



# SHARING THE GLOBAL EMISSIONS BUDGET

This appendix sets out the approaches to sharing a global emissions budget and complements the discussion in Chapter 8.

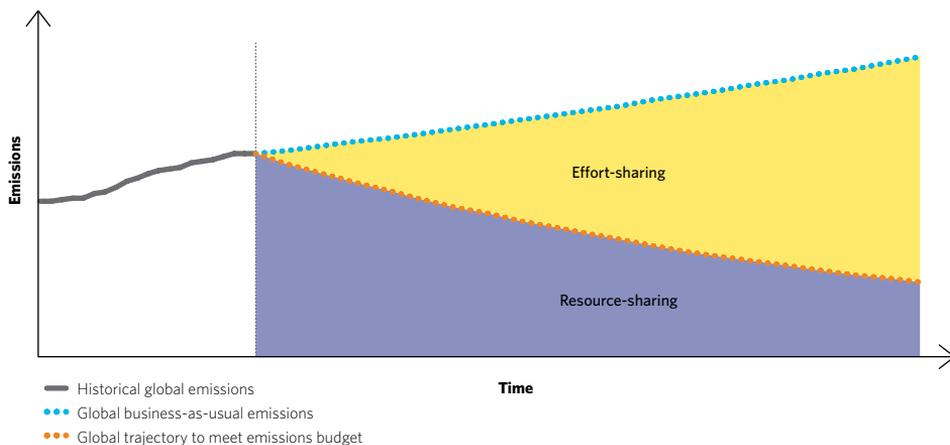
## APPENDIX C1 APPROACHES TO SHARING A GLOBAL EMISSIONS BUDGET

There are two broad approaches to sharing emissions reduction efforts:

- sharing the global emissions budget—‘resource-sharing’
- sharing the emissions reductions required to meet that budget—‘effort-sharing’ (Figure C.1).

In some ways, the two approaches are similar—sharing the remaining budget implicitly sets a mitigation task and vice versa. From a practical perspective, resource-sharing approaches are more straightforward, as they require only an estimate of the global emissions budget and equitable principles. In contrast, effort-sharing also requires an estimate of global emissions in the absence of climate change action; that is, a BAU trajectory. As more countries take more action, this trajectory becomes increasingly abstract and difficult to estimate.

**FIGURE C.1: RESOURCE-SHARING VERSUS EFFORT-SHARING**



Source: Climate Change Authority

While almost all of the approaches are conceptually based on the emissions rights of individuals, none would allocate rights directly to individual Australians. Rather, these approaches allocate budgets by starting with principles based on individuals, then aggregating to the national level.

The Authority's recommended emissions reduction goals for Australia, including the budget to 2050, are 'net' goals. That is, they reflect Australia's contribution to global emissions reduction efforts, not a fixed limit on Australia's domestic emissions. To the extent that domestic emissions exceed the budget, they must be offset by genuine emissions reductions purchased from overseas.

## C1.1 RESOURCE-SHARING APPROACHES BASED ON EMISSIONS RIGHTS PER PERSON

The Authority examined four resource-sharing approaches based on equal emissions rights per person in detail. Three involve a gradual move to equal rights per person and the fourth involves immediate equality.

### C1.1.1 CONTRACTION AND CONVERGENCE

Under contraction and convergence, emissions per person contract over time in countries above the global average, and rise over time in countries below the global average, reaching a 'convergence level' of equal per person rights in a specified future year. The convergence year is a key variable in this approach. A shorter convergence period results in smaller budgets for countries that, like Australia, start with above average per person emissions.

The Authority has used 2050 as its preferred convergence year when analysing these approaches, balancing the feasibility of the transition with the goal of equalising per person emissions rights.

### C1.1.2 MODIFIED CONTRACTION AND CONVERGENCE

This approach was proposed by Professor Garnaut in his 2008 Review. It involves two main modifications to simple contraction and convergence:

- fast-growing developing countries are allowed additional growth in their per person emissions rights for a transitional period
- developed countries' rights contract more quickly to provide this headroom (Garnaut 2008, pp. 206-7).

Specifically, it allows developing countries' allocations to grow at half their economic (GDP) growth rate, if that is greater than the growth rate of their allocated emissions under the simple contraction and convergence approach.

