CHAPTER 4: DESCRIPTION OF POLICY SCENARIOS

Key points

The policy scenarios assume coordinated global action to reduce greenhouse gas emissions to a level that allows stabilisation of atmospheric concentrations around 2100.

- The Garnaut -10 and CPRS -5 scenarios are consistent with stabilisation at around 550 ppm CO_2-e in 2100.
- The CPRS -15 scenario is consistent with stabilisation at around 510 ppm CO_2-e in 2100.
- The Garnaut -25 scenario is consistent with stabilisation at around 450 ppm CO_2-e shortly after 2100, after an initial overshoot during which concentrations exceed 450 ppm.

The mitigation scenarios use global market-based policy mechanisms to reduce global emissions.

The Garnaut scenarios assume unified global action from 2013: all economies participate in a global emissions trading scheme that covers all sources of greenhouse gas emissions. These scenarios compare the relative mitigation costs of different stabilisation levels.

The Carbon Pollution Reduction Scheme (CPRS) scenarios assume multi-stage global action: economies gradually join a global emissions trading scheme from 2010 to 2025. These two scenarios incorporate information on the Government's preferred scheme design as outlined in the *Carbon Pollution Reduction Scheme Green Paper* (DCC, 2008).

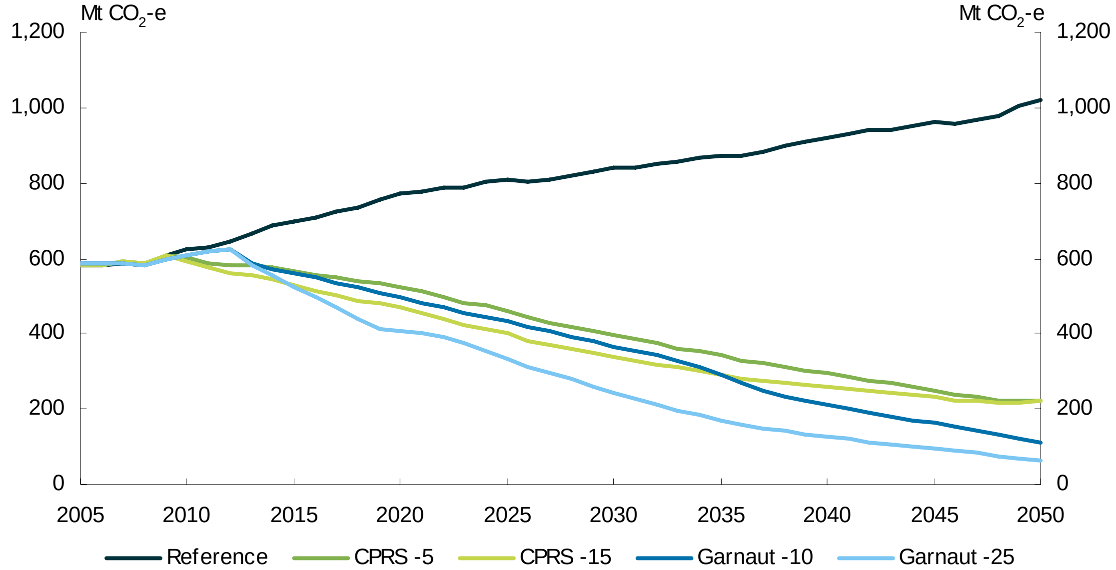
The reference scenario projects how Australia and the world could evolve if no new climate change mitigation policies are introduced. This chapter describes the mitigation policy scenarios, which assume global action to stabilise atmospheric concentrations of greenhouse gases. The assumptions described in this chapter are in addition to the assumptions in the reference scenario.

Four main policy scenarios were modelled. These were complemented with the modelling of several sensitivity scenarios to explore a range of uncertainties.

Two scenarios, Garnaut -10 and Garnaut -25, were modelled in conjunction with the Garnaut Climate Change Review. These scenarios form the basis of the Review's independent analysis of the costs and benefits of mitigation action. In this report, only the costs of mitigation action are considered. These scenarios involve stylised assumptions about global action to reduce emissions, with all economies assumed to join an emissions trading market covering all emission sources from 2013. Emission rights are shared between countries using a per capita allocation rule. For Australia, the Garnaut Climate Change Review scenarios correspond to emissions reductions targets in 2020 of 10 per cent and 25 per cent below 2000 levels for the Garnaut -10 and Garnaut -25.

