CHAPTER 3: THE REFERENCE SCENARIO — ASSUMPTIONS AND PROJECTIONS

Key points

The reference scenario presents a development pathway for the Australian and world economies, in the absence of climate change. It provides a robust starting point for the analysis of various climate change mitigation scenarios.

The reference scenario is a major determinant of the estimated costs of mitigation because the emissions level in the reference scenario defines the amount of mitigation required to reach the environmental goals of the policy scenarios.

The reference scenario describes a world of strong economic growth and continued improvement in technology and resource use efficiency.

Australian and world emissions continue to grow strongly. By 2050, world greenhouse gas emissions increase by over 140 per cent from current levels and Australia's greenhouse gas emissions nearly double. As a result, the concentration of greenhouse gases in the atmosphere rises strongly to over 1,500 ppm CO_2-e by 2100.

Global world output per capita increases three times to 2050, and is dominated by developing economies; productivity convergence gradually narrows the GDP per capita gap between economies.

Australia's GDP per capita is 1.7 times higher by 2050 than today, with Australia benefiting from the pattern of global development.

Fossil fuels continue to be the engine of economic growth and dominate energy supply to 2050.

The reference scenario presents a development pathway for the Australian and world economies to 2100. As this report's focus is on mitigation policies, this chapter's focus is on the period to 2050. This pathway has no new policies to reduce emissions and no impacts of climate change (Box 3.1).[1] It presents a plausible future path for economic growth, population levels, energy consumption and greenhouse gas emissions in a world without climate change. The reference scenario is not a prediction and does not include risks arising from climate change itself.

The reference scenario provides a robust starting point for the analysis of various climate change mitigation scenarios. It is a point of departure to highlight the possible implications for the Australian and world economies of policies to reduce greenhouse gas emissions.

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1 While the reference scenario aims to project a world as if climate change mitigation policies did not exist, firms and households probably anticipate climate change mitigation policies and modify their actions. Accordingly, the impact of climate change mitigation policies may indirectly be included in the reference scenario to the extent that it affects historical data.

The reference scenario is a major (and perhaps the single biggest) determinant of the estimated costs of mitigation because the emissions level in the reference scenario defines the amount of mitigation required to reach the environmental goals of the policy scenarios. The Treasury researched and consulted extensively in developing this scenario, particularly on historical trends and possible future economic, social and technological developments.

Expert opinion on many key variables varies widely. The Treasury, in partnership with the Garnaut Climate Change Review and other expert advisers, developed a set of assumptions which represent its best assessment of likely trends.

Where possible, assumptions used in the reference scenario are consistent across the suite of CGE and sectoral models. However, differences in the structure and level of detail contained in the models will result in differences in the reference scenario across models. The reference scenario provided the basis for the Garnaut Climate Change Review's independent analysis of the potential economic impacts of climate change.

Box 3.1: Climate change policies in the reference scenario

Governments in Australia and around the world have implemented a range of climate change mitigation policies. Many others are being considered and developed.

Given this evolving policy landscape, defining a reference scenario with no new climate change mitigation policies is not straightforward. It is complicated by the multifaceted aims of some greenhouse gas mitigation policies, such as local environmental protection or industry support.

For Australia, the pre-existing policy measures included in the reference scenario include the 9,500 gigawatt hour (GWh) Mandatory Renewable Energy Target (MRET), the Victorian Renewable Energy Target (VRET), the NSW and ACT Greenhouse Gas Reduction Scheme and the 15 per cent Queensland Gas Scheme. However, major new mitigation policies, such as the planned expansion of the Renewable Energy Target to 45,000 GWh a year, the CPRS and the Australian Government's target to reduce emissions by 60 per cent from 2000 levels by 2050 are not included.

For the world, the reference scenario does not include any specific targets or measures. However, industry-specific policy measures, such as mandatory technology targets, are captured the extent to which they have altered historical emission intensity or influenced technology shares in sectors producing energy services.

3.1 The world

Economic output is determined by three components: population, participation and productivity (the '3Ps').[2] The pattern and rate of GDP growth is therefore a function of the assumptions regarding movements in population; changes in participation rates; and the growth of productivity. Trends in these variables differ across geographic regions and industry sectors.

2 The 3Ps framework is discussed in the Australian Government's second intergenerational report (2007), p 10.

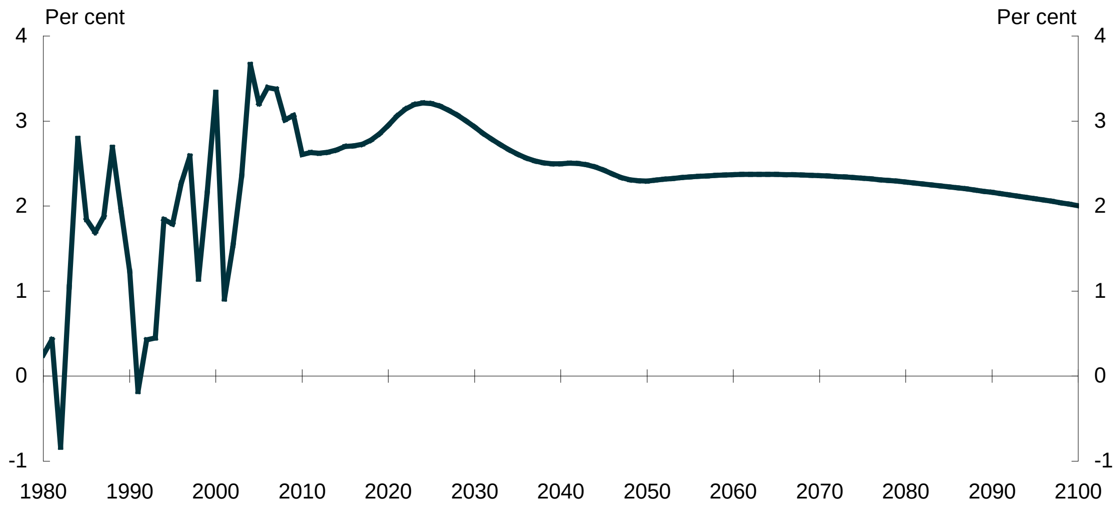
The reference scenario describes a world of strong economic growth and continued improvement in technology and efficient resource use. Global population peaks in the second half of the century, and the productivity gap between economies narrows, reducing regional differences in per capita income.

Productivity growth primarily drives the global economy, with per capita GDP projected to increase by more than 940 per cent from 2005 to 2100, compared with a 380 per cent increase from 1900 to 1999 (Chart 3.1). Overall, the global economy is projected to be roughly five times larger by 2050 and 15 times larger in 2100 than in 2005.

Productivity growth rates vary across economies, reflecting their different stages of development and an expectation of conditional convergence in productivity levels. Despite some evidence of conditional convergence in living standards, growth in world living standards has not been uniformly distributed across economies over the past century. In 2005, the GDP per capita of the world's poorest economies was up to 80 times less on average than the GDP per capita of the world's high income economies.

Existing differences in productivity levels are expected to narrow. Developed economies all improve their productivity at around the same rate, while developing economies accelerate towards, but do not reach, the productivity levels of developed economies. This acceleration occurs for all developing economies, but the rate of acceleration in the nearer term takes into account each economy's recent growth performance.

Chart 3.1: Gross world product per capita growth



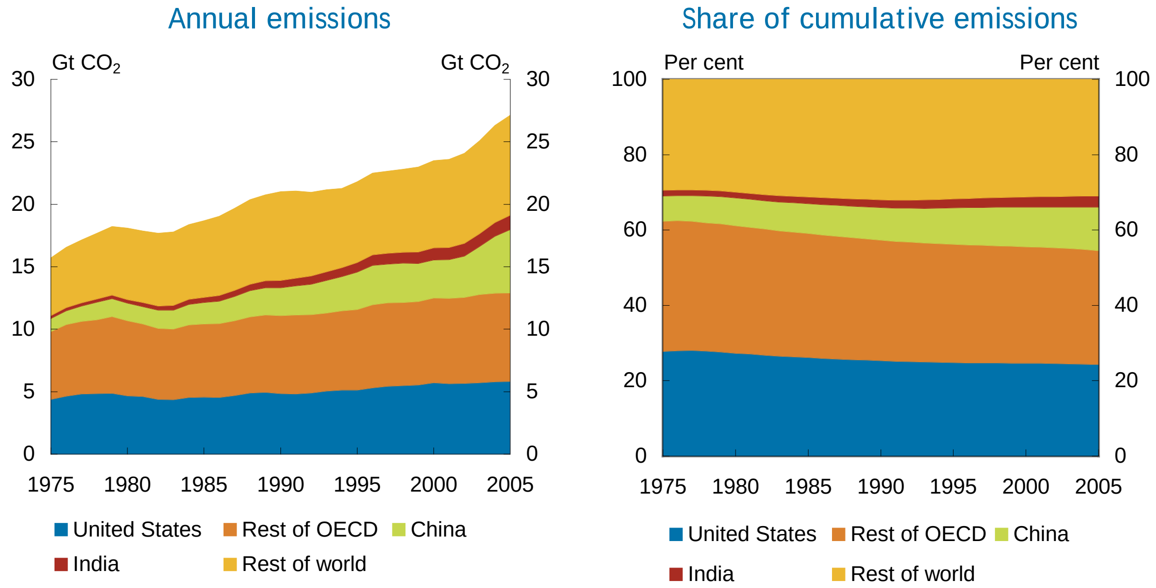
Source: IMF, 2008; and Treasury.

3.1.1 World emissions

Much of the world's economic activity has depended, and will continue to depend, on emission-intensive energy. Despite an overall fall in the energy intensity of world output, total primary energy demand grew more than 80 per cent from 1975 to 2005, with most energy coming from fossil fuels (IEA, 2007a).

A growing world economy and rising energy consumption have caused the world's greenhouse gas emissions to rise considerably over the past 30 years (Chart 3.2). This growth has occurred despite a fall in the emission intensity of output. Most of the world's historical emissions come from the world's high income economies, with the OECD accounting for 48 per cent of CO_2 emissions from fuel combustion in 2005 and 55 per cent of the total volume of CO_2 emissions from fuel combustion over the past 30 years (OECD/IEA, 2008). In contrast, India, accounted for just 4 per cent of CO_2 emissions from fuel combustion in 2005 and around 3 per cent of total cumulative CO_2 emissions from fuel combustion over the past 30 years.

Chart 3.2: Fuel combustion emissions



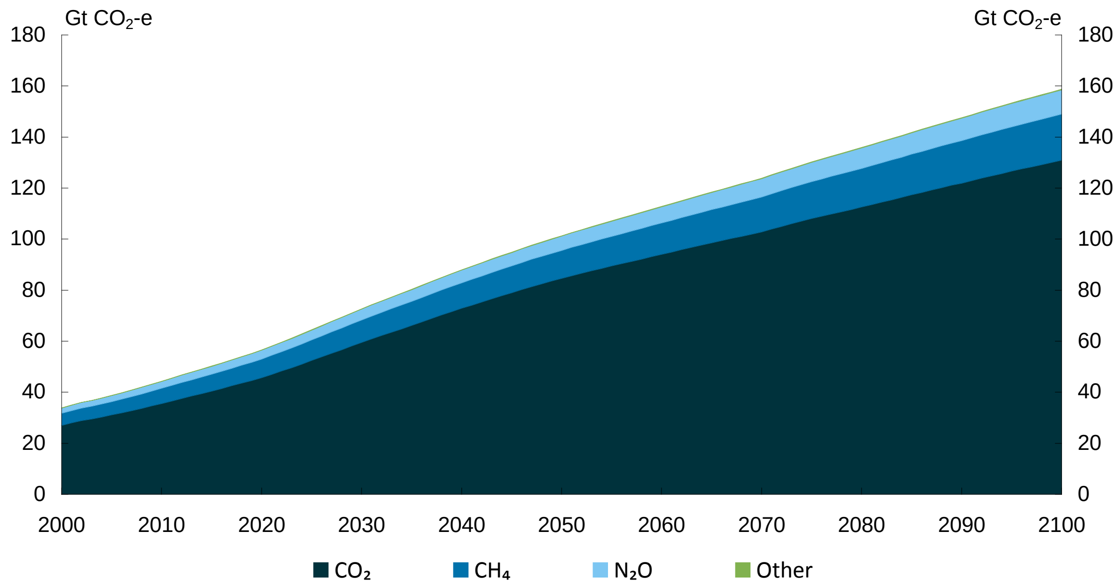
Source: OECD/IEA, 2008.

In the reference scenario, the world economy continues to rely on fossil fuel combustion to power growth, which in turn leads to increased greenhouse gas emissions, despite considerable falls expected in the emission-intensity of growth.

With the world economy projected to grow strongly this century, annual greenhouse gas emissions increase by over 2½ times between 2005 and 2050, from 39 Gt of CO_2-e to just over 102 Gt in 2050. By 2100, annual emissions are projected to be higher still at 161 Gt (Chart 3.3). The annual rate of growth of emissions is expected to slow from around 2 per cent now to less than 1 per cent by 2100. In total, around an extra 10,000 Gt of greenhouse gases are projected to be released into the atmosphere this century (Box 3.2).

These emissions are mostly carbon dioxide from energy use and deforestation, and methane and nitrous oxide from agriculture (Table 3.1). Other gases such as hydrofluorocarbons HFCs and perfluorocarbons (PFCs) maintain a small share (less than half of 1 per cent).

Chart 3.3: Global emissions by gas



Source: Treasury estimates from GTEM.

Table 3.1: Global emissions

Emissions by region

	2005	2020	2050
	Gt CO_2-e	Gt CO_2-e	Gt CO_2-e
United States	7.2	7.7	9.4
EU-25	4.9	5.2	5.5
China	7.2	16.1	31.4
Russia + CIS	3.3	4.7	5.5
Japan	1.4	1.3	1.1
India	1.8	3.7	11.7
Canada	0.8	0.9	1.2
Australia	0.6	0.7	1.0
Indonesia	0.8	1.0	2.2
South Africa	0.5	0.7	1.4
Other South and East Asia	1.7	1.9	3.7
OPEC	1.8	2.9	6.2
Rest of world	7.2	10.2	22.2
Total	39.1	57.2	102.3

Emissions by gas and type

	2005	2020	2050
	Gt CO_2-e	Gt CO_2-e	Gt CO_2-e
Carbon dioxide	31.1	45.7	84.5
Combustion	27.0	42.0	78.1
Fugitive/Industrial process	1.2	2.3	5.8
Waste	0.04	0.04	0.03
LUCF	2.8	1.4	0.5
Methane	5.3	7.3	11.0
Combustion	0.4	0.5	0.8
Fugitive/Industrial process	3.6	5.3	8.4
Waste	1.3	1.5	1.8
Nitrous oxide	2.4	3.4	5.6
Combustion	1.4	2.1	3.1
Fugitive/Industrial process	0.9	1.3	2.4
Waste	0.03	0.03	0.03
Other gases	0.4	0.7	1.3
Total	39.1	57.2	102.3

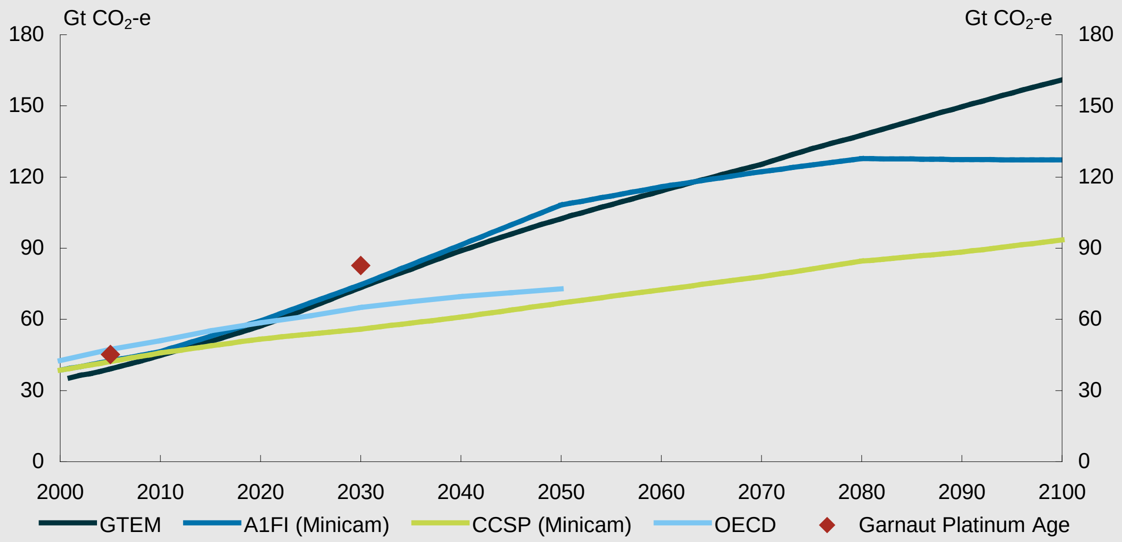
Source: Treasury estimates from GTEM.

Box 3.2: Reference scenarios compared

Global emissions projected under the reference scenario are substantially higher than other recent studies, and roughly equivalent to the highest emission scenario of the IPCC Special Report on Emission Scenarios, A1FI (IPCC, 2000).

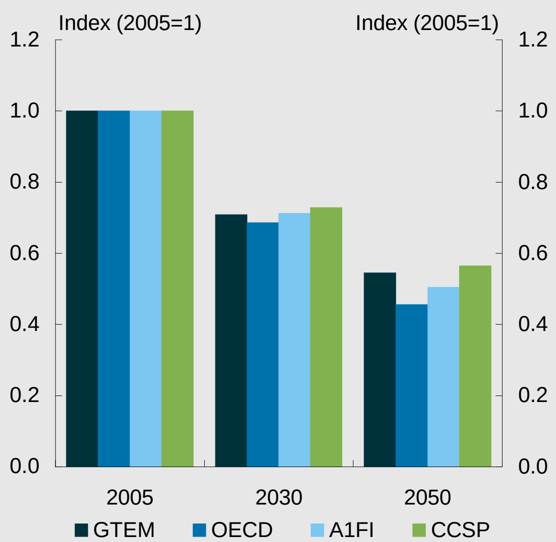
The GTEM reference scenario is higher than results from the OECD Environmental Outlook, a United States Climate Change Science Program (CCSP) report and the A1FI scenario from the IPCC's Special Report on Emissions Scenarios (Chart 3.4) (OECD, 2008; IPCC, 2000; CCSP, 2007). However, it is slightly lower at 2030 than the Platinum Age scenario explored by Garnaut (Garnaut et al., 2008). The GTEM reference scenario projects stronger global GDP growth, particularly in developing economies, than the OECD and CCSP scenarios. As incomes rise, demand for energy and other emission-intensive goods and services grow. Given significant reserves exist, and without an emission constraint, fossil fuels remain the primary source of energy and the biggest source of emissions.

Chart 3.4: Global greenhouse gas emissions



Source: Treasury estimates from GTEM; CCSP, 2007; OECD, 2008; IPCC, 2000; Garnaut et al., 2008a.

Chart 3.5: Emission intensity



Emission intensity (emissions per unit of economic output) is quite similar across the four studies, falling substantially and reflecting the factors discussed in this reference scenario (Chart 3.5).

Differences in emission levels across studies largely reflect assumptions about the likely rate of economic growth to 2050, not assumptions about technology. Economic growth in the CCSP and OECD scenarios is considerably lower than the reference scenario.