Professor Garnaut proposed modified contraction and convergence because some rapidly growing developing countries are already close to the global per person average for greenhouse gas emissions. Under simple contraction and convergence, they would have to either halt growth in their per person emissions very soon or purchase large volumes of emissions reductions from other countries. Garnaut argued that, for these nations, the first is difficult and the second inequitable. The modified approach provides some 'headroom' to allow high-emitting developing countries to make a more gradual adjustment. All countries converge to equal per person rights by 2050.

### C1.1.3 COMMON BUT DIFFERENTIATED CONVERGENCE

Under this variant of contraction and convergence, developing countries are provided headroom through delayed reductions rather than larger allocations. Countries' per person emissions rights begin to fall once they reach a specified threshold of the (time-varying) global average, then move linearly to the convergence level. Regardless of when countries and allocations begin to fall, they have the same amount of time to reach the convergence level.

The threshold level of emissions and the amount of time to reach the convergence level are policy choices that depend on the global emissions budget. For budgets aimed at limiting temperature increases to below 2 degrees, this approach provides no headroom for some higher emitting developing countries (Höhne and Moltmann 2009, p. 25).

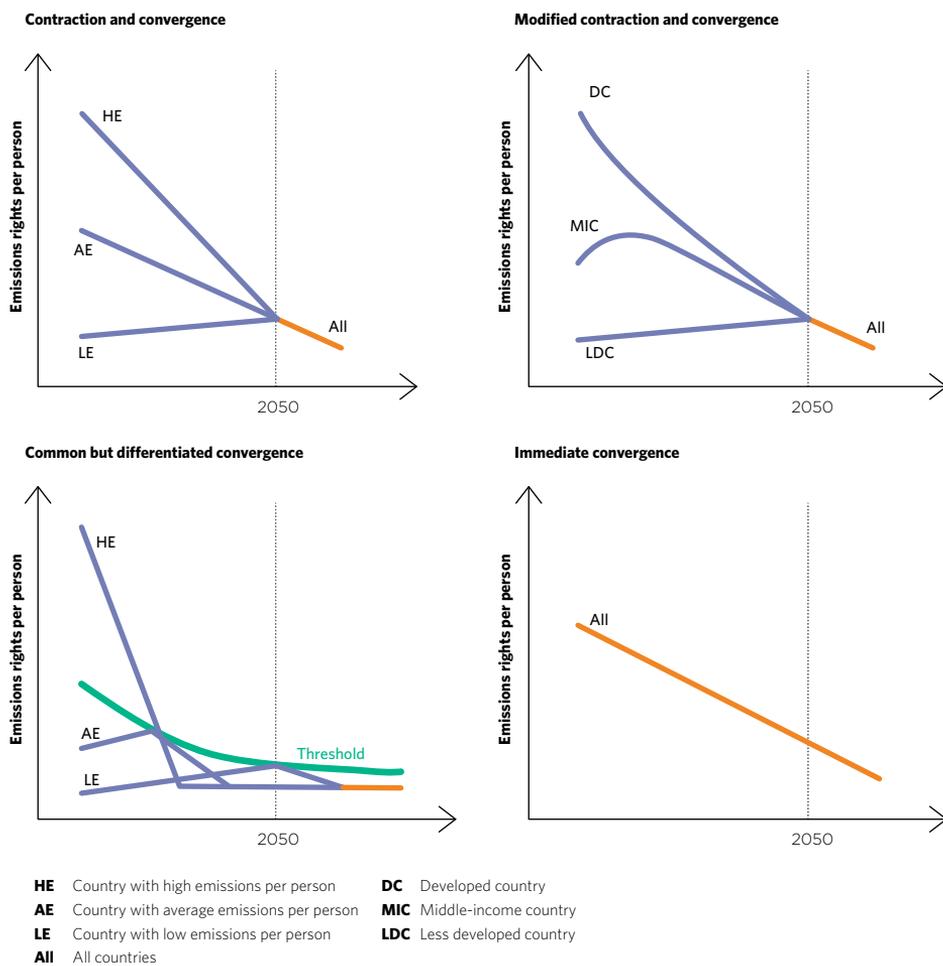
### C1.1.4 IMMEDIATE CONVERGENCE

Contraction and convergence equalises per person emissions rights at a point in the future. Immediate convergence—also referred to as an equal cumulative per person emissions approach—equalises per person rights straight away. The Authority has calculated indicative budgets using this approach, adjusting for changes in countries' share of the global population over time so that each person alive in a given year has an equal share of that year's available emissions.

