AUSTRALIA'S EMISSIONS IN A GLOBAL CONTEXT

7

Key points

Australia's per capita emissions are the highest in the OECD and among the highest in the world. Emissions from the energy sector would be the main component of an expected quadrupling of emissions by 2100 without mitigation.

Australia's energy sector emissions grew rapidly between 1990 and 2005. Total emissions growth was moderated, and kept more or less within our Kyoto Protocol target, by a one-off reduction in land clearing.

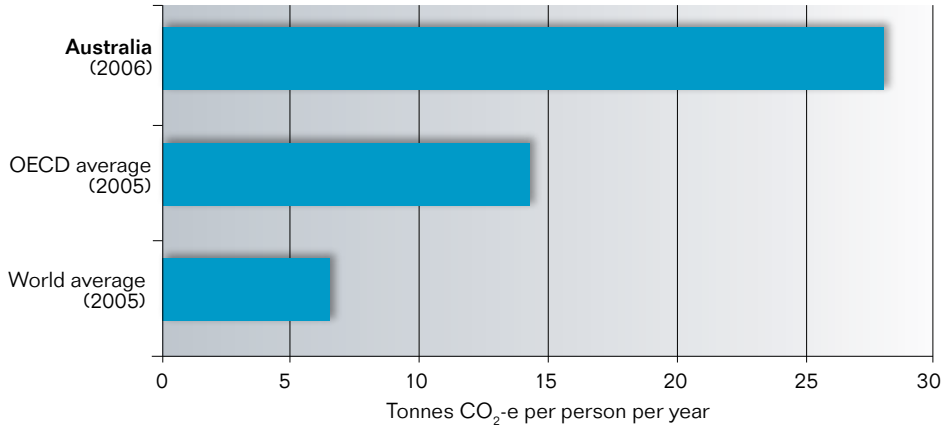
Relative to other OECD countries, Australia's high emissions are mainly the result of the high emissions intensity of energy use, rather than the high energy intensity of the economy or exceptionally high per capita income. Transport emissions are not dissimilar to those of other developed countries. Australia's per capita agricultural emissions are among the highest in the world, especially because of the large numbers of sheep and cattle.

The high emissions intensity of energy use in Australia is mainly the result of our reliance on coal for electricity. The difference between Australia and other countries is a recent phenomenon: the average emissions intensity of primary energy supply for Australia and the OECD was similar in 1971.

7.1 Australia's emissions profile and international comparisons

Australia's per capita greenhouse gas emissions are the highest of any OECD country and are among the highest in the world. In 2006 our per capita emissions (including emissions from land use, land-use change and forestry) were 28.1 tonnes carbon dioxide equivalent (CO_2-e) per person (DCC 2008d). Only five countries in the world rank higher—Bahrain, Bolivia, Brunei, Kuwait and Qatar. Australia's per capita emissions are nearly twice the OECD average and more than four times the world average (see Figure 7.1).

Figure 7.1 Per capita greenhouse gas emissions



Sources: DCC (2008c); IEA (2007a).

For the calculation of per capita greenhouse gas emissions illustrated in Figure 7.1, the data source used for Australia was the Department of Climate Change, while the International Energy Agency (IEA) was the source used for all other countries. There are other data sources for developed countries, such as the United Nations Framework Convention on Climate Change (UNFCCC) and relevant national agencies. There is some variation between emissions estimates by source (see Table 7.1 for a comparison of IEA and UNFCCC estimates for the highest per capita OECD emitters).

Table 7.1 Comparison of the highest per capita emissions among OECD countries (tonnes per person per year)

	2005, excluding land use, land-use change and forestry[a]	2006, excluding land use, land-use change and forestry[b]	2006, including land use, land-use change and forestry[b]
Australia	30.3	26.0	26.7
United States	24.5	23.5	20.6
Luxembourg	24.0	26.6	26.1
New Zealand	22.6	19.0	13.4
Canada	22.5	22.1	23.1
Ireland	15.6	16.6	16.5
Czech Republic	14.3	14.4	14.1

Sources: a. IEA (2007a); b. For emissions data, UNFCCC (2008); for population data, Population Reference Bureau (2008).

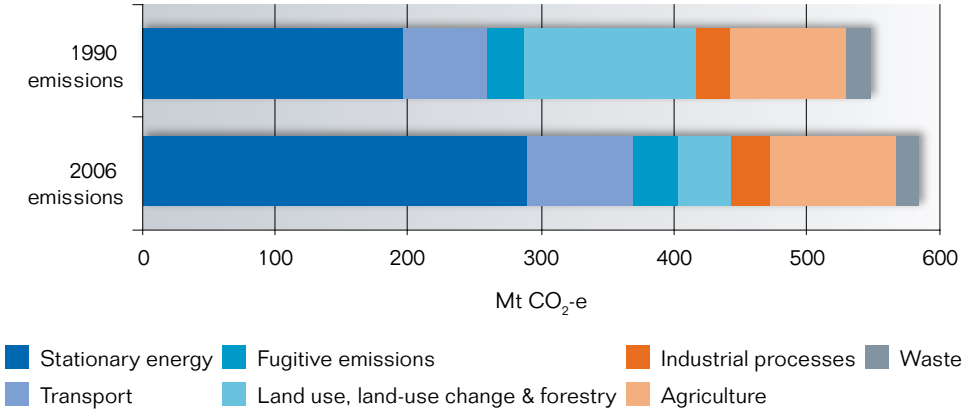
7.1.1 Recent growth trends in Australia's emissions

In 2006 Australia's net greenhouse gas emissions were 576 Mt CO_2-e using Kyoto Protocol accounting provisions (DCC 2008c). From 1990 to 2006, Australia's net emissions increased by 4.2 per cent (23.4 Mt).

Emissions for 1990 and 2006 by sector are illustrated in Figure 7.2. Energy sector emissions increased by about 40 per cent between 1990 and 2006. Over the same period there was a substantial reduction (about 71 per cent) in emissions from land use, land-use change and forestry.

Stationary energy sector emissions are from energy industries (for example, electricity generation and petroleum refining), fuel combustion in the manufacturing and construction industries, and fuel combustion in other sectors such as commercial, residential, agriculture, forestry and fishing. Fugitive emissions arise during the extraction, transportation and handling of fossil fuels. Industrial process emissions are from production of metals, minerals, chemicals, pulp and paper, and food and beverages.

