



**Australian Government**  
**Department of Climate Change  
and Energy Efficiency**

## AUSTRALIAN NATIONAL GREENHOUSE ACCOUNTS



# National Greenhouse Gas Inventory

accounting for the KYOTO target **May 2010**



**thinkchange**

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**May 2010**

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# 1. Quarterly Estimates of Australia's National Inventory: December Quarter 2009

- This report provides estimates of Australia's national greenhouse gas inventory based on the latest available data and the accounting rules that apply for the Kyoto Protocol.
- This section of the report provides estimates and shows trends in Australia's National Inventory up to the December quarter of 2009. The quarterly National Inventory includes emission sources listed under Annex A of the Kyoto Protocol – *energy, industrial processes, agriculture and waste* sectors – but does not include emissions under article 3.3 of the Kyoto Protocol, *Land Use, Land Use Change and Forestry* (LULUCF) activities, for which data are not yet available.

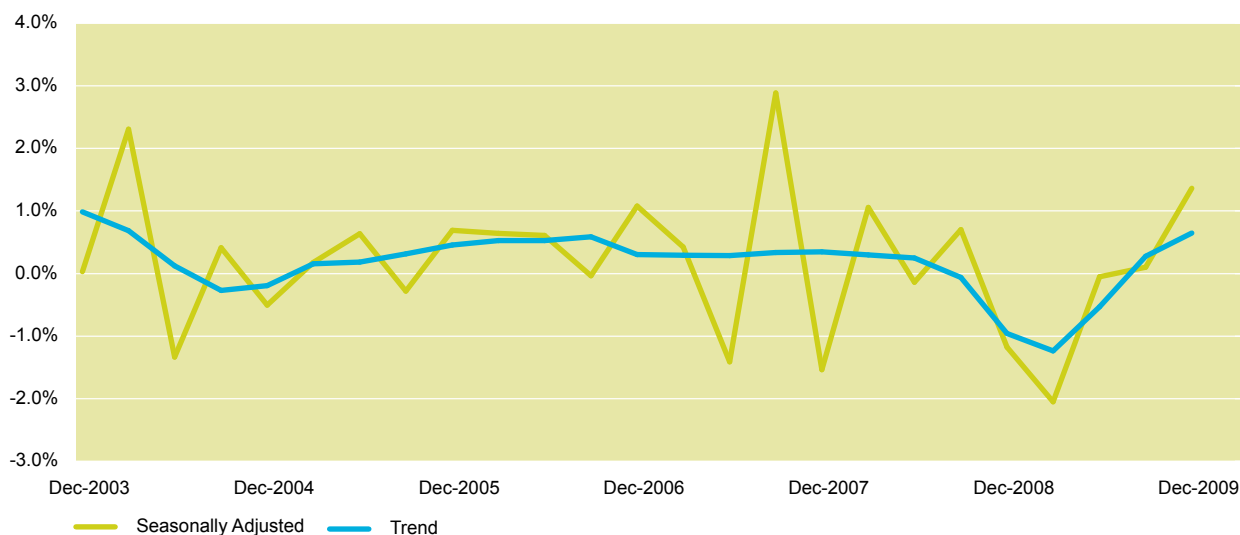
**Table 1: Change in National Inventory, Annex A sectors<sup>(a)</sup>: December quarter 2009**

Emissions Growth Rate, Quarterly Change – Trend	0.6%
Emissions Growth Rate, Quarterly Change – Seasonally Adjusted	1.3%
Emissions Growth Rate, Annual Change through to December Quarter	-2.4%

Notes: (a) The national inventory total does not include estimates of net credits from the article 3.3 Land Use, Land Use Change and Forestry activities, which are estimated on an annual basis only.

- Positive emissions growth in both trend (0.6%) and seasonally adjusted (1.3%) terms indicates that emissions have increased in the December quarter.
- The quarterly change in the national emissions growth rate from December 2003 to December 2009, in both trend and seasonally adjusted terms, is shown in Figure 1.

**Figure 1: National Inventory, Annex A sectors, seasonally adjusted emissions growth rates, quarterly change – December quarter 2003 to December quarter 2009**



Notes: The national inventory total does not include estimates of net credits from the article 3.3 Land Use, Land Use Change and Forestry activities, which are estimated on an annual basis only.

