication series on ecology, volume 1, Berlin: Heinrich-Böll-Foundation, Christian Aid, EcoEquity and the Stockholm Environment Institute.

Table 2: Budget allocated, used and remaining according to Ecofys analysis (excluding LULUCF)

Effort sharing approach	Total budget allocated to Australia (1990-2100) Mt CO2-e	Budget used (1990-2012) Mt CO2-e	Budget remaining (2013-2100) Mt CO2-e	How long will the budget last at current rates of emissions?
Contraction and convergence	18,009	11,738	6,271	11 years
Common but differentiated convergence	17,594	11,738	5,856	10.5 years
Greenhouse development rights	14,111	11,738	2,373	4 years

Figure 4: Emission trajectories required to stay within the carbon budget under different effort sharing options, excluding LULUCF (source: Ecofys analysis).



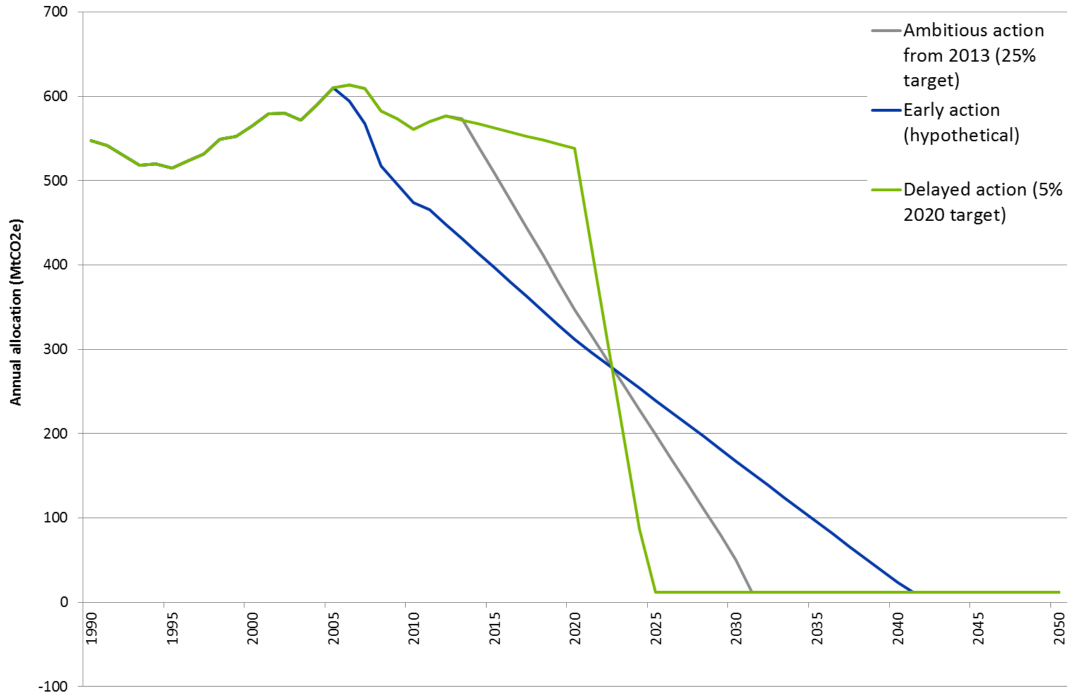
One of the limitations of the Ecofys analysis is that it excludes emissions and removals from afforestation, reforestation and deforestation, whilst Australia's emissions target includes forestry related emissions and removals. According to the Australian Government, net emissions from afforestation, reforestation and deforestation are projected to remain broadly stable out to 2020 (i.e. will not rise significantly from the current level). If the Government's projections are used, the implied emissions cuts for 2020 do not vary significantly from Ecofys' analysis of emissions trajectories that exclude forestry emissions and removals (28 – 35 per cent below 2000 levels, including afforestation, reforestation and deforestation).

It is important to note that Ecofys and others argue that net emissions from afforestation, reforestation and deforestation are more likely to decline to zero by 2020, driven mostly by a significant decline in deforestation emissions. While it could be argued that this additional abatement in the land sector would simply free up more of the carbon budget for other sectors of the economy, it could also be used to top-up Australia's overall 2020 target.

While in theory it could be possible for Australia to adopt a relatively weak 2020 target and make this up by adopting much stricter targets in the future, this approach may lack credibility, as it would imply unrealistically deep targets in the post-2020 period. This is illustrated in

Figure 5, which shows the effect of delay vs early action.

Figure 5: The impact of delay. The blue line shows a hypothetical scenario in which Australia had taken early and ambitious action to reduce emissions from 2005 (when the Kyoto Protocol came into force). The grey line assumes ambitious action from 2013, including achieving a 25 per cent target for 2020. The green line shows the impact of further delay whereby Australia cuts emissions by 5 per cent by 2020. The longer the delay the steeper the emissions trajectory.



Implications for Australia's current targets

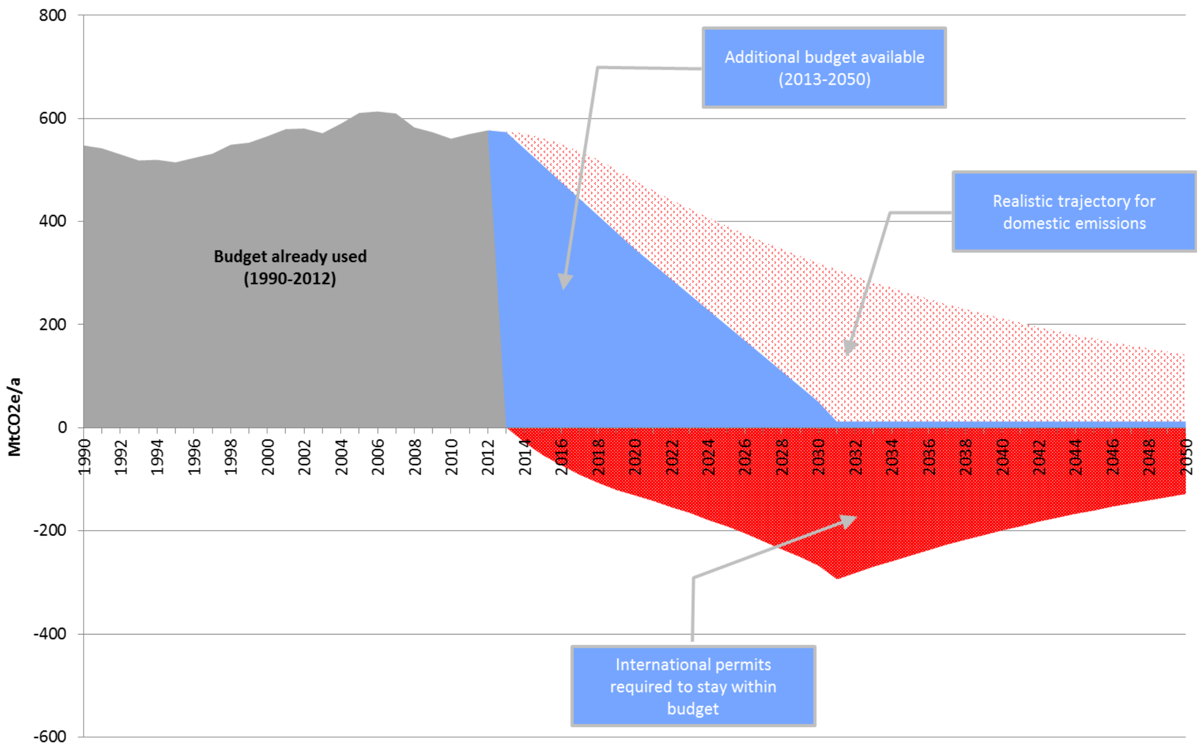
The Ecofys analysis highlights the inadequacy of Australia's existing target commitments. Only the upper end of the 5-25 per cent range comes close to what the Ecofys analysis suggests would be required from Australia as a fair contribution to staying below 2°C. Moreover, an 80 per cent target for 2050 falls well short of what would be required to stay within a safe carbon budget.

As noted above, Australia does not have to stay within the carbon budget through domestic abatement alone. Indeed, Ecofys found that even if emissions were reduced by 4 per cent each year (assumed to be the upper limit of what is currently possible), Australia would still significantly exceed its emissions budget. It is conceivable that in the long-term this budget shortfall could be made up (at least partially) through the deployment of technologies that have negative emissions (e.g. electricity generation from biofuel with carbon capture and storage). However, in the short-term purchasing abatement from overseas will be required.

Figure 6 provides an illustration of how Australia could balance its carbon budget through a combination of ambitious abatement efforts domestically and annual purchases of overseas abatement. For illustrative purposes, the option presented here assumes that the annual overshoot in emissions is offset each year by purchasing the same amount of abatement from overseas. In fact a number of different trajectories could be adopted for these overseas purchases. For example, it may make sense to purchase large quantities of overseas abatement early on while the global carbon price is low, then scaling down overtime.

International permits can be imported either via a direct government purchase, or by adopting a stronger cap under the emissions trading scheme. In our view, at least in the short-term, it makes more sense to use a stronger cap as this would put less pressure on the federal budget.

Figure 6: Options for balancing the budget. The light blue area shows the total carbon budget available to Australia under the CDC effort sharing option. The pink shaded area shows the annul overshoot of the carbon budget if Australia adopts an ambitious, but technically achievable pathway for domestic abatement (cuts of 4 per cent p.a.). The red area shows how much abatement will need to be purchased from overseas each year in order to balance the budget. Emissions and removals from afforestation, reforestation and deforestation are included here.



Recommendation: The CCA should shift away from using the current 2050 target (80 per cent) as a reference point for its analysis and instead base its recommendations on the findings of the carbon budget analysis. This also applies to the Australian Government's current 2020 target – the current target range of 5-25 per cent should not constrain the CCA's assessment or recommendations of what is required from Australia. The analysis presented here implies that a 25 per cent target should be considered Australia's minimum level of ambition.

Recommendation: The CCA should assess options for using overseas abatement to balance Australia's carbon budget. This should include the option of the Government purchasing international abatement as well as the option of liable entities being responsible for these purchases.

4.4. Budget and target timeframes:

It is possible that in either 2014[26] or 2015 Australia will need to make an international commitment on post-2020 targets. This provides a strong rationale for the CCA to also consider the post-2020 period. Otherwise there is a very real risk that the Government will adopt international targets for the post-2020 period which are inconsistent with a fair long-term carbon budget for Australia.

Recommendation: The CCA should make recommendations on an emissions target for 2030 that is consistent with the long-term budget.

5. ECONOMIC COSTS AND BENEFITS FOR AUSTRALIA

WWF-Australia commissioned Vivid Economics and Monash University to assess the economic costs and benefits of Australia adopting a more ambitious 2020 target for carbon pollution. In essence the modelling found that Australia could shift to a 25 per cent target while shaving just an extra 0.01 per cent off GDP in 2020, which could be made up in less than 2 months. The full report has been included as an annex to this submission and can also be downloaded at wwf.org.au. A brief summary of the report's findings is provided below.

5.1. Background of this study

WWF-Australia commissioned London-based consulting firm, Vivid Economics, to assess the economics costs and benefits of Australia moving to a stronger 2020 emissions target. There are two key parts to study:

- Quantification of the additional costs of Australia moving to a stronger target; and
- A qualitative assessment of the potential economic benefits of more ambitious action on climate change.

The macro-economic modelling underpinning this study was undertaken by Monash University's Centre of Policy Studies, using the Monash Multi-Regional Forecasting (MMRF) model. The MMRF model has been used extensively by the Commonwealth Treasury to assess the economic implications of introducing a carbon price.

5.2. Economic costs of moving to a stronger target

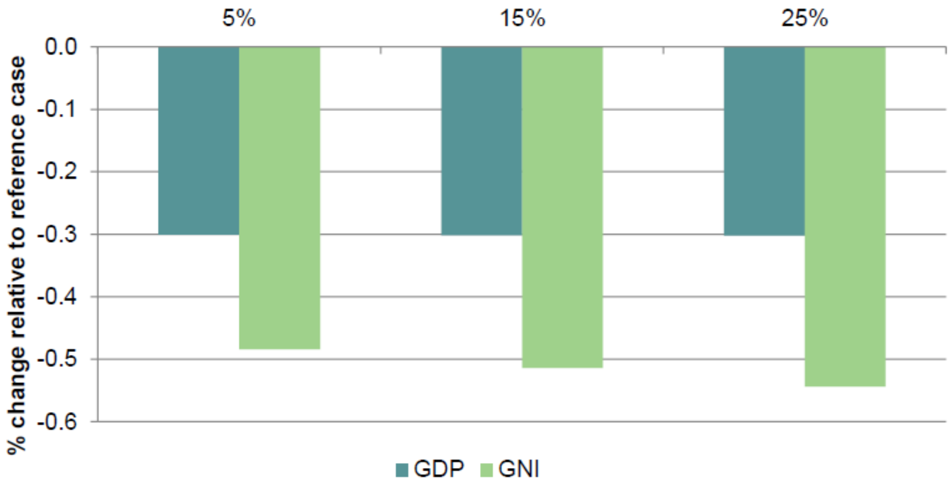
Below is a summary of the key findings from the Vivid Economic study:

- Under current policy settings Australia could strengthen its 2020 emissions target from 5 per cent to 25 per cent (off 2000 levels) at very little extra cost (Figure 7). There is almost no additional impact on gross domestic product (GDP) (0.01 per cent) and only a 0.06 per cent reduction in gross national income (GNI).

[26] The UN Secretary General plans to hold a leaders' summit in 2014 and will be pushing for renewed pledges from all countries, including Australia.

- The economic costs of a 25 per cent target are four times lower than projected by Treasury in 2008 for the Garnaut Review. The main reason is access to much lower priced international emissions credits.

Figure 7: The additional cost of achieving a stronger target is very small[27]



Source: *Vivid Economics based on modelling results from CoPS MMRF.*

- A stronger target could also be achieved by increased domestic abatement action. Additional costs are still relatively small, shaving just 0.1 per cent p.a. off national economic growth between now and 2020, in a scenario where domestic emissions cuts are almost three times as large. Reducing demand for overseas permits would substantially lower the GNI impact, with $1.2 billion less flowing offshore each year.

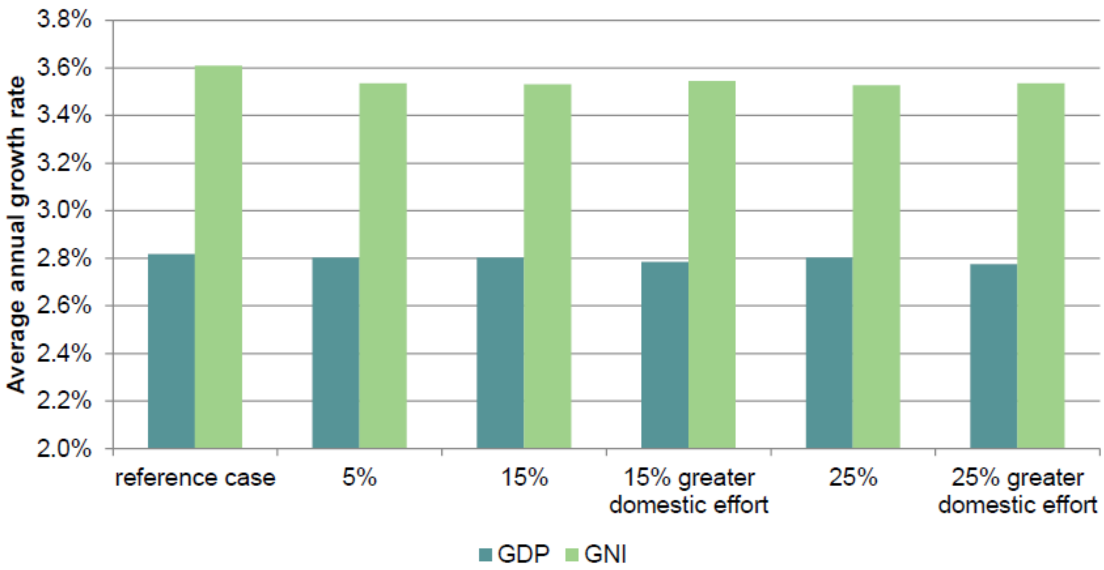
- Under all scenarios Australia's economy continues to grow. Even with a 25 per cent target and restrictions on the use of international permits, Australia's economy is projected to expand by 27 per cent by 2020 (Figure 8).

- While not explicitly modelled here, the impact on electricity prices is expected to be significantly lower than previously projected by Treasury, due to much lower carbon prices.

- At the industry level the growth outlook remains strong, irrespective of the 2020 emissions target. For the vast majority of industries—which together account for 84 per cent of national industrial output—growth will either be stronger, or reduced by less than 0.5 per cent if Australia adopts a 25per cent target.

[27] Full Vivid Economics report is included as an annex to this submission.

Figure 8: Across all scenarios, the impact on average annual growth rates is barely discernible (Vivid Economics[28])



5.3. Potential economic benefits of more ambitious action

Vivid Economics also pointed to a number of potential economic benefits of Australia achieving greater levels of abatement domestically. These potential benefits identified by Vivid Economics are presented in Box 1.

5.4. Implications for the CCA Review

Cost of achieving targets

We acknowledge that the CCA's recommendations will be based on a broad range of factors, including the level of action from other countries. While it is useful to compare Australia's targets to the commitments of other countries, we urge the CCA to not lose sight of the fact that the economic costs of moving to a stronger target are in fact very small. Indeed, it is clear that Australia can afford to be more ambitious, almost irrespective of what happens in other countries.

Broadening the economic debate

The Vivid Economics study points to a number of potential benefits that could flow from more ambitious action from Australia. We urge the CCA to pick up on this theme and to provide a robust assessment of the significance of these potential benefits. We welcome the CCA's intention to 'explore the opportunities and risks associated with linkages between the domestic carbon pricing mechanism and international carbon markets over the long term'.

[28] Full Vivid Economics report is included as an annex to this submission.

