TOWARDS A LOW-EMISSIONS ECONOMY

23

Key points

Australian material living standards are likely to grow strongly through the 21st century, with or without mitigation, and whether 450 or 550 ppm is the mitigation goal. Botched domestic and international mitigation policies are a risk.

Substantial decarbonisation by 2050 to meet either the 450 or 550 obligation is feasible. It will go fastest in the electricity sector, then transport, with agriculture being difficult unless, as is possible, there are transformative developments in biosequestration.

There is considerable technological upside. This could leave Australian energy costs relatively low, so that it remains a competitive location for metals processing.

Australia's human resource strengths in engineering, finance and management related to the resources sector are important assets in the transition to a low-emissions economy. They will need to be nurtured by high levels of well-focused investment in education and training.

The introductory impact of the Australian emissions trading scheme will not be inflationary if permit revenue is used judiciously to compensate households.

Within the policies recommended by the Review, the Australian economy has good prospects of reducing emissions by 80 per cent (under a 550 stabilisation scenario) or 90 per cent (under a 450 scenario) by mid-century, alongside continued strong growth in living standards. Decarbonisation will be associated with changes in industry structure, changing contributions by various sectors to steady falls in emissions, and a changing Australian economic relationship to the rest of the world.

While the prospects are generally favourable, there are three main downside risks in the outlook that are associated with climate change or its mitigation. The first relates to failure to achieve international agreement on mitigation. The second is associated with climate change impacts turning out to be at the bad end of the probability distribution. The third would come from mismanagement of mitigation policy. There are significant possibilities that technological outcomes will be superior to those assumed in the Review's quantitative analyses.

23.1 The dynamics of economic adjustment with global mitigation

The choice of 400 ppm, or 450 ppm, or 550 ppm, or for that matter 850 ppm, is a choice of different time paths to low emissions rather than different end points. If the mainstream science is roughly right, human net emissions will need to be close to zero by late in this century, whatever the level of concentrations. Steeper paths through mitigation to stabilisation, or to 'peaking', will have larger transition costs, but will be associated with less damage and fewer risks from climate change.

Mitigation coordinated on a global scale will be less costly and more effective than independent national action. Independent national action could not add up to a good global outcome. The difference in costs and effectiveness between comprehensive global agreement and separate national actions is so large that it is reasonable to presume that, sooner or later, the world will find its way onto that path.

Sooner or later, a small number of global rights to emit greenhouse gases will be divided among countries. It is hard to see any basis being accepted except that of equal per capita emissions. Along the way, a global system of carbon pricing can be established so long as participating countries have clearly defined trajectories for emissions entitlements.

With carbon pricing, the prices of emissions-intensive goods and services will have increased relative to those of other products. Comparative advantage in trade in goods and services will be determined by a comprehensive set of costs that includes the price of emissions.

So long as there is comprehensive pricing, countries with a comparative advantage in emissions-intensive products, and firms with a competitive advantage, will find that the prices have risen enough to cover the cost of purchasing emissions permits. These countries and firms will tend to buy permits on international markets. When all of the costs are taken into account, some countries will have a comparative advantage in emissions-intensive goods and services. These countries will tend to be net purchasers of permits, and their emissions will exceed their shares of the global population and permit allocations.

If emissions permit markets are working well, the carbon price will rise steadily at the interest rate. If it is $20 in 2010 (2005 dollars), forward prices stretching into the future will be, in real terms, around $40 in 2030, $80 in 2050 and $320 in 2090 (all measured in 2005 dollars). The whole forward price structure will rise with any disappointment of expectations of technological improvement, and fall on any good surprises.

23.1.1 Innovation and incentives

Comprehensive emissions pricing on a global scale, and large-scale fiscal support everywhere for research, development and commercialisation of low-emissions technologies, will provide incentives for exploring ways to economise on the use of emissions-intensive goods and services, and emissions-intensive ways of producing goods and services.

These incentive structures will direct the attention of generations of people over the world who are more numerous, better educated, better informed, better connected and better equipped for productive innovation than any of their predecessors. In its first 150 years, the modern global economy was built on the genius of a small corner of humanity. There was relatively little contribution to the new inventions that drove industrial modernity to ever-rising material standards of living from China, or South Asia, or Southeast Asia, or the Middle East, or Africa, or Latin America—despite the seminal and disproportionate contribution that people from several of these regions had made to the intellectual content of human civilisation in earlier and formative eras. Over the 21st century, out of the expansion of opportunity from the rising incomes and global integration of the Platinum Age, the whole of the genius of humanity will be contributing to innovation in the global economy. Invention will occur in more places and, more than ever before, invention in one part of the world will move quickly to enrich the whole.

Soundly based global mitigation policies will provide incentives for an expanded world population's talent for innovation to be focused especially on low-emissions technologies.

The Australian mitigation effort will be the beneficiary of innovation everywhere. National economic performance will be related closely to how quickly and how well the best new knowledge is absorbed from abroad. Australian prosperity will be related as well to the efficiency with which it develops new and adapts established technology that is especially suited to Australian natural and human endowments. National economic performance will be related closely to how well an economy adjusts to changes in costs and opportunities associated with carbon pricing and emissions-related technological change.

23.1.2 Backstop technologies

At some time, there will be breakthroughs that fundamentally lower the costs of producing goods and services in the low-emissions economy. One or more of these will be 'backstop technologies' that become commercially viable at one or two or three or four hundred dollars per tonne of carbon dioxide equivalent. These backstop technologies will take carbon dioxide from the air at some cost, without relevant limit, and so end the inexorable rise in the carbon price. Research is currently proceeding around the world on a number of possibilities, both industrial and biological.

In Australia, the most interesting work on what could become backstop technologies are in the applied biological sciences—areas of traditional Australian scientific and economic strength. One of these, the use of algae to convert carbon-rich wastes or carbon dioxide from the air into stable carbohydrates, would utilise the biological processes that converted an earlier carbon-rich atmosphere of earth to the oxygen-rich air that made life possible for mammals and therefore humans. They would enhance natural processes by selecting organisms and their growing conditions specifically for the sequestration task.

The emergence of backstop technologies will mark the end of history for the decarbonisation of particular and various sectors of economic activity.

Until these technologies emerge, the rising carbon price will apply ever-increasing pressure for reduction in demand for emissions-intensive goods, and for substitution away from carbon-intensive ways of producing goods and services. Decarbonisation will occur earlier in some goods and services than in others. But occur it will. After half a century, emissions will be confined to a small number of highly valuable goods and services, which have no close substitutes in demand or supply. Beyond this time, the increase in the cost of mitigation is determined by the resistance to substitution in supply and demand of a few goods and services that people continue to value highly even when their prices have risen way beyond old relativities. This will all be happening in a world much richer in purchasing power for goods and services than it is today.

23.1.3 Carbon pricing and inflation

The introduction of carbon pricing will generate a once-and-for-all increase in the general price level. The inexorable rise in the carbon price, beyond the initial shock, will not contribute comparable continuing pressure on the price and cost structure. At a $20 per tonne initial price (2005 dollars), the subsequent annual increases in carbon prices would be about one dollar in the early years, and would gradually increase in annual impact after that. If the direct price effect of the increase in the emissions price were initially to raise the general price level by about one percentage point, the next year's impact would be about one twenty-fifth of a percentage point. As the process of decarbonisation proceeds, the products of newly competitive low-emissions processes can be expected to experience more rapid technological improvement than established high-emissions products and processes, so that their relative prices fall over time. At some point, part of the way through the decarbonisation process, falling economy-wide costs of newly competitive products and processes would outweigh the effects on costs through the economy as a whole of the rising carbon price.