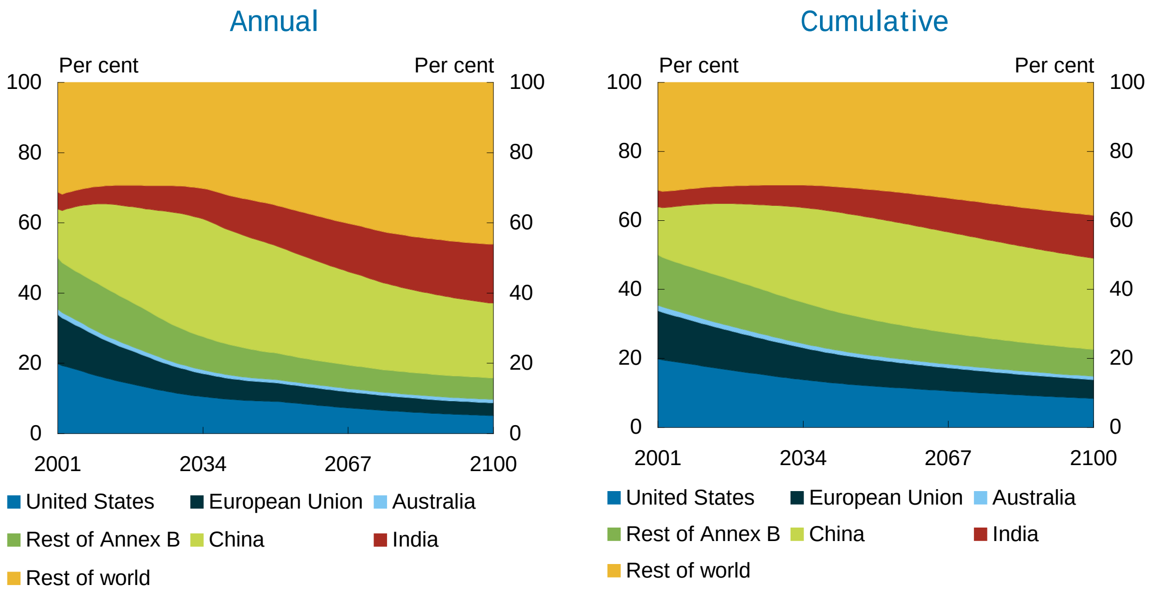
The composition of world emissions changes over this century, with developed economies' share of emissions declining each year, while the developing economies' share rises (Chart 3.6).

In the medium term China dominates world growth in emissions, overtaking the United States to become the world's highest emitting economy. China's share of global emissions grows from 18 per cent in 2005 to 33 per cent of global emissions in 2030, then falls back to 31 per cent in 2050 and 21 per cent in 2100. In contrast, the United States and European Union together generated 31 per cent of global emissions in 2005, but their share falls to 18 per cent in 2030, then to less than 15 per cent in 2050 and 9 per cent in 2100.

While the current high income economies are responsible for most of the emissions currently in the atmosphere, developing economies are projected to be responsible for most cumulative emissions released into the atmosphere this century (Chart 3.6). By 2050, around 30 per cent of this century's emissions are from China; around 12 per cent from the United States; only 8 per cent from India; and 1 per cent from Australia.

The projected future composition of world emissions highlights the economies currently responsible for the atmospheric concentration of greenhouse gases and the economies likely to be responsible in the future. This distinction underscores the importance of global agreements to limit emissions in the future, and the difficulties in international negotiations requiring agreement over emissions allocations between economies.

Chart 3.6: Shares of global emissions



Source: Treasury estimates from GTEM.

Global emissions are expected to rise strongly, despite considerable falls in the emission intensity of growth (Table 3.2). The emission intensity of the world economy falls by more than 45 per cent by 2050 compared with 2005. The progressive fall in emission intensity of world growth is a result of changes in the composition of the world economy (with service sectors capturing a rising share in the longer term), ongoing energy efficiency improvements and the advancing technological frontier.

While the emission intensity of output varies significantly across regions, these differences are expected to narrow as differences in economic structures and technology diminish across economies (Table 3.2). Nevertheless, variations in key factors, such as consumer preferences, geographical location, resource endowments and comparative advantage, will cause some differences in emission intensity to remain.

While emissions per unit of output are projected to decline, global per capita emissions are projected to almost double between 2005 and 2050 (Table 3.2).

Differences in per capita emission levels are projected to narrow as incomes in developing regions rise, flowing through to increased consumption of energy and other emission-intensive goods. China's emissions per capita quadruple to 2050 and approach the same levels as the United States. India's emissions per capita remain below the world's average by 2050, despite strong growth. Emissions per capita are projected to be quite stable for developed economies, reflecting continued energy efficiency, technological change and rising consumption of low-emission services.

Table 3.2: Emissions by region

Emission intensity of GDP

	2005	2020	2050
	kg CO_2-e/$US		
United States	0.55	0.43	0.29
European Union	0.37	0.30	0.22
Australia	0.80	0.62	0.43
Rest of Annex B	0.72	0.66	0.50
China	1.38	0.95	0.57
India	0.81	0.52	0.35
Rest of world	0.88	0.58	0.34
World average	0.70	0.57	0.38

Emissions per capita

	2005	2020	2050
	t CO_2-e/person		
United States	23.9	22.6	23.3
European Union	10.7	10.9	11.9
Australia	28.9	28.8	29.3
Rest of Annex B	12.3	16.1	20.0
China	5.4	11.3	22.2
India	1.6	2.7	7.1
Rest of world	4.2	4.7	7.4
World average	6.0	7.46	11.1

Note: Emission estimates vary from Table 3.2 due to database differences between the MMRF and GTEM models. GDP measured in 2005 US dollars (purchasing power parity).
Source: Treasury estimates from GTEM.

3.1.2 The world economy

In the reference scenario, the world economy shows continued strong growth, driven by the continued process of catch-up of lower income economies towards the GDP per capita levels enjoyed by high income economies.

Gross world product (GWP) is projected to rise from $54 trillion in 2005 to $268 trillion in 2050.[3] The average projected annual increase of GWP of 3.5 per cent is slightly slower than the 3.9 per cent experienced on average over the past 50 years. GWP growth is expected to be around 4 per cent to 2030, before slowing due to likely demographic developments (Chart 3.7).

World population growth is expected to slow, reflecting likely demographic developments in turn driven by rising living standards and economic transformation (United Nations, 2004 and 2006). After growing from 2.5 billion in 1950 to 6.1 billion in 2000, the world's population is expected to peak at 9.5 billion in 2075, before falling slightly to 9.3 billion in 2100 (Chart 3.8). Most population growth occurs in South Asia, the Middle East and Central Asia, Africa, and South America.

3 Unless otherwise noted, all gross world product (GWP) and regional comparisons of gross domestic product (GDP) levels and growth rates in this report are reported in purchasing power parity terms, 2005 US dollar terms.

Box 3.3: Climate change projections in the reference scenario

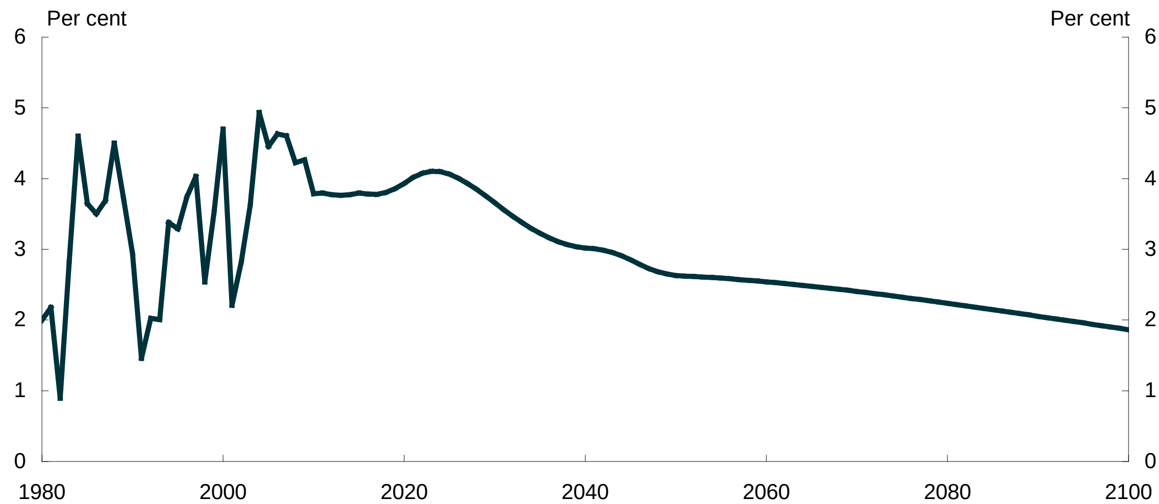
Without new policies to reduce greenhouse gas emissions, the reference case sees continued strong growth in global emissions. As a result, the concentration of greenhouse gases in the atmosphere rises to over 1,500 ppm CO_2-e by 2100.

This corresponds to an increase in global average temperature of 5°C above pre-industrial levels by 2100, and of 8°C or more above pre-industrial levels[4] in the following centuries (assuming concentrations stabilise around this level) (Garnaut, 2008a). A temperature increase of this magnitude brings very high risks of extreme and irreversible climate change impacts, including:

- loss of complete ecosystems, such as the Great Barrier Reef;
- severe water availability problems, seriously limiting the viability of human occupation and agriculture;
- significant and widespread shortages of food;
- large areas of Australia's coastline permanently or periodically inundated;
- significant infrastructure costs associated with asset protection and replacement; and
- greater international instability, particularly in the developing world (Pearman, 2008).

The Garnaut Climate Change Review extensively discusses likely economic, social and environmental impacts of such a 'no mitigation' scenario (Garnaut, 2008b).

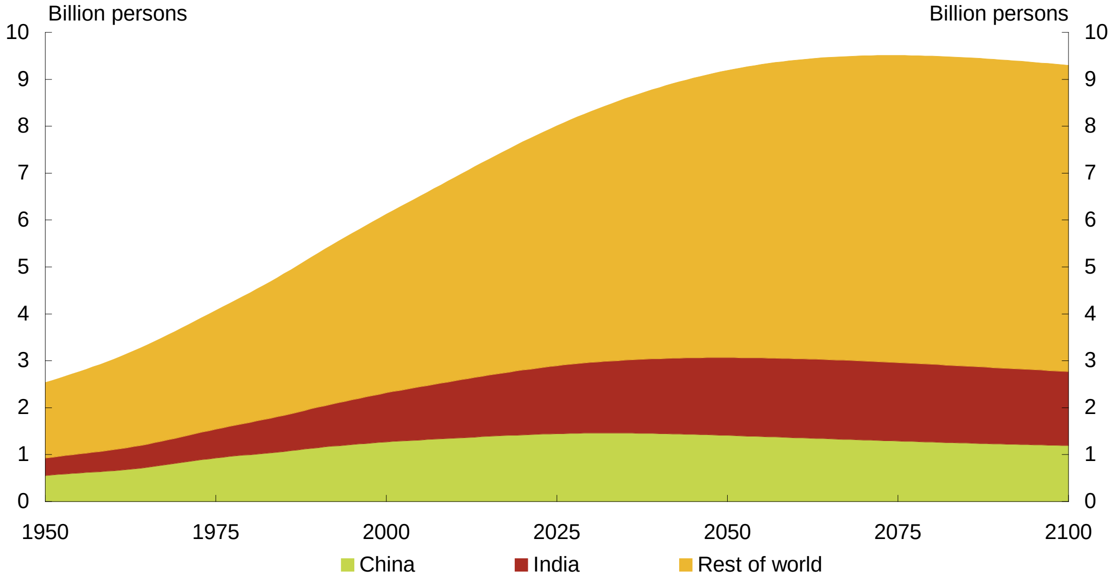
Chart 3.7: Gross world product growth



Source: IMF, 2008; and Treasury.

4 All temperature changes are based on the median estimate of climate sensitivity, calculated using the simple climate model MAGICC (Garnaut, 2008a). There is substantial uncertainty in such estimates (Pearman, 2008).

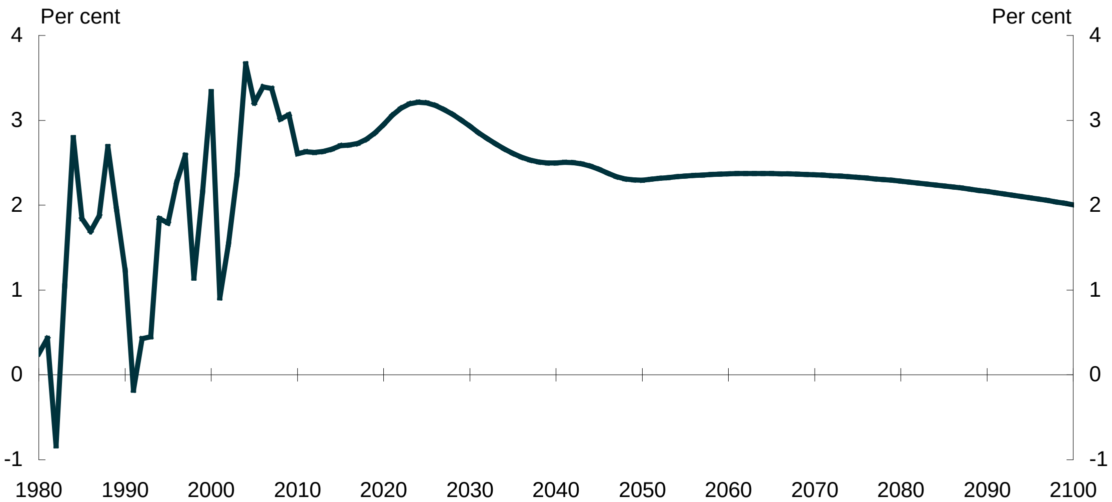
Chart 3.8: World population



Source: United Nations, 2006.

Per capita GWP growth is projected to remain strong throughout this century (Chart 3.9).

Chart 3.9: Gross world product per capita growth



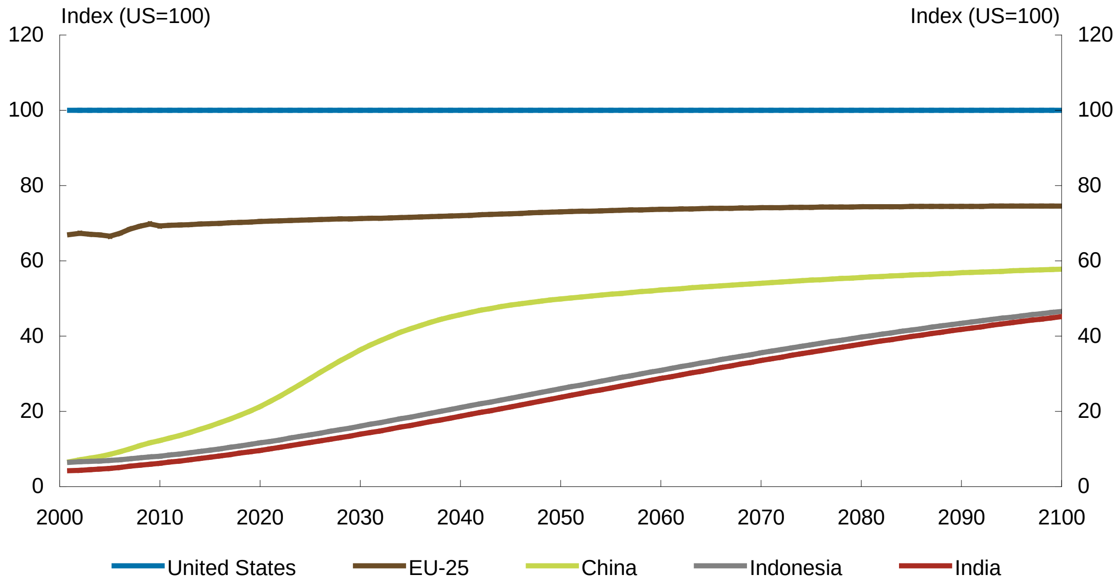
Source: IMF, 2008; United Nations, 2006; Treasury.

The main driver of the strong per capita growth is the catch-up, or convergence, of lower income economies towards the income levels of richer economies (Barro and Sala-i-Martin, 1992). In the past 50 years, several economies have demonstrated convergence (Japan, Hong Kong, Singapore, Ireland and South Korea), but some low-income economies have grown more slowly than convergence would suggest (Pritchett, 1997). Explanations for this divergence include internal conflict, poor governance or natural disasters.

The reference scenario assumes that conditional convergence occurs across low-income economies, as some of these difficulties are resolved (Chart 3.10). The European Union remains at around the same level relative to the United States, while less developed regions such as China, Indonesia and India catch up, but do not draw equal to the United States. China's growth is relatively rapid until 2030, reflecting continued strong growth in productivity and investment

(Garnaut et al., 2008). However, by 2050 China still remains considerably below the income level of the United States, reflecting the remaining gap in capital stocks and productivity. Indonesia and India grow more slowly, with substantial increases in their income levels.

Chart 3.10: Gross domestic product per adult



Source: Treasury.

The projected productivity convergence leads to both rising living standards across the world and reductions in the variations in living standards between regions over time. In 2005, US GDP per capita is highest, around 4 times larger than per capita GWP, while both Chinese and Indian per capita GDP is less than half the average world per capita GWP. By 2050, China's per capita GDP reaches 2005 United States levels and by the 2070s India reaches this level. By 2100, per capita GDP has moved closer between all regions, with the United States approximately only twice as large as per capita GDP, and both China and India within 10 per cent of world per capita GDP (Table 3.3).

Table 3.3: Gross domestic product per capita

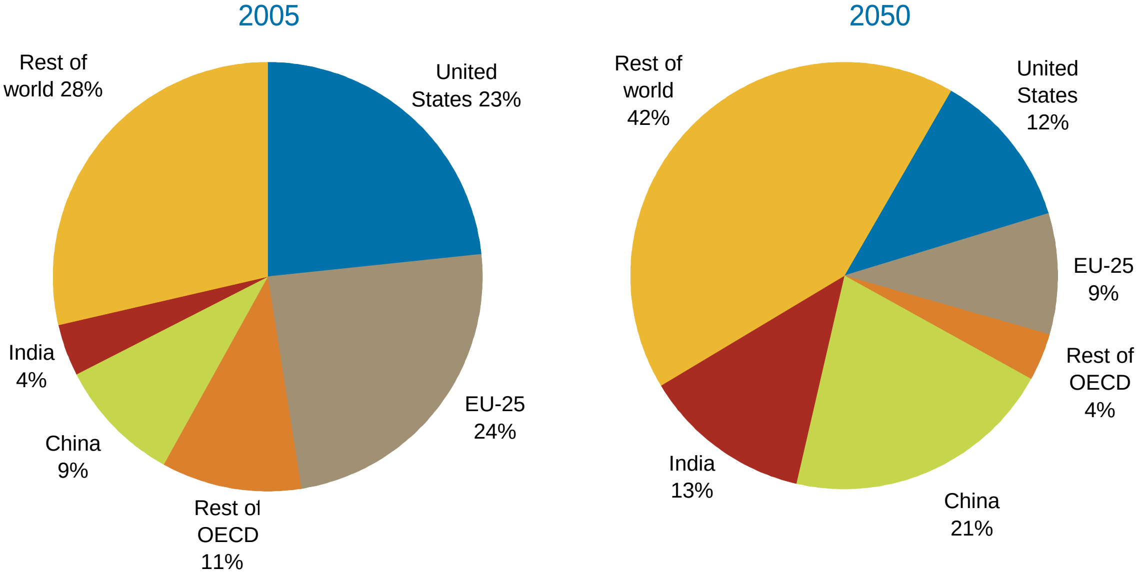
	2005	2050	2100	2050-2005	2100-2005
	$'000/person			Change, per cent	
Australia	36	68	137	89	280
United States	44	79	171	82	292
EU-25	29	53	118	83	305
China	4	39	97	887	2364
India	2	20	84	938	4140
Rest of Annex B	17	40	102	134	498
Rest of w orld	5	22	79	349	1539
Average	9	29	89	240	940

Source: Treasury projections.