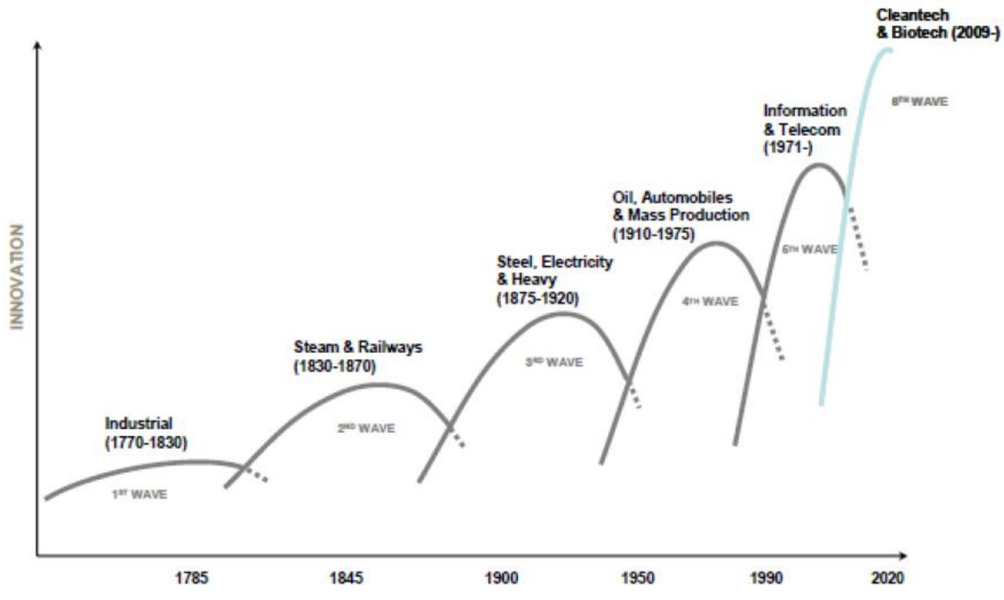
Box 1: Potential economic benefits of stronger domestic abatement identified by Vivid Economics

Acting now may save costs later. Adopting a more ambitious target to 2020 may require a less steep trajectory of emissions reductions in following decades. Deferring emission reductions to the future would allow Australia's emission reductions to take place when the country is richer. But early action to reduce emissions can reduce the risk of 'lock-in' of high carbon assets, which might otherwise mean higher costs in the medium to long run

Many analyses find that that the cost of delay may be significant. Earlier Treasury modelling found that delayed action increases Australia's future mitigation costs, with a three year delay resulting in higher mitigation costs of 2 to 10 per cent in 2050. International academic analysis suggests that more ambitious early action can help to reduce total costs over time, and could drastically reduce the magnitude of future carbon prices. The International Energy Agency finds that if strong global mitigation is to be achieved, for every dollar of investment avoided by taking less action before 2020, an additional four dollars would need to be spent between 2021 and 2035 to compensate for the higher emissions

The transformation to a low-carbon society will require a radical shift in technologies. To avoid dangerous climate change, rapid, extensive and widespread low-carbon innovation will be required, in a transformation that has been compared to the advent of information technology. Countries that are able to develop a comparative advantage in key technologies may see economic benefits. Australia may be able to develop intellectual property that will be valuable in a low-carbon future, for example in geothermal and other forms of renewable energy, biosequestration, as well as carbon capture and storage.

Australia may not be well positioned for a global low carbon economy at present, but stronger domestic emissions reduction action will help. The required change in technologies to realise a low-carbon future could be massively disruptive to existing patterns of international trade and comparative advantage. Continued and strengthened domestic mitigation action including through carbon pricing will be important in turning this threat into an opportunity.



Source: Stern (2010) China's growth, China's cities and the new global low-carbon industrial revolution

Annex 1: Technical Report by Ecofys

Annex 2: Vivid Economics Report commissioned by WWF-Australia

Australia's carbon budget based on global effort sharing

Technical report

Australia's carbon budget based on global effort sharing

Technical report

By: Hanna Fekete, Markus Hagemann and Niklas Höhne
Date: 30 May 2013

Project number: CLIDE13854

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Acronyms

ARD	Afforestation, Reforestation and Deforestation
BAU	Business As Usual
C&C	Contraction and Convergence
CDC	Common but Differentiated Convergence
EVOC	Evolutions of Commitments
GDRs	Greenhouse Development Rights
GHG	Greenhouse Gas
LULUCF	Land Use Land Use Change and Forestry

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1 Introduction

Stringent global greenhouse gas (GHG) emissions reductions by all sectors and all countries will be necessary to keep global average temperature increase below 2°C. There are various approaches to share the effort of reducing emissions between countries. These effort sharing approaches consider factors like historic responsibility, capacity, potential and/or equality.

In 2009, Ecofys on behalf of WWF international prepared a report on the global carbon budget (Höhne, Moltmann 2009)[1] (hereafter called "2009 report"). Within this report, the global carbon budget was distributed to countries and regions using a number of different effort sharing approaches.

WWF Australia now aims to build on this report in presenting the implications of the attribution of such global carbon budget to Australia on its future emissions target pathway, taking into account recent developments and potentially delayed action until 2020.

The main research questions are:

- What carbon budgets does Australia have available for the time period from 1990 to 2100 according to different effort sharing approaches?
- What effect does the starting year for reducing emissions have on possible future emissions trajectories?
- Which implications does the starting year have on possible emissions levels in the years 2020 and 2030?
- How does the emissions target pathway provided by global effort sharing approaches relate to realistic future emissions development in Australia?

To answer these questions, we use data from the previous report and include recent developments and delayed action by developing three scenarios: The "What if…"-scenario starting emissions reductions in 2005, the "It's not too late…"-scenario starting reductions in 2013 and the "Delayed action"-scenario following the pledged emissions levels until 2020 and only then starting reductions necessary to stay within the allocated carbon budgets. The scenarios are explained in more detail in chapter 2.2.

This technical report includes three parts: Chapter 2 explains the approach used to develop the data further and analyse it, chapter 3 illustrates and explains quantitative results and chapter 4 names most important conclusions from these results.

[1] Available at http://awsassets.panda.org/downloads/wwf_ecofys_carbon_budget_final.pdf

2 Methodology

The following sections describe the approach we took to process data from the previous project, include more recent information and develop different scenarios. Summarising the methodology, we first calculate the remaining carbon budgets for Australia (see 2.2). We develop exemplary trajectories of emissions allocations which would comply with these budgets (see 2.3). In a third step, we develop technically realisable trajectories, as could be implemented in Australia (see 2.4). In a last step, we think about how Australia can cover the difference between the technically possible and the allocated budgets (see 2.5).

2.1 General approach

The starting point of our analysis is the results of the 2009 report (Höhne, Moltmann 2009). This report provides carbon budgets for individual countries that result from three different effort sharing approaches. The analysis was based on a global carbon budget of 1 800 GtCO2e excluding Land Use, Land Use Change and Forestry (LULUCF) emissions from 1990 to 2100, which is similar to stabilizing GHG concentrations at 450 ppm CO2eq / 400 ppm CO2. The carbon budget allocated to individual countries was determined using Ecofys' internal Evolutions of Commitments (EVOC) Model.

The effort sharing approaches the report considered and which this assignment analyses for Australia are:

- Contraction and Convergence by 2050 (C&C)
- Common but Differentiated Convergence (CDC)
- Greenhouse Development Rights (GDRs)

These approaches are explained in detail in the Annex.

In a second step, we calculate the carbon budget already spent and remaining. This split depends on the assumed starting year for emissions reductions and thus differs for the scenarios developed:

- **Scenario 1** – "**What if…"** : We assume that Australia started reducing emissions according to its allocated carbon budget already in 2005. Australia thereby follows a historical emissions path until 2005 and then starts reducing its emissions according to the carbon budget allocated to Australia.

  Aim: The scenario aims to show what emissions levels Australia could have reached already in 2020 and 2030, had it taken a more ambitious pathway early on.

- **Scenario 2 – "It's not too late…"**. We take account of the recent emissions development and predictable future emissions development until 2013. After 2013 we assume for this scenario that the emissions will be reduced in a manner that allows the country to stay within the carbon budget.

Aim: The scenario aims to show that it is not too late for Australia to take action if the efforts are increased in the coming years.

- **Scenario 3** – "**Delayed action"**. For the third scenario we assume that Australia will reach its pledged target of 5% below 2000 emissions in 2020 and will only thereafter start reducing emissions in a manner that allows the country to stay within the carbon budget.

  Aim: The scenario aims to illustrate the effort needed by Australia after 2020 if it decides to only reach its 5% below 2000 level in 2020 target.

In a third step we determine how the unused budgets theoretically could be spread over the remaining years. We call these emissions pathways the "exemplary trajectories complying with budgets". Chapter 2.3 illustrates this further.

Important to note here already is that, depending on the assumptions and remaining budgets, the yearly emissions reductions required by the scenarios can exceed the technically possible (compare chapter 2.4). The emissions reductions to comply with these budgets do thereby not necessarily need to take place in Australia but can be achieved through supporting other countries in achieving emissions reduction (e.g. though offset or climate finance) where these might be more economical feasible. We therefore also show realistic, technically possible but ambitious emissions trajectories.

As the original budget calculations exclude emissions from LULUCF, we also exclude this share of emissions in the assigned carbon budgets. Chapter 2.2.2 contains further information on how we deal with Australia's pledge, which includes emissions from Afforestation, Reforestation and Deforestation (ARD). As this share of emissions has significantly contributed to Australian emissions in the past and is likely to play a certain role for at least the near term future, we additionally show the scenarios adding ARD emissions.

2.2 Calculation of remaining carbon budgets

2.2.1 Data sources

Two data sets are of relevance for this step:

- Data generated for the 2009 report: Total carbon budgets for Australia for the time period 1990 – 2100 according to three effort sharing approaches: C&C, CDC and GDRs.
- Australia's Emissions Projections 2012 (Department of Climate Change and Energy Efficiency 2012): Historic emissions and Business As Usual (BAU) projections for the time period 1990 - 2030

The carbon budgets represent the cumulative amount of GHG emissions Australia is would be assigned between 1990 and 2100 based on the global carbon budget and the effort sharing approaches. The resulting budgets thereby depend on the effort sharing approach, assumptions made on a number of parameters (such as level and year of convergence, income threshold for GDRs etc.) and the underlying data used for the calculations in the 2009 report. Data used includes historic emissions, BAU emissions projections, population data, income and others. In total three different budgets were used, for each effort sharing approach one.

It is important to note that the data used for the calculations in the 2009 report is based on earlier versions of the Australian GHG inventory and other data sources and is therefore slightly different to the current official Australian data. Both aspects – the use of up to date information and officially recognised sources – are however of high relevance to this assignment. We therefore consider Australia's Emissions Projections 2012 and combine those with numbers from the 2009 report: While we determine the total available carbon budget using the old data sets, we calculate already spent budgets using the Australian emissions projections.

To analyse if the impact of combining different data sets would be relevant for the project outcomes, we compare historic and projected emissions of both sources in Figure 1.

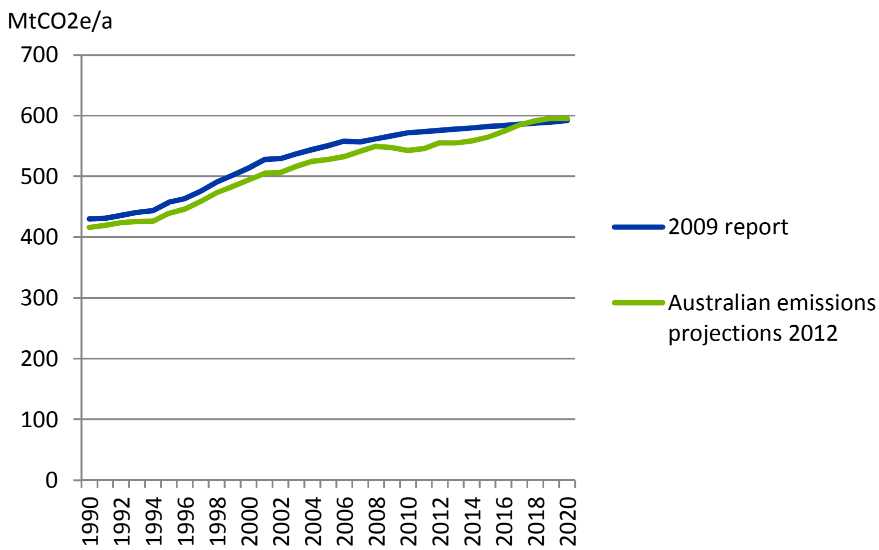

Figure 1: Comparison of historic emissions and projections until 2020 in EVOC model and official Australian statistics, excl. LULUCF

As the graph shows, the difference is small between the two data sets. Using official Australian data will lead to a slightly lower carbon budget spent in the past, and will thus be a little more generous regarding future budgets.

2.2.2 Determining spent budgets under the different scenarios

Some specific adjustments are necessary for all three scenarios. Those are explained in the following paragraphs.

Scenario 1 ("What if…") assumes that emissions reductions would already have started after 2005. 2006 is the first year where there is a difference between the reduction scenario and the BAU.

The spent budget is equal to the accumulated emissions between 1990 and 2005, as given by official Australian historic data.

Scenario 2 ("It's not too late…") assumes that emissions follow BAU until 2013 and then start reducing emissions. The spent budget is equal to the accumulated emissions between 1990 and 2013, as given by official Australian historic data and projections.

Scenario 3 ("Delayed action") assumes that emissions follow official Australian historic data until 2012 and the develop linearly towards the unconditional pledge of 5% below 2000 levels in 2020. The spent budget is equal to the accumulated historic emissions between 1990 and 2012 and projected emissions under the pledge between 2013 and 2020. Emissions reductions start in 2021.

Australia's emissions reduction pledge excludes LULUCF emissions, but includes emissions from ARD. To determine the value of the pledge without any forestry related emissions, we use the absolute value related to the pledge as given in Australia's Emissions Projections 2012 (Department of Climate Change and Energy Efficiency 2012) and subtract assumed forestry related emissions from the that value that also represent an effort. As the BAU included in the official projections does not reflect any additional political effort, we do not use those projections but instead the linear trend extrapolation of historic emissions (1990-2010). This reflects the assumption, that the efforts to decrease forestry emissions will continue as over the last decades, while the official BAU assume relatively stable net emissions for forestry.

2.3 Development of exemplary emissions trajectories complying with the carbon budgets

In order to illustrate implications of pathways for different years, we distribute the remaining carbon budgets to future years. It is important to stress that this reflects the distribution of emissions rights, not actual physical emissions. Emissions could be traded between countries and years and can therefore be different from allocated emissions according to effort sharing.

We simplify the curve of future emissions trajectories using a linear decrease from the base year (t,base) to a year of convergence (t,con), producing a slope comparable to results of the EVOC model for the 2009 report. We optimise the year of convergence for the area under the curve to match remaining budgets. From the year of convergence on, the emissions remain stable until the end year 2100 (t,end).

The level of stabilisation reflects results from the model runs for the 2009 report and differs per effort sharing approach. For the C&C and CDC emissions stabilised in the model runs from 2009 at a certain value which we use directly as a level of stabilisation in this assessment. For the GDRs, the emissions trajectory was more complex in 2009, first decreasing to a negative level and then recovering to increase well above zero again. We therefore use the average of all years starting with the first year with a negative value until the end year.

As illustrated in Figure 2, we can then determine the year of convergence via the remaining budget (A2 + A3) and the stabilisation level (E(t,end)).

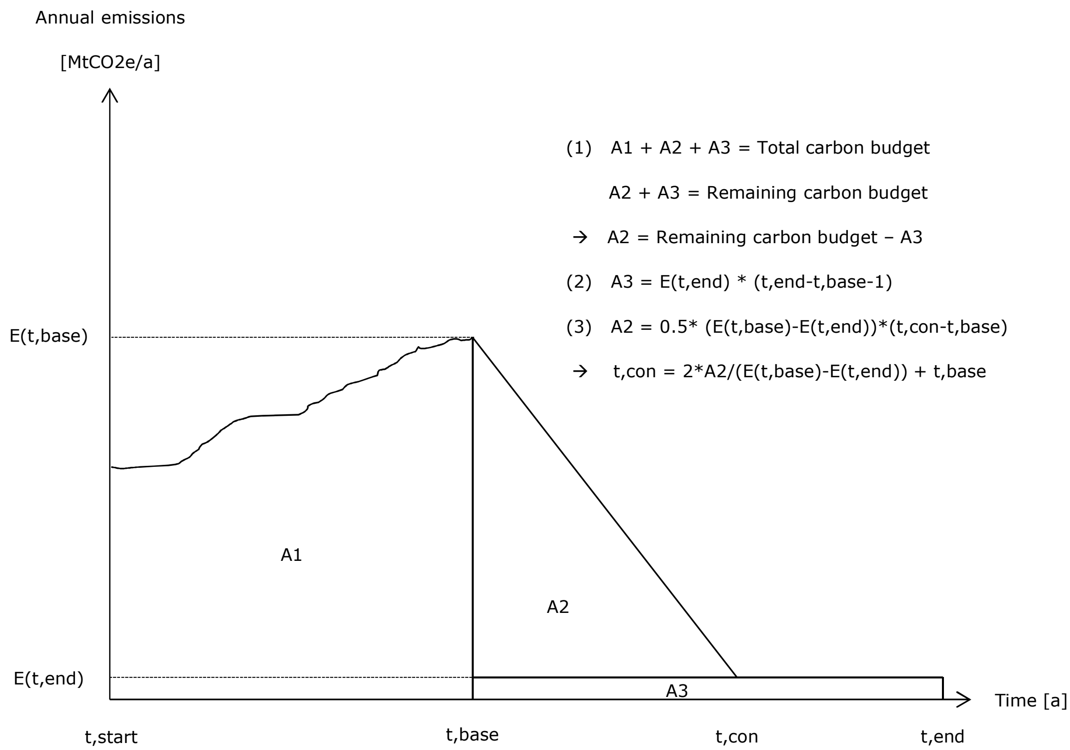

Figure 2: Illustration of approach to development of exemplary emissions trajectories

The resulting carbon budget used in the future varies slightly from the remaining budgets used as an input to these calculations. This is due to rounding of values for t,con to complete numbers.

2.4 Development of technically realisable but ambitious emissions trajectories

The emissions trajectories in the scenarios complying with carbon budgets designed as explained in the previous chapter may be very steep and - depending on the effort sharing approach – reaching negative levels. It is important to mention that these scenarios merely present a possible distribution of emissions *allocation*, not real emissions in Australia.

To show what a possible emissions trajectory for Australian emissions can be, we furthermore design a "technically realisable" scenario. It is based upon the simple assumptions that annual emissions reductions rates and growth trend changes can only reach maximum. As default values, we use 4% for maximum annual reductions and 0.5% per year for trend changes. These values are already ambitious compared to historical levels and future scenarios. Historical emissions have increased o average by 1.5% per year over the last 30 years. Recent emission reduction scenarios compatible with the 2°C limit show that a reduction of at the most 4% per year are possible (Vliet et al. 2012, OECD 2011).

2.5 Distribution of purchase of emissions rights to comply with budgets

As the trajectories complying with the budgets and those reflecting a technically possible scenario are likely to differ in terms of accumulated emissions over the considered time period, we assess how this difference can be balanced. One important option is international trade. If the realisable emissions reductions do not comply with the given budgets, Australia could purchase permits or support emissions reductions abroad through other mechanisms.