A starting price in 2010 of around $20 per tonne in 2005 prices would raise the consumer price index by about one percentage point. As the Governor of the Reserve Bank of Australia observed in September 2008, this would not require a tightening of monetary policy in response if it were a once-for-all increase that did not then trigger subsequent increases in the general cost and price level.[1] On the other hand, if introduced at a time of strong demand and a tight labour market, it could raise inflationary expectations and generate pressures for compensating wage increases.

One important element in a set of policies to prevent a flow-on into the general cost structure is a household compensation package that at least maintains real purchasing power of people with incomes at levels covered by the regulated wage system. The proposed household adjustment package, directing half the permit revenue to the bottom half of the income distribution, would provide this element. Normal prudence in management of monetary conditions would avoid the transmission of the price increases associated with the introduction of the emissions trading scheme to other income levels.

Thus the household compensation package is not only important for equity, but a critical element in maintaining price stability and avoiding monetary tightening that would not otherwise have occurred.

Household incomes are projected to increase at rates comparable to historical trends in the reference case and also in the 550 and 450 mitigation scenarios as shown in Table 23.1. After-tax income per capita in 2020 would be 17 per cent higher than in 2006 with no mitigation, 15 per cent higher with 550 mitigation and also 15 per cent higher with 450 mitigation. By 2050, average income per capita after tax would be 66 per cent higher than in 2006 with no mitigation, 57 per cent higher with 550 mitigation and 55 per cent higher with 450 mitigation. In the second half of the century, the gap closes then reverses.

Table 23.1 Total after-tax per capita income (2005 dollars)

	2006	2020	2050
Reference	$36 548	$42 676	$60 622
Reference—relative to 2006	–	+17%	+66%
550 standard technology scenario	–	$42 207	$57 304
550 standard technology scenario—relative to 2006	–	+15%	+57%
450 standard technology scenario	–	$42 044	$56 675
450 standard technology scenario—relative to 2006	–	+15%	+55%

Source: MMRF reference case and policy simulations without climate change impacts.

The greatest impact on consumption is projected to be on electricity, as described in Chapter 20. Residential electricity prices for the 550 and 450 backstop technology scenarios would be 21 per cent and 37 per cent, respectively, higher by 2020 than they would have been in the reference case. Beyond electricity, there would also be minor reductions in consumption of air transport, heating and some chemicals. However, these changes are small when compared with the changes in overall consumption that occur over time as a result of normal changes in consumer preferences and incomes.

23.2 The economy to and at 550 ppm

The Review's joint modelling with the Australian Treasury focused on an emissions constraint to meet Australia's proportionate share of either a global 550 or 450 objective. Average output and consumption of Australians at the end of the century are more than three times as high as now under any of the modelled scenarios.

The no-mitigation scenario from the Garnaut–Treasury modelling has GNP growth much slower than GDP growth over the next decade, as Australia's terms of trade fall from extraordinary and unsustainable heights to high but more moderate levels. From 2013 to 2020, average annual growth is expected to be 2.7 per cent for GDP and 2.1 per cent for GNP. Incidentally, the assumed fall in the terms of trade deducts almost twice the amount of incomes growth as does the more ambitious of the mitigation scenarios.

Average annual GNP growth rates from 2013 to 2020 are expected to fall from 2.1 per cent with no mitigation, to around 1.9 per cent under a 550 scenario with backstop technology assumptions (see Chapter 11) and 1.8 per cent under a 450 backstop technology scenario.[2] These initial costs are not small. The growth costs of mitigation fall after the carbon pricing has been established, and lessen over time. The difference between no-mitigation and 550 growth rates falls to a tenth of a percentage point between 2020 and 2050 (Table 23.2).

Table 23.2 Annual average growth rates for GNP and GDP under the no-mitigation, 550 and 450 scenarios with backstop technology (Type 1 and Type 2 benefits of mitigation) (per cent)

Average annual growth rates	2013–20	2021–50	2051–2100
Unmitigated climate change (GNP)	2.1	1.7	2.0
Unmitigated climate change (GDP)	2.7	1.7	2.0
Stabilisation to 550 ppm backstop technology (GNP)	1.9	1.6	2.1
Stabilisation to 550 ppm backstop technology (GDP)	2.5	1.7	2.1
Stabilisation to 450 ppm backstop technology (GNP)	1.8	1.6	2.2
Stabilisation to 450 ppm backstop technology (GDP)	2.5	1.6	2.1

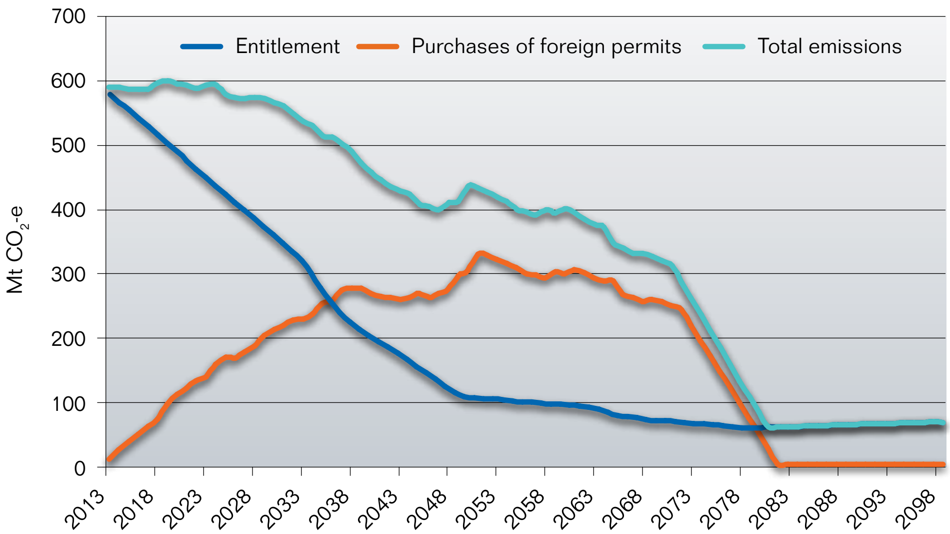
Source: MMRF adjusted to include Type 2 costs of climate change (see Chapter 11).

The modelling has the Type 1 and estimated Type 2 benefits from avoided climate change significantly reducing the net economic costs of mitigation from 2030, and increasingly so with passing decades. Over the second half of the century, average growth rates are a tenth of a percentage point higher under 550 than with no mitigation, and higher still under 450. By 2100, GNP is slightly higher with mitigation than it would have been without it.

The achievement of this mitigation task involves a major change in the structure of the economy. Australia's total emissions entitlement in the 550 scenario will be 35 per cent below business-as-usual emissions in 2020 and 90 per cent by 2050. Note that the comparison is with business-as-usual for 2020 and 2050, and not with a base year from the MMRF modelling. As shown in Figure 23.1, Australia purchases a significant volume of emissions permits from other countries. Beyond a certain point, it is cheaper for Australia to buy permits from abroad at the prevailing international price than to reduce emissions from the domestic economy. International purchases cease once a backstop technology is adopted.

The proportion of domestic mitigation relative to purchases of permits is influenced by the specific parameters of the models used. For example, GTEM shows higher levels of domestic mitigation than MMRF for the same permit price.