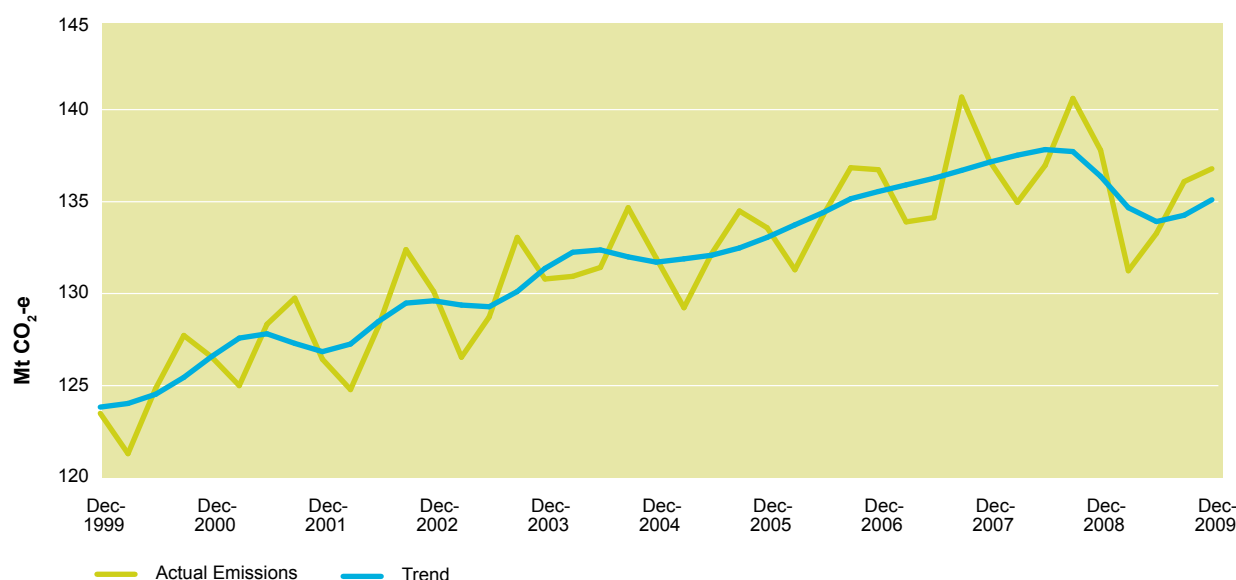
- The negative annual emissions growth rate of -2.4% indicates that emissions for the whole year to December are lower than for the corresponding period of the previous year.

- Negative emissions growth experienced in previous quarters was mostly attributable to relatively low emissions in key sectors such as electricity generation, steel production and agriculture, mainly reflecting the international economic slowdown and weather conditions. The December quarter has seen a return to positive emissions growth which is expected to continue, principally on the back of stronger economic growth.
- The original quarterly estimates have been adjusted using SEASABS to remove the effects of seasonal factors. The trend series reflects the seasonally adjusted series with irregular components smoothed and provides the best indication of underlying movements in the inventory (Figure 1).

## Quarterly Change in Emissions – Key Points

- The positive growth in seasonally adjusted emissions in the December quarter is mainly due to a rebound from the low September levels in key sectors such as electricity generation and to a lesser extent other stationary energy and industrial processes. Electricity generation is coming off a particularly low level in the September quarter when unseasonably warm temperatures resulted in less demand for electricity. Other stationary energy and industrial processes are also increasing from the low emission levels experienced through the first half of 2009 as economic activity has increased.
- In figure 2, the actual emissions estimate for each quarter and the trend emission estimate are shown. The trend series shows a bounce back in the December quarter from the marked decline experienced in previous quarters.
- Actual emissions fluctuate during the year as a result of seasonal weather patterns and variations in economic activity. In general, higher emissions from a relatively high level of economic activity in the December quarter tend to be offset by relatively low emissions from electricity production in that quarter. The March quarter tends to have a relatively low level of economic activity which influences emissions directly, particularly as a result of lower activity in manufacturing, commodities and transport while the September quarter corresponds to the winter months and generally has higher emissions due to a higher level of electricity use.