The distribution of the purchase of the permits over time does not affect the accumulated emissions, but is likely to have an impact on concentration levels in 2100. We do not further assess this impact of the distribution, but show different options of distributing permits over time:

- Option 1: Purchase permits to match yearly emissions (yearly emissions comply with trajectory we have designed according to the budgets)
- Option 2: Purchase of permits spread evenly across years (trajectories comply with total remaining budgets)
- Option 3: Increase purchase of permits steadily starting at 0 in base year for a certain amount of time (default 10 years), then stabilise at this level (trajectories comply with total remaining budgets)

Option 1 is the preferred scenario as the allocated emissions per year orient at the emissions trajectories given by the EVOC model and therefore at global emissions pathways which represent a more adequate approximation to what is necessary to also keep GHG concentration in a certain range. It is also the option that we find can be argued for in the best manner. It requires the country to first increase the number of permits that have to be purchased when the country slowly starts to move to a low carbon trajectory. Once a country has fully embarked upon such trajectory, the purchase of permits can slowly be decreased again. Finally, once a low carbon society is reached, no more credits need to be purchased.

3 Results

The following sections illustrate and describe most important results of the quantitative analysis.

3.1 Remaining carbon budgets

As a starting point, we extract the total carbon budgets for the three effort sharing approaches. The remaining carbon budgets vary according to those approach and the scenario. Table 1 shows the remaining budgets after the base year for all nine combinations and total budgets for each of the effort sharing approaches.

The total budget available for the time period 1990 – 2100 is highest for C&C, closely followed by CDC. GDRs are significantly more stringent than the other two approaches. Looking at the different scenarios, we can clearly see that the remaining budget is much bigger for the scenario with an earlier base year. In one case, Australia has already emitted more emissions than allocated according to the effort sharing approach (Scenario 3, GDRs).

Table 1: Carbon budgets according to different effort sharing approaches and scenarios

	Budgets in MtCO2e		Effort sharing approaches		
		Time period	C&C	CDC	GDRs
Scenario	Total budget	1990 - 2100	18,009	17,594	14,111
Scenario	"What if"	1990 - 2005	10,521	10,106	6,623
Scenario	"It's not too late"	1990 - 2013	6,151	5,736	2,254
Scenario	"Delayed action"	1990 - 2020	2,339	1,924	-1,559

3.2 Trajectories complying with allocated budgets

The following graphs show a possible distribution of allocated emissions which would comply with the remaining budgets calculated. While the slope of the curve varies much depending on the scenario (or more specifically the starting year) (compare Figure 3 to Figure 5), the effort sharing approach chosen has only little impact (compare Figure 6 to Figure 8).

We find that for all approaches, a fast decline of emissions to very low levels is necessary. Per definition, the allocated emissions cannot become negative for the CDC and C&D approach. This is possible for the GDRs approach. Nevertheless, the stringency of the approach balances out the possibility to go below zero so the decline of emissions needs to be even a little faster than for the other approaches.

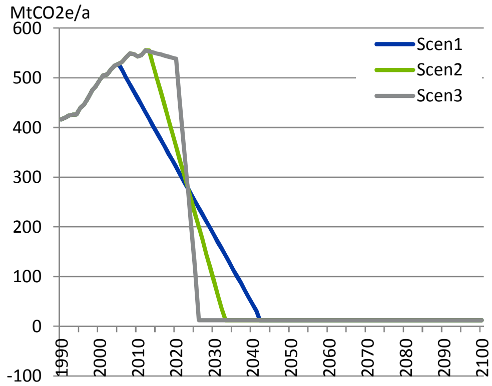

Figure 3: Trajectories complying with budgets for different scenarios (C&C approach)

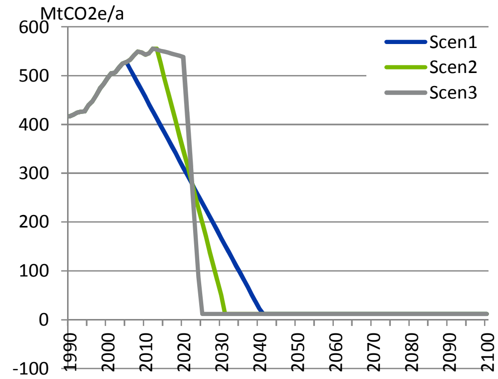

Figure 4: Trajectories complying with budgets for different scenarios (CDC approach)

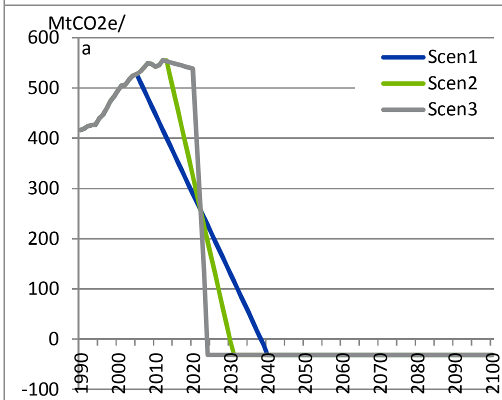

Figure 5: Trajectories complying with budgets for different scenarios (GDRs approach)

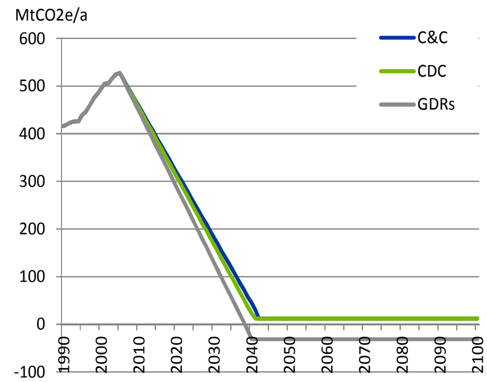

Figure 6: Trajectories complying with budgets for different effort sharing approaches (Scenario1)

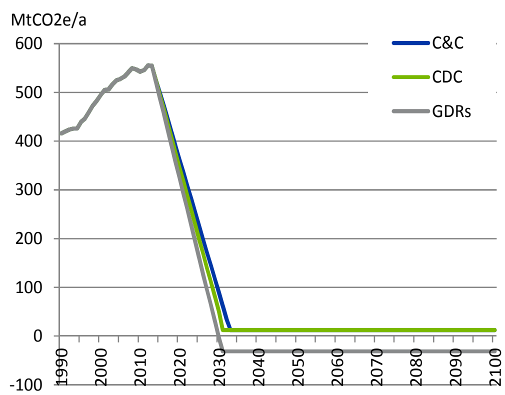

Figure 7: Trajectories complying with budgets for different effort sharing approaches (Scenario2)

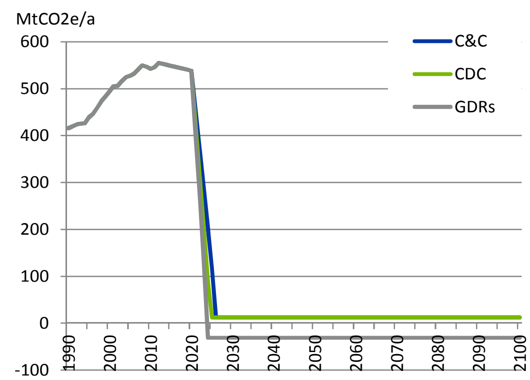

Figure 8: Trajectories complying with budgets for different effort sharing approaches (Scenario3)

3.3 Technically realisable but ambitious emissions trajectories

With the assumptions as explained in the methodology chapter, possible trajectories to reduce emissions are as shown in Figure 9 below. These graphs show technical feasible emissions trajectories generated with a simplified approach that can theoretically be achieved in Australia, not allocations.

Table 2 illustrates the cumulative emissions needed after the base year according to these three scenarios. Table 3 shows the difference between the budgets needed at the minimum in the technically realisable scenarios and the remaining budgets according to effort sharing approaches.

We find that for none of the scenarios or approaches, Australia can reduce emissions domestically to not exceed allocated budget. The numbers in Table 3 can be interpreted as emissions allowances, Australia would need to purchase in order to remain within the allocated budgets.

The difference is higher the later Australia would start reducing emissions and for the more stringent effort sharing approach (GDRs).

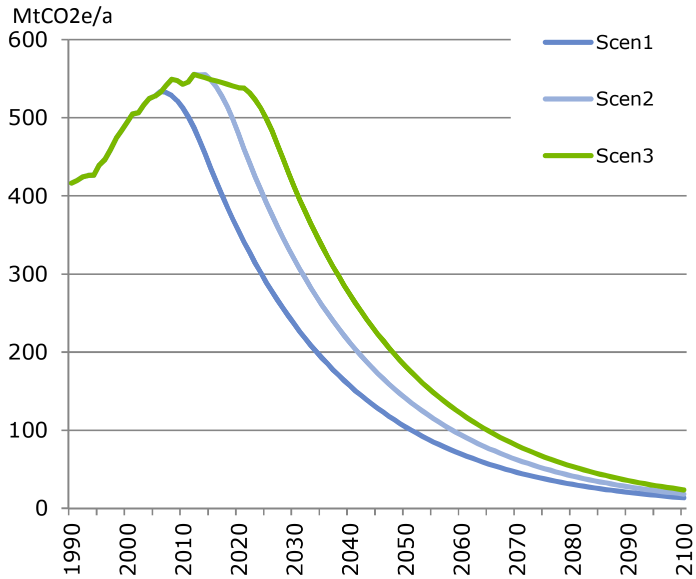

Figure 9: Technically realisable emissions trajectories for different scenarios

Table 2: Minimal technically realisable budget to be spent between base year and end year

	Budgets in MtCO2e	**Minimal technically realisable budget needed**	**Time period**
Scenario			
	"What if"	15,101	2005 - 2100
	"It's not too late"	11,509	2013 - 2100
	"Delayed action"	14,036	2020 - 2100

Table 3: Overrun of allocated budgets with technically realisable trajectories

	Budgets in MtCO2e	Time period	Effort sharing approach C&C	CDC	GDRs
Scenario	"What if"	1990 - 2100	4,580	4,995	8,478
	"It's not too late"	1990 - 2100	5,438	5,853	9,336
	"Delayed action"	1990 - 2100	11,698	12,113	15,596

3.4 Distribution of emissions permits

If we distribute the overrun over time as indicated in "Option 1" in the methodology chapter, the resulting trajectories for purchasing emissions result, as illustrated in Figure 10 to Figure 12. For all scenarios, there is a relatively steep increase in purchase of permits in until the year of stabilisation of allocated emissions. Afterwards, the permits needed per year decrease again and move towards 0 over time. The results also show, that the start year of emissions reductions influences the level of permits needed heavily. The later emissions start decreasing in Australia, the higher the number of permits needed in certain years.

The graphs below (Figure 13 to Figure 15) show the same scenarios, but we added a scenario for ARD emissions. We take the historical ARD emissions and extend the trend assuming a linear decline to 0 net emissions until 2020. Australian projections show a stabilization of the current emissions until 2020. The values in the figures therefore assume that some effort is made in ARD in addition to the efforts made in the other sectors.

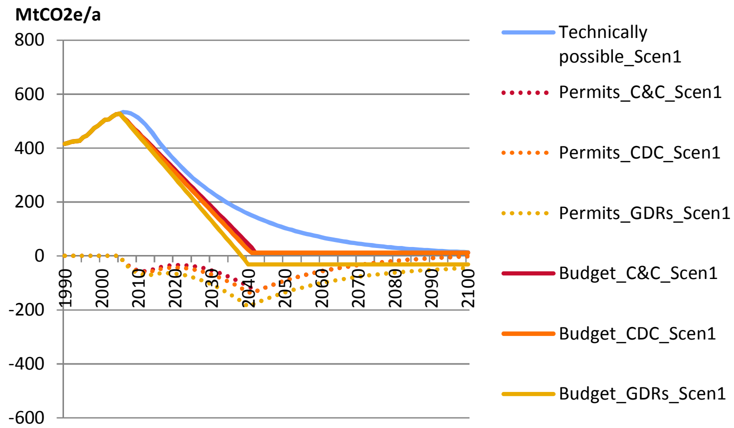

Figure 10: Trajectories complying with budgets (A), technically possible scenario (B) and permits that need to be purchased (A-B) (Scenario1, excluding ARD)

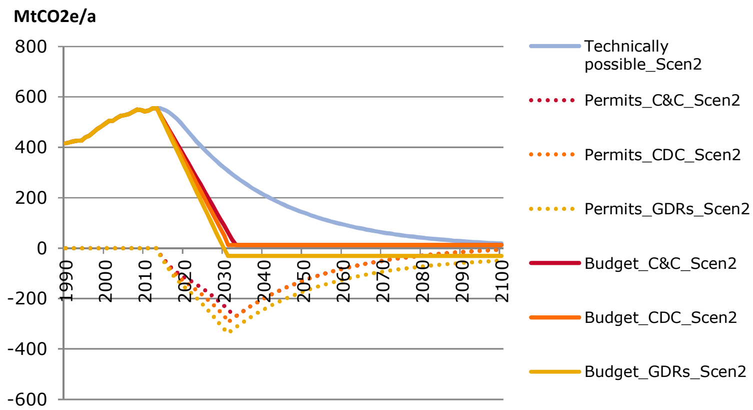

Figure 11: Trajectories complying with budgets (A), technically possible scenario (B) and permits that need to be purchased (A-B) (Scenario2, excluding ARD)

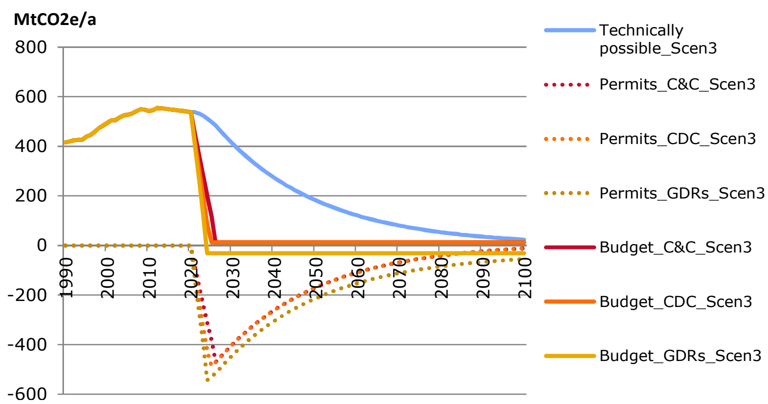

Figure 12: Trajectories complying with budgets (A), technically possible scenario (B) and permits that need to be purchased (A-B) (Scenario3, excluding ARD)

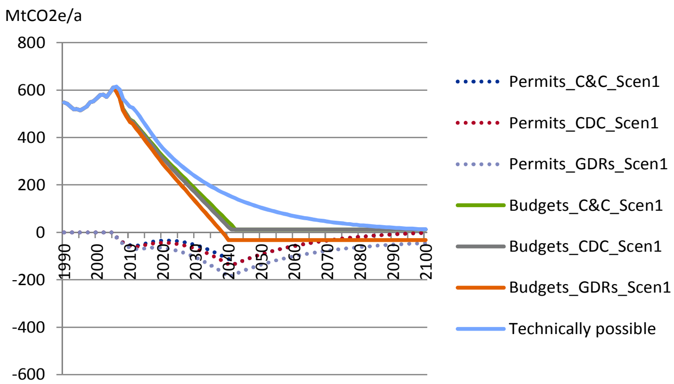

Figure 13: Trajectories complying with budgets and needed permits for effort sharing approaches (Scenario1, a scenario for ARD emissions is added for illustrative purposes)

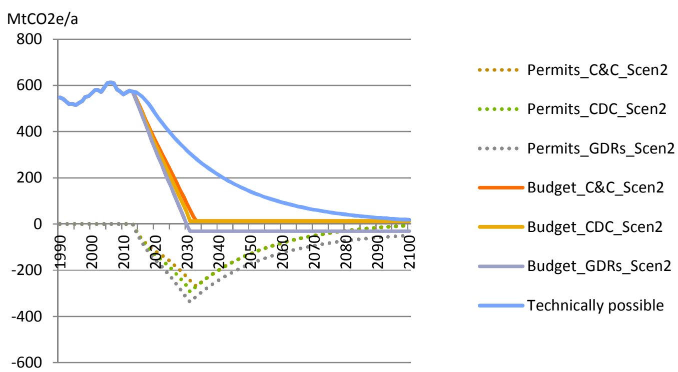

Figure 14: Trajectories complying with budgets and needed permits for effort sharing approaches (Scenario2, a scenario for ARD emissions is added for illustrative purposes)

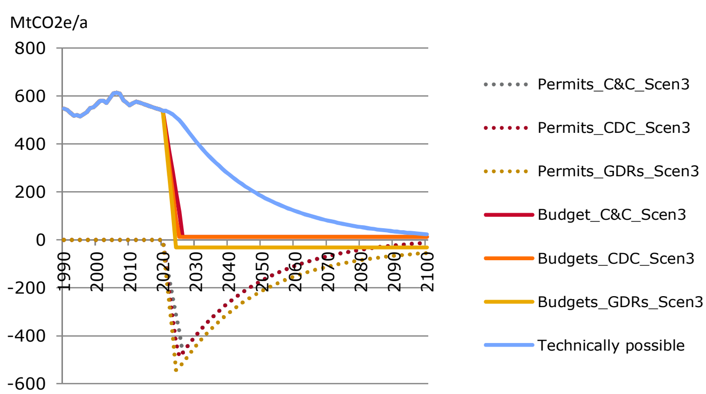

Figure 15: Trajectories complying with budgets and needed permits for effort sharing approaches (Scenario3, a scenario for ARD emissions is added for illustrative purposes)

4 Key commentary on results

The following bullets illustrate most important conclusions from this assignment:

- Australia has already spent a substantial share of its "fair" carbon budget since 1990 until today.
- All scenarios show that Australia needs to reduce emissions rapidly and drastically. The choice of the effort sharing approach does not influence the trajectories much. When emissions reductions are started has a significant impact on the speed of required reductions. Australia has or will have spent 42 – 53%, 66 - 84% and 87 - 111% of its 1990 to 2100 carbon budget with emissions until 2005, 2013 and under the 5% pledge until 2020.
- The "fair share" emission target levels in 2020 vary between 41% and 27% below the level in the year 2000 (excl. LULUCF), depending on the scenarios and effort sharing approach calculated here. This is more stringent than the "fair share" which the Garnaut review 2008 (Garnaut 2008) provides (25% below 2000 in 2020). For 2030, our model results in a target range of negative emissions ("Delayed action" scenario) and 63% ("What if" scenario) of 2000 levels.
- All scenarios show that Australia needs to reach near carbon neutrality in the long term, in order to remain within the allocated emissions budgets.
- The necessary emissions reductions according to effort sharing go beyond what is technically realisable in Australia domestically. As a result, the allocated budgets would require Australia to offset its emissions, e.g. by purchasing permits abroad or supporting emissions reductions via other mechanisms. The amount of "overrun" of the budgets is substantial: between 4.6 and 15.6 GtCO2e depending on scenario and effort sharing approach. Starting to reduce emissions sooner rather than later minimizes the overrun. It roughly doubles if stringent reductions are postponed to after 2020 compared to starting reductions now.
- The gap between the realistic and the required emissions reductions can be filled with buying international offsets and/ or financing low emissions reduction trajectories abroad. We suggest that these credits are best purchased in "real time" so that the emissions trajectory complying with the annually allocated emissions can be kept. This means that Australia would have to buy additional credits in the first years until it has fully embarked on a low carbon trajectory. In the years thereafter Australia could then gradually reduce its international credit purchases until they will have reached a very low level.