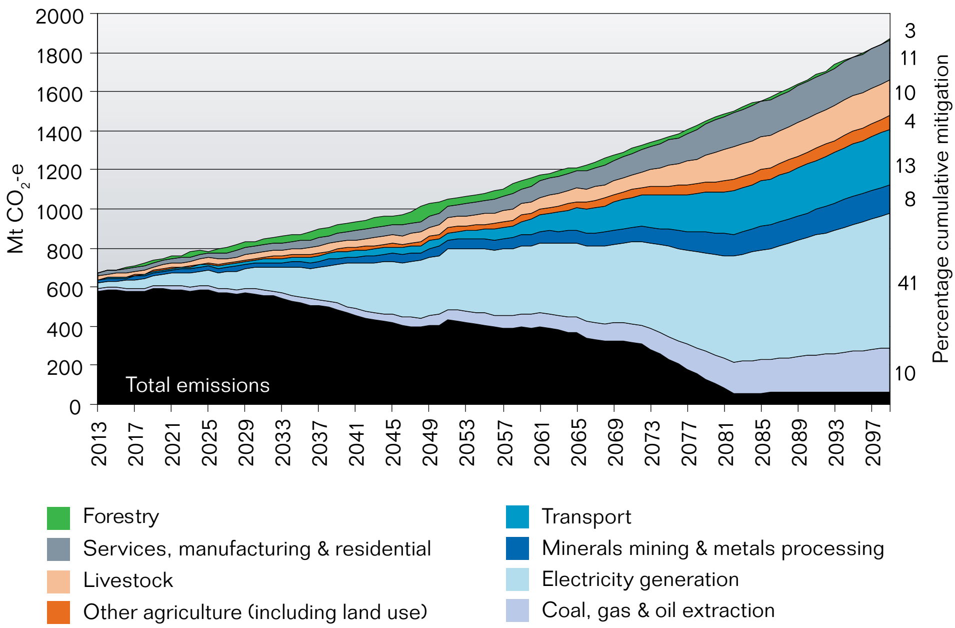
Figure 23.1 Australia's emissions in the 550 backstop scenario (global entitlement, net of trading)



Note: These results were generated using MMRF.

Figure 23.2 shows how mitigation under the 550 backstop scenario is achieved in Australia. Electricity generation makes the largest contribution, with the sector largely decarbonised by mid-century. The modelling indicates that there will be little growth and, over time, some pressure for contraction of highly energy-intensive, trade-exposed sectors such as non-ferrous metals in Australia. This follows from the exceptionally high emissions intensity of Australian energy. However, as discussed further below, this is one area of uncertainty, as there is some prospect that Australian energy costs will remain low by world standards. Other determinants of Australian competitiveness in processing minerals and energy commodities will strengthen.

Figure 23.2 Sources of mitigation under the 550 backstop scenario



Note: These results were generated using MMRF.

The rising and eventually high price of emissions accelerates a move away from fossil fuels, first of all coal. This would have to occur in the longer term regardless of climate change. It will come sooner with mitigation. Beyond this period, and in line with achieving emissions reductions of 80 or more per cent below 2000 levels by mid-century, the sources and cost of mitigation will be determined by the emergence of technologies either to provide net greenhouse gas absorption, or to deal with the remaining fugitive emissions from ruminant livestock and some other activities, probably including civil aviation.

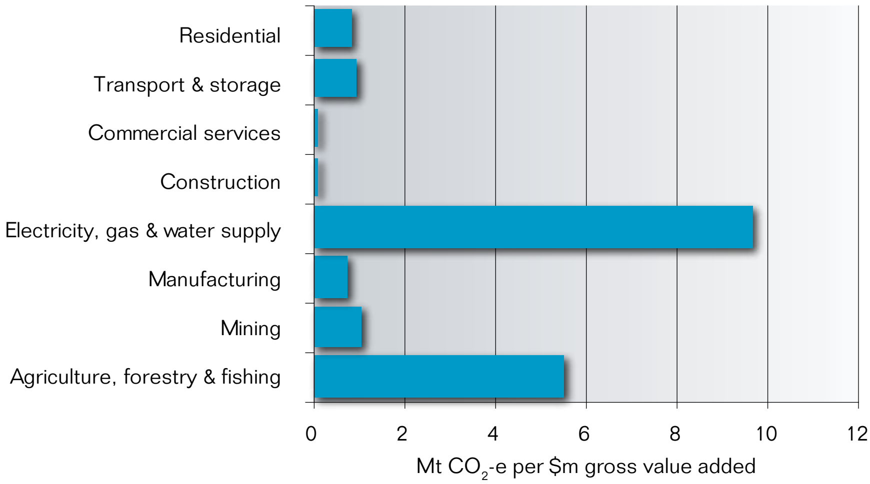
The sectoral implications of climate change mitigation

The responses of various sectors to the rising emissions price are triggered by the emissions intensities of wider supply chains. The immediate impact is on sectors with large direct emissions, as illustrated in Figure 23.3 for 2005. Electricity, gas and agriculture stand out for their high direct exposure to emissions pricing.

Electricity is a primary input to many industries. The impact on electricity generation flows through to consumers and also to electricity-intensive downstream sectors such as aluminium. This is shown in Figure 23.4, which includes both direct and indirect emissions.

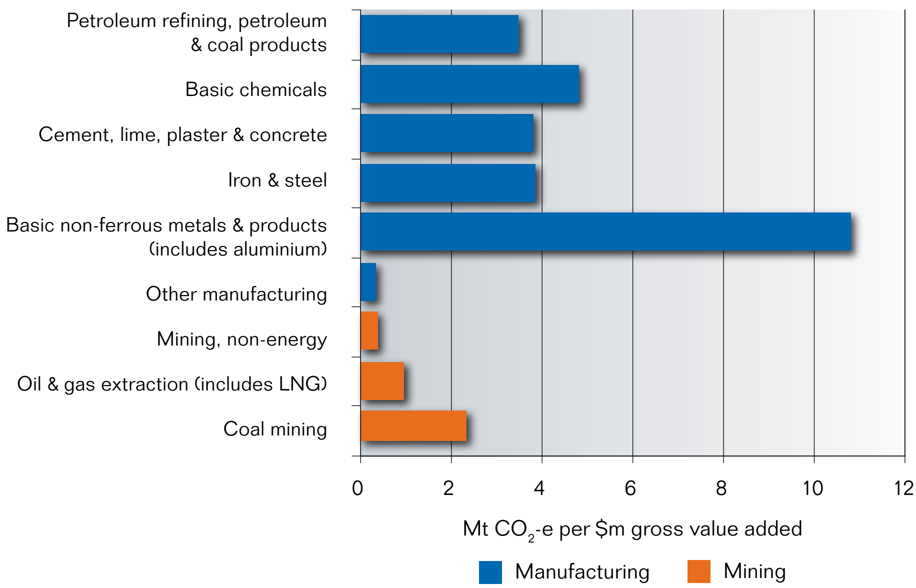
The ratios in the figures are sensitive to the relevant commodity prices. In the resource-based sectors such as coal, liquefied natural gas, non-ferrous, iron and steel, the rising prices of recent years will have significantly reduced these intensities.

Figure 23.3 Direct emissions per million dollars value added, 2005



Sources: ABS (2008); DCC (2008b).