**Figure 2: National Inventory, actual quarterly emissions estimate and trend emission estimate – September quarter 1999 to December quarter 2009**



Note: The national inventory total does not include estimates of net credits from article 3.3 Land Use, Land Use Change and Forestry activities, which are estimated on an annual basis only. Emission estimates have been compiled by the Department of Climate Change and Energy Efficiency using the estimation methodologies incorporated in the Australian Greenhouse Emissions Information System (AGEIS) and preliminary activity data obtained under the National Greenhouse and Energy Reporting System and from a range of publicly available sources – principally ABARE, the ABS, the Australian Energy Market Operator and the Department of Resources, Energy and Tourism. As more data becomes available from the Department's reference sources – in particular the National Greenhouse and Energy Reporting System – these preliminary activity data will be replaced and the estimates of emissions revised before submission to the UN. The Department's assessment is that the 90% confidence interval for the national inventory (before taking account of article 3.3 activities) is  $\pm 1\%$  (ie there is a 90% probability that future revisions will be limited to  $\pm 1\%$  of the current estimate).

## 2. Annual Emissions to December Quarter

- Over the four quarters to the December quarter of 2009, Australia's national inventory was an estimated 537 Mt CO<sub>2</sub>-e (million tonnes of carbon dioxide equivalent).
- This is a decrease of 2.4% compared with the corresponding period for the previous year (table 2).

**Table 2: National Inventory: for the four quarters to December quarter 2009**

Category	Annual emissions through to the December quarter Mt CO <sub>2</sub> -e <sup>(a)</sup>		% change in annual emissions <sup>(d)</sup>
	December quarter 2008 <sup>(c)</sup>	December quarter 2009 <sup>(c)</sup>	
<b>National Inventory – Annex A sectors</b>			
Energy – Electricity	207	202	-2.0%
Energy – Stationary energy excluding electricity	93	89	-4.2%
Energy – Transport	80	79	-0.7%
Energy – Fugitive emissions	39	41	3.1%
Industrial processes	31	27	-10.6%
Waste	15	15	1.5%
Agriculture	86	84	-2.8%
<b>National Inventory total<sup>(b)</sup></b>	<b>550</b>	<b>537</b>	<b>-2.4%</b>

Source: Department of Climate Change and Energy Efficiency preliminary estimates.

Notes: (a) Carbon dioxide equivalent, CO<sub>2</sub>-e; this concept enables the aggregation of individual greenhouse gases through the use of Global Warming Potentials (GWPs).

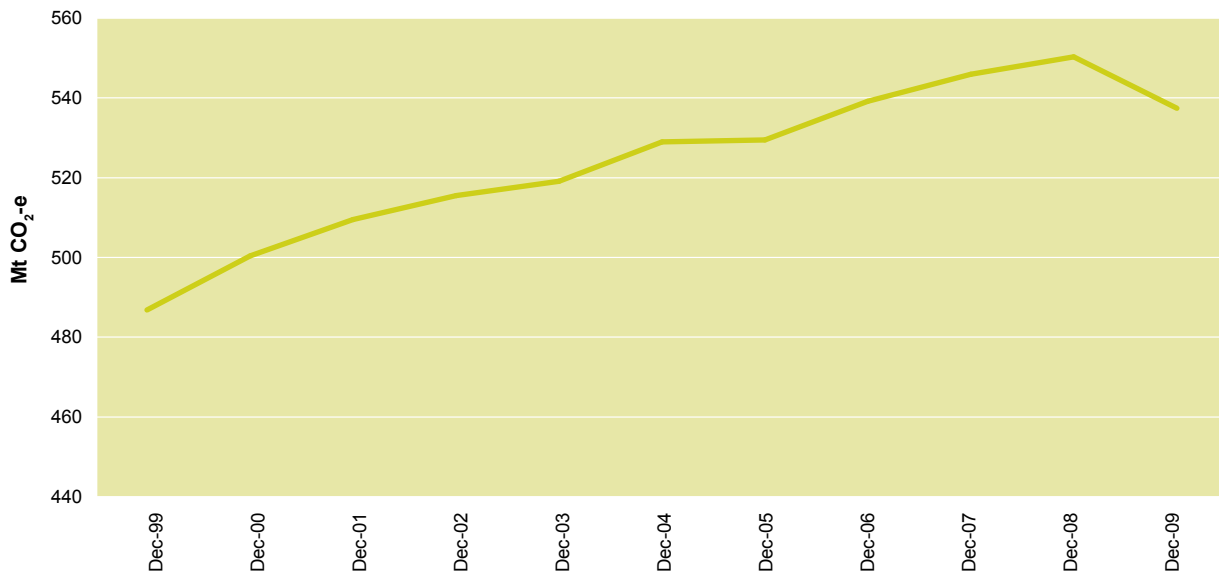
(b) The national inventory total does not include estimates of net credits from article 3.3 Land Use, Land Use Change and Forestry activities, which are estimated on an annual basis only.