Given the catch-up in productivity and the higher population in the developing world, the distribution of world economic activity is expected to change substantially by 2050. The OECD's share of GWP will fall from nearly 75 per cent in 2005 to around 34 per cent in 2050, the same share as China and India combined, which today comprises 13 per cent of GWP (Chart 3.11). The largest expansion is the 'rest of world', from 28 per cent of GWP in 2005 to 42 per cent in 2050.

By 2021, China overtakes the United States as the world's largest economy; in 2083, India overtakes China, largely due to higher population growth. India's GDP reaches nearly US$34 trillion by 2050. By 2050, China, India and other currently developing economies comprise over 67 per cent of global GWP (Chart 3.11).

Chart 3.11: Distribution of gross world product



Source: Treasury projections.

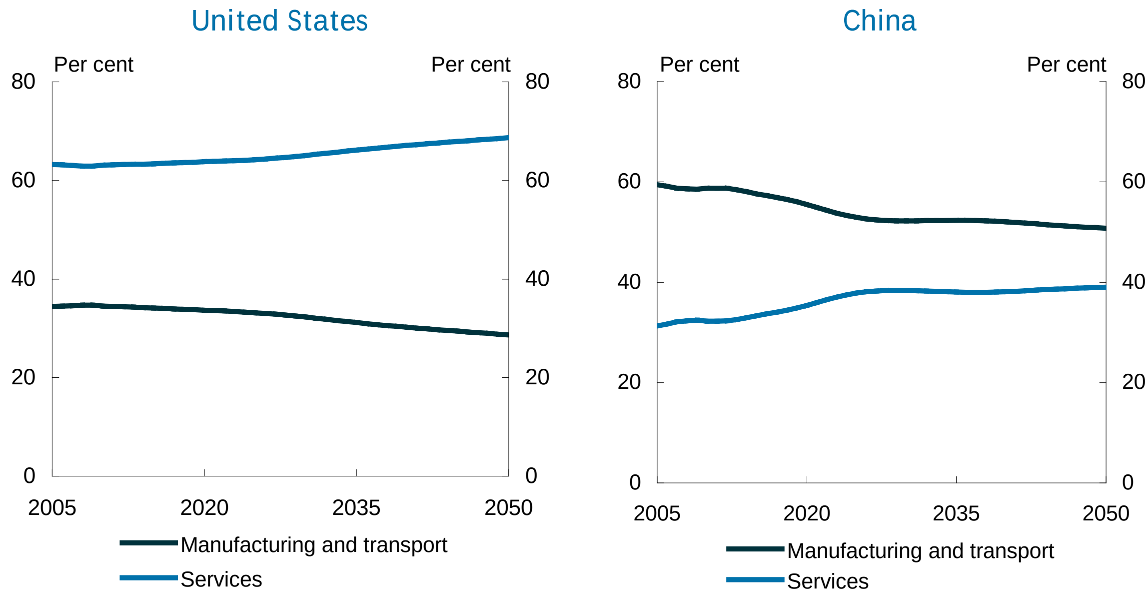
3.1.3 Sectoral analysis

As developing economies' living standards improve, the composition of their economies is expected to adjust. The share of GDP being derived from the services sectors will shift as more luxury goods appear in developing economies. This generally lowers the emission intensity of output, as the services sector is relatively low in emissions.

However, other trends push in the other direction. Adjustments occur in the types of goods in demand within sectors. For example, meat consumption, which is relatively more emission intensive, is expected to increase, while grain consumption is expected to fall in relative terms.

Developed economies continue the trend towards an increased share of the service sector (Chart 3.12). The United States service sector increases from around 63 per cent of total output in 2005 to over 68 per cent in 2050. At the same time, the share of other sectors such as manufacturing declines. A similar pattern occurs in developing regions, where the share of the service sector increases from around 32 per cent of total output in 2005 to 41 per cent by 2050.

Chart 3.12: Share of total output by sector



Source: Treasury estimates from GTEM.

Emission intensity declines in all industries as productivity, including energy efficiency, improves. However, in some scenarios, the increased share of activity in sectors offsets the downward trend (Chart 3.13).

Electricity and manufacturing's share of global emissions rises, owing largely to electricity's expansion and continued strong demand for manufactured goods in the developing world.

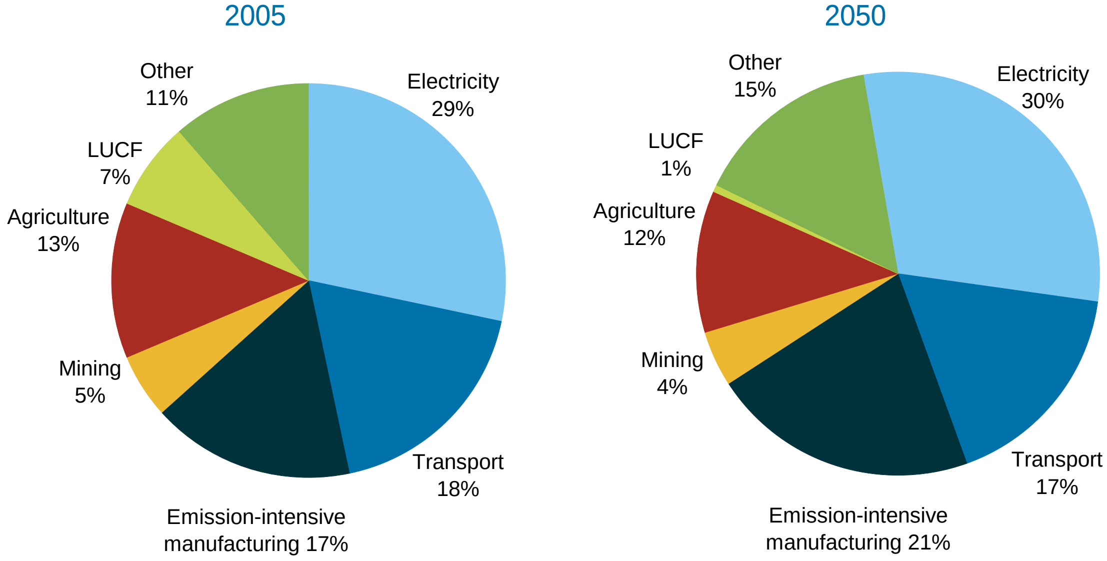
Transport's share of global emissions falls slightly; demand grows strongly in developing economies, while developed economies are already close to saturation (particularly for road transport demand) and experience efficiency improvements due to technological innovation.

Globally, more than a billion hectares of land is projected to be deforested, particularly in Africa and South America. Plantation expansion offsets some of the emissions from deforestation. However, the land-use change and forestry sector is projected to be a net source of 49 Gt CO_2 emissions between 2005 and 2050. This falls within the broad range of estimates from other projections (Sathaye et al., 2006).

Services' share of emissions increases, reflecting its growing share of global economic activity.

Agriculture's share rises slightly, despite its falling share of global GDP, reflecting a change in the emission intensity of products with agriculture.

Chart 3.13: Global emissions by sector



Note: 'Other' includes the production of rubber, plastics and metals, and land-use change and forestry.
Source: Treasury estimates from GTEM.

Electricity

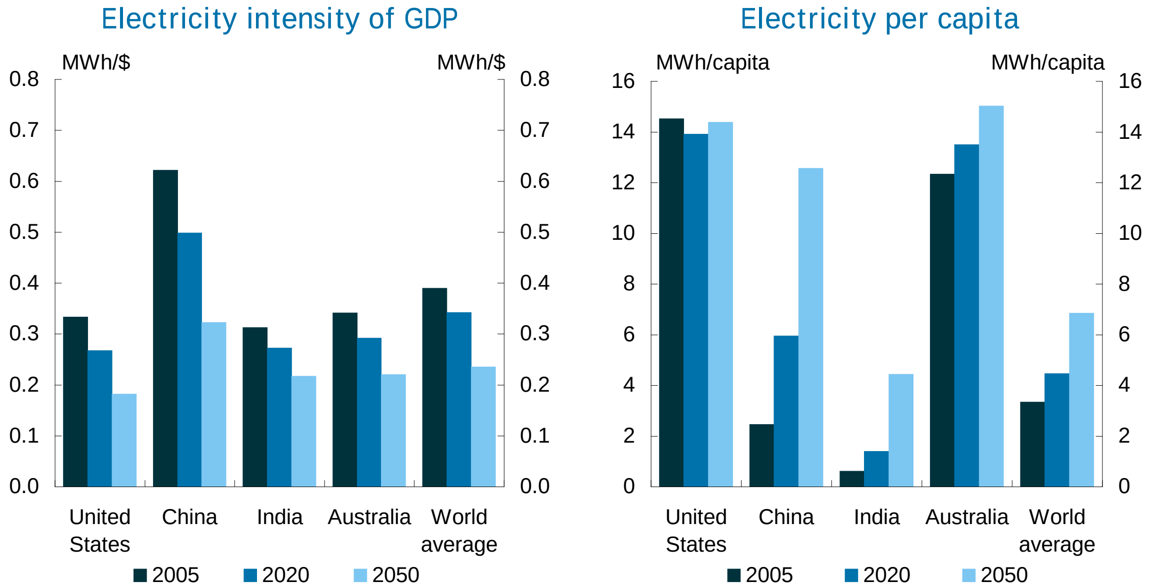
World electricity generation increased more than 200 per cent from 5,256 Terra Watt hours (TWh) in 1971 to 18,307 TWh in 2005 (OECD/IEA, 2008). Developed economies generate most of the world's electricity, with the OECD accounting for 57 per cent of electricity generation in 2005 (OECD/IEA, 2008). Coal was used to generate 40 per cent of the world's electricity in 2005 (IEA, 2007b).

Under the reference scenario, global electricity generation increases to 63,000 TWh in 2050, an average annual growth rate of 2.3 per cent. Most demand growth comes from developing regions, with India and China accounting for 35 and 16 per cent of the growth from 2005 to 2050.

Access to electricity is uneven throughout the world; the average Indian currently consumes one-twentieth of the electricity of the average Australian (Chart 3.14). As developing economies grow more strongly over coming decades, their generation of electricity is expected to increase.

Electricity demand is expected to grow more slowly than output, with the global economy using around 0.5 to 1 per cent less electricity per dollar of GDP each year (Chart 3.14). This reduction in the electricity-intensity of output reflects the changing composition of regional growth, sectoral output and continued overall energy efficiency improvements in the economy.

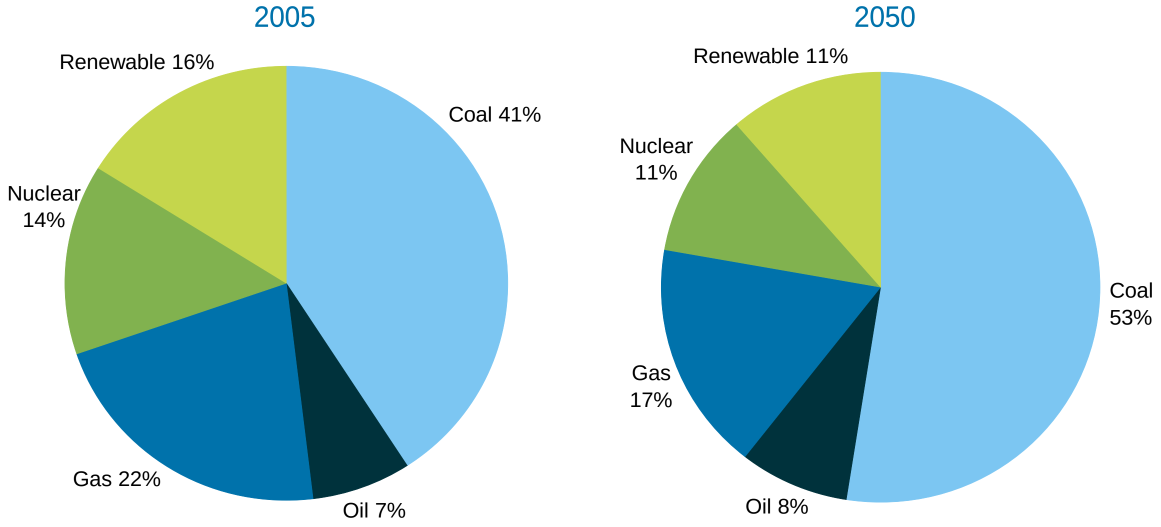
Chart 3.14: World electricity demand



Source: Treasury estimates from GTEM.

Coal continues to dominate electricity generation, reflecting its global abundance and low cost, particularly for base load generation. Coal's share of electricity generation comprises more than half of world electricity generation after 2050 (Chart 3.15). The share of renewables rises gradually to 2020, before falling, as viable sites for hydropower are exhausted. Generation of wind and solar power increases by more than 10 and 30 times, reflecting their low starting levels. However, their combined share remains less than 2 per cent by 2050.

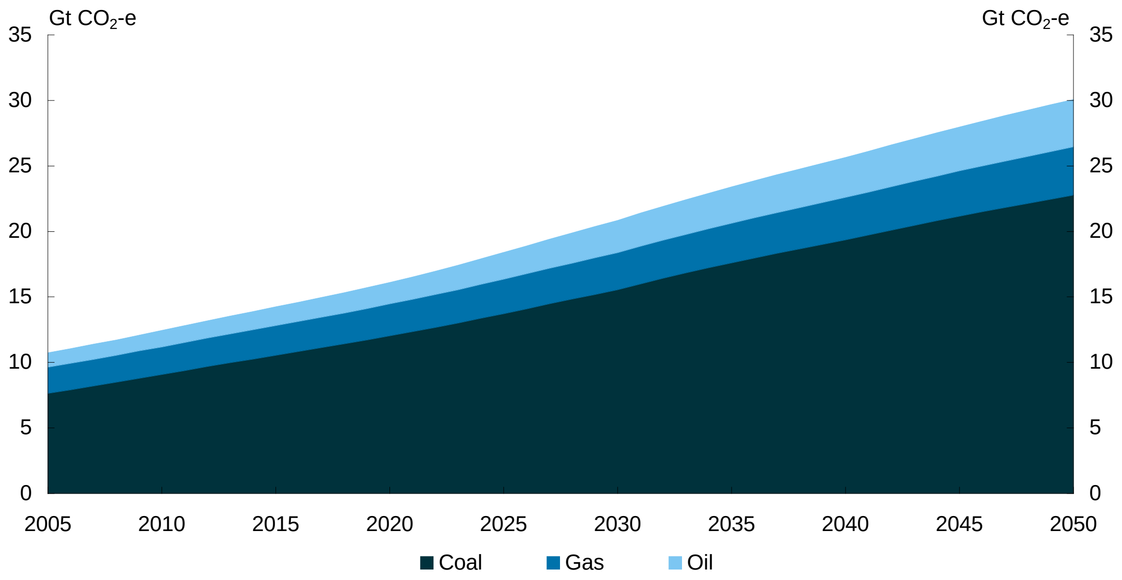
Chart 3.15: World electricity generation by fuel



Source: Treasury estimates from GTEM.

With fossil fuels continuing to dominate global electricity generation, global electricity emissions nearly triple by 2050, rising from roughly 11 Gt CO_2-e in 2005 to around 30 GT CO_2-e in 2050 (Chart 3.16). The emission intensity of global electricity supply remains broadly constant, at around 0.5 t CO_2-e/MWh.

Chart 3.16: World electricity emissions by fuel

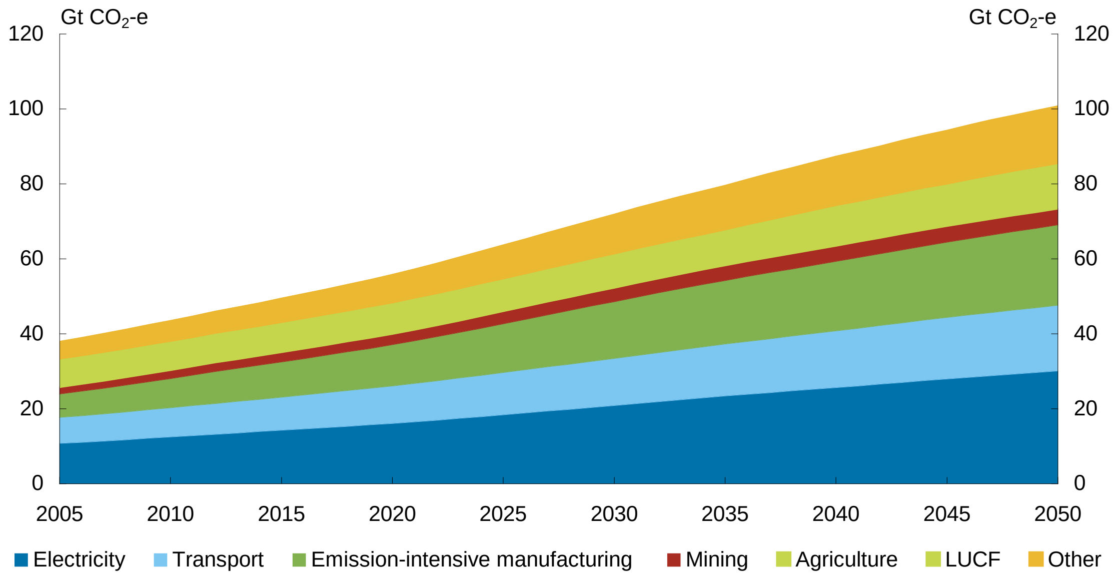


Source: Treasury estimates from GTEM.

Transport

World transport sector emissions grow strongly in absolute terms, but fall as a share of total emissions (Chart 3.17). Global transport demand rises modestly. Air and water transport grow faster than road and rail transport, owing to strong growth in incomes.

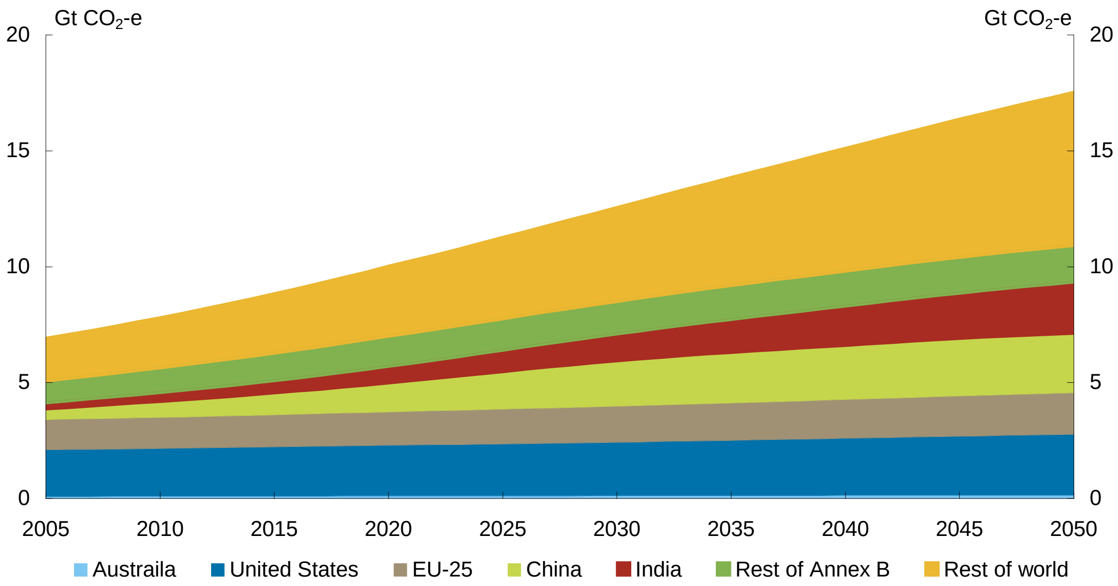
Chart 3.17: Mode of global transport



Source: Treasury estimates from GTEM.