Figure 23.4 Direct and indirect emissions per million dollars value added, mining and manufacturing, 2005

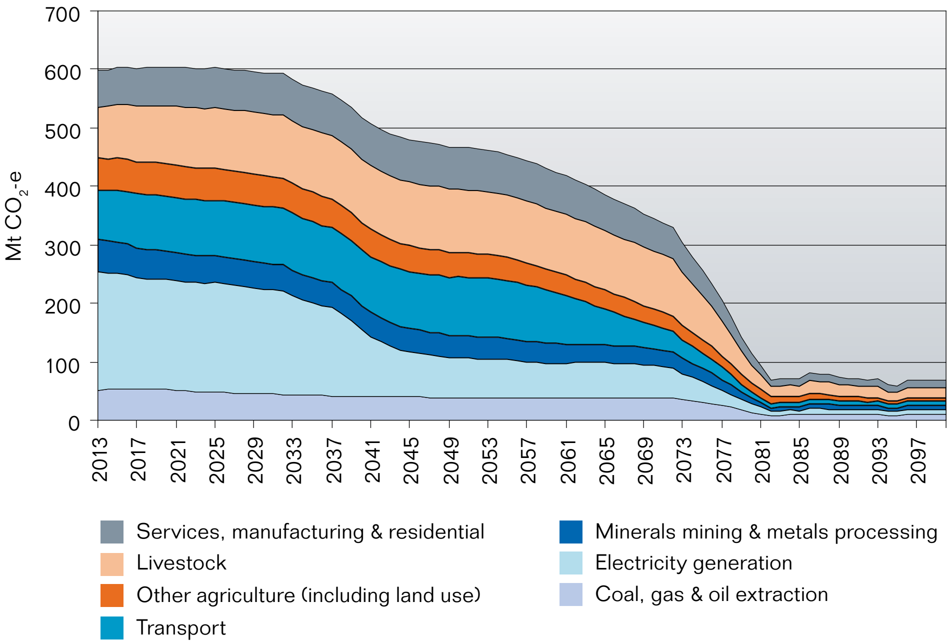


Sources: ABS (2008); DCC (2008a).

The direct impact on petroleum products will be felt through the transport sector, and subsequently in sectors where transport is a significant input cost.

Figure 23.5 illustrates how emissions are projected to fall across major sectors as the rising carbon price forces change. It highlights differences in the incidence of pressures for structural change across various Australian industries. Whereas Australian emissions are heavily concentrated in electricity in the early years, by the later decades of the century a high proportion is associated with livestock. This reflects the substantial known technology opportunities to reduce electricity sector emissions, and the more limited known opportunities for livestock.

Figure 23.5 Emissions sources (not including forestry) in the 550 backstop technology scenario



Note: These results were generated using MMRF.

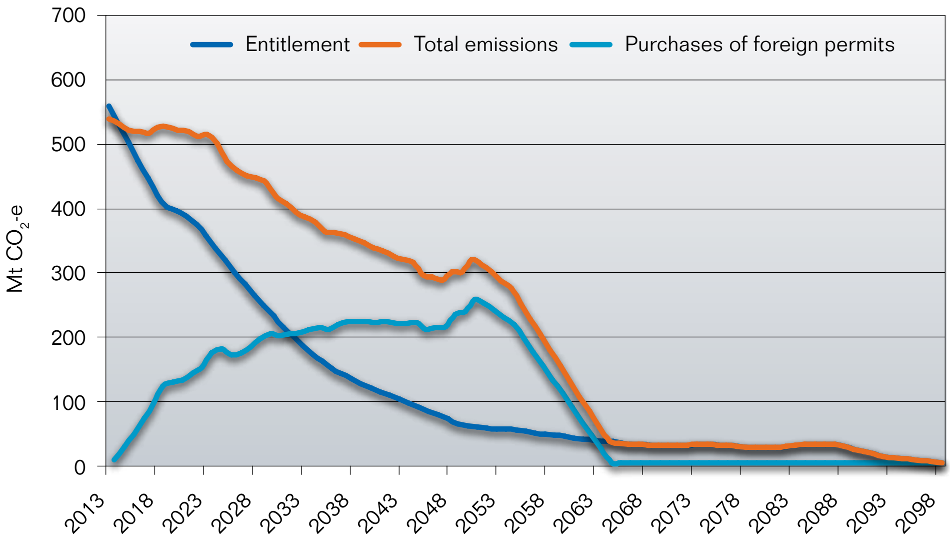
Mitigation results in strong expansion of some industries, in particular agriculture, forestry and renewable electricity generation. Agriculture is particularly exposed to the effects of climate change. Global mitigation of climate change will therefore result in significant benefits to agriculture as the more severe outcomes are avoided.

23.3 The difference between 550 and 450

Stronger mitigation deepens and accelerates the changes described in the 550 scenario. In the 450 scenario, Australia's emissions entitlement would be 47 per cent below the levels that it would have been in 2020 in the absence of mitigation, and 94 per cent lower by 2050.

As the permit price rises in each of the scenarios, but more quickly and powerfully in the 450, deeper utilisation of domestic mitigation opportunities becomes cost effective. The international price of permits is substantially higher in the 450 backstop technology scenario, and Australians buy fewer permits abroad despite the greater abatement task (Figure 23.6).

Figure 23.6 Australia's emissions in the 450 backstop technology scenario (global entitlement, net of trading)

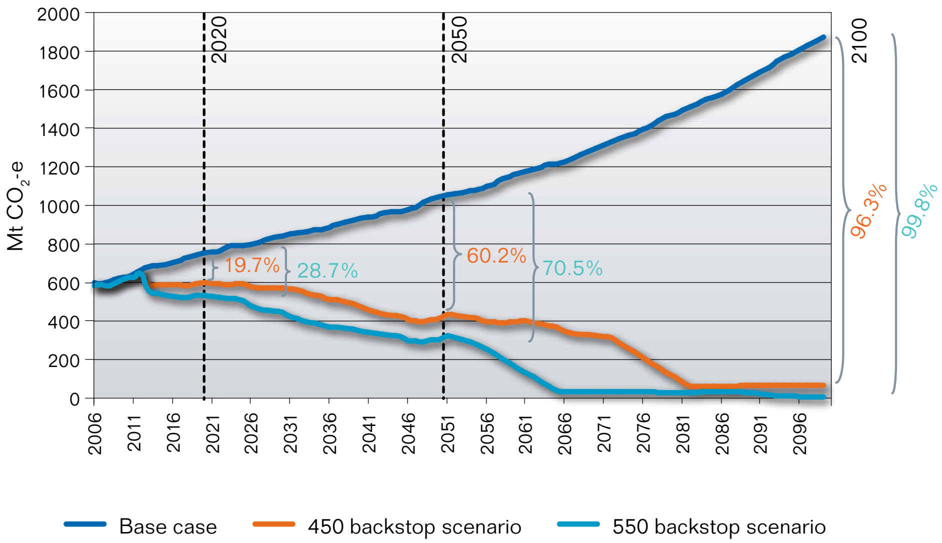


Note: These results were generated using MMRF.

Australia's emissions, even after substantial permit acquisition through trading, will be significantly below what they would have been in a scenario without mitigation, as illustrated in Figure 23.7.

Many of the changes under the 450 backstop technology scenario are qualitatively similar to those in the 550 scenario, but they are larger and occur sooner. Retail electricity prices increase more and continue increasing (approximately 70 per cent higher in real terms by 2020, compared with 40 per cent for 550). Decarbonisation of the electricity sector and electrification of the transport sector occur earlier, with consequences for the roles of fossil fuels and renewable technologies, as described in Chapter 20. Some existing high-emissions electricity generation plant retires earlier.

Figure 23.7 Total emissions for the no-mitigation, 450 and 550 backstop scenarios



Note: These results were generated using MMRF.