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Annex

Description of effort sharing approaches used

Contraction and convergence by 2050

Under Contraction and convergence (C&C) (GCI 2005, Meyer 2000), all countries participate in the regime with quantified emissions targets. As a first step, all countries agree on a path of future global emissions that leads to an agreed long-term stabilisation level for greenhouse gas concentrations (‘contraction’). As a second step, the targets for individual countries are set in such a way that per capita emissions allowances converge from the countries’ current levels to a level equal for all countries within a given period (‘convergence’). The convergence level is calculated at a level that resulting global emissions follow the agreed global emissions path. It might be more difficult for some countries to reduce emissions compared to others, for example, due to climatic conditions or resource availability. Therefore, emissions trading could be allowed to level off differences between allowances and actual emissions. However, C&C does not explicitly provide for emissions trading.

As current per-capita emissions differ greatly between countries some developing countries with very low per capita emissions, (e.g. India, Indonesia or the Philippines) could be allocated more emissions allowances than necessary to cover their emissions (‘hot air’). This would generate a flow of resources from developed to developing countries if these emissions allowances are traded.

Common but differentiated convergence

Common but differentiated convergence (CDC) is an approach presented by Höhne et al. (Höhne et al. 2006). Annex I countries’ per capita emissions allowances converge within, for example, 40 years (2010 to 2050) to an equal level for all countries. Individual non-Annex I countries’ per capita emissions also converge within the same period to the same level but convergence starts from the date, when their per capita emissions reach a certain percentage threshold of the (gradually declining) global average. Non-Annex I countries that do not pass this percentage threshold do not have binding emissions reduction requirements. Either they take part in the CDM or they voluntarily take on positively binding emissions reduction targets. Under the latter, emissions allowances may be sold if the target is overachieved, but no emissions allowances have to be bought if the target is not reached.

The CDC approach, similarly to C&C, aims at equal per capita allowances in the long run (see Figure 8). In contrast to C&C it considers more the historical responsibility of countries. Annex I countries would have to reduce emissions similarly to C&C, but many non-Annex I countries are likely to have more time to develop until they need to reduce emissions. Non-Annex I country participation is conditional to Annex I action through the gradually declining world average threshold. No excess emissions allowances (“hot air”) would be granted to least developed countries.

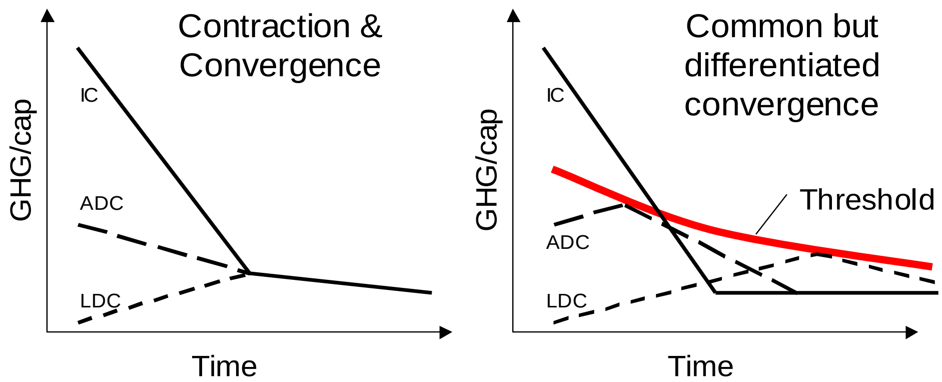

Figure 16: Schematic representation of GHG emissions per capita for three types of countries (an industrialized country (IC), an advanced developing country (ADC) and a least developed country (LDC)) under Contraction & Convergence (left) and under Common but Differentiated Convergence (CDC)

Greenhouse Development Rights approach

The Greenhouse Development Rights (GDRs) approach to share the effort of global greenhouse gas emissions reduction was developed by Baer et al. (Baer et al. 2007). It is based on three main pillars:

The right to develop: Baer et al. assume the right to develop as the essential part for any future global climate regime in order to be successful. Therefore a development threshold is defined. Below this level individuals must be allowed to make development their first priority and do not need to contribute to the global effort of emissions reduction or adaptation to climate change impacts. Those above this threshold will have to contribute regardless their nationality. This means that individuals above this threshold will have to contribute even if they live in a country that has an average per capita income below this level. The level for this development threshold would have to be matter of international debate. However Baer et al. 2008 suggest an income-level of $7,500 per capita and year. Based on this, the effort sharing of the GDRs is based on the capacity and the responsibility of each country.

Capacity: The capacity (C) of a county is reflected by its income. The income distribution among individuals is taken into account by the gini coefficient of a country. A gini coefficient close to 1 indicates low equality while a value close to 0 indicates a high equality in income distribution. As the countries capacity is needed to define per-country emissions allowances the sum of income of those individuals per country above the development threshold is summed and considered to calculate each countries capacity.

Responsibility: The responsibility (R) is based on the 'polluter pays' principle. For the GDRs according to Baer et al. it is measured as cumulative per capita CO2 emissions from fossil fuel consumption since 1990. However, it should be distinguished between survival emissions and luxury emissions. Baer et al. assume that emissions are proportional to consumption, which again is linked to income. Emissions related to that share of income below the development threshold are equivalent to the part of national income that is not considered in calculating a country's capacity. Therefore, they shall be considered as survival emissions. Those emissions linked to income above the development threshold are luxury emissions and shall account for a country's responsibility.

Allocation of emissions rights: The allocation of emissions reduction obligations and resulting emissions rights is based on each country's responsibility and capacity, combined in the Responsibility Capacity Index (RCI). This is defined as , where a and b are weighting factors. Baer et al. assume and equal weighting of 0.5 for a and 0.5 for b, which gives capacity and responsibility an equal weight.

Two global emissions development paths are considered. First, the BAU case and second the reduction path necessary to reach the emissions level in order to stabilise global emissions (see Figure below). The difference of these two is the amount of emissions that need to be reduced globally. Each country's annual share of this reduction is determined by the relative share of its RCI compared to the sum of RCIs of all other countries.

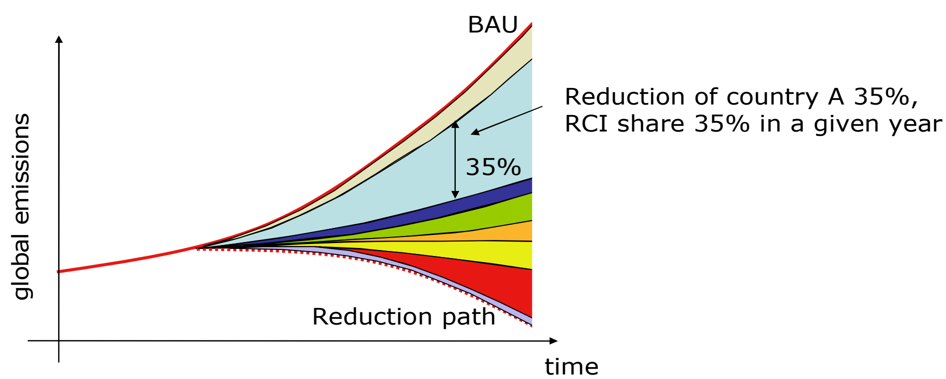

Figure 17: Effort sharing under the Greenhouse Development Rights (GDR) approach according to the Responsibility Capacity Index (RCI)

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The costs and benefits of greater Australian emissions reduction ambition

Report prepared for WWF - Australia

Final report
May 2013

An appropriate citation for this report is:

Vivid Economics, *The costs and benefits of greater Australian emissions reduction ambition*, report prepared for WWF Australia, May 2013.

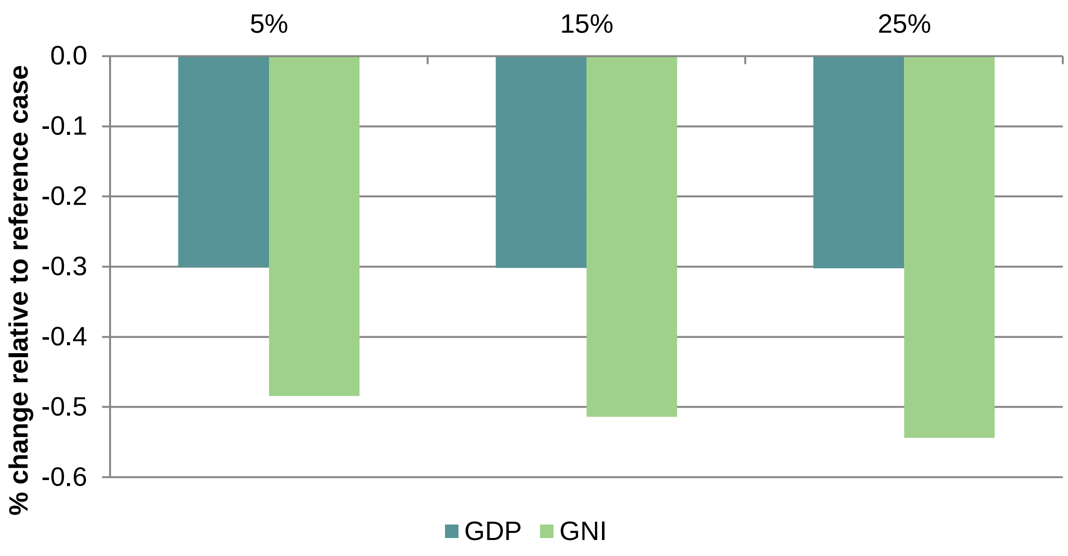
The modelling for this report was undertaken by the Centre of Policy Studies (CoPS), Monash University.

Executive Summary

This report contributes analysis to the debate on Australia's emission reduction ambition. It provides input into the process for the 'Caps and Targets Review' by the Climate Change Authority. We present new macroeconomic modelling analysis of the economic impact of Australia adopting a more ambitious emissions reduction target. The modelling takes account of recent changes in both economic and policy circumstances, especially the much lower price outlook for carbon prices in Australia and internationally. We also investigate the effects of greater domestic mitigation effort and fewer imported emissions reductions. Further, we provide a review of possible long-term benefits associated with taking more ambitious action on climate change in the near term. We use the Monash Multi-Regional Forecasting (MMRF) model with modelling undertaken by the Centre of Policy Studies (CoPS) at Monash University.

The macroeconomic costs of achieving Australia's 5 per cent emissions target are moderate. Achieving a 5 per cent national emissions reduction at 2020 in our modelling would result in gross domestic product (GDP) and consumption being 0.3 per cent lower in 2020 than in the reference case which assumes no additional action to curb emissions. The same level of GDP would be reached less than two months later than if no action was taken; the annual reduction in the pace of economic growth would be less than 0.05 per cent.

Figure 1. **The additional cost of achieving a stronger target is very small**

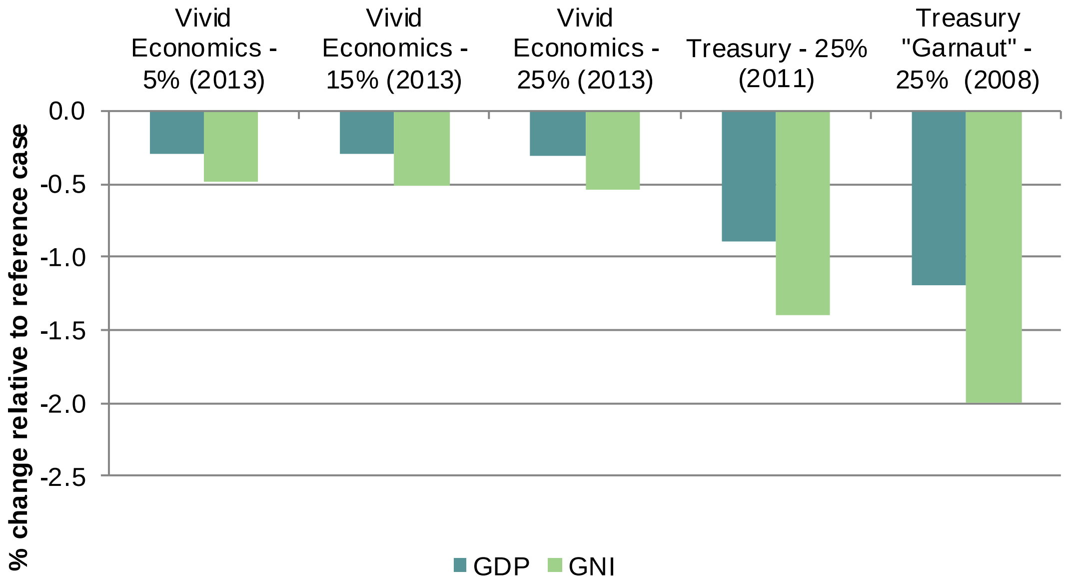


Source: *Vivid Economics based on modelling results from CoPS MMRF.*

Moving to a stronger reduction target has very low additional macroeconomic costs. The level of domestic economic activity, as measured by GDP, remains unchanged when moving from the 5 per cent to a 15 per cent or 25 per cent target. This is because, under current policy settings, additional reductions would come predominantly from international sources. The impact on gross national income (GNI), which includes the purchases of emissions reductions from other countries, is very slightly larger as a result of moving to a stronger target: changing from a reduction of 0.48 per cent in 2020 in the 5 per cent scenario to 0.54 per cent in the 25 per cent reduction scenario. This is in the context of projected underlying growth in GNI of 27 per cent from 2013 to 2020.

The costs of achieving a stronger target are much lower than expected when the target range was originally set. The lower price outlook for international emissions permits and offset credits reduces both Australia's domestic economic impacts and the amount of money spent on international emissions units. This results in much lower macroeconomic costs in terms of both GDP and GNI. The Australian Treasury's 2011 modelling study showed a 0.9 per cent reduction in GDP and a 1.4 per cent reduction in GNI relative to the reference case for the 25 per cent target case, and the need to purchase around A$7.3 billion of international emissions units. Treasury's 2008 modelling of a 25 per cent scenario showed even greater macroeconomic costs and international transfers. By contrast, in our updated modelling of a 25 per cent target, the GDP impact at 2020 is 0.3 per cent, the GNI impact is 0.5 per cent, and the cost of purchase of international emissions units are A$2.2 billion.

Figure 2. **The macroeconomic costs of a stronger target are much lower than previously estimated**



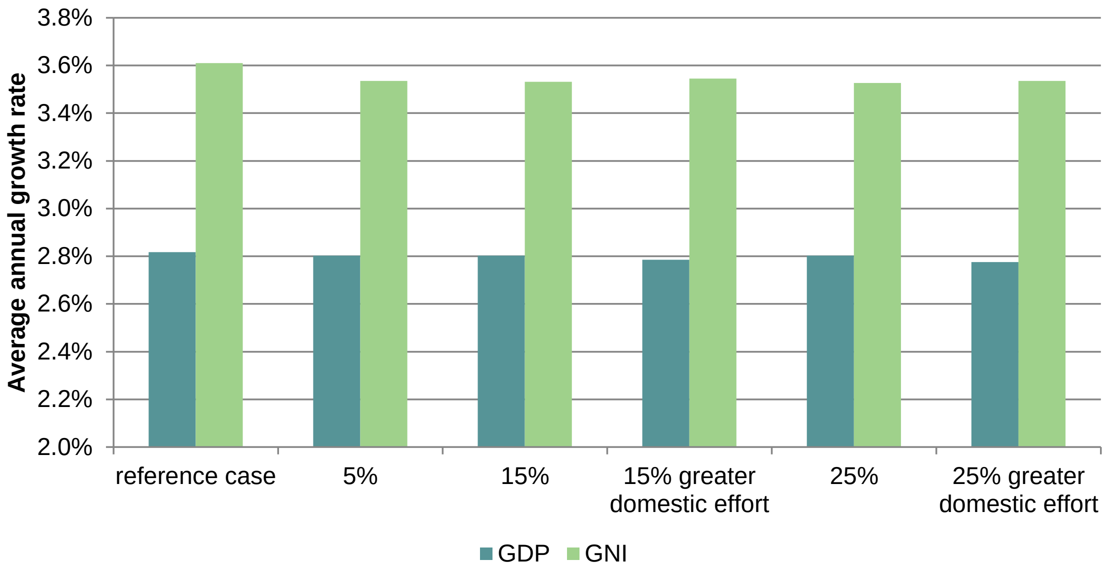
Note: Treasury's 2008 report reports GNI as GNP (gross national product). The two measures are very similar.

Source: Vivid Economics based on modelling results from CoPS MMRF.

A stronger target might call for greater domestic effort. Irrespective of the target level, under the relatively low current price outlook, the emissions levels in Australia as modelled would continue rising, up 7 per cent from 2012 levels in 2020. This is because any additional emission reductions would come from the purchase of international units. While this is a low-cost strategy for meeting a given target, greater domestic effort could better position Australia's economy for deeper cuts in the longer term. Furthermore, community expectations might call for a stronger target to be translated into stronger domestic action. It would also send a stronger signal of Australia's commitment to the international community.

Shifting the balance towards greater domestic effort and away from overseas emissions permits means a larger impact on domestic GDP, but reduces the impact on GNI. We construct "greater domestic effort" scenarios where domestic emissions levels fall by 4 per cent and 8 per cent respectively from 2012 to 2020, with the Australian carbon price significantly higher than assumed in the standard scenarios. In these scenarios, the impact on domestic GDP is increased by around half for the 15 per cent target, and almost doubled for a 25 per cent target. Nonetheless, the overall GDP impact is still moderate; an economy which achieves a 25 per cent target with more than half of the emissions reductions achieved domestically would still reach the same level of GDP as achieved without any climate policy just three months later. The impact on annual economic growth rates is very small. At the same time, the overall cost of purchasing international emissions units falls to less than half of that in the corresponding standard scenarios. Australia's GNI is modelled to be affected *less* in the "stronger domestic effort" scenarios than under the standard assumptions.

Figure 3. **Across all scenarios, the impact on average annual growth rates is barely discernible**



Note: *Note vertical axis starts at 2 per cent*

Source: *Vivid Economics based on modelling results from CoPS MMRF.*

Industry-level output changes are minor, and largely confined to a small number of industries that will continue growing in absolute terms. This is possible because of technological improvements and substitution away from high-emissions inputs towards low-emissions inputs. In a scenario in which emissions are reduced by 25 per cent by 2020, among Australia's 25 largest industries, only the coal, gas and electricity industry are modelled to experience output reductions of greater than 2 per cent, relative to the reference case. In absolute terms, these industries are modelled to keep growing with employment in the coal and gas industries expected to either remain stable or grow. For 9 out of the 25 largest industries it is projected that output value will actually increase relative to the baseline of no climate policy.