Transport emissions grow strongest in developing economies (Chart 3.18). China's share of total transport emissions increases from around 7 per cent in 2005 to around 15 per cent in 2050.

Chart 3.18: Global transport emissions

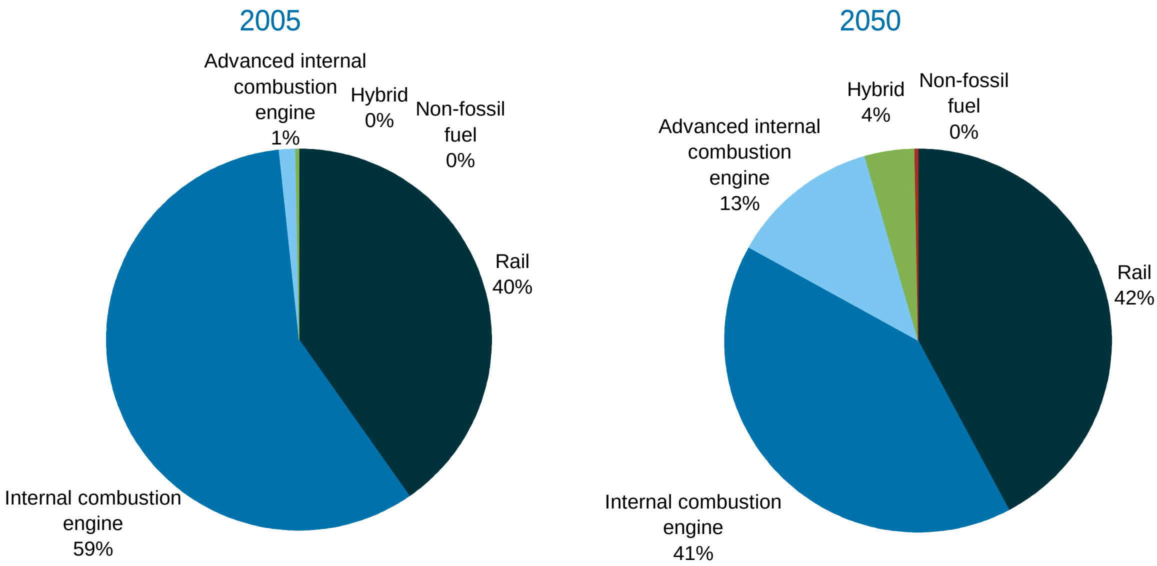


Source: Treasury estimates from GTEM.

In road transport, demand is expected to slow reflecting slowing population growth. Rail's share in land transport is expected to remain broadly constant. However, as oil prices rise relative to other energy prices, the road transport sector will deploy increasingly efficient technologies and diversify fuel sources.

Cars with internal combustion engines dominate the road transport sector in 2005; advanced internal combustion engines (including partial hybrid engines) meet only a small share of demand. As oil prices rise relative to other energy sources, and the capital cost of advanced vehicles falls, the share of conventional internal combustion engines falls. By 2050, advanced internal combustion engines comprise almost 15 per cent of total road transport output and full hybrid cars have a noticeable share. The advanced internal combustion engine captures a growing market share after 2050, eventually eclipsing its conventional counterpart. Non-fossil fuel vehicles such as electric and hydrogen cars remain uncompetitive compared with combustion vehicles, with only a 0.2 per cent share by 2050 (Chart 3.19).

Chart 3.19: Global road transport technology share



Source: Treasury estimates from GTEM.

Land-use change and forestry

Globally, around 580 million hectares is projected to be deforested by 2050, half in Africa (Table 3.4). This reflects continued demand for forestry products and land clearing for agriculture. In contrast, plantations are projected to expand by only 280 million hectares by 2050, mostly in Asia and the United States. The net global effect by 2050 is a loss of forested area of around 300 million hectares.

Table 3.4: Global plantations and deforestation
Cumulative since 2000

	2010		2020		2050		2100	
	Plantation	Deforestation	Plantation	Deforestation	Plantation	Deforestation	Plantation	Deforestation
	Million hectares		Million hectares		Million hectares		Million hectares	
Africa	2	55	4	117	10	283	20	501
Central America	1	9	2	17	4	37	8	64
China	14		29		63		63	
European Union	2		4		11		21	
India	7		13		22		22	
Oceania	2		4		9		18	
Rest of Asia	15	21	29	40	73	90	146	159
Russia	6	0	11		29		57	
South America	3	36	6	72	16	173	32	329
United States	10		19		48		97	
Total	61	122	121	246	284	583	483	1053

Source: Lawrence Berkeley National Laboratory estimates from GCOMAP (Sathaye, 2008).

With the substantial loss in global forested area by 2050, the sector is a net source of emissions, contributing around 49 Gt CO_2 from 2005 to 2050. Emissions are highly concentrated in South America and Africa, while reafforestation delivers substantial net sequestration in Asia and the United States (Table 3.5).

Table 3.5: Cumulative global land-use change and forestry emissions since 2005

	2020 Gt CO_2	2030 Gt CO_2	2040 Gt CO_2	2050 Gt CO_2
Africa	-20	-33	-46	-57
Central America	-2.4	-3.7	-4.9	-6.1
China	3.3	7.0	11	16
European Union	0.5	1.3	2.4	3.8
India	3.0	6.0	8.5	9.0
Oceania	0.6	1.3	2.3	3.3
Rest of Asia	2.2	10	19	26
Russia	0.4	1.1	2.2	3.7
South America	-22	-35	-48	-61
United States	2.5	5.9	11	16
Total	-32	-40	-42	-47

Note: Negative numbers indicate emissions, positive numbers indicate sequestration. These estimates do not include emissions from land-use change in Australia.
Source: Lawrence Berkeley National Laboratory estimates from GCOMAP, 2008.

Other emission-intensive sectors

Four other industry groups together comprise around 40 per cent of world emissions: mining, resource processing (particularly steel and aluminium), emission-intensive manufacturing and agriculture (Table 3.6). Mining growth is projected to be strong in most regions, reflecting the continued strong demand for coal, iron ore, oil and other mined products. Strong mining growth, in turn, leads to strong growth in resource processing, dominated by the transformation of mined products into steel and aluminium. Emission-intensive manufacturing and agriculture grow, but generally not as strongly as overall economic growth, reflecting the falling share of the overall manufacturing and agriculture sectors.

Table 3.6: Growth of other emission-intensive sectors

	Mining		Resource processing		Emission-intensive manufacturing		Agriculture	
	2005-2020	2020-2050	2005-2020	2020-2050	2005-2020	2002-2050	2005-2020	2020-2050
	Per cent per year		Per cent per year		Per cent per year		Per cent per year	
United States	2.9	2.0	1.9	1.3	1.6	1.1	3.2	2.4
EU-25	1.9	0.8	0.8	0.4	1.0	0.4	2.0	1.6
China	9.2	4.4	8.7	4.1	6.2	2.4	8.2	4.3
Russia + CIS	4.6	1.5	4.6	1.7	4.3	1.7	4.4	2.0
Japan	1.2	0.7	0.6	-0.1	0.4	-0.3	1.0	0.3
India	7.9	5.6	6.7	4.9	5.3	3.3	6.8	4.4
Canada	3.1	1.8	0.3	0.1	1.5	0.8	3.6	2.5
Australia	2.8	2.2	1.3	0.6	2.3	1.6	3.7	2.5
Indonesia	5.0	4.1	3.0	3.6	4.0	2.7	5.9	4.8
South Africa	5.0	3.7	4.5	3.4	4.0	2.5	5.0	3.3
Other South and East Asia	3.2	2.9	4.2	2.9	3.6	2.3	4.5	3.2
OPEC	5.6	3.5	5.6	4.4	4.3	3.2	4.7	3.5
Rest of world	4.6	4.2	5.0	4.3	4.4	4.0	5.0	4.4

Source: Treasury estimates from GTEM.

The share of total emissions remains broadly constant, with mining's slight fall offset by emission-intensive manufacturing's rise (Table 3.7).

Table 3.7: Share of world emissions (direct and indirect)

	2005	2020	2050
	Per cent	Per cent	Per cent
Mining	5.9	6.2	5.1
Resource processing	8.4	9.1	7.6
Other emission-intensive manufacturing	15.5	18.0	20.6
Agriculture	12.8	12.5	11.4
Total	42.6	45.8	44.7

Source: Treasury estimates from GTEM.

Box 3.4: The reference scenario in G-Cubed

G-Cubed models the world economies in a more aggregated way than GTEM, making it less suited to providing disaggregated sectoral projections of the world economy although it gives a richer dynamic story. Because of this limitation at the sectoral level, the reference scenario was implemented differently from in GTEM. Assumptions about energy intensity, electricity technology mixes, and non-combustion emission intensity cannot be applied directly to the model, so a calibration approach was followed.

In this approach, rather than focus on the inputs for the reference scenario, the modelling took the results of the GTEM reference scenario and calculated a set of reference scenario assumptions that would produce consistent results on key variables. The results were calibrated as emission levels by gas. The calibration used an iterative approach and does not perfectly match the emission levels between the two models.

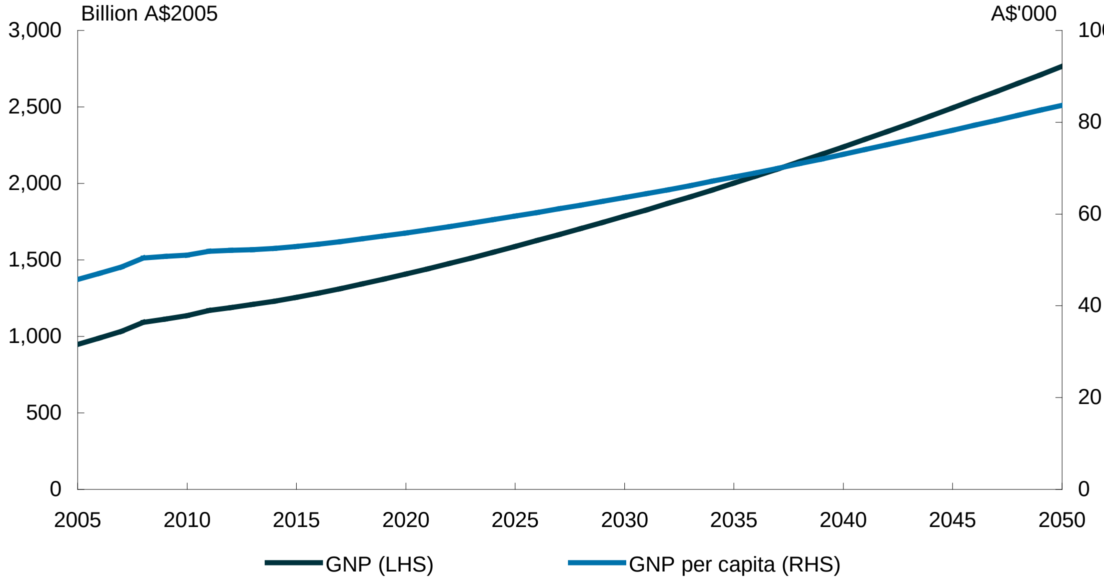
Consequently, by design, the G-Cubed reference scenario does not have any additional analytical use beyond the GTEM reference scenario. Effectively, the reference scenarios were aligned. As a result, G-Cubed specific results are not discussed in this chapter. This calibration exercise was conducted only for the reference scenario, and does not affect the modelling of the policy scenarios.

3.2 AUSTRALIA

In Australia, population, participation and productivity growth boost Australia's GNP level by around 200 per cent between 2005 and 2050, and over 800 per cent to 2100. GNP growth gradually moderates to a long-term average of around 2 per cent per year, largely due to demographic trends, slowing population and labour force growth, despite modestly rising terms of trade — the price of exports relative to the price of imports. Over the next 100 years, Australia's population is projected to more than double, from 20 million in 2005 to 33 million in 2050 and nearly 47 million by 2100.

Australians are projected to be significantly richer in 2050 than today, with GNP per capita projected to increase from around $48,000 in 2007-08 to around $83,600 in 2050 (in 2005-06 dollars). Per capita GNP is expected to grow by 77 per cent between 2005 and 2050, slightly slower than the average from 1985 to 2005 (Chart 3.20).

Chart 3.20: Real GNP and real GNP per capita



Source: Treasury estimates from MMRF.

In Australia, both supply and demand-side factors drive sectoral trends. On the supply side, industry sectors are assumed to have different productivity growth rates. The dispersion of productivity growth rates across industry sectors is based upon historical estimates.

As a small open economy, Australia is strongly affected by global economic forces. Rising per capita incomes in developing economies are expected to result in more of the world's population spending a larger share of their income on more energy-intensive goods and higher-value food. These forces will create strong demand for Australia's commodity exports and substantially change its pattern of trade with other economies.

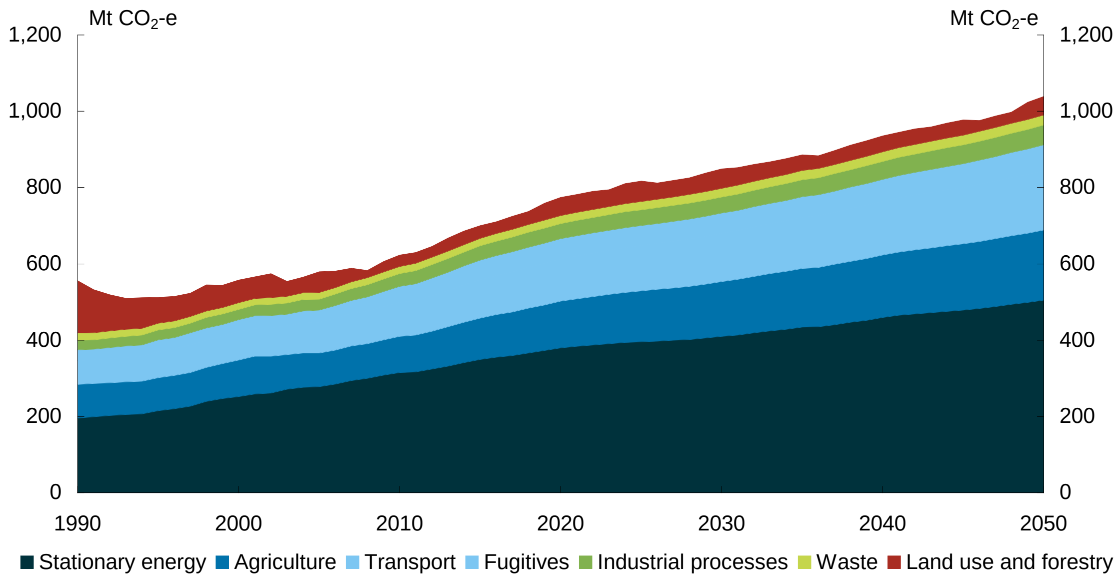
In recent years, these energy and emission-intensive industries have influenced Australian living standards more than their share of production implies. This reflects their high prices in world markets. Over the past three years, Australia's terms of trade have improved by 20 per cent, mainly owing to rising minerals prices. Real national income per capita grew at an average annual rate of 3.3 per cent, considerably faster than the 2.0 per cent growth in real GDP per capita.

Broadly, the historical pattern of growth across sectors is expected to continue. The services share of the economy continues to grow steadily, while the mining sector initially benefits from the current surge in world demand for commodities, before slowing in response to declining commodity prices and supply constraints in the oil and gas industries. The Australian manufacturing and agricultural sectors are expected to continue their historical trend decline.

3.2.1 Australian emissions

Australia's net greenhouse gas emissions were 576 Mt CO_2-e in 2006, up 4.2 per cent from 553 Mt in 1990 (Australian Government, 2008a). Australia's greenhouse gas emissions are expected to double by 2050, growing by 1.5 per cent per year from 2005 to 2050 (Chart 3.21).

Chart 3.21: Australian emissions



Source: Australian Government, 2008a; and Treasury estimate from MMRF.

Australia's emissions mainly flow from energy production, dominated by use of black and brown coal. Stationary energy is the largest source of emissions, at around half of total emissions, with electricity generation contributing more than two-thirds. Energy sector emissions grew by 40 per cent (114.8 Mt) from 1990 to 2006 and are expected to grow to 728 Mt CO_2-e by 2050. Stationary energy emissions comprise four sub-elements: electricity generation, other stationary energy, transport and fugitives. The strongest growth within this sector is from electricity generation, which is projected to increase by almost 200 Mt CO_2-e by 2050, as demand for electricity continues, as the population grows and reliance on black and brown coal continues (Table 3.8).

Table 3.8: Emissions by source

	2005		2020		2050		Growth rate	
	Mt CO_2-e	Per cent	Mt CO_2-e	Per cent	Mt CO_2-e	Per cent	2005-2020	2020-2050
Energy	390	67	544	70	728	70	2.2	1.0
Electicity generation	195	34	265	34	348	34	2.1	0.9
Other stationary energy	83	14	115	15	156	15	2.2	1.0
Transport	81	14	111	14	156	15	2.1	1.1
Fugitives	31	5	53	7	67	6	3.5	0.8
Agriculture	88	15	122	16	184	18	2.2	1.4
Industrial process	29	5	40	5	52	5	2.1	0.9
Land-use change	74	13	44	6	44	4	-3.4	0.0
Forestry	-20	-3	3	0.5	5	0.5	na	na
Waste	17	3	21	3	26	3	1.3	0.8
All sectors	579.1	100.0	774.2	100.0	1039.1	100.0	2.0	1.0

Source: Treasury estimates from MMRF.

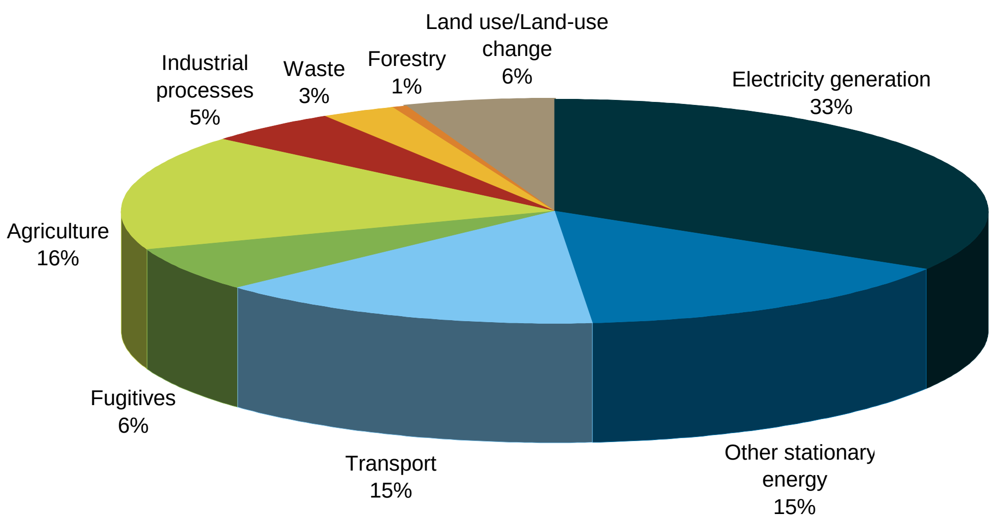
Agriculture and changes in land use, unlike in most OECD economies, contribute significantly to Australia's emissions. Emissions from agriculture are expected to grow broadly in line with growth in agricultural output as there are limited opportunities to reduce emission intensity without emission pricing. Output growth reflects ongoing productivity growth and strong world demand for Australian beef and lamb. By 2050, emissions from agriculture are projected to almost double to around 184 Mt CO_2-e.