The sources of mitigation and the changing profile of Australia's emissions in the 450 scenario are shown in figures 23.8 and 23.9. These can be compared with figures 23.2 and 23.5 to see the differences across the scenarios.

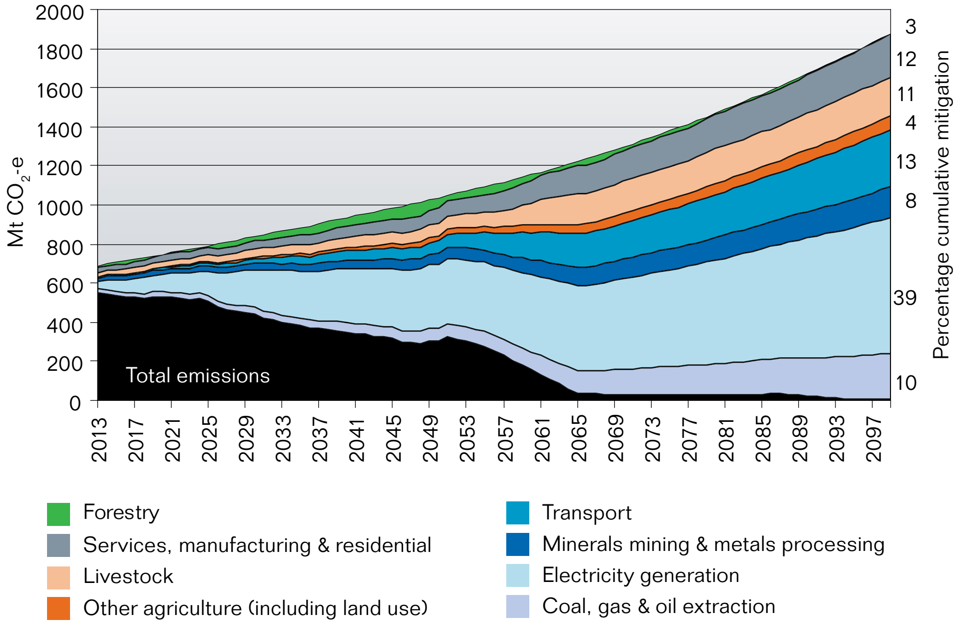
An overarching conclusion from the above is that the availability of superior low-emissions technology becomes more urgent as more ambitious targets are contemplated. This places an even heavier load on early support for research, development and commercialisation of such technologies (see Chapter 18).

23.4 Australia in the low-emissions world energy economy

Global mitigation is likely to lower Australia's terms of trade through its effects on demand for fossil fuels. Australia would experience these costs whether or not it was itself engaged in strong mitigation. In this, Australia's position is different from that of most other developed countries. The United States, the European Union, Japan, New Zealand and Korea are all net importers of fossil fuels. Their terms of trade would all rise with strong global mitigation.

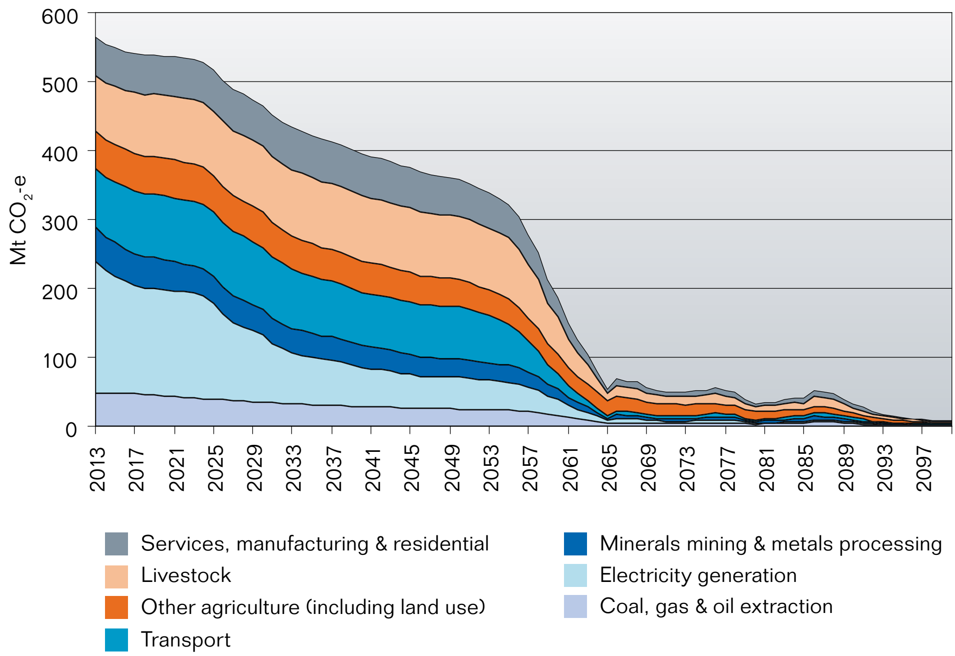
Will Australia continue to have low (carbon-price-inclusive) energy costs on an international scale? The answer to this question will be the main determinant of whether Australia continues to have a comparative advantage in metals processing, and exports metals and other processed mineral products. Countries with superior natural opportunities for low-cost biosequestration or geosequestration of emissions will have an advantage in producing goods and services with large

Figure 23.8 Sources of mitigation under the 450 backstop technology scenario



Note: These results were generated using MMRF.

Figure 23.9 Emissions sources (not including forestry) in the 450 backstop technology scenario



Note: These results were generated using MMRF.

emissions from fossil fuels. If geosequestration with high capture efficiency (near 100 per cent) is commercially successful, the answer will be in the affirmative. It would be in the affirmative for energy based on fossil fuels even if its geosequestration sites were of average quality in global terms. Australia seems to be relatively well endowed with sites that are suitable for geosequestration. If, as may be the case, biosequestration based on the use of algae to convert carbon dioxide wastes to stable carbohydrates becomes commercially viable, Australia will also be a favourable location. Our sequestration sites seem to be of superior economic quality across the range of possible technologies. Australian energy costs will be lower than international costs to the extent that carbon capture and storage or biosequestration is commercially successful, as the export parity price of gas, especially, and coal, will be much lower than the price in importing countries.

For a number of years, new investment in energy-intensive processing, for example aluminium smelting, will be concentrated at sites with low-cost, low-emissions energy supply that do not have established outlets in major urban and industrial centres. Hydroelectric and conventional geothermal capacity in developing countries will be the first prize, and gas deposits that are not easily developed for export through pipelines or liquefaction second. But it will not take long to exhaust this capacity, and whether or not Australia re-emerges as an attractive location for energy-intensive processing beyond that point will depend on the many factors that will determine whether it has relatively low energy costs in a low-emissions world.

Natural gas, from traditional geological formations but increasingly from coal seams, will receive a powerful competitive boost in the early years of a rising emissions price. The growth and prices of coal exports will soon be damaged by other countries' mitigation in the absence of carbon capture and storage in our major markets and beyond (Chapter 20). Partial capture and storage of carbon emissions from coal combustion will provide a long reprieve. But a time will come, over the next several decades, when only full capture and storage of carbon wastes from coal and gas combustion can hold a role for coal in power generation. Metallurgical coal exports would hold up better for longer in the absence of capture and storage.

If carbon capture and storage and commercial-scale biosequestration of carbon wastes fail, so that fossil fuels become unimportant in the global energy equation, Australia may still be a country of relatively low energy costs. We seem to have exceptionally low-cost resources, in abundance compared with population, for most renewable energy: deep hot rocks (geothermal), solar, wind, wave, biomass and second-generation biofuels.