Figure 7.2 Greenhouse gas emissions by sector, 1990 and 2006



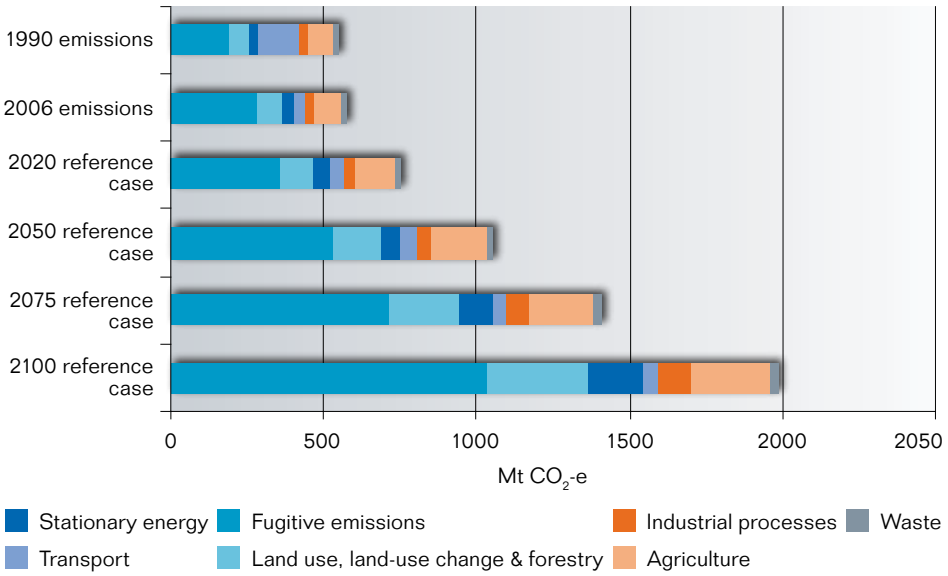
Source: DCC (2008b).

7.1.2 Future emissions growth in Australia

Figure 7.3 presents expectations of future emissions under the Garnaut–Treasury reference case (see Chapter 11). In the absence of mitigation measures, energy-related emissions are expected to grow rapidly and to increase their share of the total.

In the reference case, stationary energy sector emissions are projected to increase by about 85 per cent by 2050 and about 260 per cent by 2100. Growth in emissions from the stationary energy sector is largely driven by the structure and growth of Australia's economy, the fuel mix in electricity generation, and energy efficiency across the economy.

Figure 7.3 Greenhouse gas emissions by sector: 1990, 2006 and reference case scenarios



Sources: 1990 and 2006 emissions are from the most recent National Greenhouse Gas Inventory (DCC 2008b); 2020–2100 projections are from the Monash Multi Regional Forecasting model.

Transport-related emissions are also projected to grow rapidly. Transport-related emissions would almost double by 2050 and more than quadruple by 2100.

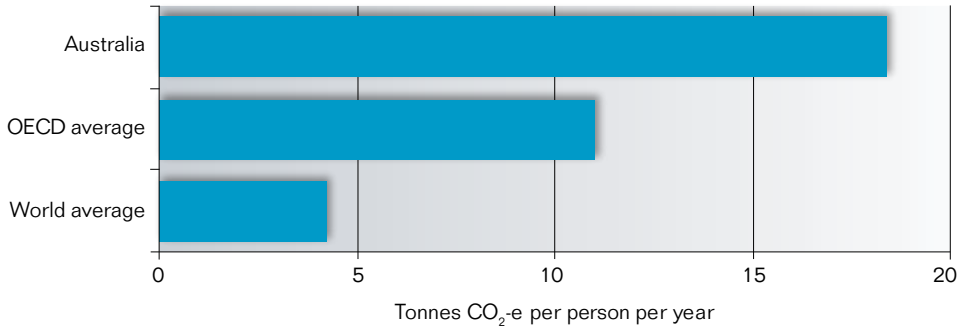
Emissions arising from land-use change depend on the area of forest cover removal, the method of forest conversion and land development. The estimates rely on assumptions about the amount of carbon sequestered in biomass and soils, which varies by vegetation type, geography and climate (DCC 2008d). Reductions in the rate of forest cover removal since 1990 have been the main source of the reduction in land-use-related emissions.

7.1.3 Australia's energy emissions relative to other countries'

In 2006 Australia's greenhouse gas emissions due to energy were 401 Mt CO_2-e (DCC 2008b), which represented about 70 per cent of Australia's total. From 1990 to 2006, Australia's net emissions from energy increased by about 40 per cent (114 Mt).

Australia's per capita greenhouse gas emissions due to energy are the third highest of any OECD country and the seventh highest in the world, after Luxembourg, the United States, Qatar, Kuwait, Bahrain, the United Arab Emirates and Netherlands Antilles. Australia's per capita greenhouse gas emissions due to energy in 2005 were about 67 per cent higher than the OECD average and more than four times the world average (see Figure 7.4).

Figure 7.4 Per capita emissions due to energy use, 2005



Source: IEA (2007a).

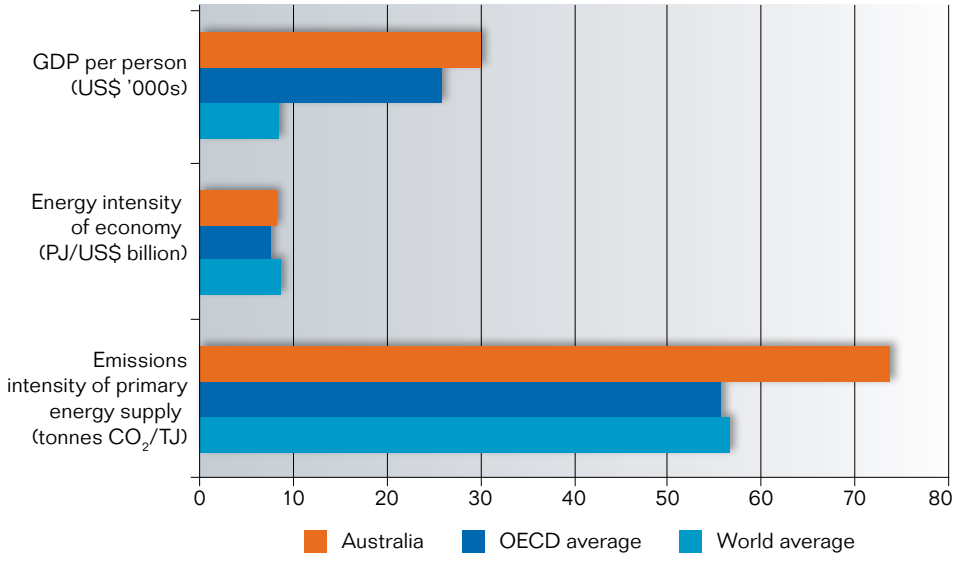
The energy intensity of an economy is a measure of the amount of energy used per unit of economic activity generated. The emissions intensity of energy is a measure of the amount of greenhouse gases emitted per unit of energy used.