From 1990 to 2006, emissions from land use, land-use change and forestry fall as state governments enacted policies to reduce deforestation. In the absence of new government policies, emissions from this sector are expected to remain stable to 2050.

Fugitive emissions include liberated gas previously trapped within coal seams, emissions released in producing and processing oil and gas, and gas leakage though transmission and distribution. Emissions from the fugitives sector grow strongly, around 1.7 per cent per year from 2005 to 2050, more than doubling to 67 Mt CO_2-e in 2050. Continued strong world demand for Australia's fossil fuels, namely coal and gas, drives this growth although it is partly offset by rising gas prices that encourage greater capture of methane emissions, which can be used for energy generation. This capture is also assumed to occur in the waste sector.

The cumulative amount of emissions released into the atmosphere determines possible climate change impacts, not emissions in any one year (Chart 3.22).

Chart 3.22: Share of cumulative emissions 2005 to 2050



Source: Treasury estimates from MMRF.

Emission intensity of energy-intensive industries is expected to fall slightly to 2050, largely reflecting continual assumed improvements in energy efficiency (Box 3.5). However, as the economy shifts towards the services sectors, the aggregate emission intensity of output is expected to fall (Chart 3.23).

Box 3.5: Energy efficiency

Energy efficiency occurs when less energy is used to make the bundle of goods and services we consume. This can occur through a number of mechanisms, including:

- firms substituting capital, labour and other inputs for energy;
- technologies improving so the same good is created using less energy; and
- consumers substituting away from energy-intensive goods.

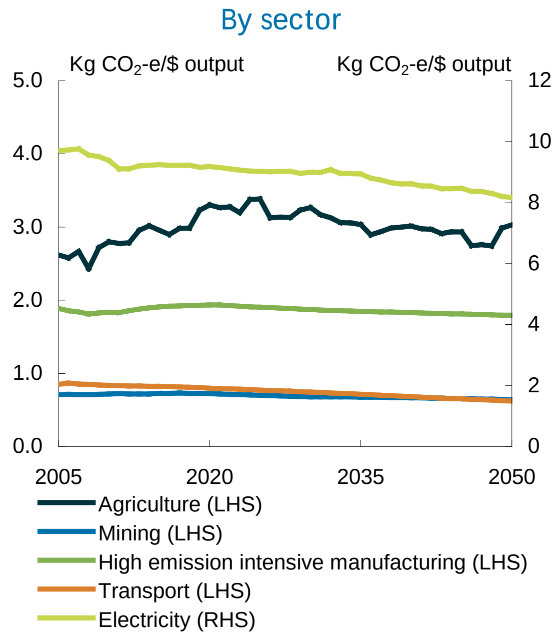
These mechanisms are all directly modelled within the CGE and bottom-up models used.

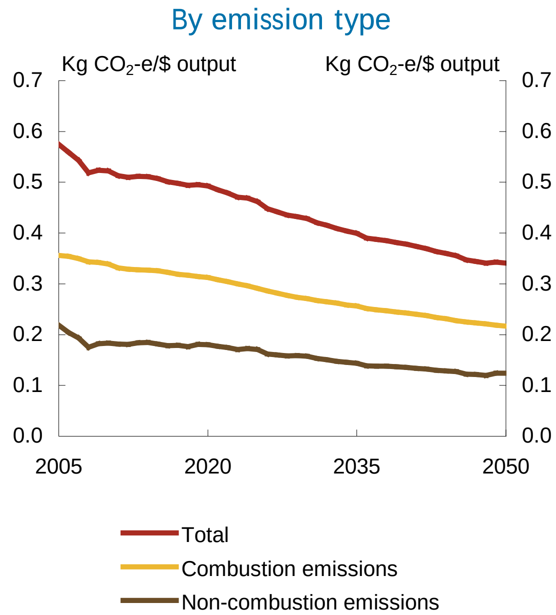
Additional technology and behavioural changes in sectors not modelled in detail are represented through an autonomous energy-efficiency improvement (AEEI) parameter.

The reference scenario for Australia assumes AEEI at the rate of 0.5 per cent per year for all sectors outside the electricity and transport sectors, reflecting available estimates of historical energy efficiency by Tedesco and Thorpe (2003), Cuevas-Cubria and Riwoe (2006) and the IEA (2004 and 2007c). For other regions, GTEM generally uses 0.5 per cent per year.

Arriving at estimates of future energy efficiency is difficult given uncertainty about how energy efficiency will evolve over long timeframes. A sensitivity scenario explored a higher energy-efficiency assumption in the reference scenario, with an additional 1 per cent per year from 2013 to 2030, an extra 0.5 per cent per year from 2031 to 2040, and no extra improvement thereafter assumed. Greater energy efficiency reduces emissions as demand for energy for a given level of economic activity falls. By 2050, global emissions were around 10 per cent lower than in the central reference scenario.

Chart 3.23: Emission intensity

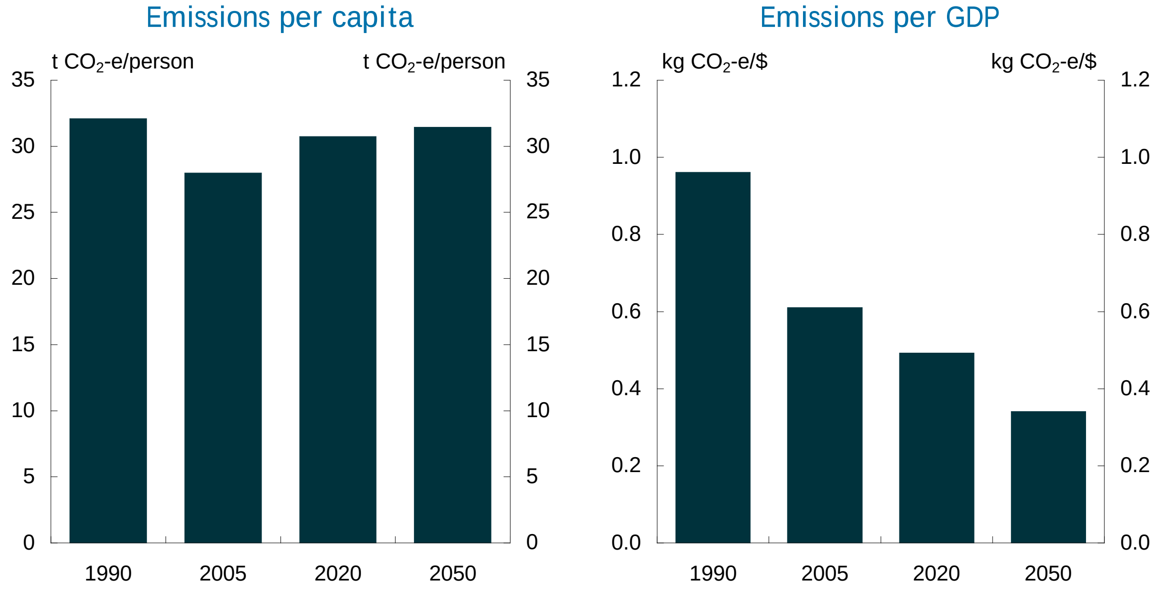




Source: Treasury estimates from MMRF.

Australia's per capita greenhouse gas emissions are the highest in the OECD and among the highest in the world. However, they are broadly comparable to similar resource rich economies such as Canada. In 2006, Australia's per capita emissions were 27.7 t CO_2-e per person and are expected to remain broadly unchanged to 2050 (Chart 3.24).

Chart 3.24: Emissions in Australia



Note: Emission estimates vary from Table 3.2 due to database differences between the MMRF and GTEM models.
Source: Treasury estimates from MMRF.

In 2050, CO_2 is projected to remain the main contributing gas, accounting for around 77 per cent of emissions. Methane is second, with 17 per cent of emissions, largely from agriculture, then nitrous oxide with around 5 per cent of emissions.

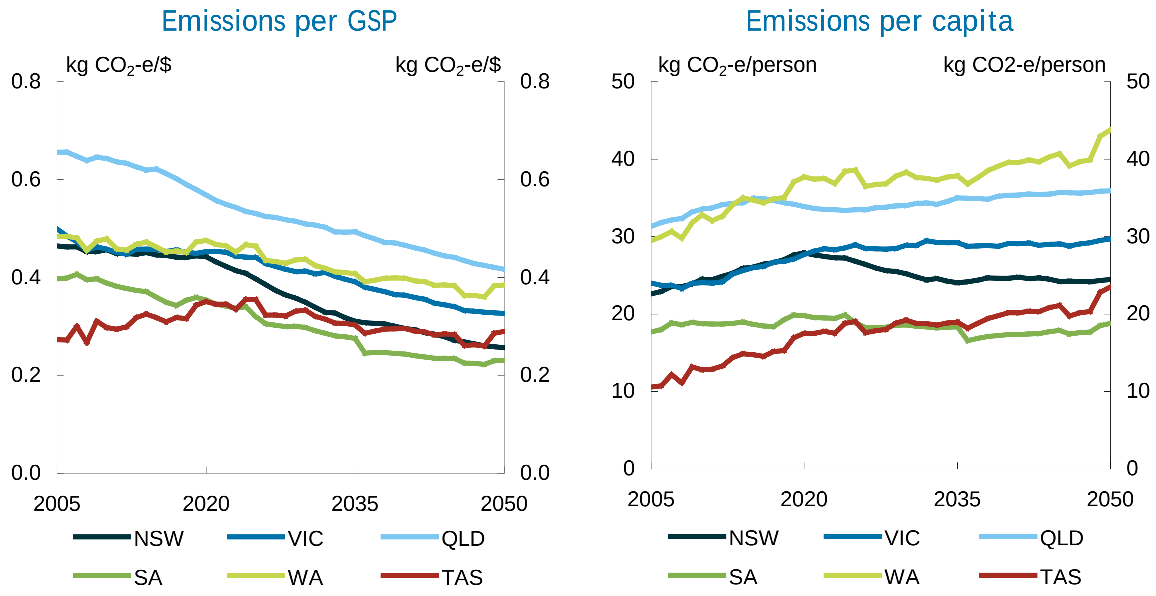
Emissions by state/territory

The level of emissions in each Australian state is determined by economic size and industrial composition. The emission intensity and emissions per capita show similar patterns for each state (Chart 3.25).

Emission intensity of output and per capita emissions are highest for Northern Territory, Western Australia and Queensland, reflecting specialisation in energy-intensive production for domestic and export markets.

The modest decline in emission intensities is due to the assumed known technological changes in the production processes.

Chart 3.25: Emissions by state/territory



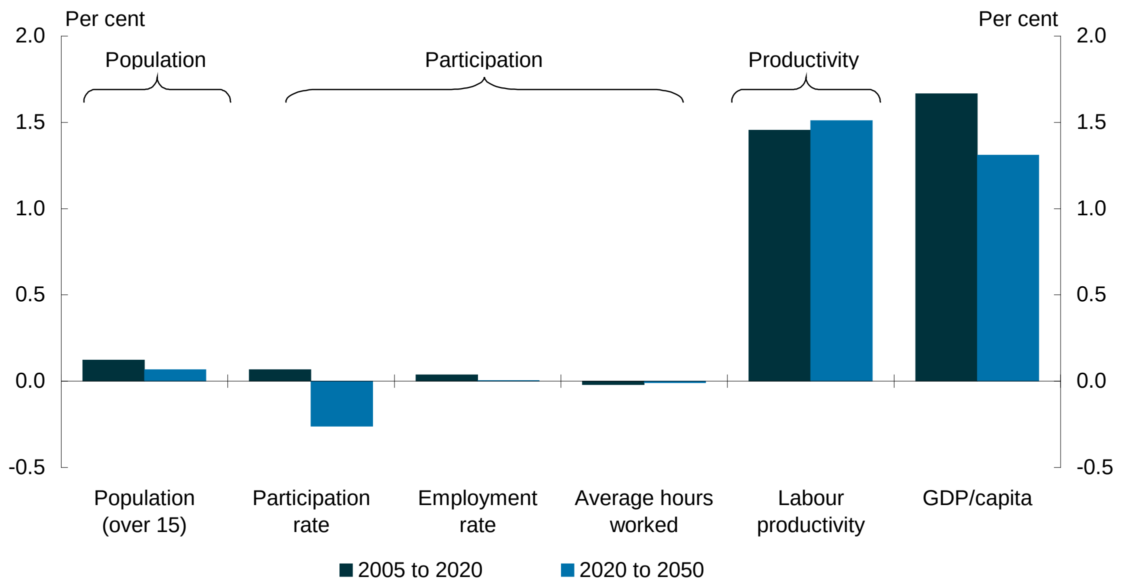
Source: Treasury estimates from MMRF.

3.2.2 The macroeconomy

Economic output

In the reference scenario, the pattern and rate of GDP growth is a function of assumptions on movements in population (the number of people of working age, 15 and over); changes in participation rates (which take into account labour force participation rates, the unemployment rate and hours of work); and the growth of productivity (the average output produced per hour worked) (Chart 3.26).

Chart 3.26: Decomposition of GDP growth



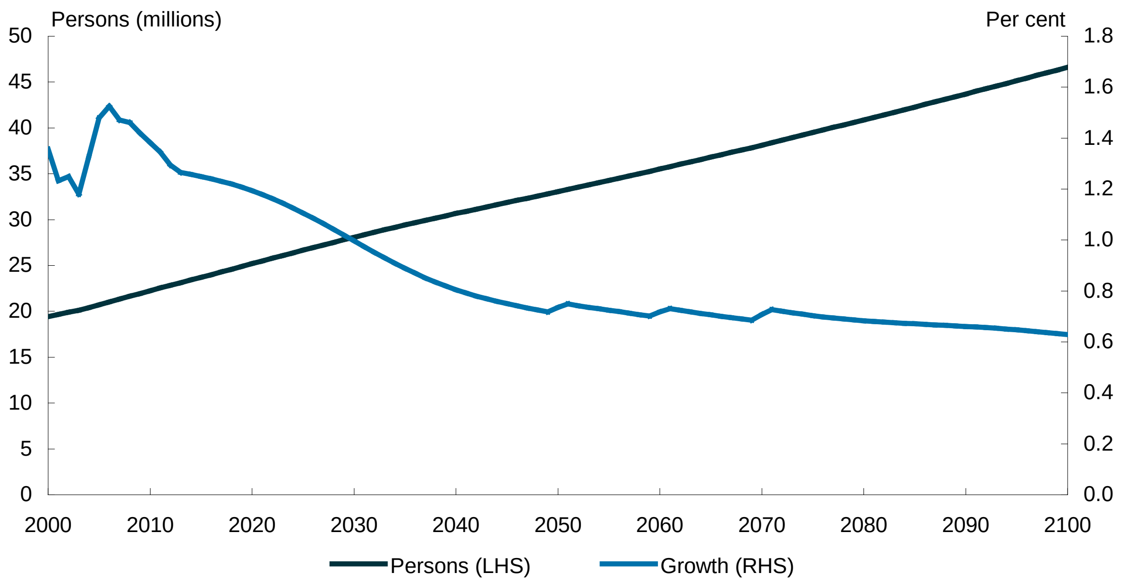
Source: Treasury estimates from MMRF.

Population

Australia's population is assumed to more than double, from 20.7 million in 2005 to 33 million in 2050, and is expected to reach nearly 47 million in 2100 (Chart 3.27). Australia's population growth moderates from around 1.5 per cent in 2005 to around 0.6 per cent after 2050 as fertility rates decline.

Australia's population estimates are based on Australian Bureau of Statistics (ABS) projections and the methodology of the Government's intergenerational report, revised in light of Treasury's most recent analysis of immigration trends. This sees net migration of 150,000 people per year until 2050, increasing to 200,000 people per year by 2070, then remaining constant to 2100.

Chart 3.27: Australian population



Source: ABS and Treasury.

The regional distribution of Australia's population shifts. Western Australia, the Northern Territory and Queensland capture a rising share; South Australia and Tasmania have a declining share (Table 3.9).

Table 3.9: Population growth by state/territory

Decade	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
2000s(a)	1.1	1.4	2.0	1.0	2.1	0.8	1.7	1.5
2010s	1.0	1.2	1.8	0.7	1.8	0.5	1.6	1.2
2020s	0.9	1.0	1.6	0.5	1.4	0.3	1.5	0.8
2030s	0.7	0.8	1.3	0.2	1.1	0.0	1.5	0.7
2040s	0.6	0.6	1.1	0.1	1.0	-0.2	1.4	0.6
2050s	0.7	0.6	1.0	0.1	0.9	-0.2	1.3	0.6
2060s	0.7	0.7	0.9	0.0	0.8	-0.1	1.0	0.7
2070s	0.7	0.7	0.8	0.0	0.8	0.0	0.8	0.7
2080s	0.7	0.7	0.7	0.0	0.7	0.0	0.7	0.7
2090s	0.7	0.7	0.7	0.0	0.7	0.0	0.7	0.7

(a) 2000s commence 2005-06, consistent with the base year in the MMRF model.
Source: ABS and Treasury analysis, MMRF.

Participation

Participation assumptions, including the labour supply and the proportion of Australia's population of working age, accord with the Government's intergenerational report (Australian

Government, 2007). Participation rates for each state and territory are assumed to follow the national pattern, with Australia's labour supply and employment assumed to grow at the same rate.

Productivity

Australian aggregate labour productivity is based upon Treasury forecasts and Budget projections until 2011-12 (Australian Government, 2008b). Beyond 2011-12, this rate is assumed to moderate from 1.75 per cent to 1.5 per cent per year over a ten-year period to the mid 2020s, as the Australian economy restructures towards lower productivity sectors, particularly services, reflecting the compositional shifts in consumer preferences as incomes rise.

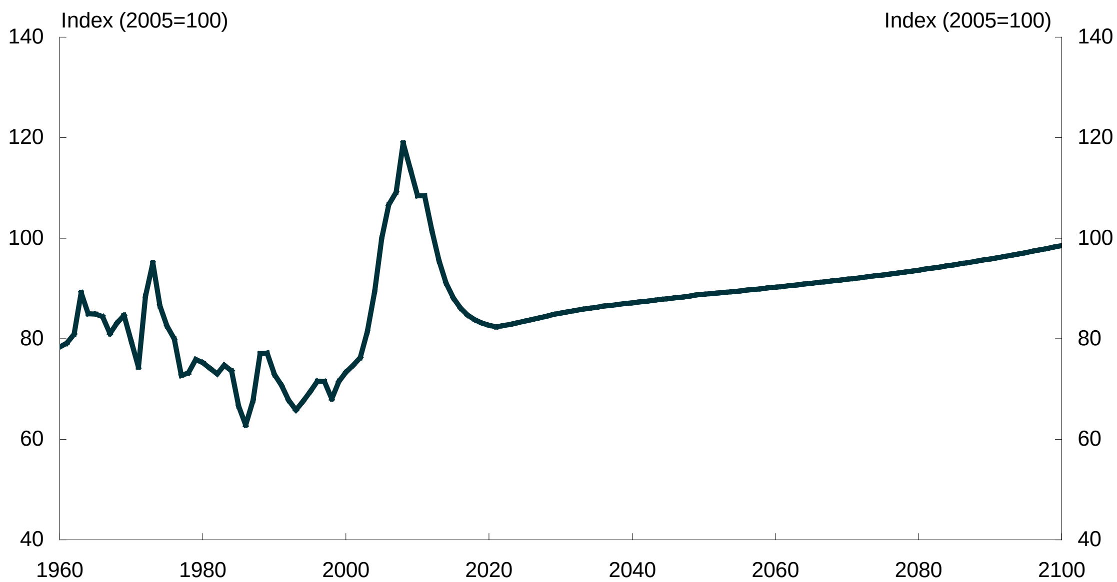
The dispersion of productivity growth across Australia's industry sectors is based on historical performance until 2020. After this, growth rates in market sector industries are assumed to converge, reflecting uncertainty about how persistent historical differences will be.