Although Australia does not have abundant hydroelectric capacity, the world's low-cost capacity is likely soon to be fully utilised. Global prices for energy-intensive products are likely still to be determined by the cost of other sources of power, in which Australia is relatively well placed on a global scale.

23.5 The downside risks

There are three types of risks that could seriously and adversely change economic outcomes in the process of transition to a low-carbon economy. The first is that there may not be an early comprehensive global agreement. The second is the possibility that, even with an effective international agreement to hold concentration at around 550 or even at 450 with overshooting, the inevitable climate change with which it is associated will turn out to be at the bad end of the probability distribution of possible outcomes. The third relates to unexpectedly high costs of mitigation emerging from technological disappointments, or unnecessarily high costs from bungling of mitigation policy design or implementation.

The biggest risk is that there will be no comprehensive global agreement at Copenhagen. This, at this stage, looks more than a small risk. The framework of international negotiations established at Kyoto in 1997, and continued in Bali in 2007, contains weaknesses that, if not removed over the year ahead, make successful agreement at Copenhagen unlikely.

The weaknesses have been described in chapters 8 to 10. The UN discussions have enshrined the idea that developing countries for the foreseeable future will not be required to enter commitments on emissions reductions. Developing country commitments are needed for the numbers to add up to effective international agreement to reach a 550 outcome.

The most likely alternative to comprehensive agreement in Copenhagen is partial, ad hoc agreement. This is a problematic second best. Strong global mitigation is impossible in an ad hoc world.

The second risk relates to uncertainty about the climate change effects of increases in greenhouse gas concentrations, and in their impacts on Australian economic activity and life (chapters 2 to 6). At concentrations of 550 ppm and 450 ppm, there is a possibility of effects on economic activity and life that are so much greater than the median prospects upon which the modelling is based that they could negatively transform the outlook, even after successful international cooperation around strong mitigation objectives.

No feasible degree of global mitigation from this time, at the end of the first decade of the 21st century, would remove the possibility of potentially destabilising outcomes. Some risks would remain even if the international community effectively committed itself now to 450 ppm atmospheric concentrations of carbon dioxide equivalent—which would require a peaking profile, and therefore periods in which concentrations went higher than 450 ppm, and then contracted.

There is some small risk that the suite of technologies available for the economic transition to low emissions will turn out to be less favourable than assumed even in the standard technology case in the modelling of costs of mitigation discussed in chapters 11, 20, 21 and 22. The risk of mitigation turning out to be much more expensive than expected for reasons outside technology is more important. It has its origin in human behaviour rather than in laws of nature. This is mostly about frictions in the introduction and operations of the mitigation regime. Three sources of friction are potentially important.

23.5.1 Frictions in the mitigation regime

There could be a long period of uncertainty about the rules of the game, and in particular about targets and trajectories going forward. Uncertainty would raise the supply price of investment to the emissions-intensive industries, and miscalculations arising out of it could greatly increase the costs of adjustment to the low-emissions economy.

Some uncertainty is inevitable, given the good reasons why trajectories will need to be adjusted from time to time. The challenge will be to economise on uncertainty. This can be done best by specifying as closely as possible and as far into the future as possible, the possible trajectories, international and national, and the conditions under which there will be movement from one to another.

Any perception that parameters of the arrangements remained open for negotiation with business after its commencement will be counterproductive. Here the greatest vulnerability would arise out of payments to trade-exposed industries, and, should the advice from this Review not be followed, compensation to business for the introduction of the emissions trading scheme. There could also be high costs from diversion of managerial effort into competition for government preferment through the interaction of national mitigation regimes with the international trading system. The differential impact across countries of arrangements affecting trade-exposed, emissions-intensive industries would lead to pressure for countervailing payments, in the form of 'free permits' or in other ways. Inevitably, this would come to interact with protectionist pressure of a conventional kind. Protectionist responses in some countries would increase pressures for the transfer of value to special interests in other countries.

The costs to good governance of continuing negotiation and encouragement of rent-seeking behaviour could be high—in the extreme, possibly as high as the unavoidable costs of mitigation itself.

There are three elements of the mitigation regime that are important in avoiding a blow-out in costs. First, any transfer of value to special interests must be undertaken transparently on the basis of clear and sound principles. Second, no elements of the regime involving transfer of value to particular interests can be left open for negotiation after the commencement of the scheme. Third, any transfers of value to particular firms must be made through an independent agency, operating at arms length from political government. Internationally, it is important that payments and trade interventions in relation to trade-exposed industries be made within a principled framework agreed within the World Trade Organization.

23.6 The upside in technology assumptions

The quantitative analysis undertaken by the Review has extended models into time frames and levels of mitigation not previously explored. In doing so, the limits of assumptions regarding technology developments and substitution possibilities become a further constraint on the timing and costs of projected mitigation in the second half of the century. Together, these assumptions become the critical determinants of the preferred sources of mitigation and the residual emissions that are shown in figures 23.2, 23.5, 23.8 and 23.9.

The consequence of these assumptions around development of mitigation technologies is that the overall cost of mitigation is kept implausibly high, even before the introduction of a backstop technology at an emissions price of $250 per tonne. A more plausible future would be one in which the increasing carbon price delivers a range of new technologies across many sectors that have not been modelled in detail at this stage. This unfolding technological reality may diverge from the modelling assumptions in ways that transform for the better the costs of change. Such developments would also transform ambitions for strong mitigation, raising perceptions of what is possible, and in all likelihood raising mitigation achievements on a global scale. A number of broad areas of opportunity have been identified that would lead to this outcome.

23.6.1 Broad opportunities

The first area of opportunity involves better use of known and established technologies. The realisation of potential for greater energy efficiency may turn out to be much less costly than anticipated in the model. The standard technology assumptions used in the joint modelling with the Australian Treasury allowed for modest gains from this source, but much less than some detailed studies have suggested were available (most recently in Australia, from the McKinsey Consultancy (2008) and by McLennan Magasanik Associates for the Climate Institute (2008)).

Chapter 17 discussed the reasons for incomplete use of established technologies for improving economic outcomes by using energy more economically. They are of two kinds. One relates to the economics of information. The other relates to flaws in incentives structures, most importantly through the presence of contractual arrangements that separate the parties who must pay the costs of change from those who benefit from change.

Can these sources of market failure be overcome at reasonable cost? We do not know what will turn out to be possible with a rising emissions price and a culture of adaptation to an emissions constraint. The standard technology scenarios assume that they can be overcome to some extent. However, it is possible that the combination of rising carbon and energy prices, some well-designed public programs on energy efficiency, and changes in the habits of communities that are focusing strongly on the changes necessary to make greenhouse mitigation work, will generate stronger results.

In energy, the range of existing primary energy sources such as coal, gas and uranium, the development of low-emission fossil fuel technologies, and the development of renewable technologies such as geothermal and solar thermal could occur faster than projected and, possibly, at lower costs than are assumed in the standard cases. A critical uncertainty in this area relates to the costs and effectiveness of geosequestration of carbon dioxide wastes. This is a source of downside as well as upside risks. It is possible that highly effective carbon capture and storage could come earlier and at lower cost than assumed in the modelling. There is also a chance, albeit assessed as much less likely, that it will come later, be more expensive or prove to be less effective. Much hangs on the outcome. A large disappointment to outcomes embodied in the models would increase the medium term costs of power, and undermine the prospects of what is now and prospectively Australia's largest export industry.