Energy-associated per capita emissions are the product of per capita GDP, energy intensity (of the economy) and emissions intensity (of energy) as follows:

$$CO_2 \text{ per capita} = \text{GDP per capita} \times \text{Energy/GDP} \times CO_2/\text{Energy}$$

Figure 7.5 illustrates the factors underlying a country's per capita emissions and compares those factors for Australia, the OECD average and the world average.

Figure 7.5 Factors underlying per capita energy emissions, 2005



Note: All financial values are measured in 2000 US$, using purchasing power parities.

Source: IEA (2007a).

Australia's GDP per capita in 2005 was about 16 per cent higher than the OECD average (IEA 2007a). While this contributes to Australia's comparatively high per capita greenhouse gas emissions due to energy use, it does not account for why they are about two-thirds higher than the OECD average.

Australia's economy is the eighth most energy intensive among OECD countries. It is about 5 per cent less energy intensive than the world average and about 8 per cent more energy intensive than the OECD average.

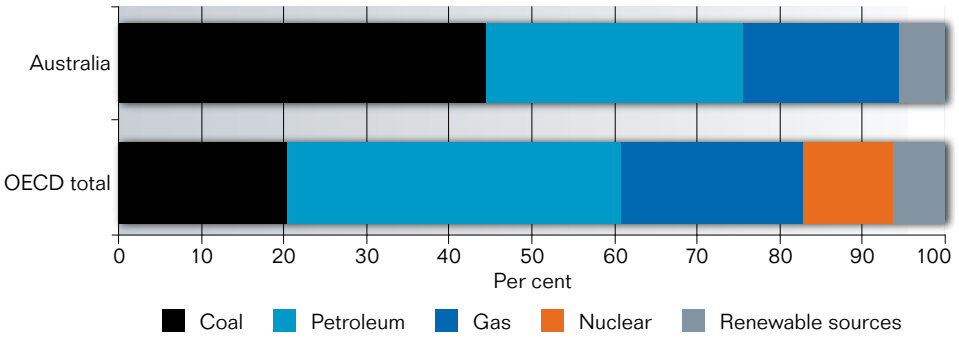
The aggregate energy intensity of the Australian economy, measured as total primary energy consumption per dollar of GDP, remained broadly stable over the 1970s and 1980s, and then fell by an average of 1.1 per cent a year during the 1990s (Syed et al. 2007).

The energy intensity of Australia's economy does not account for our extremely high per capita greenhouse gas emissions.

The emissions intensity of Australia's primary energy supply is the second highest among OECD countries. It is more than 30 per cent higher than both the OECD average and the world average. There are only five countries in the world with a more emissions-intensive energy supply than Australia's—Bosnia Herzegovina, the Democratic People's Republic of Korea, Estonia, Mongolia and Poland.

Fossil fuels play a dominant role in Australia's primary energy consumption. More than 40 per cent of Australia's total primary energy supply is derived from coal. This is a much higher proportion than in other OECD countries, as illustrated in Figure 7.6.

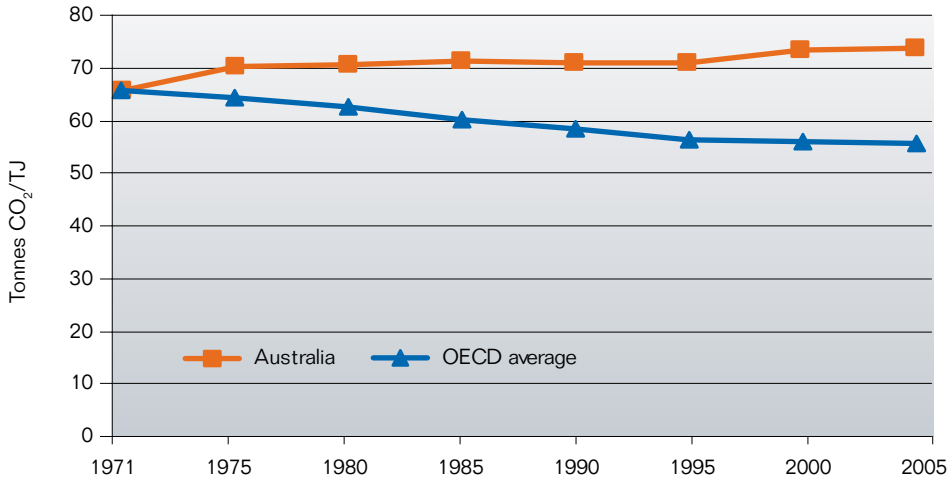
Figure 7.6 Fuel mix contributing to total primary energy supply, 2005



Source: IEA (2007b).

The exceptional emissions intensity of Australia's primary energy supply has only emerged in recent decades. Figure 7.7 shows the trends in Australia's average emissions intensity of primary energy supply compared with those in all OECD countries. The Australian average was similar to that of the OECD in 1971.

Figure 7.7 Trends in average emissions intensity of primary energy supply, Australia and OECD, 1971–2005

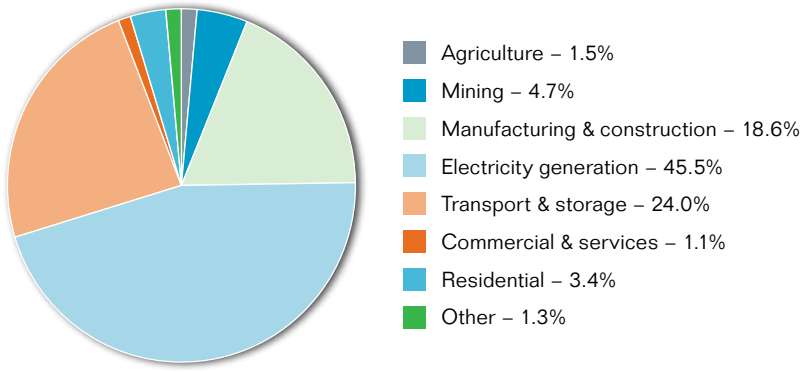


Source: IEA (2007a).

The increasing emissions intensity of Australia's primary energy supply is largely due to its increasing reliance on coal for electricity generation, at a time when other developed countries have shifted significantly to lower-emissions sources.