The macroeconomic impacts are differentiated between states. The largest overall impacts are in Queensland and New South Wales reflecting the higher proportion of coal mining and electricity generation from coal, but even here state level economic product is reduced by no more than 0.4 per cent in the standard scenarios. This is relative to a baseline of continued significant growth in all states and territories.

Acting now may save costs later. Adopting a more ambitious target to 2020 may require a less steep trajectory of emissions reductions in following decades. Deferring emission reductions to the future would allow Australia's emission reductions to take place when the country is richer. But early action to reduce emissions can reduce the risk of 'lock-in' of high carbon assets, which might otherwise mean higher costs in the medium to long run.

Many analyses find that that the cost of delay may be significant. Earlier Treasury modelling found that delayed action increases Australia's future mitigation costs, with a three year delay resulting in higher mitigation costs of 2 to 10 per cent in 2050. International academic analysis suggests that more ambitious early action can help to reduce total costs over time, and could drastically reduce the magnitude of future carbon prices. The International Energy Agency finds that if strong global mitigation is to be achieved, for every dollar of investment avoided by taking less action before 2020, an additional four dollars would need to be spent between 2021 and 2035 to compensate for the higher emissions.

The transformation to a low-carbon society will require a radical shift in technologies. To avoid dangerous climate change, rapid, extensive and widespread low-carbon innovation will be required, in a transformation that has been compared to the advent of information technology. Countries that are able to develop a comparative advantage in key technologies may see economic benefits. Australia may be able to develop intellectual property that will be valuable in a low-carbon future, for example in geothermal and other forms of renewable energy, biosequestration, as well as carbon capture and storage.

Australia may not be well positioned for a global low carbon economy at present, but stronger domestic emissions reduction action will help. The required change in technologies to realise a low-carbon future could be massively disruptive to existing patterns of international trade and comparative advantage. Continued and strengthened domestic mitigation action including through carbon pricing will be important in turning this threat into an opportunity.

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1 Introduction

This report informs the debate on the costs and benefits of Australia increasing its level of emission reduction ambition. Australia's current target, submitted to the Copenhagen Accord in 2010, commits Australia to an unconditional 5 per cent reduction in emissions from 2000 levels as well as more stringent targets in the event of greater global cooperation on mitigation. The Climate Change Authority (CCA) has recently announced the commencement of its statutory 'Caps and Targets Review' which, among other things, will provide independent recommendations on whether this target should be increased; as well as a cap for the first five years of the carbon pricing mechanism; and a national carbon budget.

The report provides two salient pieces of analysis that should be taken into account in this decision. This is in the context of the CCA's issues paper[1] which invites input from stakeholders to better inform its analysis and recommendations.

First, it presents new macroeconomic modelling analysis of the economic impact of Australia adopting a more ambitious emissions reduction target. This modelling takes account of recent changes in both economic and policy circumstances, in particular the decision made to link the Australia's Carbon Pricing Mechanism with that of the European Union Emissions Trading Scheme. This analysis uses the Monash Multi-Regional Forecasting (MMRF) model that has previously been used by the Australian Treasury in its own analysis. The modelling was conducted by the Centre of Policy Studies (CoPS) at Monash University.

A secondary, complementary analysis provides a brief review of the long-term benefits associated with taking more ambitious action on climate change in the near term. This includes an examination of the existing literature on the possible importance of avoiding high-carbon 'lock-in' as well as the potential benefits available to countries that acquire comparative advantage in low-carbon technologies.

[1] Climate Change Authority (2013) Caps and Targets Review, April.

2 Modelling the impact of more ambitious action

The cost of meeting more ambitious targets has fallen

We provide new modelling analysis on the macroeconomic impacts of Australia meeting different emission reduction targets. Our modelling shows that as a consequence of the change in policy settings, the macroeconomic context and the changes in international carbon price outlook, the costs of achieving a given emission reduction target is lower than it was thought to be back in 2009 when Australia first committed to a 5 per cent emissions reduction target by 2020. It further shows that the additional macroeconomic costs of moving from a 5 per cent to a 15 per cent or 25 per cent reduction target would be small under current policy settings, because the additional reductions would likely be achieved solely through purchases of relatively low-cost international permits.

We also model domestic emissions trajectories under greater domestic abatement effort. We show that under current policy settings, the amount of abatement achieved domestically would be less than under earlier assumptions of higher international prices, and absolute emissions would continue increasing from today's level. We model the effects of achieving a 15 per cent or 25 per cent target with greater domestic mitigation effort. While this would raise the Gross Domestic Product (GDP) costs of meeting the more ambitious emission reduction targets, as a result of higher domestic carbon prices and greater domestic mitigation action, the costs in terms of Gross National Income (GNI) would be reduced relative to relying on purchases of international emissions reductions[2]. The modelled macroeconomic costs remain below 0.1 per cent of GDP per year for a 25 per cent reduction target at 2020 even when the majority of emissions reductions occur domestically.

We begin by describing the modelling framework, then report results for standard scenarios of achieving a 5 per cent, 15 per cent or 25 per cent target along with sensitivity analysis, and then report results for scenarios where a greater share of the mitigation effort takes places domestically within Australia.

2.1 Modelling framework, scenarios and assumptions

Our modelling framework is similar to that used by the Australian Treasury in earlier analyses. We use the Monash Multi-Regional Forecasting (MMRF) model, a whole-of-economy model rich in industry detail that captures interactions between different sectors of the economy and among producers and consumers, and tracks emissions levels by economic sector and region.[3] Further details of the modelling

[2] GDP is a measure of the value of the economic activity taking place within a country. GNI is a measure of the income flowing to residents of a country; GNI adjusts GDP to take account of payments made and received from other countries.

[3] Adams, P.D., Dixon, J., Gieseke, J. and Horridge, M.J., 2011. 'MMRF: Monash multi-regional forecasting model: a dynamic multi-regional applied general equilibrium model of the Australian economy', Working Paper, Centre of Policy Studies, Monash University.

framework are provided in the Appendix. The model used is similar to that employed (alongside other models) in the Australian Treasury's 2008 and 2011 reports on modelling a carbon price.[4] The focus in the modelling for this report is domestic. We do not model carbon pricing in other countries or how changes in Australia's target might lead to indirect changes (in climate policy, for instance) in any other country.

The MMRF model has been updated for economic and policy developments. The Centre of Policy Studies at Monash University was commissioned to update the MMRF model and run specific modelling scenarios developed by Vivid Economics for this report. The model has been updated with economic and emissions data to 2012. In line with the earlier Treasury modelling, all emissions in the economy are assumed to be covered by the carbon price, while actual existing policy settings do not impose the emissions price on emissions from agriculture and forestry (except in a limited and indirect way through the Carbon Farming Initiative), parts of transport and some other emissions sources. The revenue from the carbon price is modelled to be shared between reductions in income tax, transfers to industry and any purchases of international emissions units. The allocation of permit revenue to households and industries is broadly similar to that in operation under the Clean Energy Future legislation. The earlier Treasury modelling assumed redistribution to households in a lump-sum fashion as opposed to tax cuts. The Renewable Energy Target is modelled in the policy scenarios, and not in the reference case.

The baseline has been updated. The outlook for economic growth and future emissions levels in the reference case without carbon pricing has been updated. This includes a slightly lower trajectory for future GDP growth than assumed in Treasury's previous modelling exercises, a lower growth outlook for electricity use and a higher growth outlook for output from the liquefied natural gas (LNG) industry. The reductions from the reference case needed to achieve a given emissions target at 2020 are slightly lower in our updated modelling than in the Treasury's 2011 modelling report.[5] All dollar figures relating to this report's modelling are given in 2012 Australian dollars. Results from policy scenarios are reported relative to the baseline, which is also referred to as reference case.

Our assumptions for international prices are in line with, or somewhat higher than, the current market outlook. We have updated assumptions about international permit prices to reflect the recent drop and subdued price outlook for EU emissions allowances (EUAs). Specifically, we assume that the EUA price and CER price are A$10/t and A$1/t in 2016 respectively, and that both rise by 10 per cent in real terms each year. This is above the level of forward markets for 2016 as of mid-May 2013 and in line with the Treasury's most recent price projection for Australia's carbon price in 2015/16 of $12.1/t[6]. It also implies a stronger annual rate of increase from 2016 onwards than is apparent in forward markets. In other words, it represents

[4] Australian Government (2008), *Australia's low pollution future: the economics of climate change mitigation*, Treasury; Australian Government (2011), *Strong growth, low pollution: modelling a carbon price*, Treasury.

[5] To achieve a 5 per cent reduction in net national emissions on 2000 levels by 2020, our modelling analysis suggests a 23 per cent reduction relative to the reference case is required; in the Treasury's 2011 modelling, a 24 per cent reduction was needed to achieve the same target.

[6] Combet G. (2013) *Clean Energy Future package working in Australia's interest,* Joint media release with the Deputy Prime Minister and Treasurer, the Hon Wayne Swan MP, 14th May 2013. Available at http://minister.innovation.gov.au/gregcombet/MediaReleases/Pages/CleanEnergyFuturepackageworkinginAustraliasinterest.aspx. Accessed 24th May 2013. The budget assumption is in nominal terms whereas our price assumptions are in 2012 dollars.

a significant recovery in the price outlook, either through policy change or a change in economic growth outlook for Europe. If market expectations prove correct then the actual macroeconomic impacts may be more benign than reported here. For the years 2013 to 2015, the domestic price is assumed to be as legislated under the ‘fixed price’ phase of the carbon pricing mechanism, rising from A$23 to A$25/t.

We model the existing limits on trading in CERs. We model the use of Certified Emissions Reductions (CERs) from the Clean Development Mechanism (CDM) up to 12.5 per cent of actual emissions from 2015. This is in line with the 12.5 per cent limit on the use of CERs by Australian liable entities under the current legislation, applying from mid-2015 when Australia’s carbon pricing mechanism turns into an emissions trading scheme with linkage to the EU ETS.

We model the government’s target range. We model a reduction in net national emissions (after international trading) of 5 per cent, 15 per cent and 25 per cent at 2020 relative to 2000, in line with the target range supported by both the Australian government and the current opposition.

We conduct sensitivity analysis on international prices. We model a 5 per cent reduction scenario where international prices are assumed to be the same as in the Treasury’s 2011 modelling report, about twice as high as assumed here for EUAs and without access to much cheaper CERs. We also model a 25 per cent scenario where the additional demand for emissions reductions from Australia increases the EUA price by one quarter, in order to test the sensitivity of macroeconomic impacts to possible increases in permit prices arising from increased Australian demand.

We also test the effect of greater domestic effort in achieving a 15 per cent or 25 per cent target. If a stronger target than the current 5 per cent target was agreed, it may be a consideration to combine this with a greater extent of domestic action to reduce emissions, rather than allowing the fulfilment of a stronger target purely by way of more purchases of international emissions units. We model scenarios where only half the amount of international emissions credits and permits of those used in the respective standard scenarios is used, with the domestic permit price increasing above the EUA price.

Table 1 below summarises the key modelling assumptions across the different scenarios.

Table 1. **We model five scenarios that vary according to the emission reduction target, domestic and international credit prices and restrictions on international trading**

Scenario family	Scenario description	Target (2020 relative to 2000)	International price from 2016-20 (A$2012/t$CO_2$e)	International trading of emissions units
Reference case	No emissions target	No emissions target	No domestic carbon price	No trading of emissions units
Standard scenarios	5% target	-5%	EUAs: A$10/t in 2016 rising to A$15/t in 2020 (rising 10%pa) Domestic price equal to EUA price. CERs: A$1.00/t in 2016 rising to $1.50/t in 2020 (rising 10%pa).	No restrictions on EUA use; CER use restricted to 12.5% of emissions
	15% target	-15%		
	25% target	-25%		
"Greater domestic effort" scenarios	15% target, greater domestic effort	-15%	International prices as per the standard scenarios. Domestic price determined in model to meet emissions target: at 2020, $38/t for 15 per cent target and $45/t for 25 per cent target.	EUA use limited to 50% of the amount used in the corresponding unrestricted scenario; CER use restricted to 12.5% of emissions
	25% target, greater domestic effort	-25%		
Sensitivity analysis	5% target, Treasury's 2011 price assumption	-5%	Price assumptions match those of "core policy scenario" in Treasury's 2011 modelling: A$31/t at 2020 for all international units, domestic price equal to international price	No restrictions on use of international units, no distinction between EUAs and CERs
	25% target, higher price	-25%	EUA prices 25% higher than in standard 25% scenario	As per standard scenarios

Note: *In all scenarios, the modelled carbon price during 2013-15 is in line with the fixed price as per current legislation (A$23/t rising to A$25/t).*
All policy scenarios include modelling the 2020 Renewable Energy Target (RET). The reference case does not include the RET.

Source: *Vivid Economics*

It is likely that in each scenario, accounting for forest related emissions will make for a smaller abatement task to reach Australia's emissions target, and lower macroeconomic costs, than modelled here. In all scenarios, we do not model emissions reductions and increased carbon sequestration from forest management, as well as deforestation, afforestation and reforestation. It is likely that even without carbon pricing, net emissions from these sources will significantly decrease over the period to 2020, and make it commensurately easier to achieve a given 2020 emissions target. It has been estimated that the cumulative abatement task to 2020 is reduced by 52 to 114 Mt as a result of reductions in net deforestation, and that forest management could reduce the abatement task by 96 Mt under conservative assumptions; additional reductions could arise from reforestation and afforestation.[7] It will be possible for Australia to account for deforestation, forest management and other land-related emissions and sequestration under the second period of the Kyoto Protocol. The cumulative abatement task (the difference between reference case emissions and the trajectory towards the target) for 2013-20 in our model is 685Mt for the 5 percent target, 894Mt for a 15 per cent target, and 1104Mt for a 25 per cent target. Thus including deforestation and forest management could reduce the abatement task for a 5 per cent target by between one fifth to one third, and more if reforestation and afforestation were included. In addition, the abatement task may be further reduced if accumulated surplus emissions units from the first period of the Kyoto Protocol were used, amounting to 101 to 107Mt.[8]

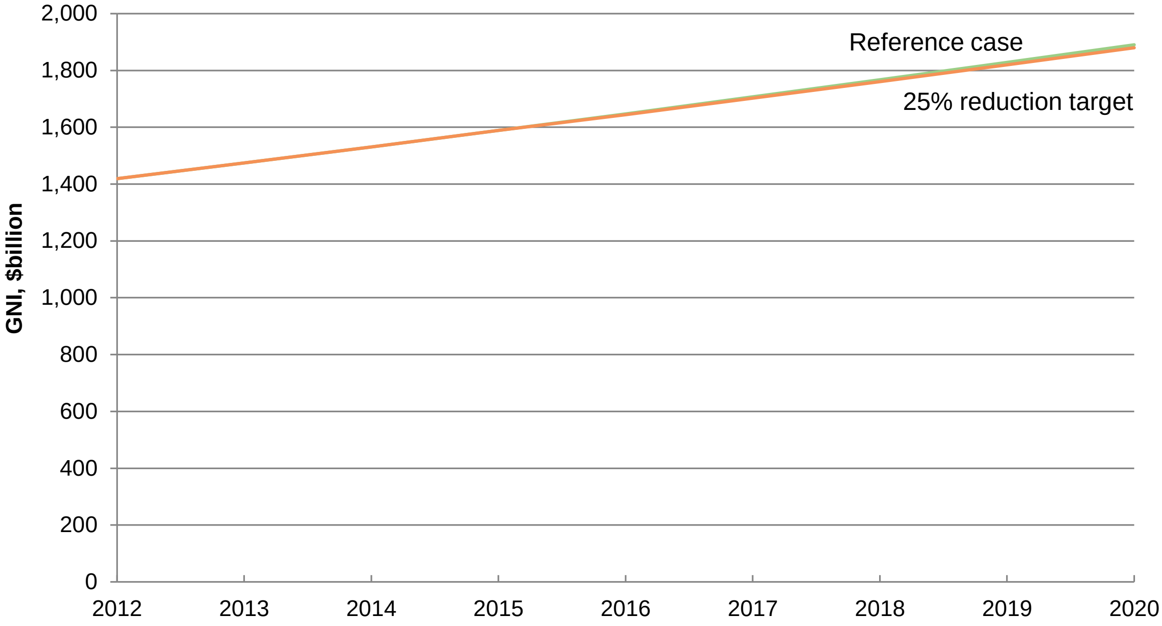
2.2 Macroeconomic costs of achieving Australia's targets

The macroeconomic costs of achieving Australia's 5 per cent emissions target are moderate. Achieving a 5 per cent national emissions reduction by 2020 in our modelling would result in GDP and consumption being 0.3 per cent lower in 2020 than in the reference case. This implies that the same level of GDP would be reached less than two months later than if no action was taken; the annual reduction in the pace of economic growth would be less than 0.05 per cent. Gross national income (GNI), which accounts for international payments, in particular the purchases of emissions reductions from other countries, is reduced by around 0.5 per cent relative to the reference case at 2020, implying that GNI would grow by just 0.1 per cent less per year than if there was no climate policy. GNI would still be 27 per cent larger in 2020 than in 2013 when achieving the 25 per cent target. This is illustrated in Figure 4 below where the trajectory for GNI over the period 2012-2020 shows very little difference between the reference case and the 25 per cent reduction target case.

[7] Macintosh, A. (2011) Are forest management reference levels incompatible with robust climate outcomes? A case study on Australia *Carbon Management* **2**:11; Macintosh, A. (2011) Durban Climate Conference and Australia's abatement task, *CCLP Working Paper Series* 2011/2

[8] Macintosh, A. (2011) Durban Climate Conference and Australia's abatement task, *CCLP Working Paper Series* 2011/2

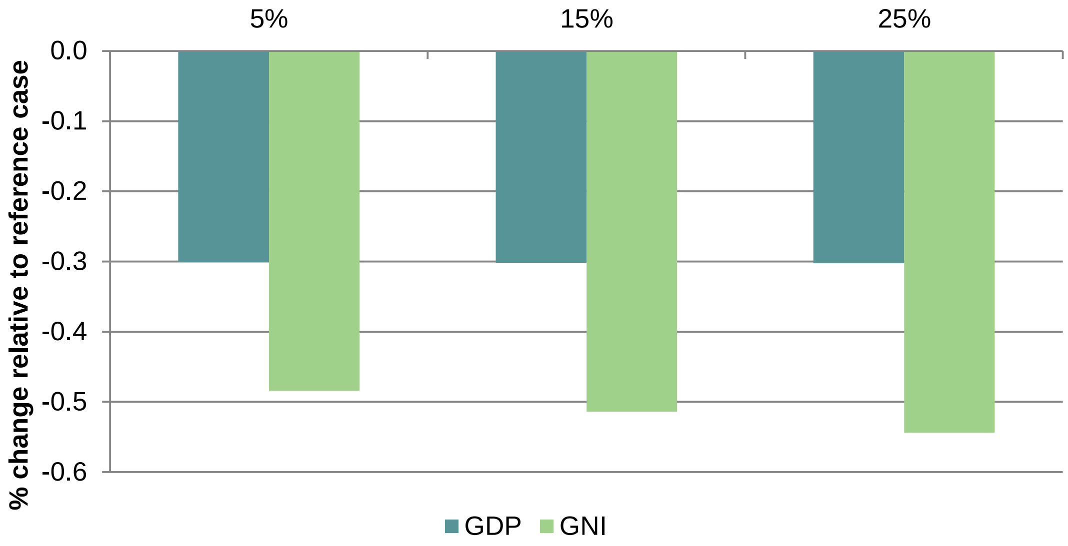
Figure 4. **The macroeconomic costs of achieving a 25 per cent reduction in emissions are very small compared to underlying economic growth**



Source: *Vivid Economics based on modelling results from CoPS MMRF.*

Moving to a stronger reduction target has very low additional macroeconomic costs. The level of domestic economic activity, as measured by GDP, remains unchanged when moving from the 5 per cent to a 15 per cent or 25 per cent target. This is because under current policy settings, it is likely that the more ambitious reductions would not induce much additional mitigation action in Australia, but would rather come predominantly from international sources, including Certified Emissions Reductions (CERs) from the Clean Development Mechanism (CDM) and EU Emissions Allowances (EUAs). The impact on GNI is very slightly larger as a result of moving to a stronger target: changing from a reduction of 0.48 per cent in 2020 in the 5 per cent scenario to 0.54 per cent in the 25 per cent reduction scenario.