Two scenarios, CPRS -5 and CPRS -15, model the Government's 2050 emissions reduction target, the design features are as outlined in the *Carbon Pollution Reduction Scheme Green Paper*, and a multi-stage approach to international emissions trading. Developed countries act first, and developing countries join over time. National emission targets gradually diverge from reference scenario trends for each country. The CPRS scenarios begin in 2010. Two illustrative medium-term targets have been modelled: 5 per cent and 15 per cent below 2000 levels by 2020 for the CPRS -5 and CPRS -15 scenarios (Chart 4.1 and Table 4.1).

Chart 4.1: Australian emission allocations



Source: Treasury estimates from MMRF.

Table 4.1: Summary of emission trajectories

	CPRS -5	CPRS -15	Garnaut -10	Garnaut -25
World				
Atmospheric stabilisation goal, CO_2-e ppm	550	510	550	450
Emission allocation, change from 2001 levels, per cent				
2020	32	24	40	29
2050	-9	-18	-13	-50
Emission allocation, per capita, change from 2001 levels				
2020	7	0	14	4
2050	-38	-44	-41	-66
Australia				
Emission allocation, change from 2000 levels, per cent				
2020	-5	-15	-10	-25
2050	-60	-60	-80	-90
Emission allocation, per capita, change from 2000 levels, per cent				
2020	-27	-34	-31	-44
2050	-77	-77	-88	-93

Note: International emissions data has been sourced from the GTEM model, whose database is from 2001.
Source: Treasury estimates from GTEM and MMRF.

Box 4.1: Climate change projections: stabilisation at 450 and 550 ppm

Stabilisation of atmospheric concentrations requires significant cuts in global greenhouse gas emissions. The stabilisation level depends on how soon emissions peak and how quickly they decline. Lower stabilisation levels require global emissions to peak within the coming decade and fall well below current levels by 2050 (IPCC, 2007a).

The global average surface temperature has risen around 0.8°C since 1850, and will rise further in the coming decades as a result of emissions that have already occurred.

Global mitigation action to achieve stabilisation at 450 ppm CO_2-e is associated with a 50 per cent chance of limiting global average warming to around 2°C above pre-industrial levels. This is the temperature threshold most frequently spoken of in the scientific literature as representing the limit beyond which ‘dangerous’ climate change may occur (for example, Hansen et al., 2007). Risks associated with this level of warming vary from region to region. For Australia, this is likely to involve substantial environmental change. Natural and agricultural production systems face significant change due to the combined effects of higher temperatures and a general reduction in rainfall across much of the nation. Risks from bushfires and other extreme weather increase, particularly in coastal and rural regions (Pearman, 2008).

Global mitigation action to achieve stabilisation at 550 ppm CO_2-e is associated with a 50 per cent chance of limiting global average warming to around 3°C above pre-industrial levels. Changes projected under a 450 ppm scenario are likely to occur sooner and become more severe under a 550 ppm world. Between 20 and 30 per cent of all species are projected to face a 50 per cent likelihood of extinction under this scenario (IPCC, 2007b). This would involve the total realignment of ecosystems across Australia. Coastal communities, agriculture and infrastructure would all face significant risks of adverse impacts. These include frequent or permanent coastal inundation for parts of the Australian coastline, a substantial increase in extreme weather across the nation, and substantial restructuring of the rural sector (Pearman, 2008).

4.1 Global emissions reductions

The policy scenarios examined assume coordinated global action to reduce greenhouse gas emissions to a level that allows stabilisation of greenhouse gas concentrations in the atmosphere. Concentration levels are a convenient measure of the scale of global mitigation effort, as they involve a single measure linked to human activities (via emissions) and environmental risks (via the relationship between concentration and temperature change) (Box 4.2). The target stabilisation levels examined vary within the range 450 to 550 ppm.

Box 4.2: Alternative specifications of targets

Strategies to address anthropogenic climate change are usually formulated as scenarios designed to meet a certain greenhouse gas emission-related target. Various targets are used in modelling exercises, each with advantages and disadvantages (Table 4.2).