Terms of trade

Australia's terms of trade is expected to fall over the next 10 years from their current 50-year high as commodity producers around the world increase the supply of resources in response to the recent demand surge.

Beyond 2020, Australia's terms of trade is expected to gradually improve as export prices return to an upward trend and import prices remain modest, reflecting the likely pattern of global productivity growth. By 2050, Australia's terms of trade remain below the level reached in 2008, and returns to around the level of 2005 by 2100 (Chart 3.28).

Chart 3.28: Australia's terms of trade

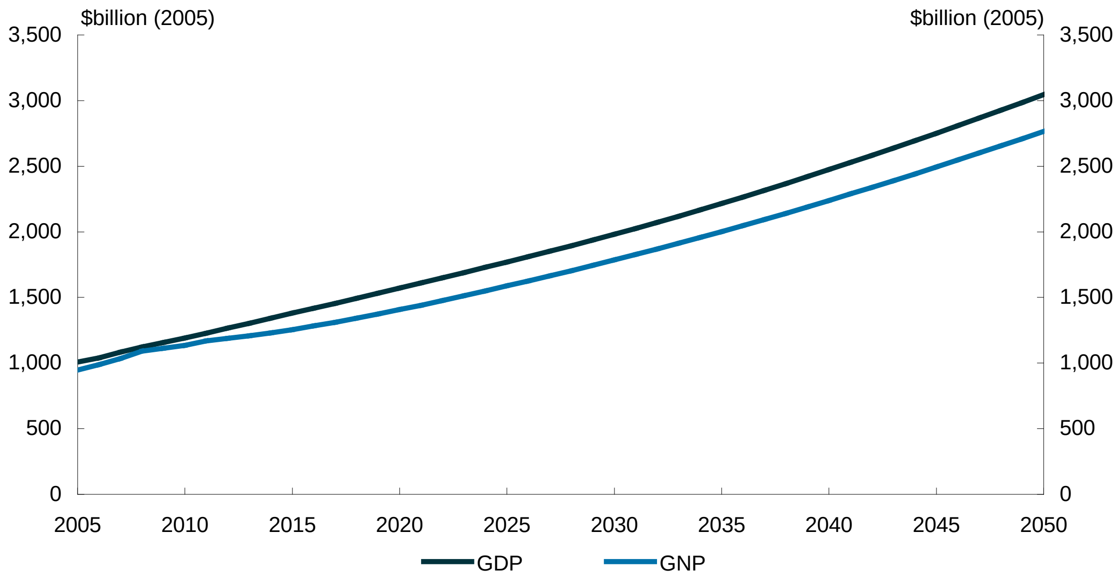


Source: Australian Government, 2008b; and Treasury estimates from MMRF and GTEM.

Gross national product

Movements in the terms of trade drive a wedge between GNP and GDP (Chart 3.29). GNP is a measure of welfare that captures current and future consumption, and indicates what a nation can afford to buy in addition to what it actually produces.

Chart 3.29: Australian GDP and GNP levels



Source: Australian Government, 2008b; and Treasury.

Consumption

Consumption remains broadly constant as a share of real GDP. Household incomes grow at an average rate of 2.3 per cent per year to 2050, and average household expenditure increases by more than 200 per cent from 2005 to 2050. As Australians' per capita income rises, the historical shifts in household preferences towards services and imported manufactures continue (Table 3.10).

Table 3.10: Consumption shares, 2020

Commodity	Per cent
Dwelling services	16.9
Other services	13.8
Public services	11.6
Other food, beverages and tobacco	10.6
Accomodation, hotels, cafes and restaurants	8.1
Transport services	5.5
Financial services	4.7
Communication services	4.0
Trade services	3.7
Textiles, clothing and footwear	3.3
Other manufacturing	2.6
Private electricity services	2.0
Chemicals	2.0
Air transport	1.8
Meat products	1.6
Private heating services	1.4
Other agriculture	1.3
Water transport	0.8
Printing	0.8
Road freight	0.6

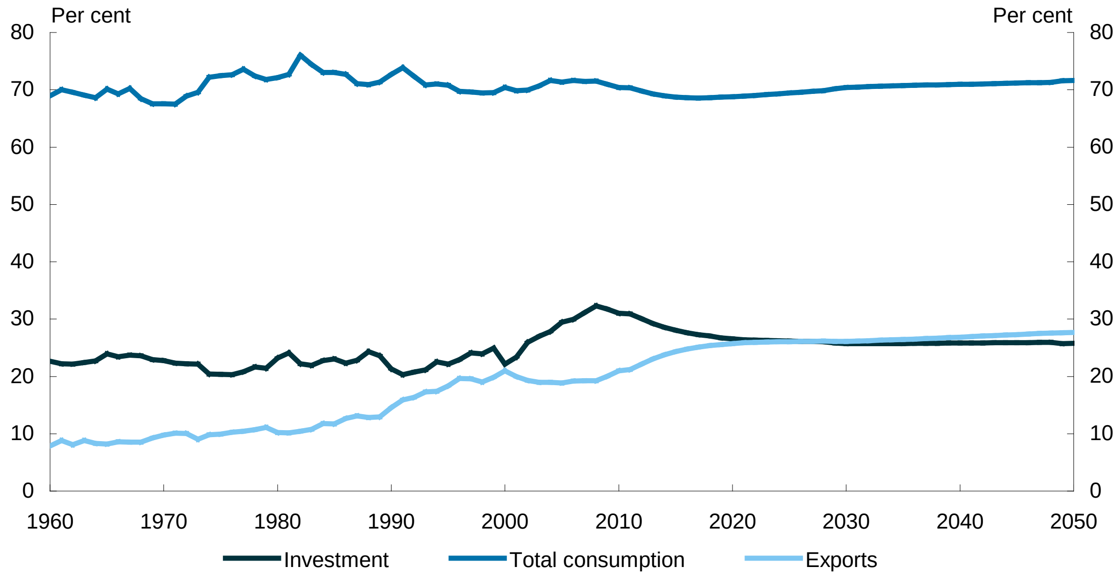
Source: Treasury estimates from MMRF.

Investment

Investment's share of real GDP is currently high as investment, particularly in mining, responded to demand from China and India for mining commodities. Investments' share of GDP falls over the decade to 2020, as the terms of trade declines and manufacturing's share of output continues to fall (Chart 3.30). Thereafter, it is assumed to remain broadly constant as a share of the real economy.

Investment rates are supported by ongoing trend declines in capital goods prices, reflecting productivity growth in world manufacturing. High levels of investment in mining are underpinned by rising marginal costs of extracting natural resources, as firms look to exploit lower quality ore deposits.

Chart 3.30: Consumption, investment and export shares of GDP



Source: Treasury estimates from MMRF.

Exports

With rising per capita incomes in developing economies, people will spend a larger share of their income on more energy-intensive goods and higher value food. These forces will create strong demand for Australia's commodity exports and substantially change Australia's pattern of trade.

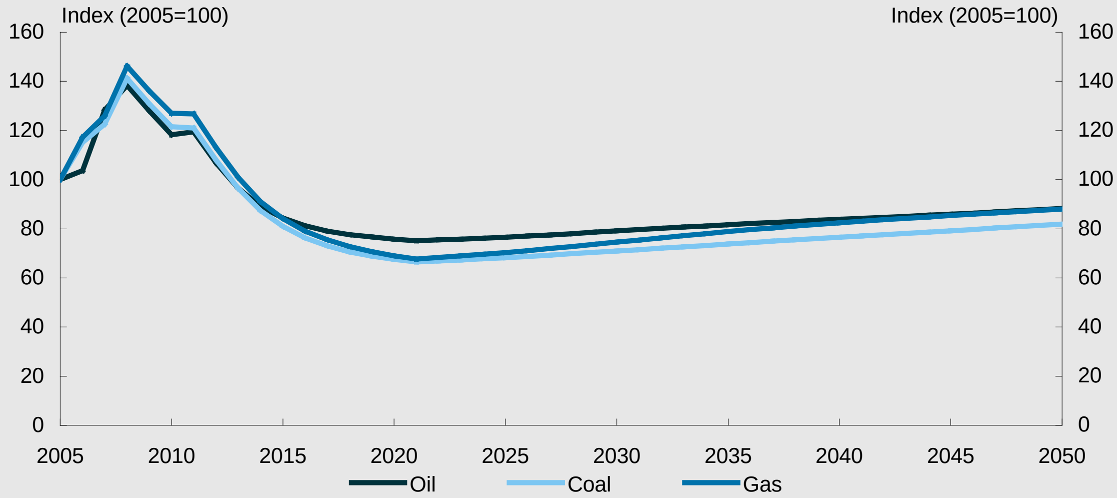
China, India and Indonesia are projected to be Australia's first, second and third largest export markets by 2050 – positions held by the European Union, Japan and the United States in 2005. The proportion of Australia's exports going to China, India and Indonesia increases from 14 per cent in 2005 to more than 35 per cent in 2050.

Export shares shift between sectors by 2050, with service exports, particularly tourism exports, becoming substantially more important (Chart 3.32). In line with these developments, the historical trend diversification of Australia's export shares is also expected to continue to 2050.

Box 3.6: Commodity prices

Global energy prices are assumed to rise gradually, as rising demand drives exploitation of more marginal resources. Movements in the international prices for key energy commodities, including oil, coal and gas, are assumed to broadly follow IEA projections (Chart 3.31).

Chart 3.31: Commodity price assumptions



Source: IEA, 2007b; and Treasury.

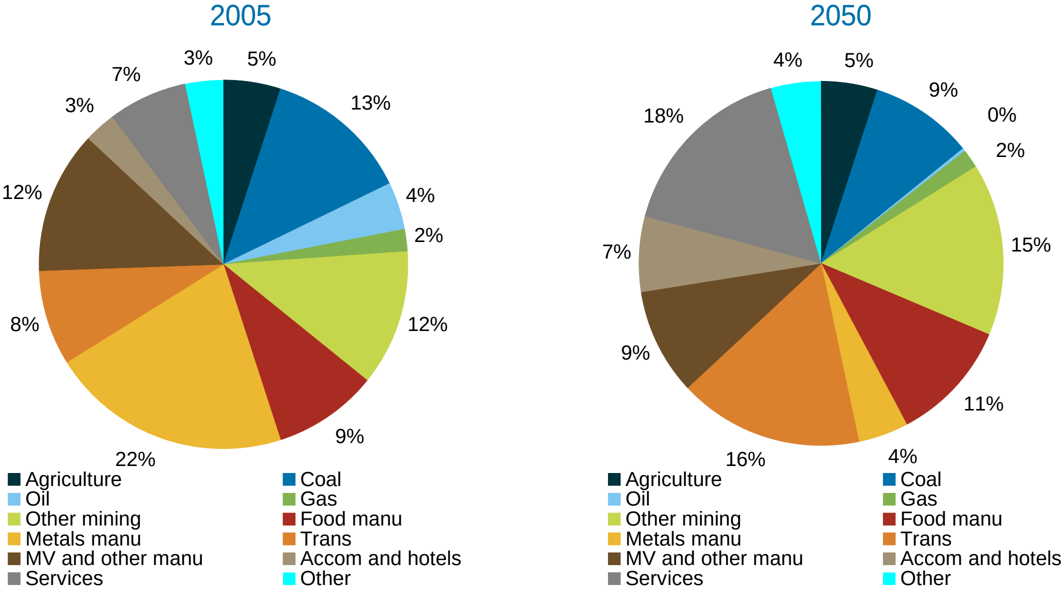
For Australian electricity generators, black coal prices are assumed to remain stable in the short term, reflecting existing contractual arrangements. However, as these contractual arrangements roll over, Australian prices begin to rise gradually in line with global trends. Australia does not export brown coal, so brown coal prices for electricity generators, notably in Victoria, are assumed to remain broadly flat, reflecting large reserves and limited alternative uses.

Australia's domestic gas market is highly regional; Western Australian prices are linked to international markets while prices in the eastern states market are not. Eastern seaboard gas prices for electricity generators are projected using a model of the gas market developed by McLennan Magasanik Associates (MMA). This model takes account of new and existing contracts, transmission costs and gas supply resources. East coast gas prices converge to world prices by around 2030, reflecting depletion of existing gas sources on the east coast over the next 20 years and links to world markets through liquefied natural gas (LNG) facility developments (Annex B).

While energy resources are not assumed to be depleted, given the uncertainty about future commodity prices, a sensitivity scenario examined the impact of energy extraction costs being 50 per cent higher than the standard assumptions. The higher extraction costs boosted oil prices, moderately increased gas prices and marginally increased coal prices, with impacts differing between regions. This results in substitution away from fossil fuels, but also a shift towards coal, the most emission-intensive fuel.

As a result, global emissions in this sensitivity scenario are around 5 per cent lower than the standard reference scenario at 2050, reflecting reduced energy demand due to higher energy prices. This means that the mitigation task would be less in the policy scenario. Compared with the Garnaut -10 scenario, GWP mitigation costs are around 10 per cent less in 2050 and 30 per cent less in 2100.

Chart 3.32: Export shares by key sectors



Source: Treasury estimates from MMRF.

Australia's exports are relatively emission intensive compared with total Australian production. The emission intensity of exports is expected to fall as productivity, including in energy use and other emission-intensive inputs, continues to improve and there is a compositional shift to relatively low-emission service exports.

3.2.3 State analysis

Differences in economic growth in each of the states and territories are a function of patterns of industrial production and population growth. Over time, South Australia and Tasmania diverge from the other states to a lower average gross state product (GSP) growth rate, largely reflecting lower assumed population growth. Queensland, Western Australia and the Northern Territory have rising shares of the national population, while South Australia, Tasmania and the Australian Capital Territory have falling national shares. Population shares for New South Wales and Victoria remain stable (Table 3.11).

Table 3.11: Gross state product

Annual average growth rates

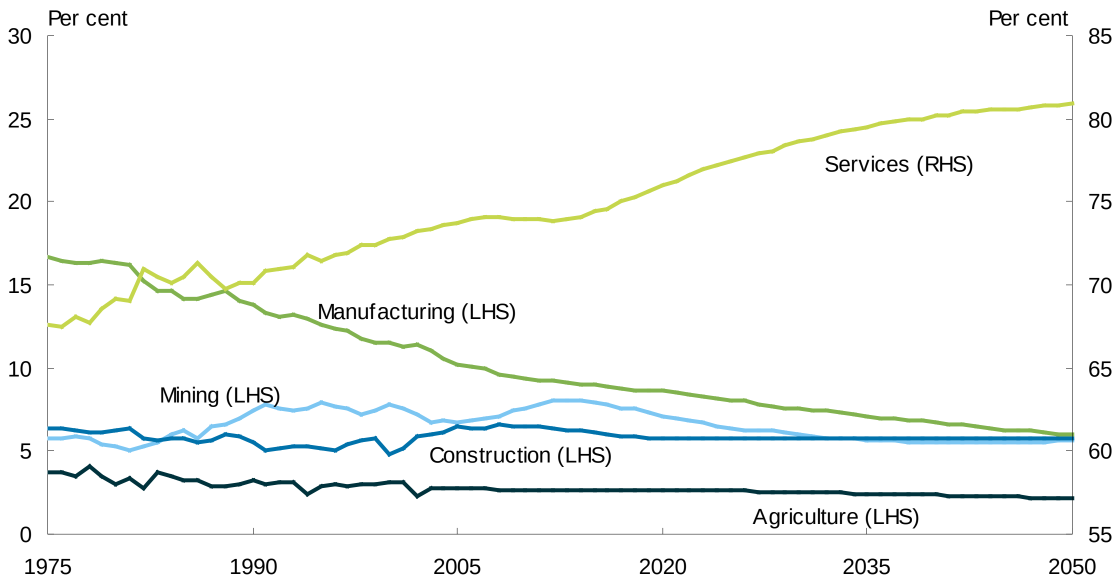
Decade	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
2000s(a)	3.0	3.2	3.8	2.7	4.6	2.9	4.3	2.9
2010s	2.6	2.8	3.2	2.2	3.2	2.0	2.8	2.6
2020s	2.3	2.3	2.7	1.6	2.4	1.7	2.3	2.2
2030s	2.2	2.1	2.6	1.6	2.4	1.7	2.6	2.1
2040s	2.0	2.0	2.4	1.4	2.3	1.5	2.7	1.9
2050s	2.0	2.0	2.3	1.4	2.3	1.5	2.7	1.9
2060s	2.1	2.1	2.3	1.5	2.3	1.6	2.6	2.1
2070s	2.2	2.1	2.2	1.5	2.3	1.6	2.5	2.2
2080s	2.1	2.1	2.2	1.4	2.3	1.6	2.4	2.1
2090s	2.1	2.0	2.2	1.4	2.2	1.6	2.4	2.1

(a) 2000s commence 2005-06, consistent with the base year in the MMRF model.
Source: Treasury estimates from MMRF.

3.2.4 Sectoral analysis

The sectoral composition of Australia's economy adjusts reflecting a continuation of historical trends. Both supply- and demand-side factors drive sectoral trends. On the supply side, industry sectors are assumed to have different rates of productivity growth. The sectoral differences assumed in the reference scenario are based on the historical dispersion of productivity growth across industry sectors. For instance, in Australia, productivity growth in the communications industry is expected to be almost twice the Australia-wide average, while productivity growth in service sectors such as public administration is expected to be below average. Over time, industry productivity growth assumptions in the market sector are assumed to converge, reflecting uncertainty about the persistence of historical differences over long timeframes.

Chart 3.33: Value added shares



Source: Treasury estimates from MMRF.

Overall, services are expected to grow at around 2.7 per cent per year to 2050, rising from around 73 per cent of real output in 2005 to almost 80 per cent in 2050. The service sectors that grow fastest include communications and property and business services.

While the service sectors provide the bulk of Australia's output, the Australian economy has a significant reliance on primary and related industries, such as agriculture, mining and mineral processing, reflecting Australia's abundance of natural resources. Over the next 50 years, all these sectors are expected to decline as a share of real GDP.

Agriculture is expected to grow more slowly, at around 1.9 per cent per year to 2050, largely reflecting land constraints. Agriculture's share of real GDP is projected to decline from around 3.2 per cent in 2005, to 2.5 per cent by 2050. However, increased world demand for agricultural products, and supply-side constraint, such as land availability, is expected to drive strong prices for agricultural commodities, and agriculture's share of nominal GDP is expected to increase to just over 5 per cent by 2050.

Initially, mining benefits from the recent surge in world demand for commodities before slowing in response to declining commodity prices and supply constraints in the oil and gas industries. Despite Australia possessing large reserves of (non-petroleum related) natural resources, as resource constraints start to affect underlying productivity in later decades, the mining sector is expected to grow by only slightly more than the national average, largely driven by strong growth in coal, iron ore and other metal ores. Overall the mining is assumed to grow at around 2.1 per cent per year to 2050.