(c) Values are estimates of annual emissions through to the end of the December quarter.

(d) The percentage change is the year on year growth rate for the December quarter (ie the increase in emissions for the four quarters to the December quarter over the corresponding period of the previous year).

- The dominant influence on the negative annual emissions growth rate is considered to be the international economic slowdown. The year to December has seen relatively low emissions from most sectors, electricity, other stationary energy, agriculture, transport and industrial processes. Emissions have been particularly low from the steel industry due to temporary production cutbacks which influences both the stationary energy and industrial processes sectors. Electricity production, which represents approximately 37% of the national quarterly inventory, declined by 2.0% due to lower demand and an increase in generation from less emission intensive sources. Agricultural emissions decreased by 2.8% mainly due to a reduction in livestock numbers.
- The annual emissions estimates for the four quarters up to the December quarter for each year from 1999 to 2009 are presented in Figure 3. The national inventory has increased from 486 Mt CO<sub>2</sub>-e in 1999 to 537 Mt CO<sub>2</sub>-e in 2009.

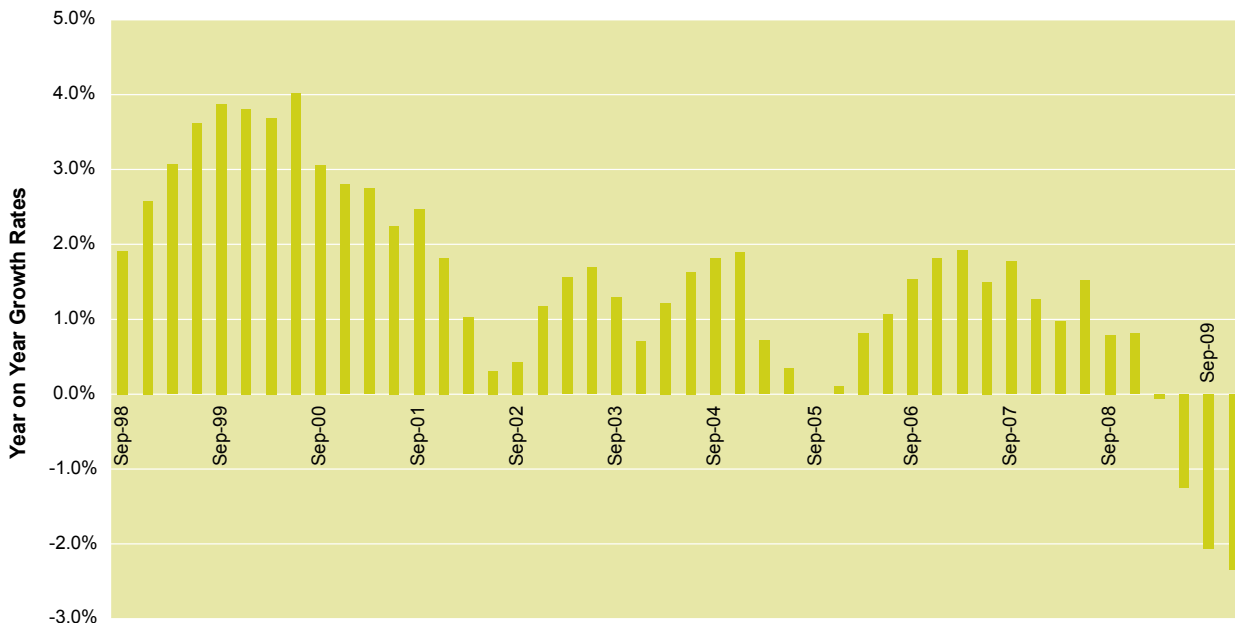
**Figure 3: National Inventory, annual emissions – four quarters to December quarter 1999 to 2009**



Note: The national inventory total does not include estimates of net credits from the article 3.3 Land Use, Land Use Change and Forestry activities, which are estimated on an annual basis only.