Table 4.2: Advantages and disadvantages of different climate change targets

Target	Advantages	Disadvantages
Maximum tolerable level of impacts (for example, no more than a doubling of the current population under water stress)	Is linked directly to the consequences to avoid.	Has scientific, economic and ethical difficulties in defining important impacts and level of change tolerated. Is uncertain in linking avoidance of a specific impact to human action. Success cannot be measured until too late to take further action.
Global mean warming (above a baseline)	Can be linked to impacts, although somewhat uncertain. Has one quantifiable variable.	Has uncertainties in linking goal with specific human actions. Cannot show lags in time between temperature changes and human influence, so difficult to measure success of human actions in moving towards the goal.
Concentration(s) of greenhouse gases (or radiative forcing)	Has one quantifiable variable. Can be linked to human actions, although somewhat uncertain. Succeeds in moving towards the goal measurably and quickly.	Is uncertain about the magnitude of the avoided impacts.
Cumulative emissions for greenhouse gases (over a given period)	Has one quantifiable variable. Is directly linked to human actions. Succeeds in moving towards the goal measurably and quickly.	Is uncertain about the magnitude of the avoided impacts.
Reduction in annual emissions by a specific date	Has one quantifiable variable. Succeeds in moving towards the goal measurably and quickly.	Is uncertain about the magnitude of the avoided impacts. Does not address the problem that impacts are a function of stocks, not flows. May limit 'what, where, when' flexibility and so push up costs.

Source: Stern, 2007.

Many possible global emissions pathways could achieve a given stabilisation goal. Each pathway implies a different allocation of mitigation effort over time, with implications for economic costs, intergenerational equity and the preservation of options to change emission budgets and stabilisation goals in light of future information.

A 'Hotelling rule' is used to construct a global emissions pathway for each scenario within the global models (GTEM and G-Cubed). The emission price grows from a specified starting level at the real interest rate, assumed to be 4 per cent per year, which represents the rate of increase in comparable financial assets[1]. Other recent climate modelling exercises use similar levels.[2]

This approach mimics the expected behaviour of an efficient global emission market that allows banking and borrowing of permits over time, and draws on similarities between mitigation policy and management of finite resources (Box 4.3). Irrespective of the initial allocation of permits, market participants would form views regarding the future emission price in light of the

1 This rate of return embodies the commercial risks of holding permits and investing in emissions-related activities. The 4 per cent rate embodies a risk-free real rate of 2 per cent and a risk premium in markets for permits of 2 per cent.

2 For example, see CCSP, 2007, p 89.

environmental objective, overall emission budget, and expected future social, economic and technological conditions.

If market participants expect the emission price to grow faster than the value of other comparable financial assets, they would 'bank' permits now for use later (to capture this higher return) and the current emission price would rise. Conversely, if market participants expect the emission price to grow more slowly than other comparable assets, they would sell banked permits (or 'borrow' future permits if required) for use now, and the current emission price would fall. The emission price derived in the models mimics the price expected in the market, given the assumptions made in each scenario. Restrictions on borrowing are assumed in the CPRS scenarios, but given the assumptions made in the models this is not enough to move the price away from the 'Hotelling path', as the pressure in the market would only be towards banking. This reflects the equilibrium nature of the models (Chapter 2), which eliminates short-term market fluctuations.

Box 4.3: Depletion of natural resources

The concept of a resource price rising with the interest rate comes from resource economics. Hotelling (1931) and Solow (1974) observed finite resources are stored for consumption in future periods if the expected growth in price is greater than the required return for an asset in an equivalent risk class. If the expected growth in price is less than the required return, the asset is sold and the proceeds invested in an equivalent risk class asset. As a result, return from the optimal extraction of a finite mineral resource will increase over time at the rate of interest.

Stabilisation of greenhouse gas concentrations in the atmosphere requires limits on total emissions over time, not emissions in any particular year. Thus the optimal release of greenhouse gases into the atmosphere over time is a problem similar to the optimal extraction of a finite resource (Peck and Wan, 1996).