Figure 7.8 shows primary energy consumption in Australia by sector. The electricity generation, transport and manufacturing sectors account for nearly 90 per cent of primary energy consumption. Coal comprises about 79 per cent of primary energy supply in the electricity generation sector. The transport sector is dominated by oil, which contributes more than 97 per cent of primary energy consumed. In the manufacturing sector primary energy supply is composed of coal (27 per cent), oil (32 per cent), natural gas (34 per cent) and biomass (7 per cent).

Figure 7.8 Primary energy consumption in Australia, by sector, 2005–06

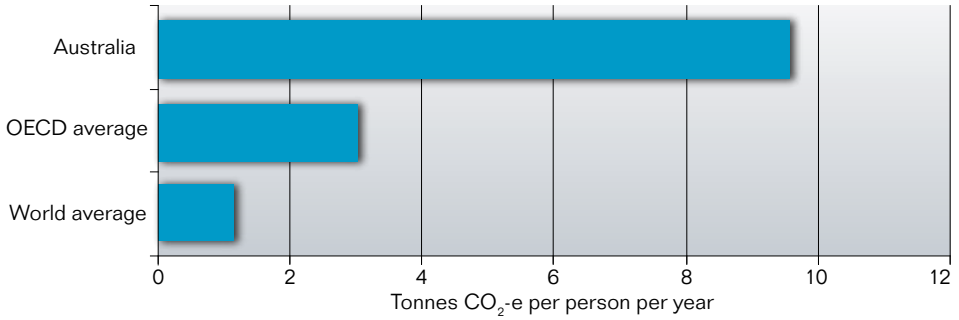


Source: Syed et al. (2007).

7.1.4 Australia's electricity emissions relative to other countries'

Australia's per capita electricity consumption is about 22 per cent above the OECD average, while our per capita emissions due to electricity generation are more than three times the OECD average (see Figure 7.9). The difference is due to the high emissions intensity of electricity generated in Australia.

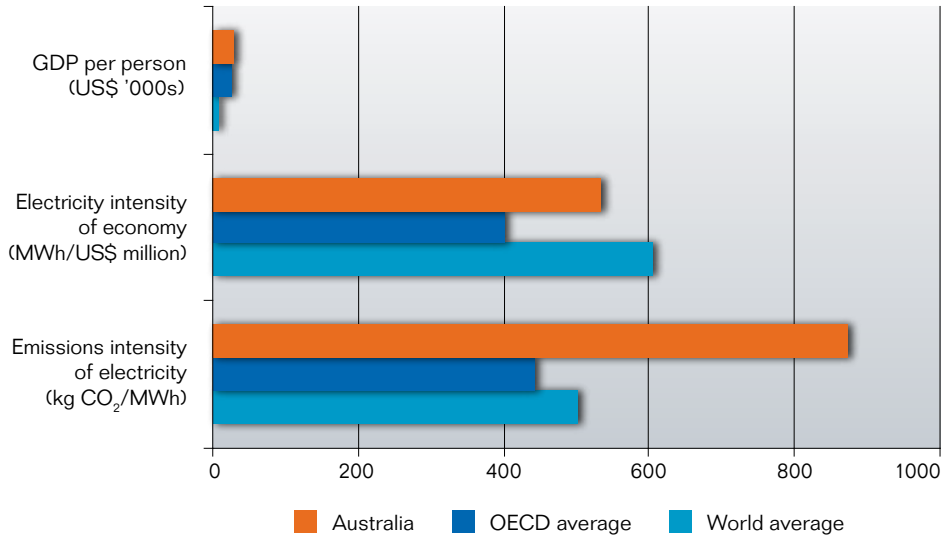
Figure 7.9 Per capita emissions due to electricity, 2005



Sources: IEA (2007a); DCC (2008b).

The emissions intensity of Australia's electricity supply is the highest of any OECD country. It is 98 per cent higher than the OECD average, and 74 per cent higher than the world average (see Figure 7.10). There are only eight countries in the world with an electricity system that is more emissions intensive than Australia's—Bahrain, Botswana, Cambodia, Cuba, India, Kazakhstan, Libya and Malta.

Figure 7.10 Factors underlying per capita electricity emissions, 2005



Source: IEA (2007a).

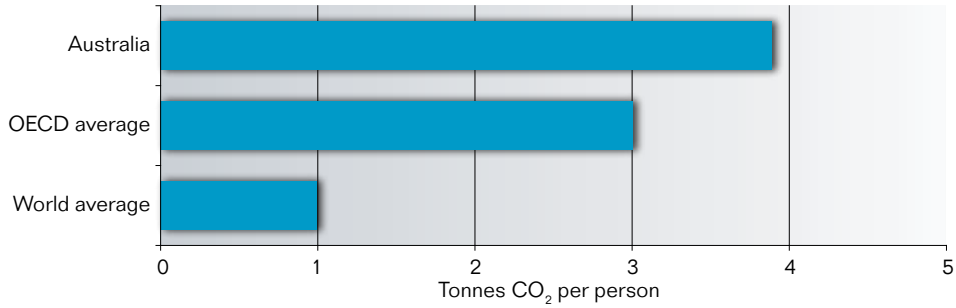
7.1.5 Australia's transport emissions relative to other countries'

In 2006 Australia's greenhouse gas emissions due to transport were 79.1 Mt CO_2-e using Kyoto accounting provisions. They do not include emissions arising from the generation of electricity used by public transport (trams and electric trains) or from fuel sold to ships or aircraft engaged in international transport (DCC 2008b).

Transport emissions represent about 14 per cent of Australia's total greenhouse gas emissions. From 1990 to 2006, Australia's net emissions from transport increased by about 27 per cent (17.0 Mt). The residential sector accounts for about 57 per cent of Australia's transport emissions. The remaining 43 per cent is attributable to Australian business.

Australia's per capita greenhouse gas emissions due to transport are the fourth highest of any OECD country and the seventh highest in the world, after Canada, Luxembourg, Netherlands Antilles, Qatar, the United Arab Emirates and the United States. Australia's per capita greenhouse gas emissions due to transport in 2005 were about 30 per cent higher than the OECD average and nearly four times the world average (see Figure 7.11).