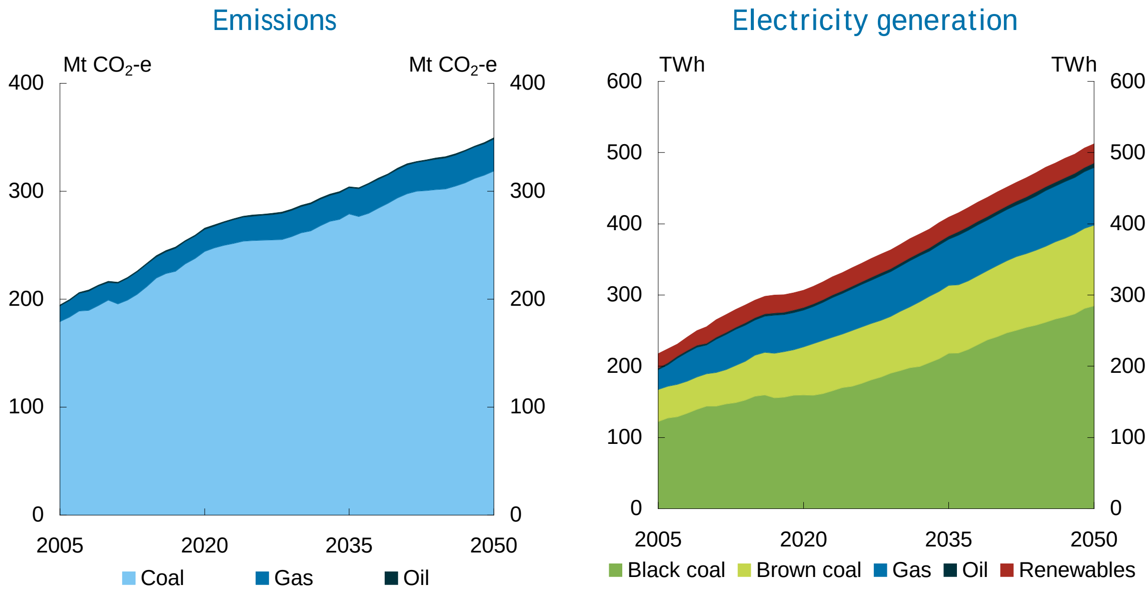
Australia's natural resource endowments provide an inexpensive and reliable supply of electricity. Access to low-cost energy provides a comparative advantage and contributes to the development of a range of energy-intensive manufacturing industries. Industries that benefit either directly (through their use of resources as material inputs) or indirectly (through their use of electricity) include mineral processing (iron and steel, non-ferrous metals), petroleum and chemicals, and wood and paper products. In 2005, together they accounted for 3.5 per cent of GDP; however, this is expected to fall to around 1.7 per cent by 2050 (Chart 3.33).

In aggregate, Australian manufacturing is expected to continue its historical decline. This decline is largely driven by strong productivity growth in global manufacturing, particularly in developing economies, resulting in a loss of competitiveness for Australian manufacturing. Overall, manufacturing is assumed to grow by 1.3 per cent per year to 2050. The contraction in manufacturing's share of the Australian economy is widespread across the sector, with metal-manufacturing industries such as steel and aluminium, textile, clothing and footwear, chemical manufacturing, and rubber and plastics industries all experiencing annual growth lower than the national average.

Electricity generation sector

Australian electricity generation is expected to more than double by 2050, growing from around 218 TWh in 2005 to around 512 TWh in 2050 (Chart 3.34). This reflects the economy's expansion and sustained growth in residential consumption and high electricity-use sectors, such as aluminium. Electricity generation grows less than output growth, reducing the electricity intensity of the economy.

Chart 3.34: Electricity sector



Source: Treasury estimates from MMRF and MMA (2008).

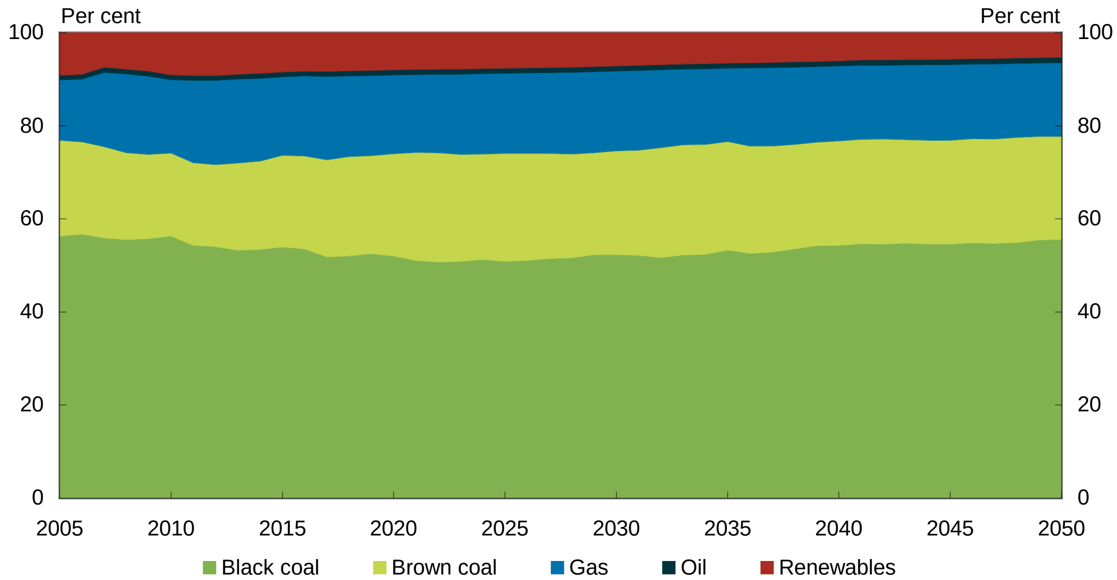
Australia has more than 100 years worth of reserves of black coal and 500 years of brown coal at 2005-06 rates of production (ABARE, 2008a). Coal accounts for around 75 per cent of Australia's electricity generation and 60 per cent of Australia's generation capacity by 2050.

The role of gas-fired electricity is projected to grow in the reference scenario, reflecting policies to encourage its take-up (such as the Queensland Government's gas scheme) and its capability to meet sudden 'peaks' in electricity demand (Chart 3.35). The ratio of peak-to-baseload electricity demand has been rising in recent years, including from the increasing penetration of air conditioners. This trend is assumed to continue until 2025 (MMA, 2008).

Gas-fired power plants rise from less than 20 per cent of Australia's current capacity to around 30 per cent by 2050, most of which is peaking plant. However, the role of gas is partly constrained by rising east coast gas prices, which reduce its competitiveness with respect to coal.

Renewable electricity sources continue to play a minor role in Australia's electricity sector. Hydroelectric capacity grows only marginally as most of Australia's hydroelectric potential is already exploited. Non-hydro renewables – particularly wind – increase their share of generation initially in response to incentives created under the pre-existing MRET scheme. However, without new policies, renewables comprise a declining share after 2020 owing to the cost advantage of fossil-fuel technology. Note that the reference scenario does not include the proposed expansion of the Renewable Energy Target scheme.

Chart 3.35: Australian electricity generation, technology shares



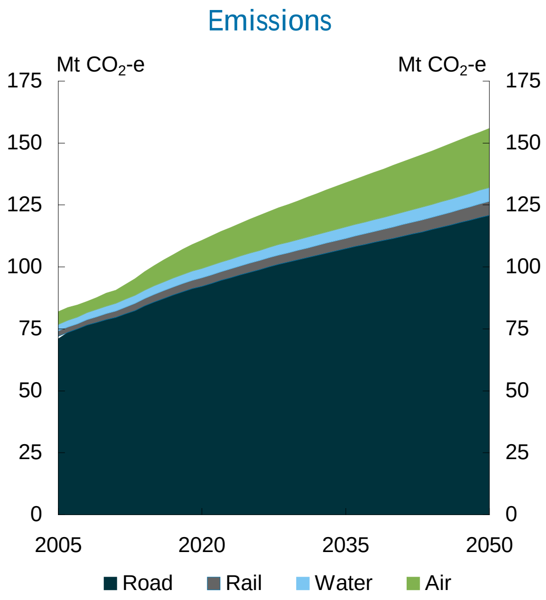
Source: MMA, 2008.

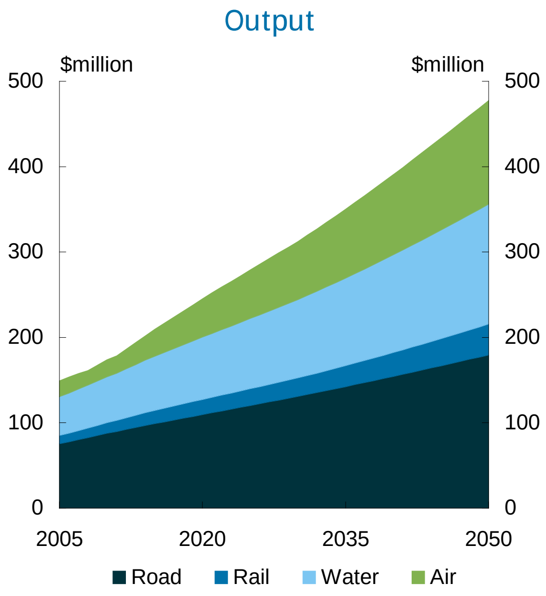
Electricity emissions in the reference scenario are projected to rise to around 348 Mt by 2050, 100 per cent more than 2000 levels of 175 Mt. The emission intensity of electricity generation remains broadly unchanged at around 0.8 tCO_2-e/MWh on average to 2050.

Transport

Output by the transport sectors (air, water, road, rail) is assumed to increase by around 2.6 times between 2005 and 2050 (Chart 3.36). This strong growth reflects the expansion of the economy and strong growth in air transport consistent with rising domestic and world incomes.

Chart 3.36: Transport sector





Source: Treasury; BITRE and CSIRO, 2008.

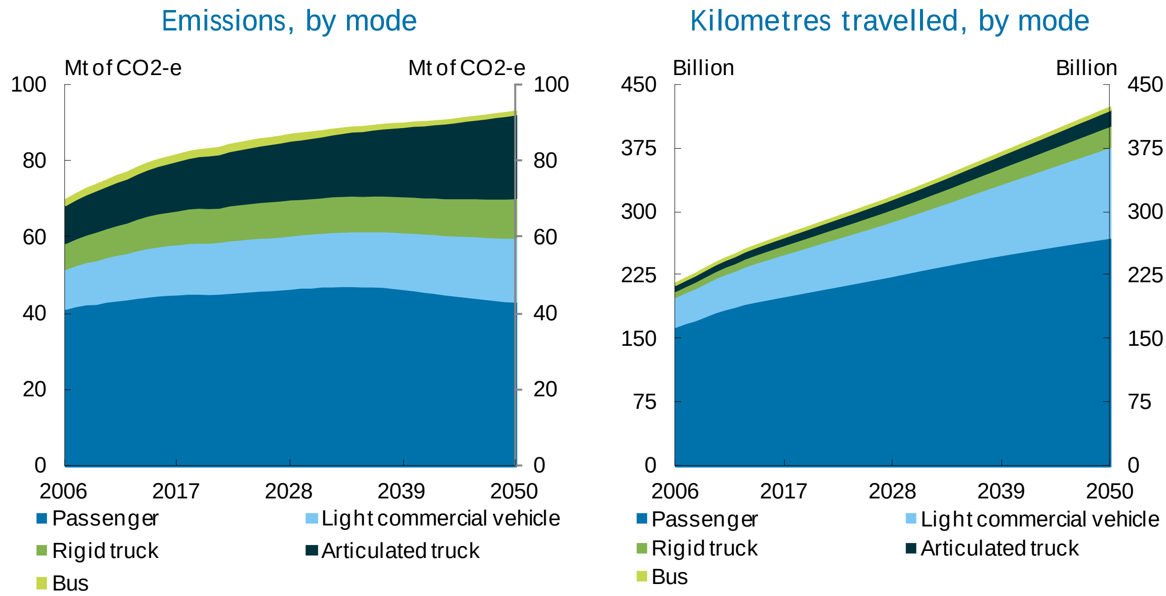
Australia's transport emissions increase modestly to 2050, with the share of total emissions relatively unchanged. Emissions growth primarily results from strong growth in the emission-intensive air transport sector, offset by moderate growth in passenger road transport emissions as demand is saturated (BITRE and CSIRO, 2008) and substitution occurs towards less fossil-fuel intensive vehicles as energy prices rise. Overall, emissions per unit of energy fall at an average annual rate of 0.1 per cent from 2005 to 2050.

Road transport

Road transport activity in Australia nearly doubles between 2006 and 2050 (Chart 3.37). Passenger transport is projected to reach a saturation point soon after 2010, whereby travel no longer increases with growth in incomes, reflecting consumer preferences to limit total time spent travelling. It then grows in line with population (BITRE and CSIRO, 2008). In contrast, freight activity continues to grow broadly in line with economic activity.

As a result, while passenger vehicles account for most of transport activity, their share falls from 75.6 to 63.5 per cent by 2050 and the share met by light commercial vehicles and trucks increases. The share of vehicle kilometres travelled met by buses remains below 1 per cent to 2050.

Chart 3.37: Road transport sector



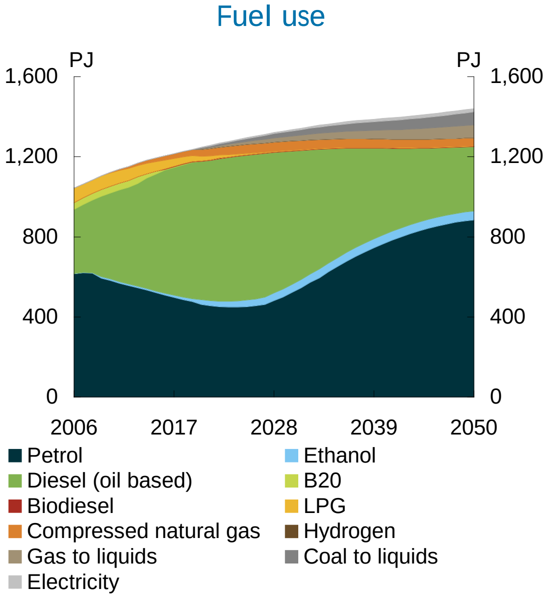
Source: Treasury; BITRE and CSIRO, 2008.

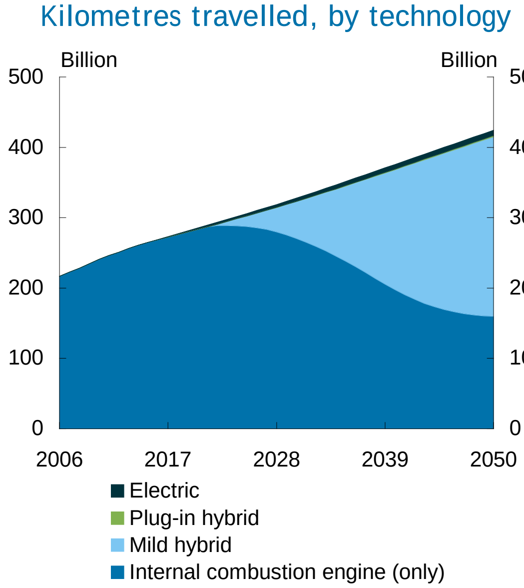
The mix of transport fuels changes over time. The changes reflect oil market conditions and technology assumptions, including the availability of fossil-fuel alternatives. Conventional fuels, such as petrol and diesel, still dominate in 2050 (Chart 3.38).

A major trend is diesel's share rises for the first 20 years, overtaking petrol as the dominant fuel, but then declines (BITRE and CSIRO, 2008). Diesel's increased share reflects the rising efficiency of diesel engines, making the fuel more attractive than petrol. Efficiency improvements are primarily due to the availability of European-designed diesel engines which until recently were not compatible with Australia's diesel fuel. Petrol regains a majority share by 2050, as the improved efficiency of hybrid engines makes them more cost-competitive than diesel.

Another major trend is fuel diversification from around 2020, with ethanol, electricity and synthetic forms of diesel (such as gas and coal to liquid) (BITRE and CSIRO, 2008). The share of ethanol related fuels (E10 and E85) increases around 2020, as technology to extract ethanol from lignocellulose feedstocks is assumed to become cost effective. Production of synthetic diesel fuels is assumed to start in 2020 in response to rising oil prices. Electricity is consumed in the small number of fully electric and plug-in electric vehicles. By 2050, a total of 17 petajoules (PJ) of electricity is used in transport – around 5 TWh – which amounts to around 1 per cent of total Australian electricity production in 2050. Hydrogen technologies are not deployed.

Chart 3.38: Road transport sector





Source: Treasury; BITRE and CSIRO, 2008.

These fuels use different engine technologies (Chart 3.38). Internal combustion engines and hybrid cars are the dominant technology, with few fully electric or plug-in electric cars. These more fuel efficient vehicles partly explain moderating emissions growth from the sector to 2050. In addition, growth in passenger kilometres slows due to a declining population growth rate and vehicle ownership saturation.

Reduction in energy use per vehicle kilometre, fuel switching and improvements in engine technology, slowing population, and improved engine technology drive a slowing in emissions. Emissions from road transport (including those from electricity used in transport) grow at an average annual rate of 1.2 per cent from 2006 to 2020, and an average annual rate of 0.8 per cent from 2006 to 2050.

Road freight emissions from rigid and articulated trucks and light commercial vehicles increase more strongly, in line with growth in mining and the economy as a whole.

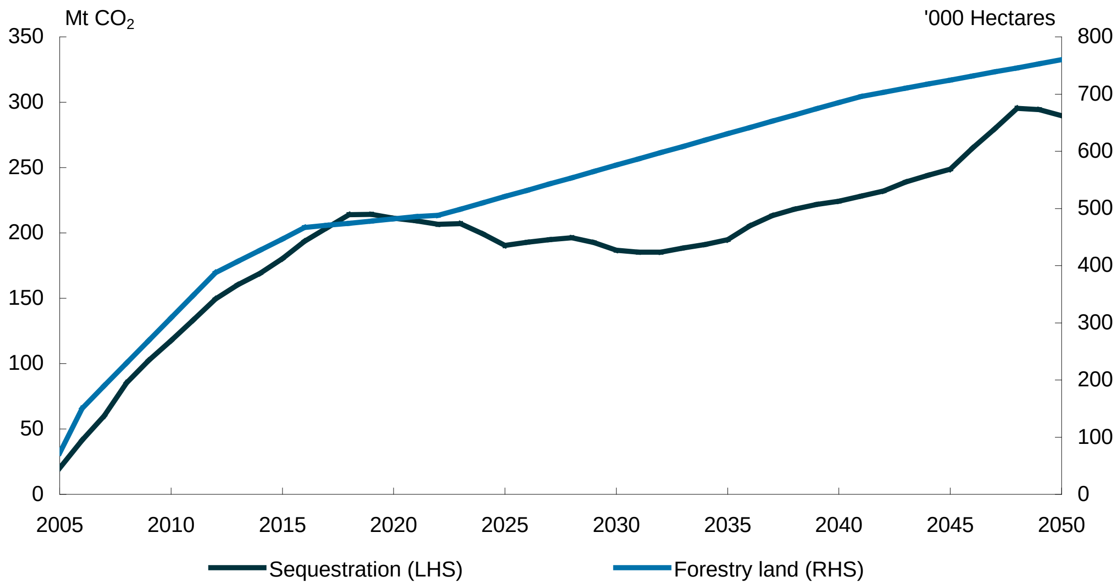
Land-use change and forestry

In Australia, more than 750 thousand hectares of new forestry plantations are projected to be established between 2005 and 2050. Western Australia is projected to have the largest uptake of new forestry plantations due to a significant increase in short rotation hardwood investments.