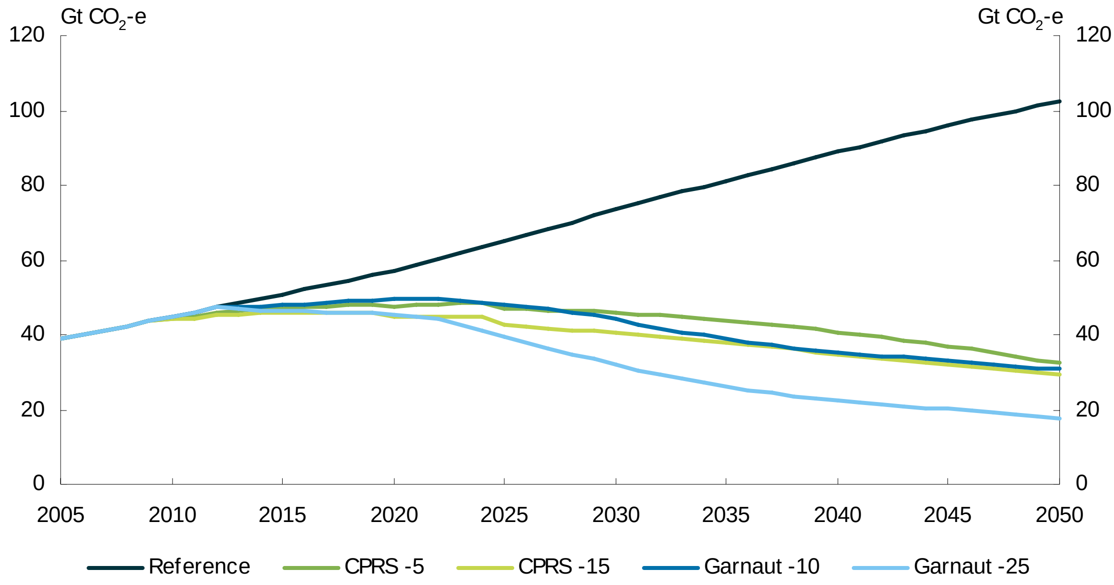
In an emissions trading scheme, emission permits encourage the efficient intertemporal allocation of mitigation effort by allowing use of a permit at any time (referred to as 'banking and borrowing'). Under these conditions, emission permits share characteristics of finite resources, as the total quantity is fixed, while their use varies over time.

A constant risk premium is applied to permits over time. Policy settings, such as the extent and credibility of future emission targets, disclosure rules for market-relevant information, and the legal nature of permits, may affect the risk premium applied in the market, and vary across economies and over time.

Different emission price paths, all growing at 4 per cent, but starting at different levels, were explored to produce an emission price path consistent with the stabilisation goal. The resulting emissions pathway is consistent with an efficient mitigation effort over time for a fixed emission budget and stabilisation target. The simple climate model MAGICC confirms that the resulting global emissions pathways are consistent with the stabilisation objective (Wigley, 2008).

In the Garnaut -10 and CPRS -5 scenarios, global emissions fall to levels consistent with achieving stabilisation at 550 ppm by 2100 (Table 4.1 and Chart 4.2). Global emissions in the CPRS -15 scenario follow a path consistent with stabilisation at around 510 ppm by 2100, and in the Garnaut -25 scenario, concentrations peak at 520 ppm in 2050, then could fall to 450 ppm just beyond 2100.

Chart 4.2: Global emissions and allocations

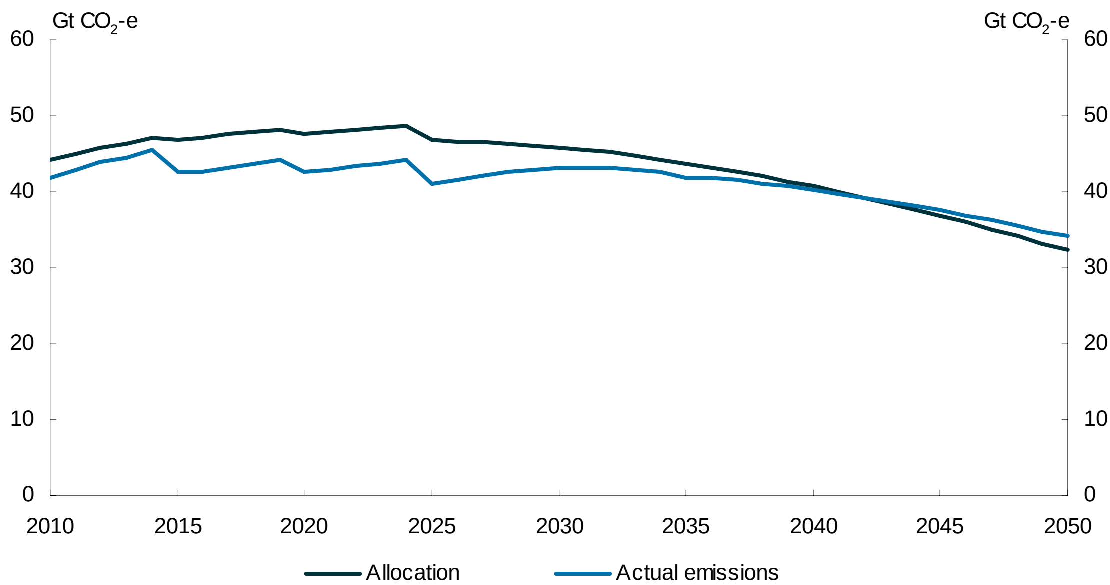


Note: Reference scenario emissions and assumed emission allocations for the policy scenarios are shown.
Source: Treasury estimates from GTEM.