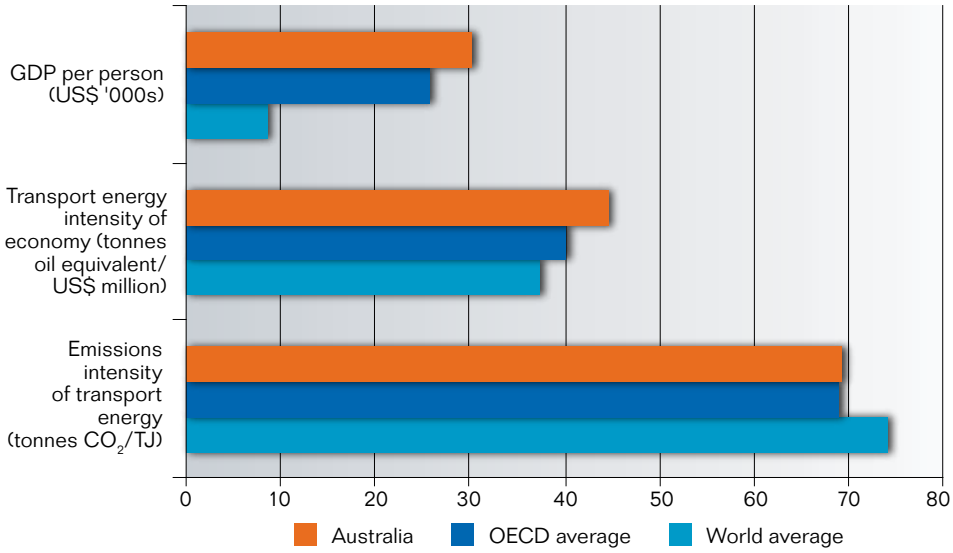
Figure 7.11 Per capita emissions due to transport, 2005



Source: IEA (2007a).

Transport-associated per capita emissions are the product of per capita GDP, the transport energy intensity of the economy and the emissions intensity of transport energy. The transport energy intensity of an economy is a measure of the amount of transport energy used per unit of economic activity generated. The emissions intensity of transport energy is a measure of the amount of greenhouse gases emitted per unit of transport energy used. Figure 7.12 illustrates the factors underlying a country's per capita transport emissions and compares those factors for Australia, the OECD average and the world average.

Figure 7.12 Factors underlying per capita transport emissions



Source: IEA (2007a).

The emissions intensity of transport energy is determined by the proportions of travel undertaken using public and private transport modes and, within modes, the combination of the engine type and fuel used.

The emissions intensity of Australia's transport energy is within a fraction of 1 per cent of the OECD average. Among OECD countries there is less than 10 per cent variation between the country whose transport energy is most emissions intensive and that which is least emissions intensive. This statistical outcome is affected by the exclusion from the data of electricity used for transport.

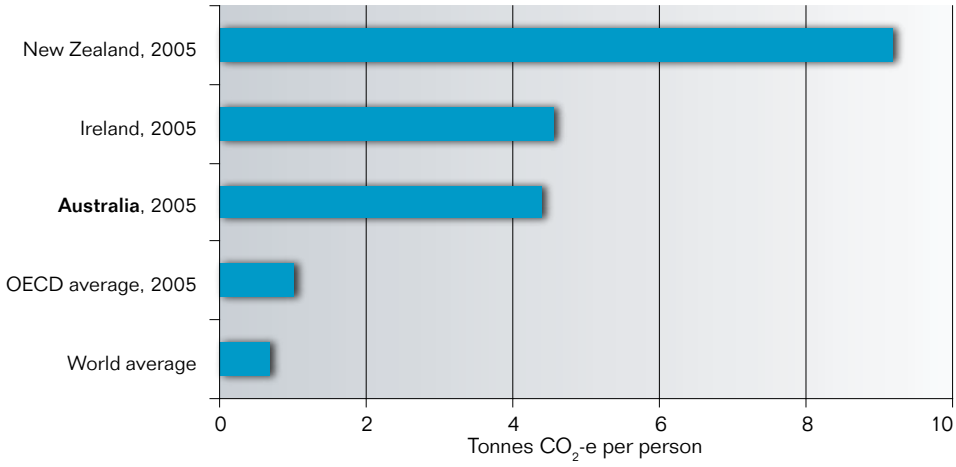
The lack of variation in the emissions intensity of transport energy among OECD countries is a reflection of the fact that, in all OECD countries, transport emissions are dominated by the same engine type (internal combustion) and the same fuel (petroleum).

The transport energy intensity of Australia's economy is the sixth highest among OECD countries and is about 10 per cent higher than the OECD average. The five OECD countries that consume more transport energy per unit of GDP generated are Canada, Luxembourg, Mexico, New Zealand and the United States.

7.1.6 Australia's agricultural emissions relative to other countries'

Australia's per capita emissions arising from agriculture are more than six times the world average, more than four times the OECD average and third highest in the OECD (see Figure 7.13).

Figure 7.13 Per capita emissions due to agricultural production



Note: Data on emissions from agricultural production in developing countries are of poor quality and a consistent dataset for recent years is not available. The world average estimate is derived from UNFCCC data on agricultural emissions of developing countries, some of which are as old as 1990.

Sources: UNFCCC (2005, 2008).

Under Article 3.1 of the Kyoto Protocol and in accordance with the 1996 IPCC guidelines (IPCC 1996), agricultural emissions are reported according to the following physical processes that give rise to them:

- **enteric fermentation in livestock**—emissions associated with microbial fermentation during digestion of feed by ruminant (mostly cattle and sheep) and some non-ruminant domestic livestock
- **manure management**—emissions associated with the decomposition of animal wastes while held in manure management systems
- **rice cultivation**—methane emissions from anaerobic decay of plant and other organic material when rice fields are flooded
- **agricultural soils**—emissions associated with the application of fertilisers, crop residues and animal wastes to agricultural lands and the use of biological nitrogen-fixing crops and pastures
- **prescribed burning of savannas**—emissions associated with the burning of tropical savanna and temperate grasslands for pasture management, fuel reduction, and prevention of wildfires
- **field burning of agricultural residues**—emissions from field burning of cereal, sugar cane and crop stubble.

Livestock emissions from enteric fermentation play a large role in the emissions profile of the agriculture sector. About 34 per cent of OECD countries' agricultural emissions are due to livestock emissions. This figure is even higher in the countries with the highest per capita emissions from agricultural production—64 per cent for New Zealand, 49 per cent for Ireland and 66 per cent for Australia.

The countries with the highest per capita agricultural emissions are those with the largest numbers of cattle and sheep relative to population.