Annual expansion of plantations is projected to peak around 78,000 hectares in 2006 before trending down to an estimated 7,100 hectares per year by around 2040. No large scale deforestation is projected for Australia, as regulations prohibit clearing of native vegetation in all states and territories.

Forestry plantation and the corresponding emissions sequestered by the forestry sector grow steadily to 2050 (Chart 3.39). Sequestration rates vary, depending on the amount of land planted, growth rates, harvesting and other factors. From 2005 to 2050, forestry provides a cumulative net carbon sink of almost 300 Mt CO_2-e.

Chart 3.39: Australian land under forestry, and associated sequestration



Note: Land under forestry is cumulative since 2005.
Source: ABARE, 2008b and DCC, 2008.

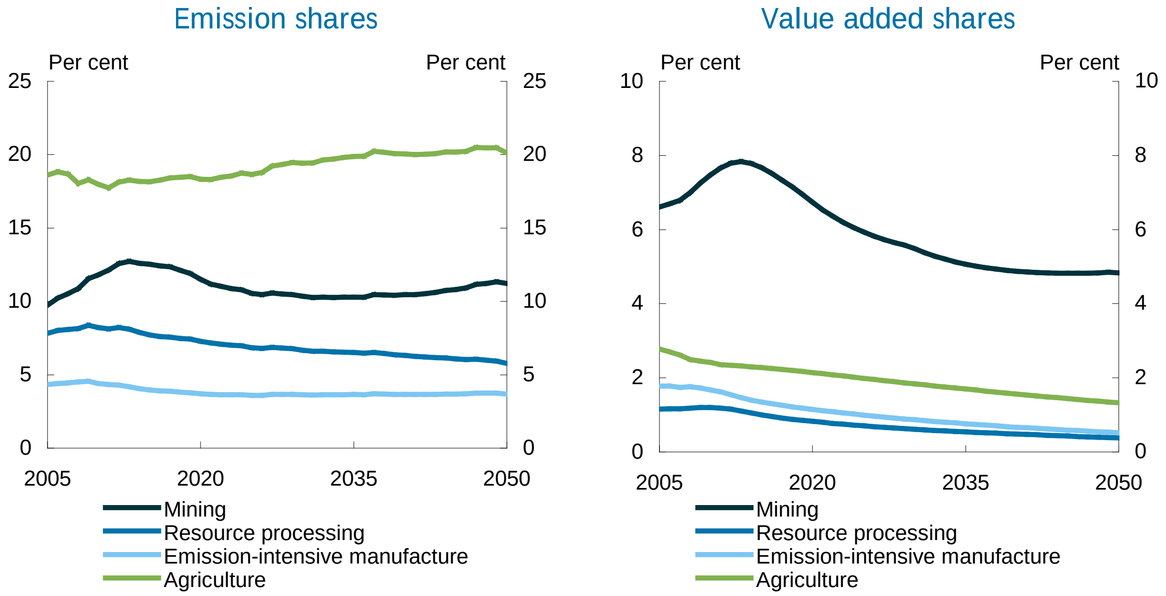
Emissions from land-use change in Australia continue at the rate of 44 Mt CO_2-e per year. This is based on a simple extrapolation from projections in the most recent national emission projections (DCC, 2008), and represents emissions from clearing of regrowth rather than any new deforestation.

Other emission-intensive industries

The other emission-intensive sectors comprise mining, resource processing, emission-intensive manufacturing and agriculture. These sectors comprise around 40 per cent of emissions and around 12 per cent of value added output. As the Australian economy becomes more service orientated, the share of output from these emission-intensive sectors falls, while their share of total emissions remains relatively constant (Chart 3.40).

These emission-intensive sectors comprise around 60 per cent of Australia's exports in 2005. This reflects Australia's rich endowment of natural resources, and access to low-cost sources of energy, a source of comparative advantage in international trade. The export share from these sectors falls to around 40 per cent by 2050, as world demand for resources slows after 2020.

Chart 3.40: Emission-intensive industries



Source: Treasury estimates from MMRF.

The resource-processing sector comprises steel, aluminium, alumina, refining and other metal-manufacturing industries. The share of output from this sector is projected to fall, as growth in output from the metal-manufacturing sectors (iron and steel, aluminium, alumina and other metal manufacturing) slows in response to slowing world demand, and higher electricity price, particularly for aluminium. Emissions from this sector are primarily from energy use (coal used in steel manufacture, and scope 2 emissions from electricity use within the aluminium sector) and industrial processes (such as PFCs generated and emitted during the production of aluminium).[5]

The emission-intensive manufacturing sector comprises paper products, chemicals, rubber/plastic, non-metal manufacturing and cement. Its falling share of output to 2050 largely reflects a loss of competitiveness because productivity growth remains strong in global manufacturing, particularly in developing economies. Emissions from this sector are largely industrial-process emissions, such as from calcification during cement manufacture releasing CO_2, and from the combustion of fossil fuels.

3.2.5 Households

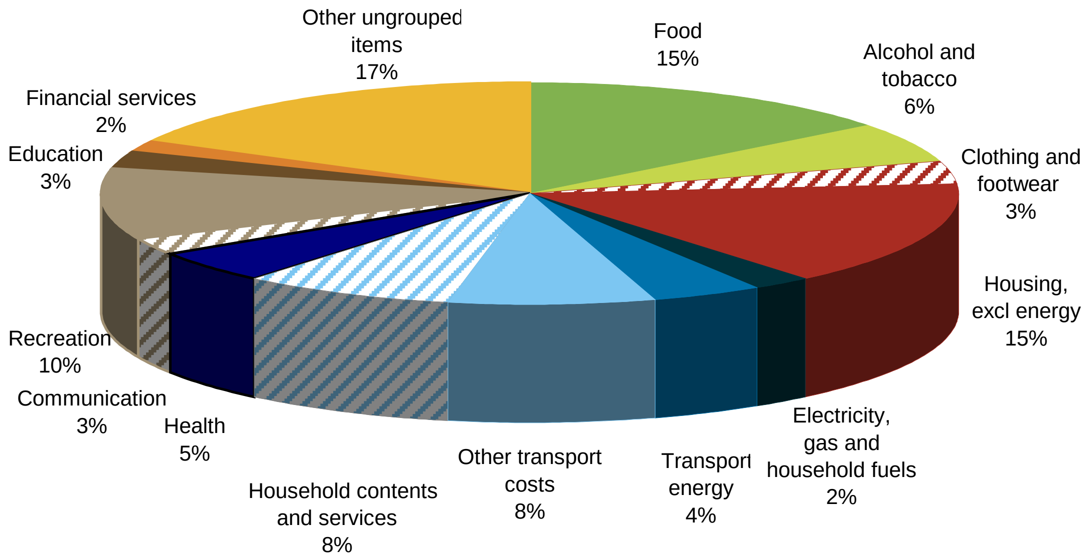
Household use of stationary and transport energy, including automotive fuel, residential electricity, gas and other energy sources, accounted for 36 per cent of energy consumption by volume in 2005-06. Transport energy spending is a large share of energy spending for most households. Total household spending on energy is around 6.3 per cent of household spending at the median, for those households that spend on energy, while spending on stationary energy is around 2.4 per cent of all spending at the median for those with spending on stationary energy.

Overall, households spend most on housing (15 per cent), food (15 per cent) and recreation (10 per cent) (Chart 3.41). Direct energy consumption represents around 6.6 per cent of all spending by Australian households, but households also consume energy indirectly, through the

5 Scope 2 emissions are indirect emissions from the generation of purchased electricity.

use of public transport, and embodied energy in household consumption, that is, the energy used in the manufacture, transportation and disposal of goods or services over the lifecycle.

Chart 3.41: Aggregate household spending
By category in 2010-11



Note: Shares of spending by category are based on aggregate spending for all households included in the HES survey sample.
Source: Treasury.

The pattern of spending by households is affected by income and other characteristics, including household composition and location.

Distributional analysis

Total household spending on energy varies across regions (Chart 3.42), possibly as a result of variation in available energy sources, prices and quantities consumed. There is also significant variation within regions as a result of transport and household consumption choices. Spending on energy by Hobart households, for example, ranges from around 5 per cent of spending at the 25th percentile to around 11 per cent of spending at the 75th percentile. Relatively low proportions of household spending on fuel in Brisbane and regional Queensland may be partly attributable to the Queensland Fuel Subsidy Scheme, which has provided a subsidy of around 8 cents per litre for Queensland motorists since July 2000.

Box 3.7: Methodology for household spending distributional analysis

In this section of the report, all distributional analysis is based on equivalised disposable household incomes. This enables comparison of income across households of different size and composition by scaling incomes back to a single person equivalent basis. Equivalised household incomes have been derived using the modified OECD equivalence scale, in which the first adult in the household is given a weight of 1.0, each subsequent person aged 15 years or more is given a weight of 0.5 and children aged less than 15 years are each given a weight of 0.3.

Incomes are generally represented in quintiles of household disposable income in the following analysis, with quintile cut-off points in 2010-11 dollar terms equivalised for a single adult as follows: $376 per week at the top of the first quintile, $5749 at the top of the second quintile, $773 at the top of the third quintile and $1043 at the top of the fourth quintile.

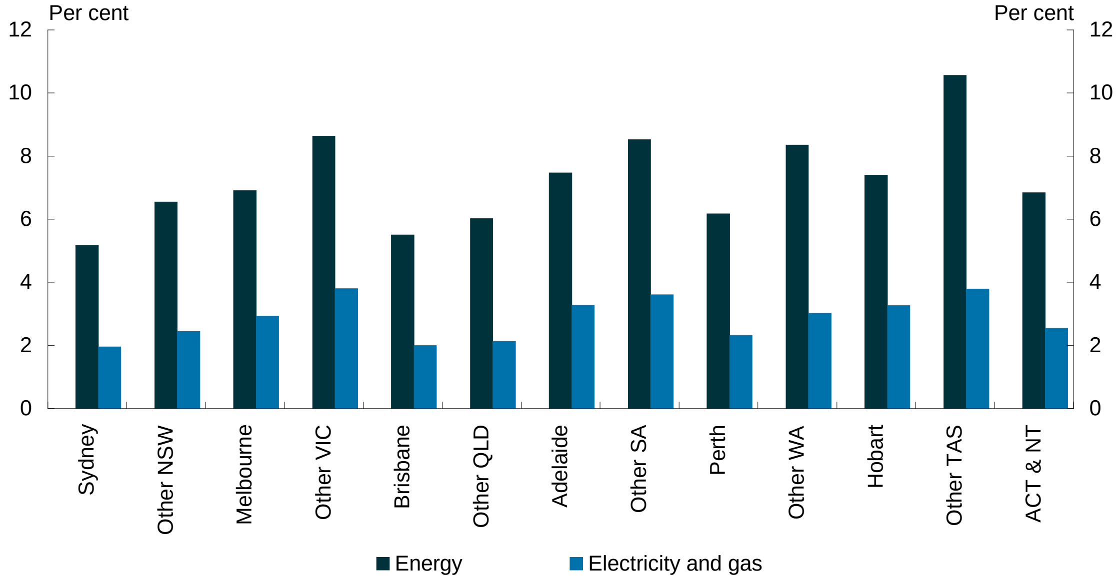
The PRISMOD.DIST model has been used for this analysis to ensure that results are consistent with the scenario results reported in Chapter 6 of this report. The model projects household spending for the 2010-11 year based on projected growth in prices for CPI expenditure classes, and projects incomes based on projected growth in wages and transfer payments and legislated tax rates and thresholds. Lump sum Government transfers of a one-off nature and other measures that are not legislated by 15 October 2008 to impact in the 2010-11 year are not modelled. The quantities of goods and services purchased by households are kept constant in the model, only prices vary over time.

Household spending on stationary and transport energy includes direct spending on electricity, mains gas, bottled gas, heating oil, wood for fuel, bottled gas for barbecues, kerosene, paraffin, petrol, diesel fuel, LPG, other gas fuels, other domestic fuel and holiday petrol. Where stationary fuel use is reported separately, petrol, diesel fuel, LPG, other gas fuels, other domestic fuel and holiday petrol are excluded.

Unless otherwise stated, households are only included in the analysis if they spend on energy and have positive disposable income. While the exclusion of households with negative or nil disposable income results in slightly fewer households in the lowest quintile being included in the analysis, it partially addresses ABS concerns that 'the (reported) income of many households in the lowest decile may not accurately reflect the level of their wellbeing'. Around 2.5 per cent of households with positive disposable income are excluded from the analysis because they report no direct spending on energy at all, while around 3.4 per cent of households with positive disposable income are excluded from analysis of spending on stationary energy because they report no spending on electricity, gas or household fuels.

Regional analysis of spending is limited to the broad areas identified in the ABS Household Expenditure Survey 2003-04 confidentialised unit record file. This particularly limits analysis for the Northern Territory and the Australian Capital Territory, which are treated as one area in the unit record file.

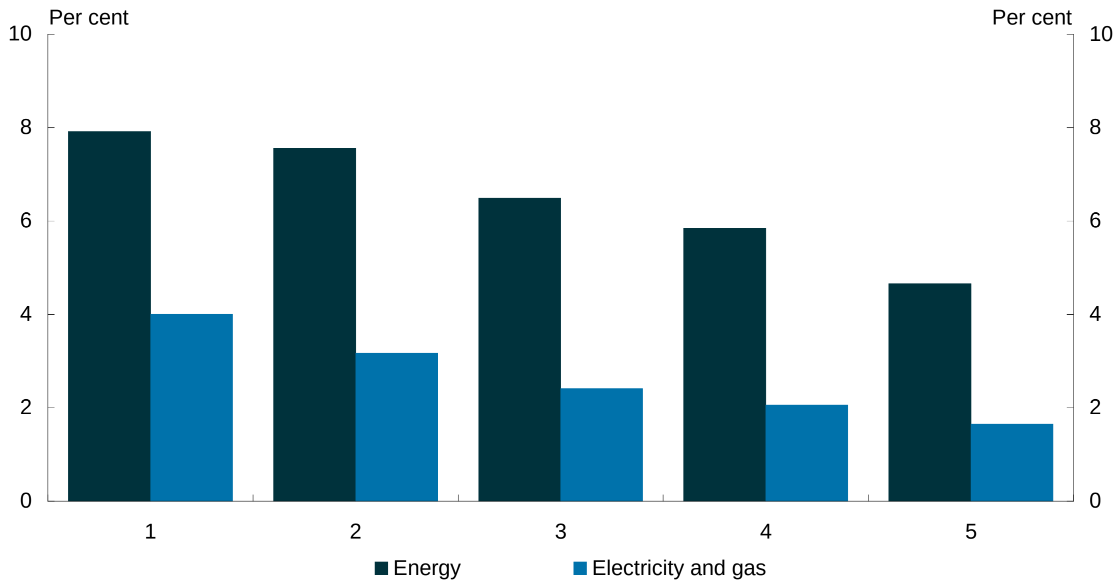
Chart 3.42: Spending on energy as a percentage of all spending
2010-11



Source: Treasury.

Spending on stationary and transport energy by low income households represents a higher proportion of total spending than for middle and higher income households (Chart 3.43). For households in the first income quintile, the median proportion of spending on energy is around 8 per cent, while the median proportion of spending on stationary energy is around 4 per cent of total spending.

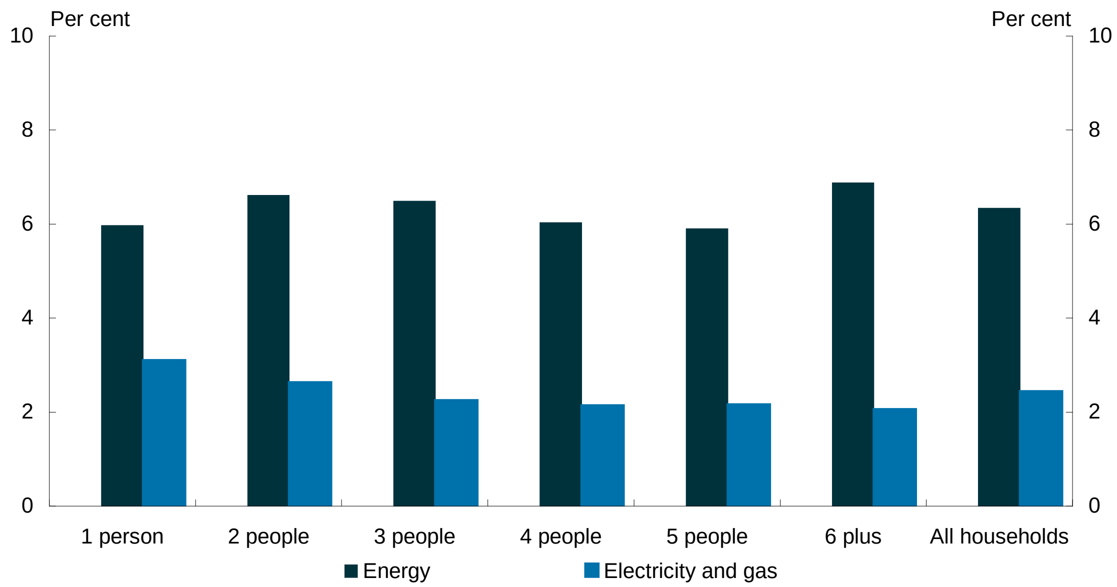
Chart 3.43: Spending on energy as a percentage of all spending
By equivalised disposable income quintile in 2010-11



Source: Treasury.

Spending on energy as a percentage of total household spending does not appear to vary markedly with household size, for households with more than two people. This may in part be due to economies of scale and government transfer payments supplementing the incomes of families with children. The picture for households with six or more people may not be consistent with the trend for smaller households, but it is difficult to draw conclusions about the spending patterns and circumstances of these households because of the relatively small number of them in the Household Expenditure Survey confidentialised unit record file. In all income quintiles except the highest, households with two people appear to spend a slightly higher proportion of their total spending on energy than households with one person. This effect is not observable for spending on stationary energy, which represents a higher proportion of the household budget for single-person households (Chart 3.44).

Chart 3.44: Spending on energy by household size
2010-11



Source: Treasury.

Households where Government transfer payments are the principal source of income spend a higher proportion of their budget on energy than other households (Table 3.12). This is also true for stationary energy alone. As suggested in the following table, the majority of these households are in the first and second equivalised income quintiles. Numbers above the third equivalised income quintile are too small to derive reliable estimates of spending patterns.

For households where Government transfer payments are the principal source of income, those in the lowest income quintiles spend a markedly higher proportion of their total budget on energy than those in the third income quintile. Households where Government transfer payments are the principal source of income in the first quintile include a high proportion of single pensioners, and the majority of couple allowees with and without children, and single allowees. In the second quintile, households where Government transfer payments are the principal source of income include more couple pensioners and Parenting Payment Single recipients.

Table 3.12: Spending on energy by principal source of household income, 2010-11

	Household income quintile				
	First	Second	Third	Fourth	Fifth
	Per cent	Per cent	Per cent	Per cent	Per cent
Spending on energy					
Households where government payments are the principal source of income	8.1	7.6	7.2	*	*
Other households	7.6	7.5	6.5	5.9	4.7
Spending on stationary energy					
Households where government payments are the principal source of income	4.1	3.5	2.6	*	*
Other households	3.4	2.8	2.4	2.1	1.7

* Sample size is too small to derive reliable estimates.
Source: Treasury.

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