Conceptually, permit banking plays an important role in the mitigation policy scenarios, particularly the CPRS scenarios. In these scenarios, national emission allocations gradually diverge from the reference scenario emission levels towards long-term emission reduction targets. However, the actual emissions in the models fall initially, in response to the introduction of an emission price at the level determined by the Hotelling rule. As a result, some allocated permits are banked for future use (Chart 4.3). The gap between allocations and actual emissions represents the permits that are banked. After 2040, actual emissions are higher than allocations, reflecting the use of previously banked permits.

Chart 4.3: Global emissions pathway and allocation

CPRS -5 scenario



Source: Treasury estimates from GTEM.

If the scenarios did not assume permits could be banked, the global emission price in all scenarios would start much lower, and accelerate much faster than 4 per cent per year. For example, if banking was not permitted in the CPRS -5 scenario, the emission price could start as low as around A$2 and grow at an annual average rate of over 20 per cent from 2010 to 2020.[3] While the emission price could be volatile when the CPRS is first introduced, banking helps ensure the price does not rise at rapid rates. Banking also allows for the efficient allocation of mitigation effort across time (Box 4.3).

The emission prices derived in the models do not incorporate the 'option' value associated with future changes to the emission budget and stabilisation target. Stochastic models that explicitly model uncertainty better suit option analysis than CGE models. In general, the starting price could be expected to rise where the market anticipates lower future stabilisation levels or emission budgets, and fall where the market anticipates higher future levels or budgets.

Emission pathways are expressed in CO_2-e emissions, calculated from the emissions of the six gases covered under the Kyoto Protocol, and combined using the 100-year global warming potentials applied under the Protocol. While the global warming potential concept is subject to continuous scientific debate, it is a convenient and widely used measure in policy analysis (IPCC, 2007c). Global warming potentials are embedded in the structure of the models used in this report.

Box 4.4: Emission targets, mitigation and trade

The Government's long-term target is to reduce Australia's net emissions by 60 per cent below 2000 levels by 2050.

Emissions generated in Australia may exceed or fall short of the national target in any particular year owing to Australia's participation in international emissions trading (DCC, 2008). Australia's target represents its contribution to the global mitigation effort. Emission trading is a mechanism to reduce the cost of Australia's contribution, and the global cost of achieving stabilisation, as emissions are reduced where it is cheapest. If Australia's emissions were higher (or lower) than its target, it would buy (or sell) permits accordingly.

In modelling reports, the gap between emissions in the reference scenario and policy scenarios over time often is characterised as the 'abatement task'. In this study, the gap between the reference scenario emissions and the Government's target in 2050 is about 800 Mt CO_2-e. This represents the difference between two alternative development pathways. The difference arises through incremental changes in the economy over time; it does not represent the actual mitigation task Australia faces in 2050. The sectoral and technological composition of the Australian economy in the reference scenario and policy scenarios gradually evolves, so the actual task Australia faces each year is a small additional mitigation effort compared to the previous year.

3 This is an approximation, as this sensitivity did not update for exogenous land-use and forestry sequestration assumptions. If these sequestration assumptions were updated, the annual average growth in the emission price could be even greater.

4.2 INTERNATIONAL ALLOCATION

'International allocation' refers to the division of emission rights and mitigation effort among economies. National contributions to the global mitigation effort are the subject of current international negotiations. While several principles guide these negotiations, national interests loom large, and the nature and timing of outcomes are difficult to predict.

Simplifying assumptions about the relative contribution of Australia and other nations are made in this report. While stylised, these assumptions provide a basis for exploring the relative costs of different stabilisation levels; give a sense of the scale of transition required; highlight differences in economic impacts across regions; and help identify which sectors are likely to be most affected.

The international allocation assumptions significantly affect Australia's mitigation costs. These assumptions determine the timing and level of Australia's contribution to the global mitigation effort. They determine the pattern of mitigation action by other economies which affect Australia through impacts on world trade and the extent of permit trade among economies. Trade in emission permits results in income or wealth transfers across economies.