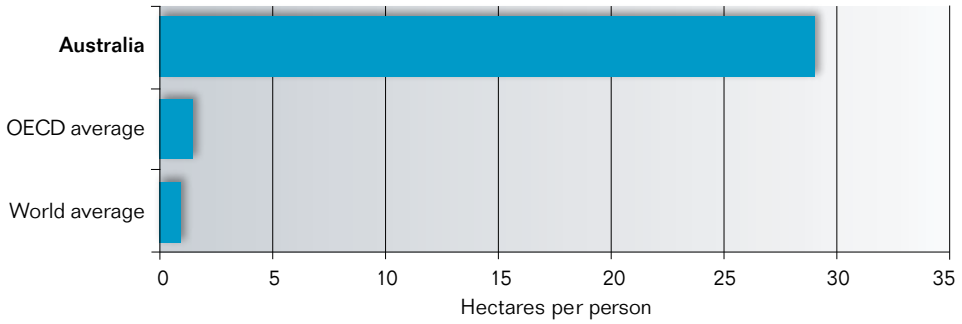
New Zealand, Ireland and Australia all produce more than 100 kilograms of beef per person per year. The world average is less than 9 kilograms and the OECD average about 22 kilograms. New Zealand, Ireland and Australia produce about 132, 18 and 29 kilograms respectively of sheep meat per person per year, compared with OECD and world averages of about 2 kilograms and 1 kilogram respectively.

7.1.7 Australia's biosequestration potential relative to other countries'

There is significant global potential for emissions removal (or carbon sequestration) through revegetation of previously cleared land and increasing the stock of carbon in forests, wooded land and soils. Management of existing forests for ecosystem services, rather than simply for fibre production, would significantly reduce emissions from degradation and deforestation.

The potential for carbon removal through existing forests and revegetation of cleared land is proportional to the land area available for those purposes. Australia has relatively large areas of forested land suitable for carbon removal and deforested land suitable for revegetation. There are about 28.8 hectares of forest and wooded land for every person in Australia (FAO 2008). This is the largest area of forest and wooded land per person in the OECD and the second largest globally behind Suriname. In OECD countries there are on average 1.4 hectares of forest and woodland per person, and across the world there are on average 0.8 hectares (see Figure 7.14).

Figure 7.14 Per capita area of forested and wooded land, 2005



Source: FAO (2008).

In addition to land area, the amount of additional carbon that can be sequestered by existing forests and woodlands and through revegetation of cleared lands is also determined by the local climate; the fertility of the substrate; the characteristics of the plant species including growth rates, wood density and their suitability to local

environmental conditions; and the impact of land use history in reducing carbon stocks below the land's carbon-carrying capacity.

Australia has an estimated 163.7 million hectares of forest and 421.6 million hectares of other wooded land (FAO 2008). The IPCC default values for temperate forests are a carbon stock of 217 tonnes carbon per hectare, 96 tonnes biomass carbon per hectare and net primary productivity of 7 tonnes carbon per hectare per year. These estimates are probably conservative for intact (unlogged) natural forests. Mackey et al. (2008) have shown that the stock of carbon for intact natural eucalypt forests in south-eastern Australia is about 640 tonnes carbon per hectare (biomass plus soil, with a standard deviation of 383), with 360 tonnes biomass carbon per hectare. The average net primary productivity of these forests is 12 tonnes carbon per hectare per year (with a standard deviation of 1.8). Mackey et al. estimate that the eucalypt forests of south-eastern Australian could remove about 136 Mt CO_2-e per year (on average) for the next 100 years. This estimate is premised on several key assumptions, including cessation of logging and controlled burning over the 14.5 million hectare study area.

In 2006 the net removal by pre-1990 plantations and native forests was estimated to be about 24.1 Mt CO_2-e (DCC 2008b). Under Article 3.3 of the Kyoto Protocol this sequestration does not contribute to Australia meeting its Kyoto target.

It is important for efficient global mitigation that the international community move to comprehensive carbon accounting related to agriculture and forestry. This is particularly important for Australia.

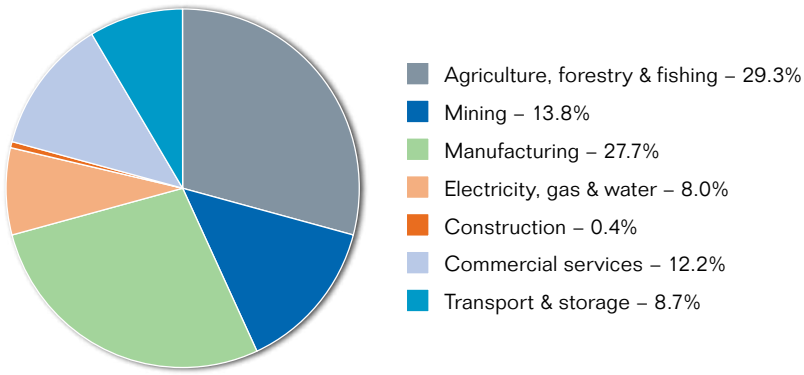
Comparative carbon accounting, among much else, would bring to account all carbon sequestered by and emitted from managed lands. This would provide significant revenue opportunities for landowners. It would also bring risks, especially, as would be required in logic, if all emissions arising from fires and the effects of drought are covered.

7.2 Emissions profiles of Australian industries

7.2.1 How do Australian industries contribute to emissions and GDP?

Figure 7.15 shows the total emissions attributable to each Australian industry, derived by summing a sector's direct emissions and the indirect emissions attributable to its electricity consumption. Emissions due to transport have not been attributed in the same way, due to lack of suitable data. Industry accounts for about 82 per cent of Australia's total emissions, with the remainder attributable to the residential sector. The agriculture, mining and manufacturing industries are responsible for large amounts of greenhouse gas emissions relative to their shares of GDP.

Figure 7.15 Emissions attributable to Australian industry by sector, 2006



Sources: DCC (2008b); ABS (2007).

7.2.2 Which industries would be most affected by a price on emissions?

The industries whose competitiveness is most likely to be adversely affected by a price on greenhouse gas emissions are those that are exposed to international trade and that have either a high degree of energy intensity or a high level of direct greenhouse gas emissions.