Some proposals for immediate convergence do not adjust for population changes over time (see, for example, German Advisory Council on Global Change 2009). Instead, they allocate each nation a share of the global emissions budget based on its share of global population in a single 'reference year'. These variants do not really give effect to the principle of equal emissions rights per person, so the Authority has not considered them in detail. Other proposals include historical emissions in the calculations; for example, Jayaraman, Kanitkar and D'Souza (2011) incorporate emissions from 1970. Under this approach, Australia's 2000–2050 emissions budget is negative—Australia's past emissions have already more than exhausted its entitlements, and the right to all ongoing emissions would have to be purchased from countries with positive entitlements. The Authority's view is that distant past emissions should not be included as these occurred when their harmful effects could not be foreseen.

Figure C.2 provides a stylised comparison of these four resource-sharing approaches. It shows how contraction and convergence, and common but differentiated convergence are based on per person emissions levels only, while modified contraction and convergence takes levels of development directly into account. Immediate convergence requires instant equality for all countries regardless of their characteristics.

**FIGURE C.2: COMPARISON OF APPROACHES WITH EQUAL PER PERSON EMISSIONS RIGHTS**



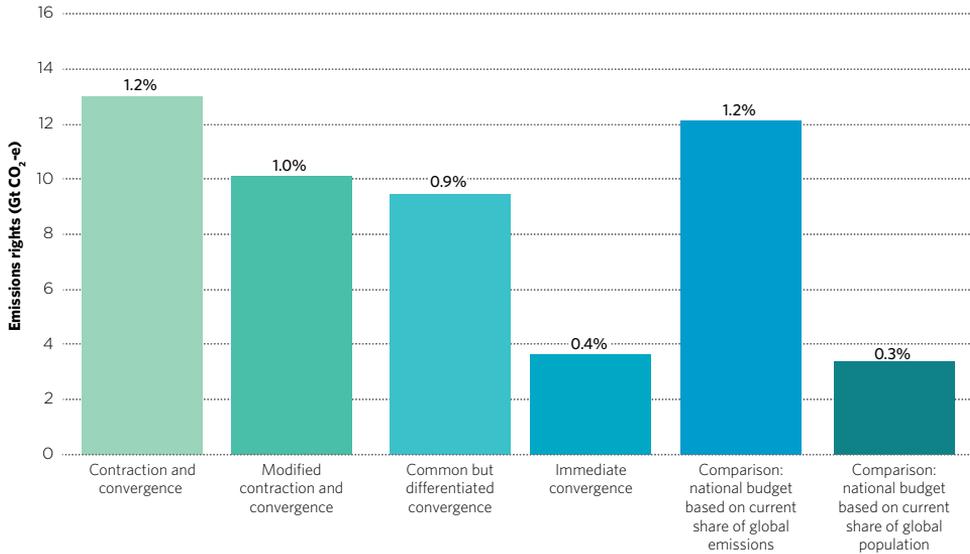
Source: Climate Change Authority based in part on Höhne and Moltmann 2009

Figure C.3 illustrates the implications of the four resource-sharing approaches for Australia’s long-term national emissions budget. These calculations are based on the share of the global 2 degree budget adopted as a reference in Chapter 3. It also shows two simple budgets to help put the others into perspective:

- a ‘status quo share’ based on Australia’s current share of global emissions
- a ‘population share’ based on Australia’s current share of the global population.

All four approaches give a budget comparable to or smaller than the one based on Australia’s current share of global emissions. Modified contraction and convergence provides a budget about 20 per cent smaller than simple contraction and convergence, in part because it allows developing countries a greater share of the global budget. Immediate convergence provides a very small national emissions budget.

**FIGURE C.3: AUSTRALIA'S LONG-TERM NATIONAL EMISSIONS BUDGET UNDER VARIOUS APPROACHES (Gt CO<sub>2</sub>-e) AND SHARE OF THE GLOBAL EMISSIONS BUDGET (PER CENT)**



**Notes:** National emissions budget for 2013–2050. All approaches share a global emissions budget consistent with a 67 per cent probability of limiting temperature increases to below 2 degrees. Australia’s status quo share based on its share of global emissions including LULUCF emissions.