The literature discusses different allocation frameworks (den Elzen et al., 2005; Rose et al., 1998; Cazorla and Toman, 2000). This report explores two approaches, 'multi-stage' and 'contraction and convergence'. These approaches differ structurally.

In the multi-stage approach, the number of economies participating in global mitigation gradually expands. National targets are based on an allocation of mitigation effort ('burden sharing'). Each country gradually diverges from its reference scenario emissions. This approach is based on responsibility and capability principles: the greater the contribution to the problem and the greater the capacity to act, the greater the share in the mitigation burden.

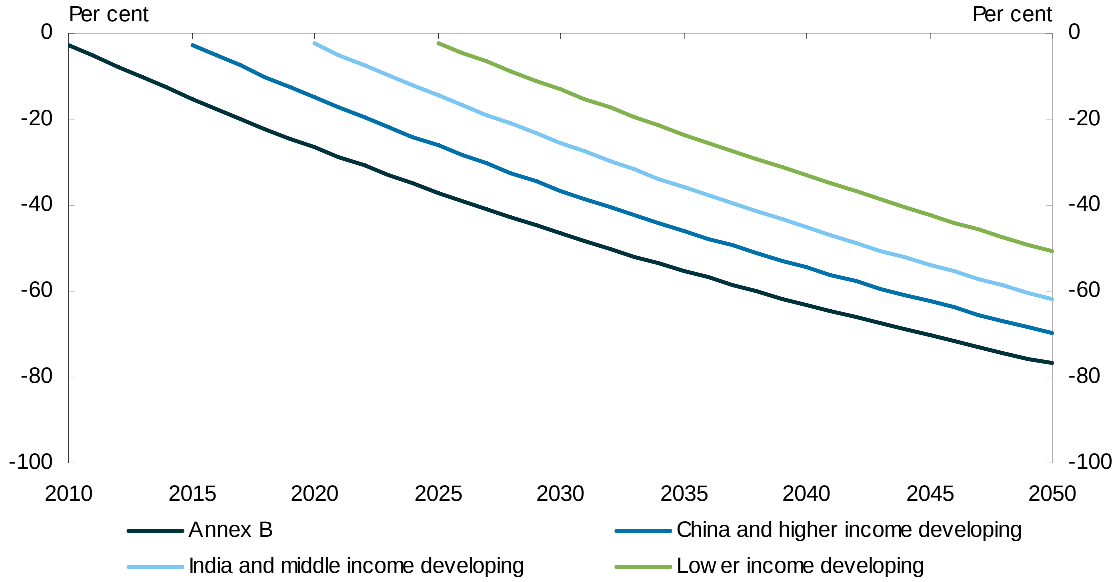
In contrast, in the contraction and convergence approach, economies participate and allocate emissions rights ('resource sharing') from the start. National targets are based on a per capita allocation rule. This approach balances egalitarian and sovereignty principles: all humans have equal rights to use the atmosphere, and current emissions constitute a 'status quo right' of economies.

The CPRS scenarios assume a multi-stage approach. Australia's level of mitigation effort is taken as the starting point. Developed economies take comparable action, and developing economies join the scheme over the period 2015 to 2025.

All economies follow their reference scenario emissions until 2009. Starting in 2010, they are then divided into different groups and assumed to take on emission targets that gradually diverge from reference scenario emission levels towards long term reductions. Economies listed in Annex B to the Kyoto Protocol are assumed to act in concert with Australia from 2010.[4] China and higher income developing economies take on targets in 2015. India and middle income developing economies take on targets in 2020, and lower income economies take on targets in 2025 (Chart 4.4).

4 This provides a simple proxy for existing and proposed mitigation policies in these countries. These policies were not included in the reference scenario.

Chart 4.4: Multi-stage emission allocations: relative to reference scenario
CPRS -5 scenario



Note: Allocations applied in the modelling diverge slightly from this chart owing to assumptions about the creation of offset credits in developing economies.
Source: Treasury.

Australia's allocation under the CPRS scenarios is 60 per cent below 2000 levels by 2050, equal to about an 80 per cent reduction relative to the reference scenario. All Annex B economies diverge from their reference scenario emissions at the same rate, reflecting the principle of comparable effort.