The Review sought to identify the trade-exposed industries that might be most affected by a price on greenhouse gas emissions. It considered data on trade, direct emissions, and indirect emissions attributable to electricity consumption. It used the 1993 Australian and New Zealand Standard Industrial Classification and the Australian National Accounts (ABS 2008) as guides to industry classification, and selected the following for analysis of the impact of an emissions price on international competitiveness:

Manufacturing

- food, beverage and tobacco
- textile, clothing, footwear and leather
- wood, paper and printing
- petroleum refining
- petroleum and coal products
- basic chemicals
- cement, lime, plaster and concrete
- iron and steel
- non-ferrous metals and products (including aluminium production)
- machinery and equipment manufacturing

Agriculture

- dairy cattle
- beef cattle
- sheep
- grains
- pigs
- poultry
- other

Mining

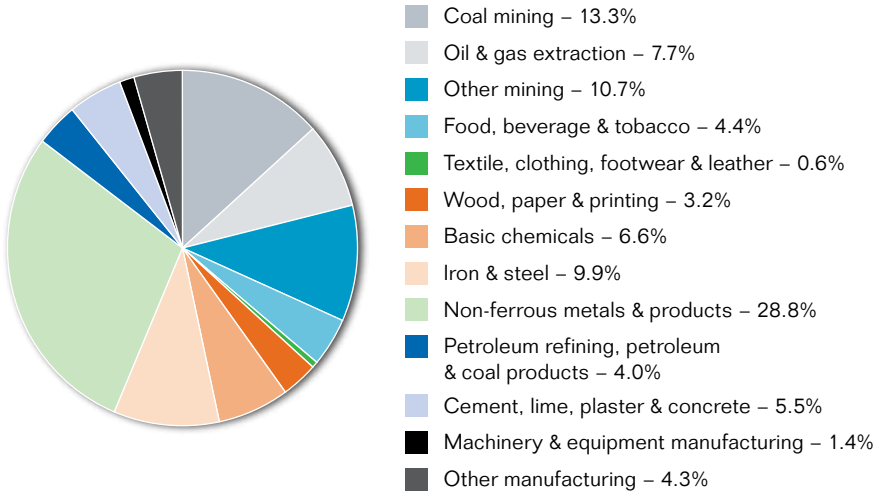
- coal mining
- oil and gas extraction (including liquefied natural gas production)
- other mining (non-energy)

Mining and manufacturing industries

In 2006 the mining industry's direct emissions were 52.1 Mt CO_2-e and its indirect emissions due to purchase of electricity were 12.9 Mt CO_2-e. In the same year the manufacturing industry's direct and indirect emissions were 69.3 Mt and 61.0 Mt CO_2-e respectively.

Due to changes in methodology adopted for Australia's 2006 National Greenhouse Gas Inventory, the manufacturing industry's indirect emissions arising from electricity consumption are no longer disaggregated by sector. This is why figures 7.16 and 7.17 use 2005 data to show industry contributions to emissions from mining and manufacturing.

Figure 7.16 Emissions attributable to the Australian mining and manufacturing industries, disaggregated by sector, 2005



Sources: DCC (2008a); ABS (2007).

Agriculture

In 2006 the agriculture industry produced an estimated 90.1 Mt CO_2-e of direct agricultural emissions and an additional 1.5 Mt CO_2-e of indirect emissions arising from the purchase of electricity. In addition, land clearing for agriculture was responsible for emissions of 74.1 Mt CO_2-e.

The guidelines of the UNFCCC require countries to report agricultural, land use and forestry emissions according to the physical processes that give rise to them. The Review calculated 2005 direct emissions and indirect emissions attributable to the purchase of electricity by commodity within the agriculture and forestry industries using the Australian National Accounts as a guide to classification (see Table 7.2).

Table 7.2 Agricultural emissions and land use, land-use change and forestry emissions, by commodity and economic sector, 2005

Commodity/ sector	Agricultural emissions (Mt)	Land use, land-use change and forestry emissions (Mt)	Total direct emissions (Mt)	Emissions attributable to purchase of electricity (Mt)	Total attributable emissions (Mt)
Sheep	19.6	–	19.6	0.1	19.7
Grains	2.2	2.7	4.9	0.2	5.1
Beef cattle	51.9	71.4	123.3	0.4	123.7
Dairy cattle	10.3	–	10.3	0.3	10.7
Pigs	1.6	–	1.6	–	1.6
Poultry	0.8	–	0.8	0.2	1.0
Other agriculture	2.9	–	2.9	0.4	3.2
Forestry	–	-21.8	-21.8	–	-21.7
Total	89.3	52.4	141.7	1.6	143.3

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

In order to gauge the potential impact of a price being placed on greenhouse gas emissions, the Review examined the effect of a permit price of $10, $20 and $40 per tonne of CO_2-e and assumed that there would be 100 per cent pass-through of emissions costs to energy consumers. The latter is a worst-case scenario from the perspective of energy-intensive industries. If this were too high, the analysis that follows would overestimate the additional costs accruing to energy-intensive industries as a result of a price being placed on emissions. Under these assumptions, the ratio of greenhouse gas emission costs to the value of production is as shown in Figure 7.17. Note that Figure 7.17 does not include emissions due to deforestation by the grain and beef cattle industries.