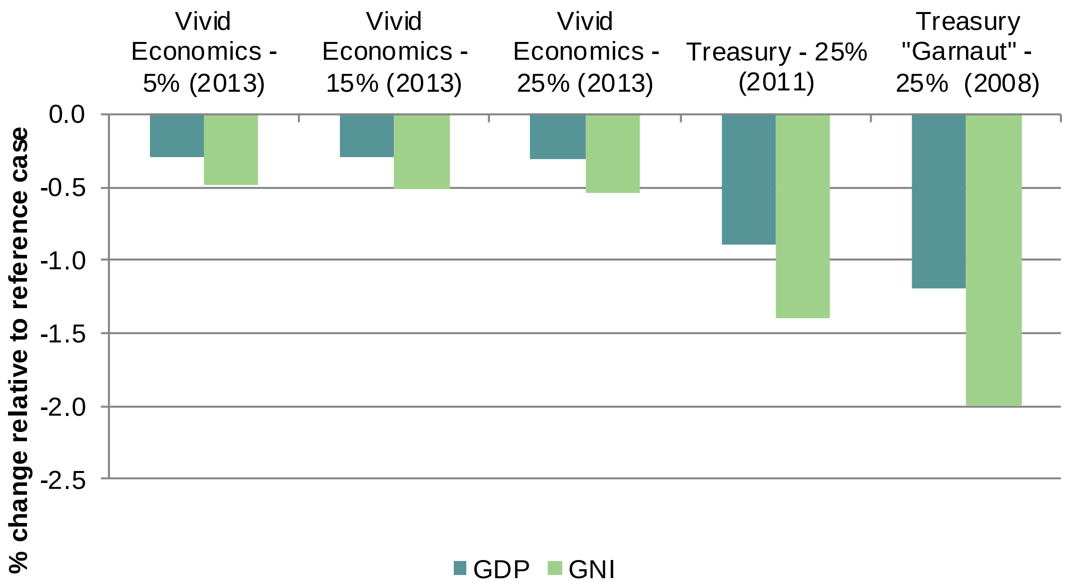
Figure 5. **The additional cost of achieving a stronger target is very small**



Source: *Vivid Economics based on modelling results from CoPS MMRF.*

The costs of achieving a stronger target are much lower than expected when the target range was originally set. The lower price outlook for international emissions permits and offset credits reduces both Australia's domestic economic impacts and the amount of money spent on international emissions units. This results in much lower macroeconomic costs in terms of both GDP and GNI. For example, the Australian Treasury's 2011 modelling study showed a 0.9 per cent reduction in GDP and a 1.4 per cent reduction in GNI relative to the reference case for the 25 per cent target case, and the need to purchase around A$7.3 billion of international emissions units. Treasury's 2008 modelling of the "Garnaut 25 per cent target" scenario showed even greater macroeconomic costs and international transfers. By contrast, in our updated modelling of a 25 per cent target, the GDP impact at 2020 is 0.3 per cent, the GNI impact is 0.5 per cent, and the cost of purchasing of international emissions units is A$2.2 billion (A$2 billion for EUAs, the rest for CERs).

Figure 6. **The macroeconomic costs of a stronger target are much lower than previously estimated**



Note: Treasury's 2008 report reports GNI as GNP (gross national product). The two measures are very similar.

Source: Vivid Economics based on modelling results from CoPS MMRF.

The modelling suggests that if extra Australian permit demand drove up the EU trading price this would only affect Australian costs to a minor extent. Increased demand for EUAs from Australia may increase the EUA price. It is unclear what the magnitude of the price effect might be, however it is likely to be relatively small given that Australia's ETS is less than one sixth the size of the EU ETS. To test the effect, we ran a sensitivity analysis where the EUA price is raised by one quarter in response to a shift from an Australian 5 per cent target to a 25 per cent target. This would be a very large price impact on the combined market. Compared to the standard 25 per cent scenario, the impact on Australia's GDP at 2020 changes from 0.30 per cent to 0.34 per cent. The impact on GNI changes from 0.54 per cent to 0.75 per cent, mostly as a result of greater costs of purchased permits.

The full set of these results is in Table 2 below.

Table 2. **The costs of achieving Australia's emissions targets are lower than previously estimated**

Modelling exercise	Scenario	% change in GDP relative to reference case, 2020	% change in GNI relative to reference case, 2020	Domestic carbon price at 2020	Amount of international permits purchased at 2020 ($MtCO_2$-eq)	Cost of purchasing international emissions units (A$billion)
Vivid Economics (2013)	5%	-0.30	-0.48	A$15/t	108	0.5
	15%	-0.31	-0.51	A$15/t	163	1.3
	25%	-0.31	-0.54	A$15/t	219	2.2
	5%, Treasury's 2011 price assumption	-0.37	-0.40	A$31/t	90	0.3
	25%, higher international price	-0.34	-0.75	A$18/t	234	2.9
Treasury (2011)	5% "core policy scenario"	-0.3	-0.5	A$29/t	94	2.7
	25% "high price scenario"	-0.9	-1.4	A$62/t	118	7.3
Treasury (2008)	5% "CPRS -5"	-1.2	-1.3	A$35/t	46	1.6
	15% "CPRS -15"	-1.2	-1.7	A$50/t	46	2.3
	25% "Garnaut -25"	-1.6	-2.0	A$60/t	100	6.0

Note: *Treasury (2011): data from Table 5.1 for MMRF model, carbon price in 2010 dollars. Treasury (2008): data from Tables 6.4 and 6.8 for MMRF model, carbon price in 2005 dollars. Treasury (2008) reported GNP rather than GNI; the two measures are very similar.*

"Vivid Economics (2013)": Modelling results from CoPS MMRF.

Source: *Vivid Economics*

2.3 Emissions and costs under greater domestic effort

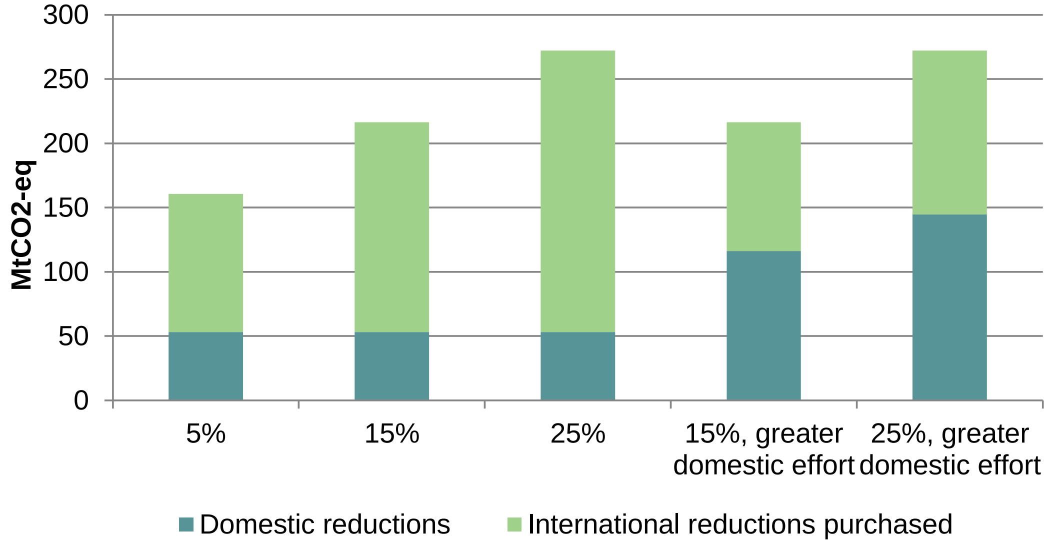
The lower market prices result in lower domestic abatement effort. In all of the scenarios presented above, the emissions levels in Australia as modelled would continue rising, up 7 per cent from 2012 levels in 2020. This is because the relatively low permit price in the EU ETS determines the Australian domestic carbon price, and results in only a relatively modest reduction in emissions relative to the reference case.[9] This occurs independently of the stringency of the target as all of the additional effort in the 15 per cent and 25 per cent scenarios is met by international permit purchases.

A stronger target might call for greater domestic effort. While meeting more ambitious targets from the purchase of international emission units is a low-cost strategy for meeting a given target, if Australia were to move to a more ambitious emissions target, there is a question as to whether this should also result in greater domestic effort. This could serve to better position Australia's economy for deeper cuts in the longer term, as discussed in Section 3 below. Furthermore, community expectations might call for a stronger target to be translated into stronger domestic action. It would also send a stronger signal of Australia's commitment to reduce emissions to the international community.

We model two scenarios where a stronger target is partly met by increased domestic abatement action. We construct "greater domestic effort" scenarios for the 15 per cent and 25 per cent target, by assuming that the amount of international emissions units used is explicitly restricted to be only half of that in the standard 15 per cent and 25 per cent targets. In turn, domestic abatement is increased. This is modelled by way of the Australian carbon price rising above the EUA price, to a level that fulfils the target at 2020. Additional domestic abatement could also be achieved through policy instruments other than carbon pricing. In both "greater domestic effort" scenarios, just over half of the total abatement would be undertaken domestically, compared to only one quarter and one fifth in the standard 15 per cent and 25 per cent scenarios.

[9] The emissions reductions relative to the reference case shown in Figure 4 also include the effect of the Renewable Energy Target.

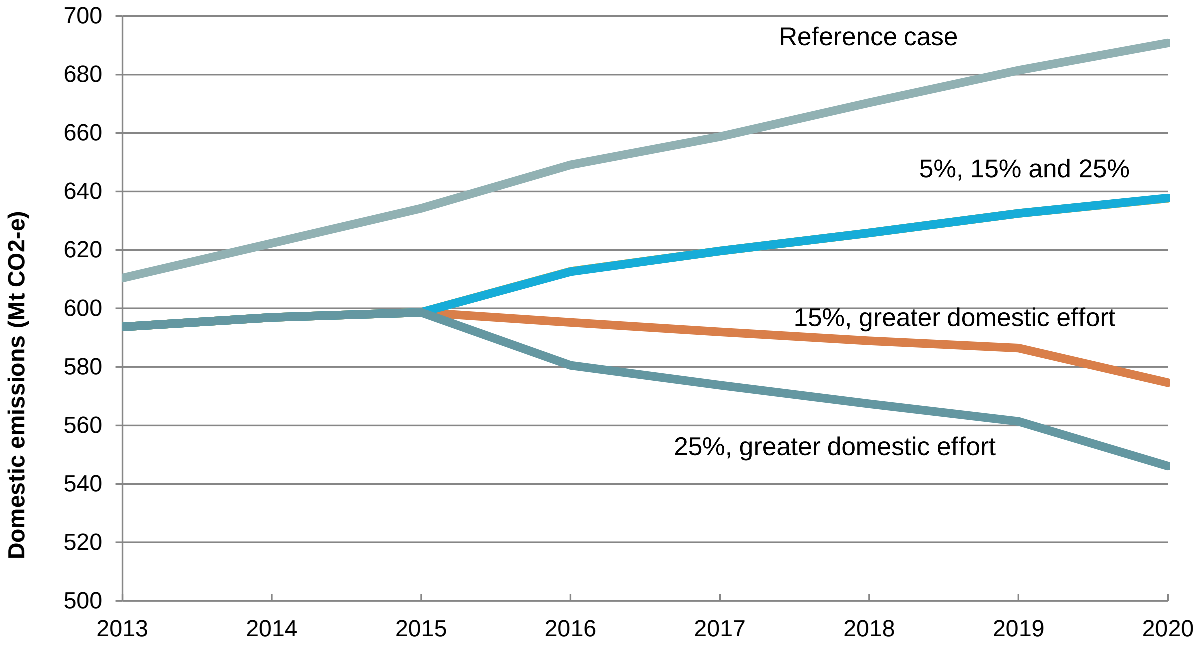
Figure 7. **The balance between domestic and international abatement differs strongly between scenarios**



Source: Vivid Economics based on modelling results from CoPS MMRF.

A higher domestic carbon price would achieve reductions in domestic emissions relative to current levels. Our "greater domestic effort" scenarios show domestic emissions levels falling by 4 per cent and 8 per cent respectively from 2012 to 2020. The Australian carbon price is significantly higher than assumed in the standard scenarios, namely A$38/t and A$45/t in the 15 per cent and 25 per cent "greater effort" scenarios respectively in 2020 (compared to the A$15/t in the standard scenarios). Greater domestic action could alternatively be achieved through policies other than the carbon price, though this is not explicitly modelled here and is likely to result in higher macroeconomic costs.

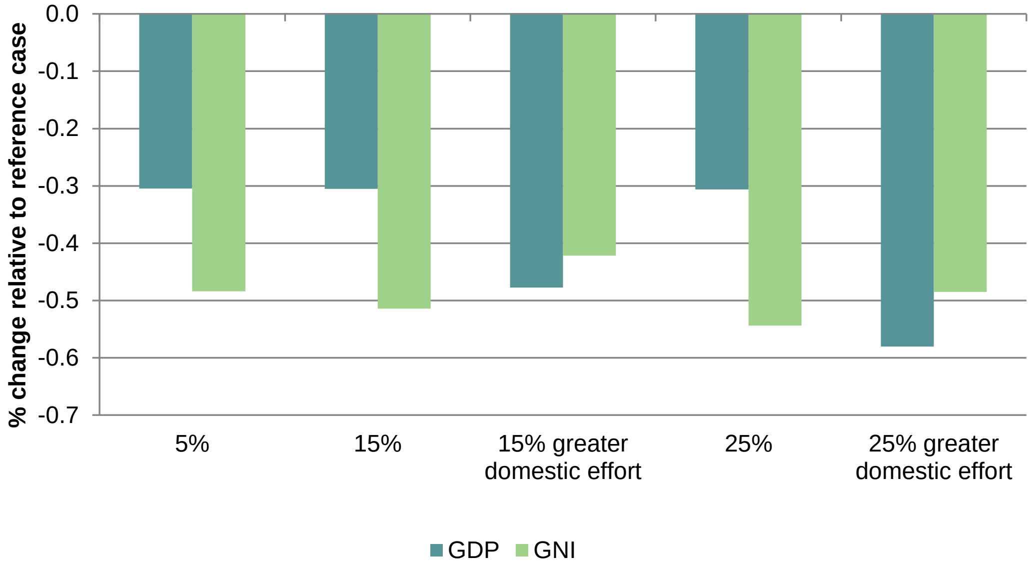
Figure 8. **Domestic emissions would rise unless more stringent targets were accompanied by a deliberate policy choice to encourage domestic abatement**



Source: Vivid Economics based on modelling results from CoPS MMRF.

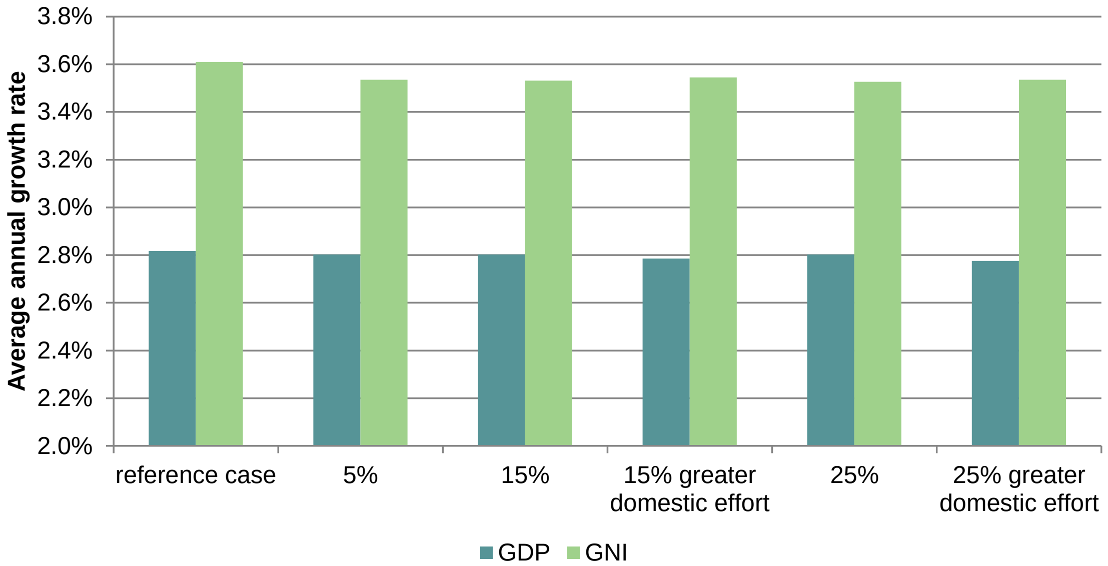
Shifting the balance towards greater domestic effort and away from overseas emissions permits means a larger impact on domestic GDP, but reduces the impact on GNI. In the "greater domestic effort" scenarios, the impact on domestic GDP is increased by around half for the 15 per cent target (from 0.31 per cent to 0.48 per cent), and almost doubled for a 25 per cent target (from 0.31 per cent to 0.58 per cent). Nonetheless, the overall GDP costs are low: amounting to less than 0.1 per cent a year for a 25 per cent target that has more than half of the emissions reductions achieved domestically. By 2020, the economy would achieve the same level of GDP as achieved without any climate policy just three months later. At the same time, the overall cost of purchasing international emissions units falls to less than half of that in the corresponding standard scenarios. This is reflected in the impact on Australia's GNI being *less* in the "stronger domestic effort" scenarios than under the standard assumptions. These results are shown below, first relative to the reference case baseline and then expressed in terms of the impact in annual average growth rates.