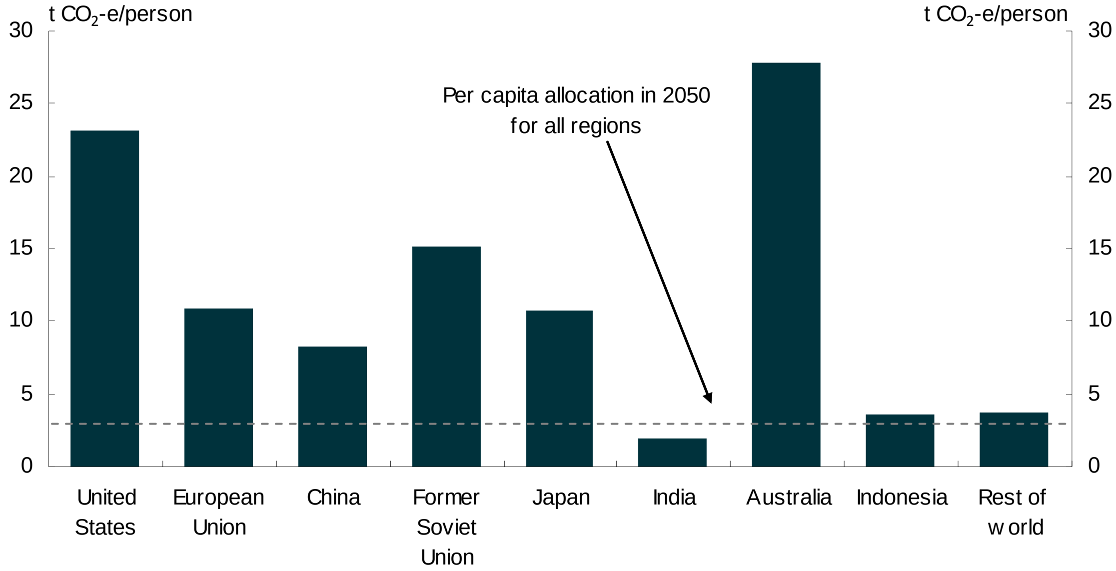
Before taking on emission reduction targets, non-Annex B economies are assumed to generate a modest volume of offset credits (such as credits generated through projects under the Kyoto Protocol's Clean Development Mechanism) for sale to Annex B economies. In the medium term, developing economies take on targets that gradually reduce emission rights, and diverge strongly from reference scenario levels by 2050. For example, China's allocation is roughly treble 2000 levels in 2030, but falls to less than double 2000 levels by 2050. This is equal to a 70 per cent reduction from China's reference scenario emission levels.

The Garnaut scenarios assume a 'contraction and convergence' approach originally developed by the UK-based Global Commons Institute, with refinements developed by the Garnaut Climate Change Review (Garnaut, 2008). Features of this approach include:

- Initial national allocations reflect actual emission levels at the start of the scheme, but over time, they converge and by 2050, rights are allocated on an equal per capita basis (Chart 4.5).

- Allocations for fast growing developing economies increase at half their rate of economic growth until their per capita allocation reaches the level of the European Union and Japan.

Chart 4.5: Contraction and convergence approach
Per capita emissions in 2012, Garnaut -10 scenario



Source: Treasury and Garnaut, 2008.

Australia currently has relatively high per capita emission levels, and so the contraction and convergence approach implies significant reduction targets for Australia over the long term: 80 per cent reductions from 2000 levels by 2050 for Garnaut -10 and 90 per cent reductions for Garnaut -25.

Nevertheless, Australia may benefit more from approaches which take into account per capita emission levels than approaches which only focus on reducing absolute emissions levels relative to an historical baseline. This is because Australia's population is projected to grow more strongly than most developed economies in the coming decades. Population is an important driver of greenhouse gas emissions growth, and so (all else being equal) Australia's emissions are likely to grow faster than other developed economies' emissions. As a result, a fixed reduction in absolute emission levels relative to an historical baseline probably will cost Australia more than other developed economies.

An advantage of contraction and convergence is that it adjusts for the effect of population growth over time, so Australia is allocated a growing share of the global carbon budget relative to countries with lower population growth.

The allocation approaches examined are based on production emissions from producing goods and services within the economy. This is the standard accounting framework applied under current international climate change agreements. Alternative allocation rules could be based on where goods containing emissions are consumed. Australia has a comparative advantage in emission-intensive industries. Allocations based on production are likely to result in higher welfare costs for Australia than allocations based on consumption.