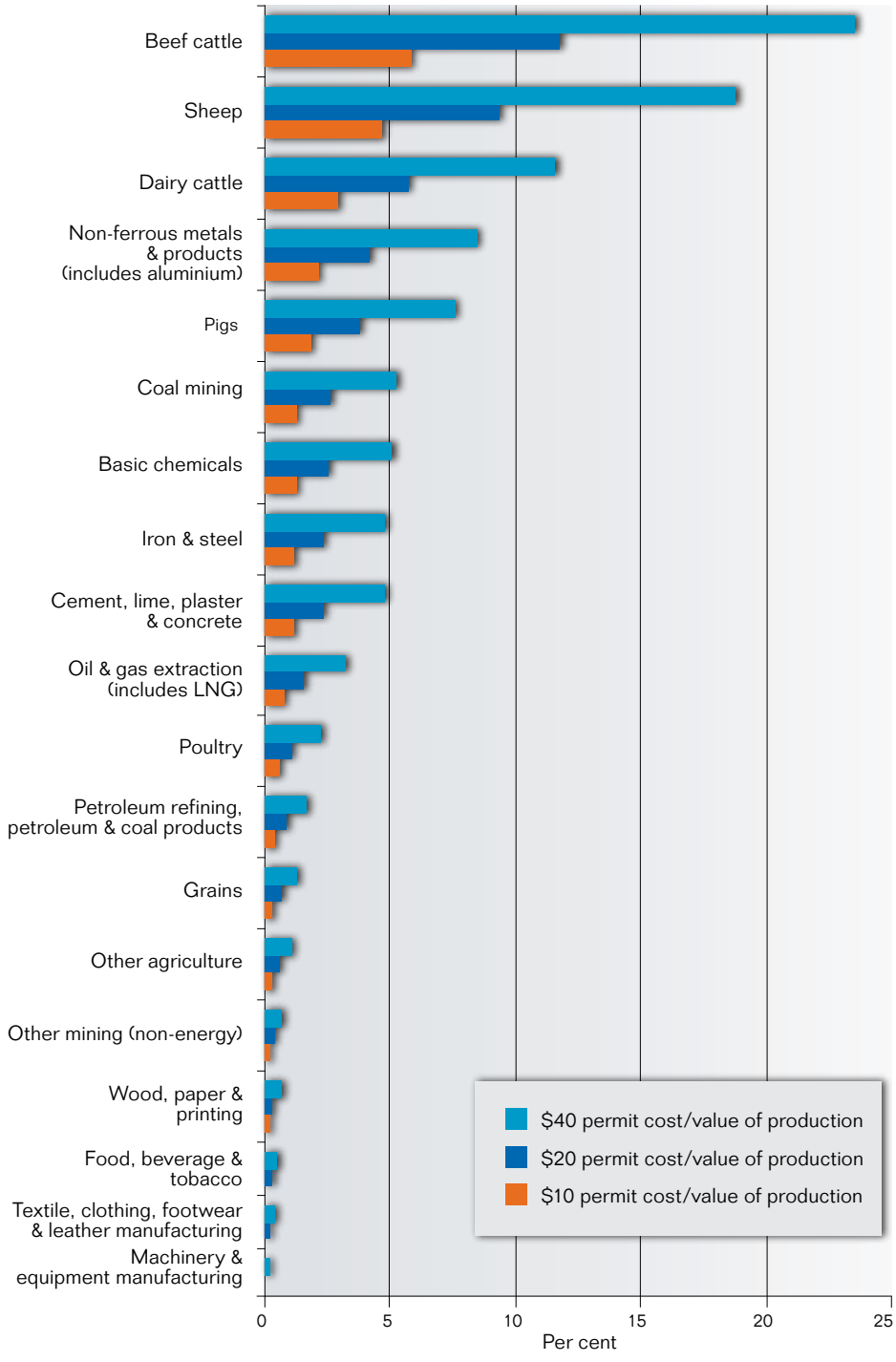
Recent and projected increases in commodity prices reduce the ratio of greenhouse gas emissions to the value of production. For example, it is estimated that projected 2008–09 increases in the price for coal exports would reduce the ratio of greenhouse gas emissions costs to the value of production for coal mining to about one-third of that shown in Figure 7.17.

7.2.3 Comparison of Australia's agriculture industry with other OECD countries'

To get some indication of the likely impact of a price on emissions upon the competitiveness of the agriculture industry, a direct comparison was made of the emissions intensity of this industry across a number of countries (see Figure 7.18). Lack of data restricted the comparison to a subset of OECD countries.

Figure 7.18 includes direct emissions only. The exceptional emissions intensity of Australian electricity generation means that inclusion of these indirect emissions would set back Australia's performance in comparison with its OECD competitors.

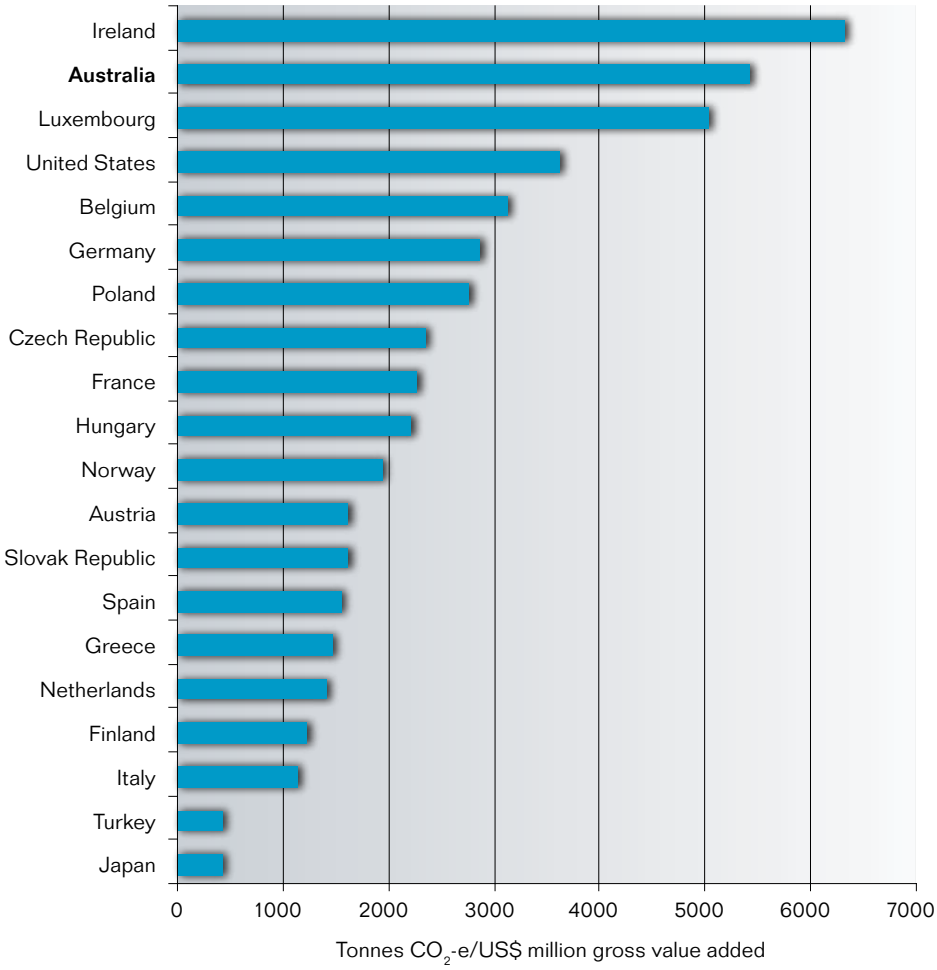
Figure 7.17 Ratio of permit costs to value of production, 2005



Note: Production is largely composed of sales revenue but also includes production for own final use.

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

Figure 7.18 Direct emissions intensity of Australia's agriculture industry compared with selected OECD countries, 2006



Sources: UNFCCC (2008); OECD (2008).

Australia's agriculture industry has the second highest emissions intensity of the countries considered and is more than twice the average. New Zealand's would be higher still, but data were not available to allow inclusion in Figure 7.18. This result reflects the large contribution that sheep and cattle production make to Australia's agricultural production.

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