Figure 9. **Scenarios with greater domestic effort would result in greater GDP costs but lower GNI costs**



Source: *Vivid Economics based on modelling results from CoPS MMRF.*

Figure 10. **Across all scenarios, the impact on average annual growth rates is barely discernible**



Note: *Note vertical axis starts at 2 per cent*

Source: *Vivid Economics based on modelling results from CoPS MMRF.*

The full results comparing the "greater domestic effort" and standard scenarios in 2020 are shown in Table 3 below.

Table 3. **The 2020 key results show that increasing the proportion of emission reductions achieved domestically increases the domestic carbon price and GDP impact but reduces the GNI impact**

Scenario	Domestic emissions reductions (Mt)	International emissions reductions purchased (Mt)	Carbon price, $/tCO$_2$-eq	Costs of international emissions purchases, A$ billion	Change in GDP relative to reference case, %	Change in GNI relative to reference case, %
5%	53	108	15	0.5	-0.30	-0.48
15%	53	163	15	1.3	-0.31	-0.51
15%, greater domestic effort	116	100	38	0.5	-0.48	-0.42
25%	53	219	15	2.2	-0.31	-0.54
25%, greater domestic effort	145	128	45	1.0	-0.58	-0.49

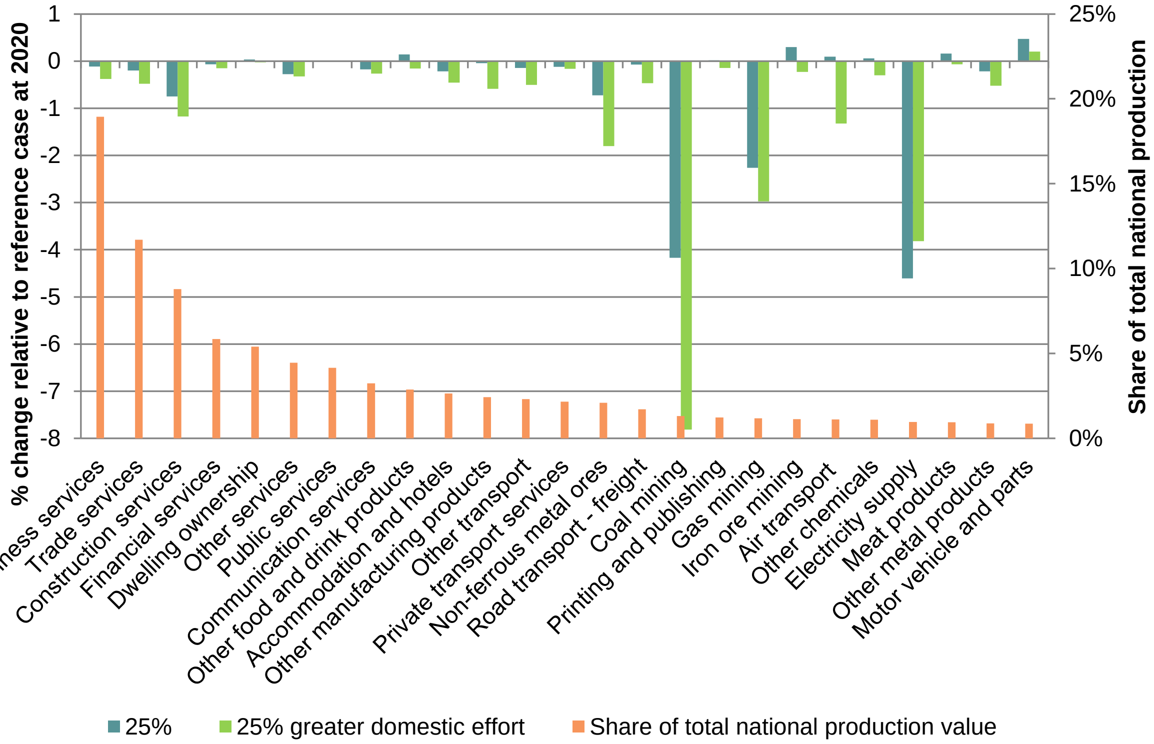
Source: *Vivid Economics based on modelling results from CoPS MMRF.*

2.4 Industry level and state level results

The modelling framework allows disaggregation of the economic impacts to the industry level and regional disaggregation by State. The model represents the Australian economy as 58 different industries. More so than for the national level results, it is important to keep in mind that the disaggregated results are indicative in nature. For instance, while based on current economic statistics, the MMRF model represents economic responses to a carbon price and other price changes in a homogenous manner for each industry. The model does not include detailed representations of the cost structures in particular plants and other idiosyncratic factors that may affect production decisions. As noted earlier, we also do not model the effect of other countries' climate policies on Australia. Below we show changes in industry production value relative to the reference case at 2020, in the standard 25 per cent scenario and the 25 per cent "greater domestic effort" scenario. The changes in the standard 5 and 15 per cent scenarios are the same as in the 25 per cent scenario, because the carbon price is the same.

Among the 25 largest industries, only the coal, gas and electricity industry are modelled to experience output reductions, relative to the reference case, of more than 2 per cent. The 25 largest industries shown in Figure 11 collectively account for ninety per cent of Australian industry output as represented in the model. The largest percentage reductions in output are in the coal industry, which sees output decline by 4 and 8 per cent relative to the baseline in the two scenarios respectively; followed by electricity which has approximately a 4 per cent reduction in both scenarios; and the gas industry where output falls by 2-3 per cent in the two scenarios. Each of these three industries accounts for less than 1.5 per cent of total national industry output value. In the standard 25 per cent reduction target scenario, nine experience increases in output value relative to the reference case and 11 out of the 25 largest industries experience reductions in value of production of less than 0.5 per cent.

Figure 11. **Changes in industry production value are small for most of Australia's large industries**

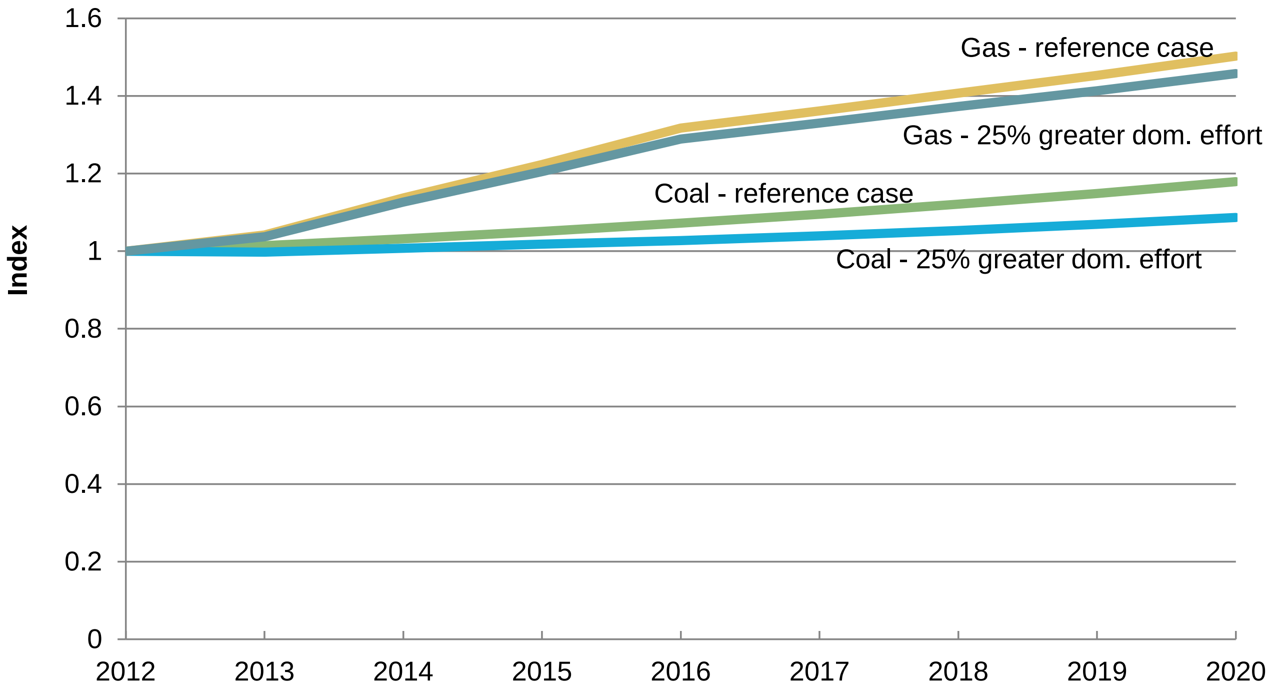


Source: Vivid Economics based on modelling results from CoPS MMRF.

Changes in output as a result of more ambitious action will take place in industries that are benefitting from an absolute growth in output. All industries except hydroelectricity increase their output over time in the reference case, on average at the rate of GDP growth (assumed to be 2.9 per cent per year on average from 2012 to 2020). The coal industry for example is projected to grow its production value by 18 per cent (adjusted for inflation) between 2012 and 2020, the gas industry by 50 per cent, and the electricity supply industry by 13 per cent. The modelled reductions of output value even under a 25 per cent "stronger domestic effort" scenario would thus result in continued growth in output value in absolute terms. This is shown for the coal and gas sectors in Figure 12 below. Similarly, in this scenario, absolute employment levels in the coal industry remain virtually unchanged over the period 2013-2020, while employment in the gas sector grows by more than 8 per cent over the same period. However it needs to be noted that only domestic climate policies are modelled here, we do not analyse the effects that other countries' policies may have on demand for Australian exports.

Reductions in emissions are achieved while the economy and value of industry output continues growing strongly. This is possible because of technological improvements and substitution away from high-emissions inputs towards low-emissions inputs.

Figure 12. **Even the most strongly affected industries experience growth in output value over time, under a 25 per cent "stronger domestic effort" scenario**



Source: Vivid Economics based on modelling results from CoPS MMRF.

It is likely that most sectors will experience smaller declines in output than would have been anticipated in earlier modelling exercises. Although we have not undertaken a detailed comparison of these sectoral results with those from earlier studies, it is likely that the pattern of lower costs seen at the macroeconomic level in section 2.2 above, would be replicated at a sectoral level. This would be both as a direct result of the lower carbon price and also because the lower carbon price would be likely to imply smaller increases in electricity prices than previously expected (although electricity impacts have not been explicitly modelled).

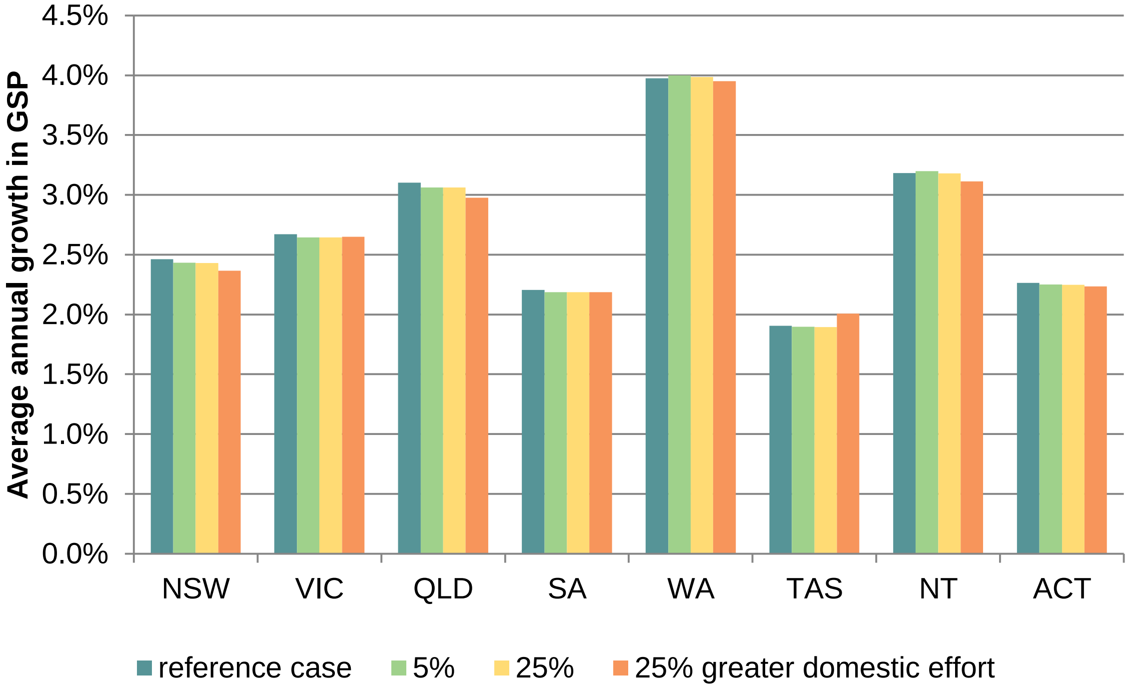
The regional macroeconomic impacts are differentiated between states. Under the standard 25 per cent target scenario, the real Gross State Product (GSP) for all states or territories is modelled to be reduced by no more than 0.4 per cent relative to the reference case at 2020. All states see annual growth in GSP of between 1.9 and 4.0 per cent, in real terms. In this scenario, the largest overall impacts are in Queensland (QLD) and, to a lesser extent, New South Wales (NSW), reflecting the higher proportion of coal mining and electricity generation from coal in these economies; but even here the effects are merely to reduce state level economic product by 0.4 per cent relative to the baseline.

The economy of the Australian Capital Territory (ACT) is almost entirely service oriented, but the disproportionate importance of energy-intensive providers of private transport and space heating for residential and commercial means that it also experiences a moderate negative impact. By contrast, Tasmania (TAS) sees much more modest declines in output under the 25 per cent standard scenario as result of an absence of coal-fired generation or gas and coal mining coupled with a high proportion of forestry and agricultural production which do relatively well under the government's plans (emissions from land use are assumed to be excluded from all schemes across all years). There is a negligible impact on GSP in the Northern Territory (NT) due to the importance of agriculture, while Western Australia (WA) sees a modest increase in GSP relative to the reference case as a result of an over-representation of gas-fired generation and natural gas production.

Macroeconomic impacts in the "greater domestic effort" scenario are more differentiated. In this scenario, even though all states continue to see an absolute increase in modelled GSP of at least 15 per cent between 2013 and 2020, the higher carbon price results in relatively stronger impacts in NSW and Queensland state product. Even so, the reductions relative to the reference case do not exceed 1 per cent at 2020. All other states' GSP is reduced by less than national GDP, and Tasmania's GSP increases relative to the reference case. Underlying these results is that the higher local carbon price affects the electricity generation sector proportionately more than it affects other industries. Most of the loss in fossil-fuel generation is projected to come from black coal generation across NSW and QLD. This electricity production is replaced by other forms of renewable generation. By contrast, as Tasmania has an over-representation of renewable energy production, its share of national GDP increases by a relatively significant amount.

In assessing state level results, it should be kept in mind that we do not model international carbon pricing and any impacts that this may have on commodity exports, such as coal (in itself, Australia's higher carbon price would be unlikely to have a significant impact on the price of such commodities which will instead be determined by international supply and demand conditions).

Figure 13. **State-level macroeconomic impacts are modest**



Source: Vivid Economics based on modelling results from CoPS MMRF.

3 The benefits of taking more aggressive early action

This section reviews the potential benefits of more aggressive emissions reduction activity. The previous sections reviewed that the costs of taking more aggressive action have fallen significantly in recent years and that there is a growing number of countries pursuing emission reduction activity. This final section briefly complements this analysis by looking at some of the potential advantages from more aggressive action today, especially more aggressive domestic mitigation action. In particular, it focusses on two issues.

- First, it considers whether a stronger emissions reduction trajectory to 2020 may be beneficial in lowering the overall costs of Australia achieving deep reductions in emissions, with the current government's 2050 target of reducing emissions by 80 per cent as a reference point. The Climate Change Authority states in its Issues Paper that it takes the 80 per cent target as a 'given' reference point for its review, however it can be argued that other – possibly deeper – reductions targets would be shown as appropriate in an analysis of principles-based global mitigation effort sharing.

- Second, it provides a brief review of the literature on the possible technological opportunities available to Australia from a global low-carbon future and discusses the importance of domestic carbon pricing as a means to realise these opportunities.

3.1 Can early action reduce long-term costs?

Adopting a more ambitious target to 2020 may require a less steep trajectory of emissions reductions in following decades. Three key factors will influence how the profile of emission reductions towards a target affects total costs.

- First, deferring emission reductions to the future would allow Australia's emission reductions to take place when the country is richer and where the relative impact of a given cost increase is correspondingly lower. This effect is captured by discounting future costs.
- In addition, if emission reductions were deferred to further in the future this implies that the cumulative emission reductions required by Australia would be smaller; although this impact will be negated if domestic policy and/or future international agreements place limits on a country's cumulative emissions[10].
- On the other hand, early action to reduce emissions can reduce the risk of 'lock-in' of high carbon assets in short-term, which might otherwise mean that carbon prices in the medium to long run have to be higher. This is likely to be particularly significant in a context in which there are strict limits on the use of international credit purchases, making the ease of achieving domestic emission reductions more important.

[10] In this context, it is noteworthy that the Caps and Targets review will recommend a budget for emissions in the period 2013-2020 and possibly beyond.

It has not been possible to undertake detailed new modelling work on this subject within the scope of this research. It may, however, be a fruitful focus of any modelling work undertaken by the Climate Change Authority.

Earlier Treasury modelling work indicates that the cost of delay may be significant. This found that delayed action increases future mitigation costs and specifically states that:[11]

> *'Delaying global action by 3 years adds around 20 per cent to the first year entry mitigation cost; a further three years adds a further 30 per cent to the first year mitigation cost. […] Depending on countries' emission reduction targets and the ability to source permits from other countries, a 3-year delay of mitigation action results in higher mitigation costs of 2 to 10 per cent in 2050.'*

Recent academic modelling also points to the benefits of early action by Australia. Jakob et al (2012)[12] use three different models to look at the question of whether countries/regions will find it cheaper to take early action towards a given target, given the behaviour of other countries and regions. This analysis includes Australia within an 'other Annex 1' grouping of countries, and also provides results for EU, US, China, India and Rest of Non-Annex 1.This analysis suggests that more ambitious early action can help to reduce total (discounted[13]) costs in high emission regions, often even if other regions choose not to take early action. In particular, some of the key modelling findings include the following:

- For the rest of Annex 1 region (including Australia), two of the three models suggest that taking action from 2010, in conjunction with other Annex 1 countries, would result in lower total discounted costs than if the region decided to defer taking action until 2020. It therefore seems likely that taking more aggressive action between 2010 and 2020 would also help reduce total costs.
- All three models suggest that it would make more sense for the EU to take action in the period 2010-2020 even if every other region in the world was not taking action. Indeed, two of the three models suggest that early action by the EU could more than halve the total costs of reaching its long term target.