**Source:** Global budget: Authority calculation based on Meinshausen et al. (2009) adjusted using IEA (2013a) and (2013b) and Treasury and DIICSRTE modelling (2013).

Approaches: Authority calculations based on spreadsheet tool used for the Garnaut Review (2008) with updates for emissions, population and GDP from Treasury and DIICSRTE modelling (2013) (contraction and convergence, modified contraction and convergence); Höhne and Moltmann (2009) and inputs to spreadsheet tool (common but differentiated convergence); Authority calculations based on Treasury and DIICSRTE modelling (2013) and IEA (2013b) (other approaches).

The Authority’s recommended budget to 2050 is different to that proposed by some stakeholders. The Climate Institute (*Draft Report submission*, p. 2) and WWF-Australia (*Draft Report submission*, p. 6) suggested a 2013–2050 national budget of about 8,400 Mt CO<sub>2</sub>-e based on a global budget with a 75 per cent probability of keeping warming below 2 degrees. Earlier analysis by Ecofys for WWF-Australia (2013) found budgets for the period 1990–2100 for Australia of between 14,000 and 18,000 Mt CO<sub>2</sub>-e using different approaches. That analysis was based on a tighter global emissions budget than the Authority used, and a different time period (1990–2100 versus the Authority’s 2013–2050).

The next section discusses two effort-sharing approaches. These are not included in Figure C.3 because the share of emissions reduction efforts by each country for the period to 2050 is not available, so comparable long-term national budgets cannot be derived.

## C1.2 EFFORT-SHARING APPROACHES

### C1.2.1 EQUAL PROPORTIONAL EMISSIONS REDUCTION COSTS

This approach seeks to equalise the wellbeing forgone when taking action to reduce emissions. It generally uses GDP as a proxy for wellbeing and allocates mitigation targets among developed countries, so that each incurs the same total emissions reduction cost as a proportion of GDP.

The implications for targets depend critically on whether countries undertake all emissions reductions domestically or use a mix of domestic and international reductions:

- If international emissions reductions cannot be used, developed countries facing higher total emissions reduction costs have weaker targets, and those facing lower costs have stronger targets, so that the cost as a share of GDP is the same in both countries.
- If international emissions reductions can be used, all countries can individually and collectively achieve the emissions reductions at a lower cost, because reductions can take place wherever in the world they are cheapest. Developed countries with higher total costs would still have weaker targets under this approach than those with lower costs; however, the difference in targets would be smaller than without trade.

Few published studies explicitly address the question of relative costs. Among those that do, a common conclusion is that Australia faces relatively high total emissions reduction costs—see, for example, McKibbin, Morris and Wilcoxon (2010), den Elzen et al. (2009) and Treasury (2008). This means that Australia's target under this approach would be relatively weaker than those of developed countries with lower costs.

It is difficult to estimate the national emissions budget that would correspond with this approach, as there is no consensus on the appropriate aggregate effort for developed countries and no generally agreed modelling approach for costs.

### C1.2.2 GREENHOUSE DEVELOPMENT RIGHTS

The Greenhouse Development Rights approach takes differences in capacity within nations explicitly into account (Baer et al. 2008). Each country's share of emissions reductions is based on two things:

- how many people in that country have incomes above a 'development threshold'
- how many emissions those people have generated since 1990.

These are combined in a Responsibility-Capacity Index, which is used to calculate the country's share of the global emissions reduction task. Under this approach, short-term targets for developed countries can be very strong indeed; for Australia, the 2020 target implied is more than 55 per cent below 2000 levels (EcoEquity and Stockholm Environment Institute 2013).

## APPENDIX C2

### AUSTRALIA'S EMISSIONS BUDGET TO 2050

Calculations of Australia's emissions budget to 2050 outlined in Chapter 8 draw on the international modelling from the Global Trade and Environment Model (GTEM) and further information provided by Treasury.

#### C2.1 APPROACHES TO SHARING GLOBAL EMISSIONS BUDGETS

Estimates of Australia's long-term national emissions budget use global population projections from GTEM. Estimates for some approaches also use GDP and/or emissions by region from GTEM. The estimates for modified contraction and convergence, and simple contraction and convergence are Authority calculations based on the spreadsheet tool used for the Garnaut Climate Change Review 2008, with updates for emissions, population and GDP from Treasury and DIICCSRTE (2013).