The broad area of biosequestration is a potentially much larger source of opportunity for upside surprises on technology beyond that assumed in the modelling. The upside here is so large that it has the potential to transform both the Australian and the international mitigation tasks (Chapter 22). There are many barriers to overcome if this potential is to be realised. There must be changes in the accounting regimes for greenhouse gases. Investments are required in research, development and commercialisation of superior approaches to biosequestration. Adjustments are required in the regulation of land use. New institutions will need to be developed to coordinate the interests in utilisation of biosequestration opportunities across small business in rural communities. Special efforts will be required to unlock potential in rural communities in developing countries, nowhere more importantly than in Australia's near neighbours.

In transport, Australia is likely to be a fast follower. However, the Australian market and its location relative to fast-growing Asian economies could facilitate a role as a testing and development market for new, low-emissions fuel and vehicle technologies. For example, the introduction of hybrid and fully electric cars may proceed more rapidly than assumed in the models under the influence of high prices for fossil fuels and a rising carbon price.

Chapters 20 to 22 drew attention to other ways in which the standard technology assumptions of the modelling were conservative on the application and potential for cost reduction in technologies that are currently close to large-scale commercial applications.

An 'enhanced technology' scenario was developed to capture some of these opportunities and to assess their impact on the mitigation scenarios. This scenario includes a greater level of energy efficiency across the economy and considers how the energy, transport and agriculture sectors might respond to stronger assumptions around technology development. These details are described in chapters 20 to 22, while the scenario and its macroeconomic implications are described in Box 23.1.

Box 23.1 Enhanced technology assumptions

The Garnaut–Treasury modelling work conducted a simulation of an 'enhanced technology' scenario in the global general equilibrium model (GTEM) to assess the potential impact of a more optimistic outlook for technology development. This scenario incorporates the combined effects of greater energy efficiency and faster technology learning in the early years, and more effective carbon capture and storage technology, as well as the elimination of non-combustion emissions in agriculture at higher carbon prices (see Chapter 11).

Under this enhanced technology scenario the effects on Australia's GDP in both the 550 and 450 ppm scenario are reduced by around one-third on average throughout the century. The cost savings are particularly strong in the second half of the century. In the 450 ppm scenario, Australia's GDP costs are reduced by almost 45 per cent. In the latter half of the century, Australia's relative cost reductions exceed the global average, as agricultural emissions and carbon capture and storage play a relatively greater role.

The effects on GNP for Australia are even more pronounced than on GDP, because of reduced expenditure on permit purchases in international markets. Under the enhanced technology scenario, Australia achieves greater levels of mitigation domestically and remaining permits that need to be bought come at a lower price because mitigation options are better in other countries as well. As a result, Australia's GNP costs in the second half of the century are reduced by over 50 per cent.

The near-zero-emissions carbon capture and storage assumption within the enhanced technology scenario plays an important role in the future composition of power generation in both scenarios, as described in Chapter 20. The share of electricity generated in Australia using fossil fuels with carbon capture and storage is substantially higher in the enhanced technology scenario, especially under 450 mitigation and under high carbon prices.

This in turn has major implications for Australian coal production and exports. Near-zero carbon capture and storage would allow a continued expansion of coal use both domestically and internationally, even under a tight global carbon constraint. By contrast, if carbon capture and storage does not move beyond 90 per cent, then it would be poised to become a transitional technology on the way to very low emissions levels, which ultimately would be achieved almost exclusively through renewable technologies and/or with the introduction of nuclear energy in circumstances described in Chapter 20.

23.7 The importance of flexible global and national markets

The maintenance and enhancement of Australian prosperity through and after the transition to a low-carbon economy will depend mainly on the same factors, plus one, that determined success in earlier times, before the realisation that global warming was an issue to be managed.

That one is the effective introduction of efficient means of constraining Australian greenhouse gas emissions, within a global system of constraints that holds concentrations to levels that avoid dangerous climate change.

Continuing and expanding prosperity will depend on sound economic governance, now including governance of an inevitably intrusive system of mitigation. These issues have been discussed at length in relation to the emissions trading scheme, the correction of market failures associated with adjustment to a carbon constraint, and adaptation to inevitable climate change (chapters 14, 15, 17, 18 and 19).

Success will depend on the presence of flexible and efficient markets for goods, services, factors of production and now emissions entitlements, all deeply integrated with international markets. It will depend on high and well-focused investment in education and the development of skills, now with even greater concentration than before on the areas in which Australia has both longstanding strengths and current deficits, related to engineering, management and financing in the resources, energy, construction and transport sectors.

In circumstances of changing relative prices of goods and services in response to the mitigation regime, there will be pressures for government to constrain the increases in prices that are a necessary part of adjustment to the emissions constraint. There will be pressures to protect particular interests and asset values from the changes that are inevitably associated with successful adjustment to the carbon constraint. There is a danger that governments will respond to these pressures in ways that greatly increase the costs of adjustment and which seriously diminish prospects for economic growth. Other governments will be under similar pressures, and there is therefore substantial risk that international markets for goods and services will be distorted by protectionist interventions.

The risks will be greatest in markets for the most emissions-intensive goods and services: energy, transport and food.

23.7.1 Energy markets

In energy markets, two innovations are critical to provide the necessary flexibility. One is the removal of price caps on retail power prices accompanied by reliance on competition to secure reasonable pricing. For this to be possible, government would need to introduce explicit, alternative approaches to fund equity measures through the budget, in ways that do not distort market pricing of power.

The second innovation required is the establishment of a genuinely national energy market across all of the regions that can be connected at reasonable cost to the main centres of generation and demand in eastern and south-eastern Australia—the electricity markets of New South Wales, Victoria, Queensland, South Australia, Tasmania and the Australian Capital Territory. This will require deeper and more dense interconnectivity between subregional markets, allowing electricity production to expand from sources at which it can be supplied at lowest cost in the new, carbon-price-inclusive environment. Deeper interconnectivity will support efficient expansion and use of potential for pump storage in Australia's main hydroelectric assets in the Snowy Mountains and Tasmania, thus easing the constraints associated with intermittency of wind and solar power. The test of the emergence of a national market is economically low differentials in electricity prices, and close correlation in changes in electricity prices, across regions.

Effective markets will require removal of constraints on investment in response to opportunity for profitable expansion of power generation and distribution capacity. This adjustment could be made through extension of the privatisation of power business assets owned by state, territory and federal governments. Where major facilities continue to be owned by governments, it is important that these assets be managed within corporate structures that allow commercially efficient responses to opportunity. To artificially constrain investment in expansion of the main hydroelectric assets, for example, would remove a major opportunity for overcoming constraints on the use of intermittent renewable energy technologies.

On managing the risks to open international markets, the main challenge is to ensure that there are principled constraints on assistance to trade-exposed industries in the period of partial, national mitigation prior to comprehensive global agreement. The formula for support of trade-exposed, emissions-intensive industries set out in Chapter 14 would be extendable internationally in ways that minimised risks of distortion.

23.7.2 Transport

In transport markets, too, there will be resistance to price changes in response to the emissions constraint. Recent Australian experience illustrates the sensitivity of this issue, with the Australian Government's proposal in the Green Paper on a Carbon Pollution Reduction Scheme effectively to exclude transport fuels from the early operations of the Australian emissions trading scheme. Such exclusions create arguments for other exclusions, and can quickly lead to a plethora of market-distorting interventions. They are to be avoided.