The notions of comparable effort and common, but differentiated, responsibilities will be central in reaching a post-2012 agreement accepted as 'fair'. Negotiations are unlikely to follow any single rule or formula, and all economies will emphasise factors that bear on their own national circumstances. The challenge is to identify principles that can harness broad support, and which will accelerate progress towards an effective international framework (Garnaut, 2008).

4.3 POLICIES TO REDUCE EMISSIONS

A wide range of policies currently used in Australia support mitigation goals, including energy efficiency incentives and standards, support for research and development into low-emission technologies, targets for renewable energy deployment, and controls on land use. A wider range of policies apply across the world, including emission taxes and emission trading schemes.

For the Garnaut scenarios, a single policy measure — a global emissions trading scheme covering all economies and all gases starting in 2013 — was used to drive emission reductions across the global economy. This stylised global policy framework allows the greatest flexibility to find and exploit the cheapest mitigation opportunities, rather than prescribe the regions and sectors in which emission reductions should occur. The international emissions trading system modelled in these policy scenarios is a simplified proxy for the range of mechanisms — from the flexibility mechanisms under the Kyoto Protocol to multilateral technology funds to voluntary emission markets — which constitute the global mitigation framework.

Similarly, in this analysis each economy or region in the model has an annual national emissions target, which forms the basis of its participation in the global emissions trading scheme. This target represents each economy or region's contribution to the global mitigation effort. The target is a simplified proxy for the range of policies and measures — from domestic emission trading schemes to bilateral cooperation on deforestation to regional technology partnerships — which constitute a national climate change response.

The emissions trading schemes modelled in the CPRS scenarios are based on the preferred policy positions as outlined in the *Carbon Pollution Reduction Scheme Green Paper* (DCC, 2008). This scheme's coverage and operation is assumed to evolve, initially offsetting some impacts of emission prices, limiting international trade, and shielding emission-intensive trade-exposed sectors ahead of full global participation (Table 4.3). Economies that participate in the global emissions trading scheme are assumed to follow similar policies to Australia.

In the CPRS scenarios, emission trading occurs between economies that have emission reduction targets. International permit trade is constrained until 2020 to reflect the Kyoto Protocol principle of supplementarity, which mandates flexibility mechanisms such as international emissions trading supplement (not replace) domestic mitigation effort. For the purposes of the modelling, constraints are calculated as half of the implicit 'mitigation effort' (that is, half of the gap between reference scenario emissions and allocations).

Developing economies, which initially remain outside the scheme, are assumed to be able to generate credits for sale into the global market ahead of taking on national emission caps, through schemes such as the Clean Development Mechanism. These parallel schemes help reduce global mitigation costs by creating access to low-cost mitigation in all economies, and help reduce global emissions by shifting developing economies onto lower emission development pathways including through the transfer of low-emission technologies.

Table 4.3: Summary of policy mechanisms

	CPRS -5 and CPRS -15	Garnaut -10 and Garnaut -25
Australia's emissions trading scheme	Starts in 2010. Based broadly on the *Carbon Pollution Reduction Scheme Green Paper*. Provides unlimited banking of permits. Excludes agriculture until 2015. Offsets impact on household fuel costs through fuel excise changes until 2013. Shields emission-intensive trade-exposed sectors until 2020 through providing free permits. Limits international trade in permits until 2020. Returns residual revenue to households as a lump-sum income transfer each year.	Starts in 2013. Covers all emissions in all sectors. Does not constrain international trade in permits. Does not shield emission-intensive trade-exposed sectors (as economies take on emissions reductions simultaneously). Returns all revenue to households as a lump-sum income transfer each year.
Other Australian mitigation policies	Includes expanded Renewable Energy Target (RET) of 45,000 GWh per year by 2020. Victorian RET and NSW and ACT Greenhouse Gas Reduction Scheme cease. Queensland 15 per cent Gas scheme remains operational.	The expanded RET and state and territory schemes cease when emissions trading starts.
International action	Multi-stage approach. Annex B economies have targets and participate in international emissions trading from 2010. Developing economies gradually join the scheme (China in 2015, India in 2020, and complete coverage from 2025). National emission targets are based on a gradual divergence from reference scenario emission levels. Scheme participants are assumed to have similar emissions trading scheme policy settings to Australia.	Contraction and convergence approach. All economies adopt targets and participate in international emissions trading from 2013. National emission allocations start at current levels and converge to equal per capita rights by 2050.

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