#### C2.2 AUSTRALIA'S 2013–2050 NATIONAL EMISSIONS BUDGET

Australia's long-term national emissions budget of 10,100 Mt CO<sub>2</sub>-e is calculated as follows:

1. The 2000–2050 global emissions budget based on Meinshausen et al. (2009; see Chapter 3) is adjusted to remove global emissions from 2000–2012. Global emissions from 2000–2012 are estimated to be 608 Gt CO<sub>2</sub>-e, based on International Energy Agency (IEA 2013a), using linear interpolation between 2000, 2005 and 2010 data points and the annualised growth rate for 2005–2010 to estimate 2011 and 2012 global emissions.
2. Projected emissions from international aviation and shipping for 2013–2050 are removed, as these are not allocated to any individual country. These are estimated to be 47 Gt CO<sub>2</sub>-e based on IEA (2013b). Cumulative emissions to 2035 are calculated using a linear interpolation of aviation and shipping emissions in the IEA's '450' scenario between 2011, 2020, 2030 and 2035. Cumulative emissions from 2036–2050 are estimated by assuming that emissions during this period grow at the IEA's annualised rate for 2020–2035.
3. Australia's share of the resulting 2013–2050 global emissions budget is calculated based on its share (0.97 per cent) of global emissions under a modified contraction and convergence approach. This is an Authority calculation based on the spreadsheet tool used for the Garnaut Climate Change Review 2008 with updates for emissions, population and GDP from the Treasury and DIICCSRTE modelling report.

All emissions in the long-term national emissions budget calculation use GWPs from the IPCC's Second Assessment Report for consistency with the original Meinshausen et al. (2009) global emissions budget. This will tend to underestimate the global and national budget by a small amount; budgets calculated using AR4 GWPs are likely to be slightly larger in CO<sub>2</sub>-e terms.

## APPENDIX C3

### 2030 TARGETS FOR AUSTRALIA AND SURVEY OF ALLOCATION METHODS

The Authority's recommendations are underpinned by analysis that uses the modified contraction and convergence approach and different global budgets. This gives 2030 targets for Australia, compared with 2000 levels, of:

- 40 per cent reductions using a global emissions budget that gives a 50 per cent chance of staying below 2 degrees of warming
- 50 per cent using a global emissions budget that gives a 67 per cent chance
- 60 per cent using a global emissions budget that gives a 75 per cent chance.

These 2030 reduction levels—which form the recommended trajectory range—are calculated by applying Australia's share of the budget under modified contraction and convergence (0.97 per cent) to different global emissions budgets, then applying straight-line trajectories from 19 per cent reductions in 2020 until the budget is exhausted.

This is broadly consistent with other studies. Höhne et al. (2014) have examined over 40 studies on allocation methods and focused on what they imply for 2030 targets. The results show that to stabilise greenhouse gas concentrations at 450 ppm CO<sub>2</sub>-e (which gives roughly a 50 per cent chance of staying below 2 degrees), required emissions reductions relative to 2010 levels are:

- approximately 50 per cent for countries that were OECD members in 1990 ('OECD 1990', including North America, Western Europe, Japan, Australia, New Zealand)—with a range of 37-75 per cent reductions
- roughly 33 per cent for Economies in Transition (Eastern Europe, Russian Federation)—with a range of 28-53 per cent reductions
- roughly returning to 2010 levels or slightly below for Asia (East, South and South-East Asia)—with a range between a 7 per cent increase and a 33 per cent reduction.

Their survey of equal per person emissions methods found a 2030 target range of roughly 30-65 per cent reductions for OECD 1990, and roughly 20-65 per cent reductions for Japan, Australia and New Zealand as a sub-group.

These results are also broadly consistent with Professor Garnaut's 2008 review, which suggested that Australia should take on reduction targets of 25 per cent by 2020 and 90 per cent by 2050 below 2000 levels, in the context of global action giving an even (50 per cent) chance of staying below 2 degrees. Further, he found that if global action gave only an even chance of staying below 3 degrees, Australia should still take on reduction targets of 10 per cent by 2020 and 80 per cent by 2050 (Garnaut 2008, p. 283).