- The year-on-year growth rates of emissions are presented in Figure 4, updated on a quarterly basis. Australia’s average annual emissions growth rate since 1999 has been 1.0%.

**Figure 4: National Inventory, year on year emissions growth rate – September quarter 1998 to December quarter 2009**



Note: The national inventory total does not include estimates of net credits from the article 3.3 Land Use, Land Use Change and Forestry activities, which are estimated on an annual basis only.

### 3. Reconciliation of Australia's National Inventory against Australia's Kyoto Target

- Progress against Australia's Kyoto Target may be monitored by comparing the national inventory with the amount of Australia's Kyoto Protocol units available for each year of the first commitment period under the Kyoto Protocol.
- After taking account of Article 3.3 *Land Use, Land Use Change and Forestry* activities, Australia had an estimated net surplus in 2007-08 of 15 Mt of Kyoto Protocol units - or around 3% of the Kyoto Target.
- Equivalently, Australia's emissions, including from Article 3.3 *Land Use, Land Use Change and Forestry* activities, were 105% of the 1990 base period.
- The preliminary estimate for 2008-09 is a net surplus of 20 Mt of Kyoto Protocol units – or around 4% of the Kyoto Target.

**Table 2: Accounting for Australia's Kyoto Target: 2007–08 and preliminary 2008–09 estimates**

		Emissions Mt CO <sub>2</sub> -e	
		2007–08	Preliminary 2008–09
<b>National Inventory – Annex A sectors</b>			
	Energy – combustion of fuels	377	375
	Energy – fugitive emissions	40	40
	Industrial processes	31	28
	Agriculture	87	85
	Waste	14	15
<b>1</b>	<b>National Inventory total</b>	<b>550<sup>(a)</sup></b>	<b>543<sup>(a)</sup></b>
<b>Kyoto Protocol units</b>			
<b>2</b>	Initial assigned amount per year under the Kyoto Protocol <sup>(b)</sup>	592	592
<b>3</b>	<i>Net credits from Article 3.3 LULUCF activities – Deforestation, afforestation and reforestation</i>	-27	-29 <sup>(c)</sup>
	Kyoto Protocol units – domestic sources total	565	563
<b>4</b>	Net purchases of credits from international sources under Articles 6, 12 and 17 <sup>(d)</sup>	0	0
<b>5</b>	<b>Kyoto Protocol units – national total (2)+(3)+(4)</b>	<b>565</b>	<b>563</b>
	<b>Annual net balance (5) – (1)<sup>(e)</sup></b>	<b>15</b>	<b>20</b>

- Notes: (a) Australia reports financial year data under the Kyoto Protocol because key reference data inputs obtained from ABARE, the ABS and, from 2010, data inputs from the National Greenhouse and Energy Reporting System (NGERs), are collected and published on a financial year basis. Australia's assigned amount was also calculated from financial year data ensuring that time-series consistency between the inventory and the Kyoto Target is maintained. Emissions for the national inventory for 2008 are reported in the *National Inventory Report 2008*, which is the Australian Government's annual submission prepared by the Department of Climate Change and Energy Efficiency to meet the Government's reporting obligations under both the UN Framework Convention on Climate Change and the Kyoto Protocol. These estimates were prepared in accordance with UN timelines and will be reviewed by international experts in accordance with standard UNFCCC procedures. Estimation methods for 2008 are detailed in that publication. The estimates presented for 2009 are preliminary and will be revised when further reference data sources become available.
- (b) Source: Australia's *Initial Report under the Kyoto Protocol*, revised submission, October 2008. Australia's commitment and the assigned amount are not allocated to individual years, the number shown is an annual average of the assigned amount without taking account of the trend increase in emissions.
- (c) Source: Department of Climate Change, Australia's Fifth National Communication on Climate Change. The estimates for article 3.3 activities are a projection only and will be revised once estimates from the National Carbon Accounting System (NCAS) become available. Consequently, this variable is subject to significant revision.
- (d) Under the terms of certain articles of the Kyoto Protocol countries may elect to purchase credits from international sources to add to the assigned amount.
- (e) The first commitment period under the Kyoto Protocol extends from 2008 to 2012. A positive net balance should be maintained over the life of the commitment period. Consequently, any net surplus of assigned amount units available in the initial years may be used to cover any deficits arising from growth of emissions in the remainder of the commitment period. The latest emissions projections show the increase over the first commitment period is projected to be around 12 Mt CO<sub>2</sub>-e.