The authors conclude that:

> *'For the majority of regions, even though appealing from the short term perspective, delaying action on climate policy does not turn out to decrease long run consumption losses. Even though late movers have the advantage of laxer reduction commitments regarding their cumulative emissions … this effect is*

[11] Australian Government (2011), *Strong growth, low pollution: modelling a carbon price*, The Treasury.

[12] Jakob, M, Luderer, G., Steckel, J. Tavoni, M, Monjon, S. (2012) Time to act now? Assessing the costs of delaying climate measure and benefits of early action, *Climatic Change,* 114: 1, pp 79-99

[13] The analysis uses a discount rate of 3 per cent.

countered by increased future mitigation costs arising from the build-up of long lived carbon intensive infrastructure.'

Such a conclusion is corroborated by a range of studies that have looked at the issue of lock-in from a global perspective. This includes both policy and academic studies.

The International Energy Agency (IEA) declares that delaying action is a 'false economy'. Its analysis suggests that every $1 of investment avoided by taking less action before 2020, an additional $4.3 would need to be spent between 2021 and 2035 to compensate for the higher emissions while keeping to a 450ppm global budget[14].

The rapid low-carbon investment required with delayed action could only be delivered by substantially higher carbon prices in the future. A recent *Nature* paper, based on a wide array of different modelling runs, suggests that, to have a 60 per cent chance of staying below 2˚C, a global carbon price of US$27/t$CO_2$ would be needed in 2012 but that this would increase by almost three and a half times, to US$93/t$CO_2$, if action was delayed until 2020. It reports that achieving this goal while delaying action to 2030 is physically infeasible[15.]

3.2 Can Australia realise opportunities to gain comparative advantage in new sectors?

The transformation to a low-carbon society will require a radical shift in technologies. To avoid dangerous climate change, rapid, extensive and widespread low-carbon innovation will be required across the globe. Although the nature of the innovation process makes it impossible to predict exactly which technologies will emerge, renewables, carbon capture and storage (and possibly other forms of carbon sequestration), and vehicle technology are all likely to require both fundamental changes and significant scale-up.[16] Placing these changes in a historical context, a number of commentators[17] have suggested that the impact could be as transformative as the industrial revolution or the advent of information technology. This idea is captured in Figure 14 below.

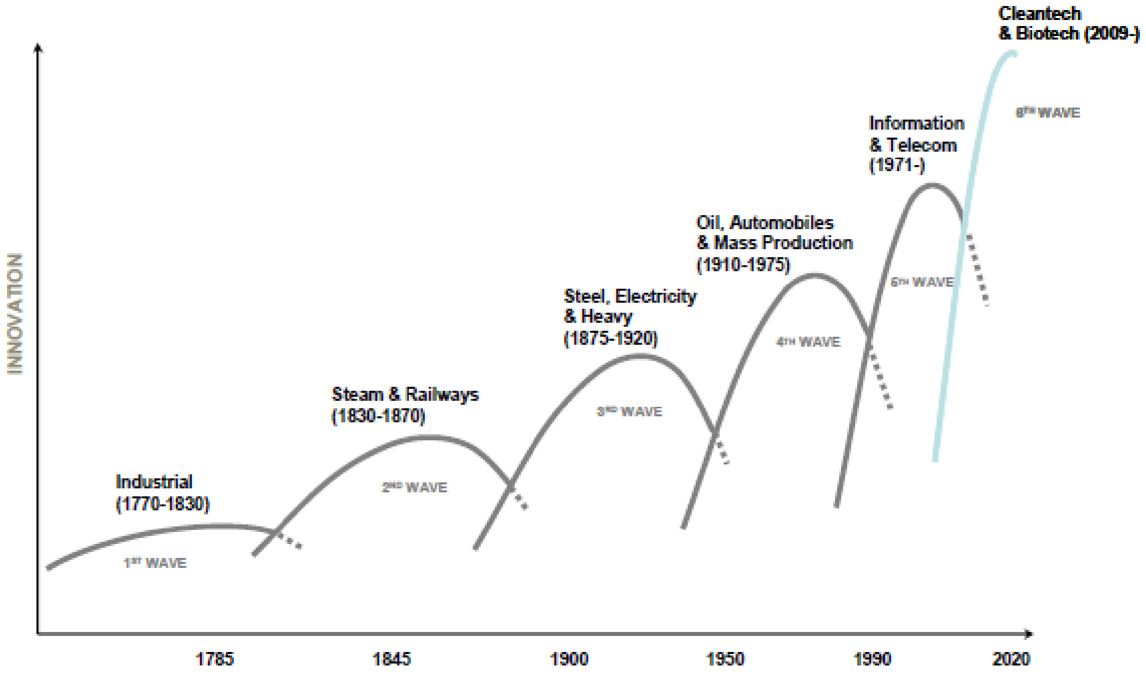
[14] IEA (2011) World Economic Outlook

[15] Rogelj, J., McCollum, D.L., Reisinger, A., Meinshausen, M. & Riahi, K. (2013) Probabilistic cost estimates for climate change mitigation, *Nature* doi:10.1038/nature11787

[16] Barrett, S (2009) The Coming Global Climate-Technology Revolution, *Journal of Economic Perspectives,* **23**:2, pp53-75

[17] Stern, N (2010) China's growth, China's cities and the new global low-carbon industrial revolution, Policy Brief, Grantham Research Institute, London School of Economics; Perez, C. (2010) Technological revolutions and techno-economic paradigms' Cambridge Journal of Economics **34**, 185-202

Figure 14. **The low-carbon technology transformation may be as radical as the advent of the steam engine and railways**



Source: Stern (2010) China's growth, China's cities and the new global low-carbon industrial revolution

The transition has already begun. For instance, the annual amount of patents related to clean energy has grown more than twice as fast as the average of all patents over the last fifteen years.[18]

This structural change will be disruptive; creating winners and losers. This form of structural change will cause expansion in some sectors – and within parts of certain sectors – and a scale back in other activities. It already appears that the 'green race' is likely to alter the present competitiveness landscape.[19] As such, those countries that are able to develop a comparative advantage in key technologies, or intellectual property development in those technologies, may see an improvement in their terms of trade and higher real incomes; whereas if the scale-back in brown sectors, is combined with rigidities in real wages and/or a lack of skills and production, then there is likely to be a (temporary) drop in output and employment.

[18] Veefkind, V. Hurtado-Albir, J. Angelucci, K. Karachalios, K. and Thumm, N. (2012) A new EPO classification scheme for climate change mitigation technologies, *World Patent Information*, 34, 106-111.

[19] Fankhauser, S., Bowen, A. Calel, R., Dechezlepretre, A., Grover, D, Rydge, J. and Sato, M. (2012) Who will win the green race? In search of environmental competitiveness and innovation, Grantham Research Institute on Climate Change and the Environment Working Paper No. 94

There are a number of technologies where Australia may be particularly well-positioned to develop intellectual property that will be valuable in a low-carbon future. For instance, the Garnaut review update[20] mentions three specific areas which there is a national interest for Australia supporting:

- Carbon Capture and Storage (CCS) where the report notes that '*the proximity of carbon dioxide sources to sites for geological storage with enormous potential resources make this technology particularly suited to further exploration and research in Australia*'
- Geothermal energy where it anticipates that Australia should have *'strong research skills in fields required for innovation ...based on its history of internationally competitive mining and related engineering and construction'*
- Biosequestration where the report discusses that *'Australia's strength in agricultural and biological research provides a clear comparative advantage for low-emissions innovation in the land sectors'*. It further notes that the economic gains from biosequestration could *'enhance the role of the rural sector in Australia's economy'*.

In the longer term, Australia might become a supplier of renewables based fuels to the region, especially if technology to make liquid synthetic fuels using solar power eventuates.

Australia may not be well-positioned in the low-carbon/green growth race at present. This report has not been able to undertake a detailed review of the risks and opportunities posed to Australia by these changes (although such a study would be valuable). However, it is striking that a recent study found that Australia only accounted for 0.9 per cent of the world's high-value low-carbon inventions between 2000 and 2005. This placed it 26th in the world, behind Germany (1st), Japan (2nd), USA (3rd), South Korea (6th) and China (10th).[21] This is broadly consistent with the findings of The Climate Institute's *Global Climate Leadership Review*[22], which placed Australia in 17th out of the 19 G20 countries in terms of preparedness for a low-carbon world. Economies that are reliant on high carbon commodities and technologies face a potential threat to these sources of economic prosperity. Australia as a large exporter of fossil fuels is in this category.

Stronger domestic emissions reduction action, such as discussed in section 2.3, will help in exploiting opportunities for low carbon growth. The existence of public policy support, such as feed-in tariffs or tradeable certificate regimes, has been a critical driver in renewable innovation activity globally[23], although sometimes at relatively high cost. Another study has shown that countries with more stringent energy and CO_2 regulations have been more successful at exporting related technologies.[24] At the same time, to exploit

[20] Garnaut, R. (2011) The Garnaut Review 2011: Australia in the global response to climate change, Cambridge University Press.

[21] Dechezlepretre, A., Glachant, I. Hascic, I., Johnstone, N. and Meniere, Y. (2011) Invention and transfer of climate change-mitigation technologies: a global analysis, *Review of Environmental Economics and Policy* **5** (1): 109-130

[22] The Climate Institute (2013) Global Climate Leadership Review. Available at: http://www.climateinstitute.org.au/global-climate-leadership-review-2013.html Accessed 22nd May 2013.

[23] Johnstone, N. Hascic, I. and Popp, D. (2010) Renewable energy polices and technological innovation: evidence based on patent counts, *Environmental Resource Economics*, 45: 133-155

[24] Costantini, V. and Crespi, F. (2008) Environmental regulation and the export dynamics of energy technologies, Ecological Economics **66** (2-3), 447-460.

these opportunities, additional public policy support explicitly targeting innovation market failures will likely be needed, which will be more efficient if it remains technology neutral.

In summary, the required change in technologies to realise a low-carbon future could be massively disruptive to existing patterns of international trade and comparative advantage. Although Australia may not be well placed to benefit from this disruption at present, continued and strengthened mitigation action including through carbon pricing will be important in turning this threat into an opportunity.

Appendix

In this appendix we give a brief description of the MMRF model. More details are given in Adams and Parmenter (2013).[25]

MMRF is a dynamic, multi-sector, multi-region model of Australia. It distinguishes 58 industries, 63 products and 8 regions representing the states and territories. Each regional economy is a fully-specified bottom-up system that interacts with other regional economies. Three industries produce primary fuels (coal, oil and gas), one produces refined fuel (petroleum products), five generate electricity and one supplies electricity to final users. The five generation industries are defined according to primary source of fuel: coal, gas, oil, hydro, other renewables. Apart from Grains and Petroleum products, industries produce single products. Grains produces grains for animal and human consumption and biofuel used as feedstock by Petroleum products. Petroleum products produces gasoline (including gasoline-based biofuel blends), diesel (including diesel-based biofuel blends), LPG, aviation fuel, and other refinery products (mainly heating oil).

General equilibrium core

The nature of markets

MMRF determines regional supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital. Labour supply at the national level is determined by demographic factors, while national capital supply responds to rates of return. Labour and capital can cross regional borders in response to relative regional employment opportunities and relative rates of return.

The assumption of competitive markets implies equality between the supply price (the price received by the producer) and marginal cost in each regional sector. Demand is assumed to equal supply in all markets other than the labour market. The government intervenes in markets by imposing *ad valorem* sales taxes on commodities. This places wedges between the prices paid by purchasers and the prices received by producers. The model recognises margin commodities (for example, retail trade and road transport) that are required for the movement of commodities from producers to purchasers. The costs of margins are included in purchasers' prices of goods and services.

Demands for inputs used in the production of commodities

MMRF recognises two broad categories of production inputs: intermediate inputs and primary factors. Firms in each regional sector are assumed to choose the mix of inputs that minimises the costs of production for their levels of output. They are constrained in their choices by a three-level nested production technology. At

[25] Philip D. Adams and Brian R. Parmenter (2013), "Computable General Equilibrium Modelling of Environmental issues in Australia: Economic Impacts of an Emissions Trading Scheme" in P.B. Dixon and D. Jorgenson (eds) *Handbook of CGE Modelling, Vol. 1,* Elsevier B.V.

the first level, intermediate-input bundles and a primary-factor bundle are used in fixed proportions to output. These bundles are formed at the second level. Intermediate-input bundles are constant-elasticity-of-substitution (CES) combinations of domestic goods and goods imported from overseas. The primary-factor bundle is a CES combination of labour, capital and land. At the third level, inputs of domestic goods are formed as CES combinations of goods sourced from each of the eight domestic regions, and the input of labour is formed as a CES combination of inputs from nine occupations.

Domestic final demand: household consumption, investment and government

In each region, the household buys bundles of goods to maximise a utility function subject to an expenditure constraint. The bundles are CES combinations of imported and domestic goods, with domestic goods being CES combinations of goods from each domestic region. A Keynesian consumption function determines aggregate household expenditure as a function of household disposable income (HDI). Capital creators for each regional sector combine inputs to form units of capital. In doing so, they minimise costs subject to a technology similar to that used for current production, with the main difference being that they do not use primary factors directly. Regional governments and the Federal government demand commodities from each region.

Foreign demand

Each regional sector faces its own downward-sloping foreign demand curve. Thus, a shock that reduces the unit costs of an export sector will increase the quantity exported but reduce the foreign-currency price. By assuming that foreign demand schedules are specific to product and region of production, the model allows for differential movements in foreign-currency prices across domestic regions.

Regional labour markets

The response of regional labour markets to policy shocks depends on the treatment of three variables – regional labour supplies, regional unemployment rates and regional wage differentials. In this work, regional wage differentials and regional unemployment rates are set exogenously and regional labour supplies are determined endogenously (via interstate migration or changes in regional participation rates). Under this treatment, workers move freely (and instantaneously) across state borders in response to changes in relative regional unemployment rates. With regional wage rates indexed to the national wage rate, regional employment is demand determined.

Physical capital accumulation

Investment undertaken in year t is assumed to become operational at the start of year t+1. Under this assumption, capital in industry i in region q accumulates according to:

$$K_{i,q}(t+1) = (1 - DEP_{i,q}) \times K_{i,q}(t) + Y_{i,q}(t), \qquad (1)$$

where $K_{i,q}(t)$ is the quantity of capital available in industry i in region q at the start of year t, $Y_{i,q}(t)$ is the quantity of new capital created in industry i in region q during year t, and $DEP_{i,q}$ is the rate of depreciation for industry i in region q. Given a starting value for capital in t=0, and with a mechanism for explaining investment, equation (1) traces out the time paths of industries' capital stocks.

Investment in year t is explained via a mechanism of the form

$$\frac{K_{i,q}(t+1)}{K_{i,q}(t)} = F_{i,q}\left[\frac{EROR_{i,q}(t)}{RROR_{i,q}(t)}\right], \qquad (2)$$

where $EROR_{i,q}(t)$ is the expected rate of return in year t, $RROR_{i,q}(t)$ is the required rate of return on investment in year t, and $F_{i,q}$ is an increasing function of the ratio of expected to required rate of return. In this work, it is assumed that investors take account only of current rentals and asset prices when forming expectations about rates of return (static expectations).

Lagged adjustment process in the national labour market

The simulations reported here are year-to-year recursive-dynamic simulations, in which it is assumed that deviations in the national real wage rate from its basecase level increase through time in inverse proportion to deviations in the national unemployment rate. That is, in response to a shock-induced increase (decrease) in the unemployment rate, the real wage rate declines (increases), stimulating (reducing) employment growth. The coefficient of adjustment is chosen so that effects of a shock on the unemployment rate are largely eliminated after about ten years.

Environmental enhancements

A number of key environmental enhancements of MMRF are necessary to facilitate modelling of the scenarios in this paper.

Energy and emissions accounting

MMRF tracks emissions of greenhouse gases according to: emitting agent (58 industries and the household sector); emitting region (8); and emitting activity (9). Most of the emitting activities are the burning of fuels (coal, natural gas and five types of petroleum products). A residual category (activity emissions) covers non-combustion emissions such as emissions from mines and agricultural emissions not arising from fuel burning. The resulting 59 × 8 × 9 array of emissions is designed to include all emissions except those arising from land clearing. Emissions are measured in terms of carbon-dioxide equivalents, $C0_2$-e. Note that MMRF accounts for domestic emissions only; emissions from combustion of Australian coal exports, say, are not included, but fugitive emissions from the mining of the coal are included.

Carbon taxes and prices

MMRF treats the price of emissions as a specific tax on emissions of CO_2-e. On emissions from fuel combustion, the tax is imposed as a sales tax on the use of fuel. On activity emissions, it is imposed as a tax on production of the relevant industries. In MMRF, sales and production taxes are generally assumed to be *ad valorem*, levied on the basic (that is, pre-tax) value of the underlying flow. Carbon taxes, however, are specific, levied on the quantity emitted by the associated flow.

Inter-fuel substitution

To allow for fuel-fuel and fuel-factor substitution that a carbon tax would be expected to induce, we (i) introduce inter-fuel substitution in electricity generation using the “technology bundle” approach; and by introducing a weak form of input substitution in sectors other than electricity generation to mimic “KLEM substitution”.

Electricity-generating industries are distinguished based on the type of fuel used. There is also an end-use supplier (*Electricity supply*) in each region and an industry (*NEM*) covering the six regions that are included in Australia’s National Electricity Market: New South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), the Australian Capital Territory (ACT) and Tasmania (TAS). Electricity flows to the local end-use supplier either directly in the case of Western Australia (WA) and the Northern Territory (NT) or via *NEM* in the remaining regions.

Purchasers of electricity from the generation industries can substitute between the different generation technologies in response to changes in generation costs. Such substitution is price-induced, with the elasticity of substitution between the technologies typically set at around 5. For other energy-intensive commodities used by industries, MMRF allows for a weak form of input substitution. In most cases, a substitution elasticity of 0.1 is imposed. Thus, if the price of cement rises by 10 per cent relative to the average price of other inputs to construction, the construction industry will use 1 per cent less cement and a little more labour, capital and other materials. For important energy goods (petroleum products, electricity supply, and gas) the substitution elasticity in industrial use is 0.25. Being driven by price changes, this input substitution is especially important in an ETS scenario where outputs of emitting industries are made more expensive.

The National Electricity Market

The National Electricity Market is a wholesale market covering nearly all of the supply of electricity to retailers and large end-users in NSW, VIC, QLD, SA, ACT and TAS. Final demand for electricity in each of these regions is determined within the CGE-core of the model in the same manner as demand for all other goods and services. All end users of electricity in these six regions purchase their supplies from their own-state *Electricity supply* industry. Each of the *Electricity supply* industries in these six regions sources its electricity from the industry *NEM*, which does not have a regional dimension; it is a single industry that sells a single product (electricity) to the *Electricity supply* industry in each of the six regions. *NEM* sources its electricity from generation industries in each *NEM* region. Its demand for electricity is price-sensitive.

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