23.7.3 International food markets

International food markets are deeply distorted by subsidies, restrictions and tariffs on imports and price controls in many countries, and most of all in the developed countries of the northern hemisphere. Such distortions will create major problems for efficient response to changing climatic conditions, competition between food and mitigation (biofuels) for land resources, and costs of inputs in the years ahead. The extent of the problem is illustrated by international responses to high food prices in 2007 and 2008, when new restrictions on exports exacerbated fluctuations in global prices, and reduced confidence in international markets in food importing countries.

The world, and Australia, will need deep and flexible global food markets to manage the fluctuations and changes in supply conditions in response to climate change and its mitigation. Population growth, greater variability in climatic conditions, and the effects of climate change on agriculture will make Australia economically a food importer from time to time, perhaps even under normal conditions. The new global challenge of climate change adds to the good reasons for giving priority to resolving the old problem of distorted global agricultural markets.

23.8 The importance of education and training

The structural changes that will emerge in a low-emissions, growing economy will change requirements for human capital. In Australia, a history of skills development has been inherent in a globally successful resources sector. Australia should be structurally well placed to apply such skills to new activities.

At the same time, the additional requirements will place added strain on an education and training system already under pressure from the resources boom and the associated shifts in employment between key sectors.

The work of the Dusseldorp Skills Forum (Hatfield-Dodds et al. 2008) has indicated that more than 2.5 million jobs will need to be filled over the next two decades. Many of these jobs will be in areas either directly or indirectly influenced by the climate change response. In addition to the construction and energy sectors, areas of potential employment change include transport, agriculture and a range of services. Many of these jobs will be in industry subsectors that barely exist today and some that lie within the imagination of farsighted entrepreneurs. The need to supply appropriately skilled people for these jobs is in addition to the need to develop new knowledge and skills in existing roles and sectors around the issues that emerge from the implementation of climate change policies. There will be few sectors left untouched.

The implications of these changes for Australia's education and training sector are yet to be fully appreciated. These implications, and the necessary response from government, business, labour and our educational and training institutions, need to be comprehensively understood and integrated into the long-term planning of these bodies.

23.9 Global mitigation and ongoing prosperity

The exceptional prosperity of Australia through the early 21st century has emerged through the productive interaction of a flexible, internationally oriented domestic economy with the opportunities generated by rapid growth in the major Asian countries. Will the international environment continue to be conducive to Australian prosperity in an era of climate change mitigation and climate change?

Sustained, strong economic growth now has deep roots in China. It is well established, at a less frenetic pace, in India and Southeast Asia. It is gaining institutional sinews but remains vulnerable in other developing and transitional economies.

Throughout the developing and transitional economies, the beneficent processes of rapid economic growth that have emerged or strengthened in the current century are vulnerable to large shocks that disturb established social and political relationships and institutions and break the momentum of growth.

The risk in China, in the two decades that are required to complete the major part of its remaining transition to a developed economy, derive mainly from the dynamics of the complex political and social change set in train by sustained rapid economic growth. Large shocks from climate change could interact with these dynamics in destabilising ways. More immediately, differences in approach to mitigation between China and the developed world, especially the United States, would add fuel to the reactions to Chinese export expansion that are already smouldering. A protectionist conflagration fuelled by differences over climate change is as likely to hurt the developed world as China. But all would be damaged—China and its trading partners, and none more than Australia.

In the developing world beyond China, shocks from climate change are among the potential threats to growth, as risks of large impacts increase through the 21st century.

Climate change mitigation in the developing world will have large effects on Australian opportunity. Australia has a strong interest in mitigation not slowing growth in developing countries. The proposals for global mitigation put forward in this Review are consistent with sustained strong growth in the developing world.

Partial mitigation would define a difficult world for Australia. This is a world in which there are large risks of trade interventions in developed countries, prompted initially by valid concerns about 'carbon leakage', but spilling over into crude protectionism. This would be directly damaging for Australian trade, and probably even more damaging through its effects on developing countries whose economic health is important for Australia.

More than other developed countries, Australia has a comparative advantage, properly assessed to take carbon externalities into account, in industries vulnerable to carbon leakage. Australia therefore has a particularly strong interest in early movement to comprehensive global mitigation. It is important for Australia that major developing countries participate in international trade in emissions entitlements, or else accept participation in sectoral agreements, applying domestic carbon taxes, in the main trade-exposed, emissions-intensive industries.

There is a large risk that governments will apply domestic mitigation policies that favour domestic over international coal sources. China and Indonesia in particular, but also India, have large domestic coal resources, while being substantial and rapidly growing importers. In a shift away from reliance on coal for power generation, there would be strong tendencies first to exclude imported coal. The only safeguards would be provided by strong international trading rules and efficient domestic mitigation regimes. Metallurgical coal is less vulnerable.

Effective mitigation regimes would affect Australian metal exports in complex ways, but would mostly be advantageous. It is likely that effective mitigation would be associated with reduction of subsidies for domestic processing of metals—such as is already important in Chinese policy development. Again, Australia has a strong interest both in an effective global trading system and in efficient mitigation.

Australia is a global leader in the wide range of skills and technologies that are relevant to high performance in the resource industries. Businesses with headquarters functions in Australia are playing major roles in development of the resource sectors in all inhabited continents. In addition, Australia is a major exporter of engineering, management, financial and legal services related to the resources sector.

The skills and capacities that are important in the resources sector, more than others, will be crucial to the global transition to a low-emissions economy. The development in Australia of low-emissions technologies in the energy and agriculture sectors in particular will provide a basis for Australian businesses to play leading roles in innovation associated with the low-emissions transition in many countries, and especially in the Asia and the Pacific. The importance of export of related services from Australia would be enhanced by early establishment in Australia of efficient and extensive mechanisms in support of research, development and commercialisation of the new technologies.

23.10 Australia in a successful world of change

The Review has recommended a necessary and sufficient mitigation policy package that will facilitate the reliable, efficient and equitable transformation for Australia to a low-emissions economy. Australia has a strong national interest in a global agreement and the development of competitive, low-emissions energy technologies such as large-scale renewables and carbon capture and storage. The former will ensure that currently emissions-intensive commodities, such as livestock and fossil fuels, do not face the risk of carbon leakage, while the latter offers the best chance for sectors such as aluminium to be competitive—except against specific locations with availability of large-scale, otherwise stranded hydro power.

The results of our economic modelling also indicate that a comprehensive global agreement will mean that Australia can play to its strengths, importing permits when relatively high domestic abatement costs cause that to be the most effective and efficient result.

Given these outcomes, Australia's advantages in resource availability and sophisticated skills in critical areas of resource development, engineering and financial management are likely to ensure that we remain a strongly competitive suppler of commodities. As described in Chapter 20, Australia is well-placed to maintain a competitive domestic energy supply sector as well as to continue as a major exporter of primary energy. The shifting global economic balance towards our near neighbours over the 21st century will also tend to act in Australia's favour as the benevolence of proximity erodes the tyranny of distance, particularly as international freight costs rise as a result of the emissions constraint. These factors, and rising international transport costs, may also provide an incentive for greater domestic, value-adding processing of raw materials.

A world of effective global mitigation, with Australia playing its proportionate part, would be a congenial world for continued Australian prosperity.

A world of partial and inadequate mitigation, overtaken from time to time with rushes to catch up with lost mitigation opportunity, would be deeply problematic.

It is worth Australia's effort to invest now, when there is time still to obtain a good result, in the best of the possibilities.

Notes

1 In evidence to the Parliamentary Committee on Monetary Policy on 8 September 2008.

2 The results presented in this chapter are for the mitigation scenarios discussed in Chapter 11, which include an assumption of a backstop technology at a carbon price of around $250 per tonne of CO_2-e.

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