# 4. Australia's National Inventory: Analysis of Trends: 1990–2008

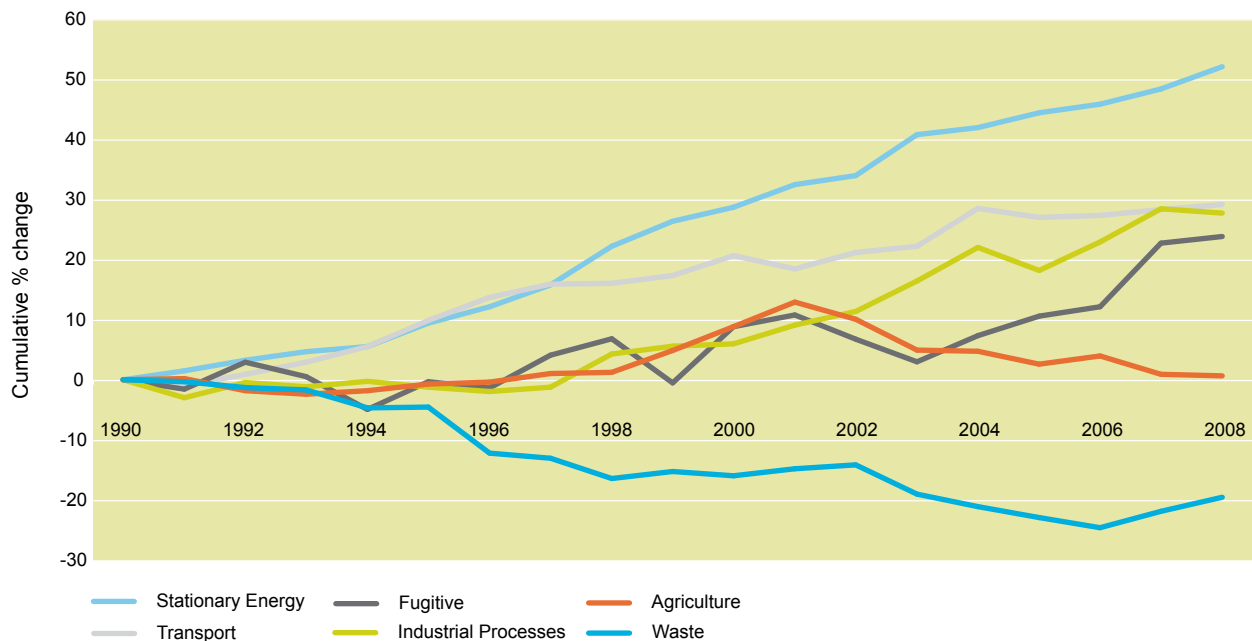
## 4.1 Overview

In 2008, Australia's national inventory of greenhouse gas emissions<sup>1</sup> was 549.5 Mt CO<sub>2</sub>-e. The *Energy* sector was the largest source of emissions comprising 75.8% of the national inventory total (416.6 Mt CO<sub>2</sub>-e). The second largest source was the *Agriculture* sector (15.9%). Relatively minor sources of emissions included *Industrial Processes* (5.7%) and *Waste* (2.6%).

The largest increase in emissions over the 1990 to 2008 period, of 52.1% (101.5 Mt CO<sub>2</sub>-e), occurred in the *Stationary Energy* sector (Figure 5). Other sources of growth include the *Transport* sector, which is the next largest growth sector with an increase of 29.2% (18.1 Mt CO<sub>2</sub>-e); the *Industrial Processes* sector, which increased 27.7% (6.8 Mt CO<sub>2</sub>-e) and the *Fugitive emissions* sector, with an increase of 23.8% (7.7 Mt CO<sub>2</sub>-e).

The *Agriculture* sector is largely a steady source of emissions, showing a slight increase of 0.7% over the period. The *Waste* sector showed a strong decline of 19.6% (3.5 Mt CO<sub>2</sub>-e), driven mainly by increasing patterns of recycling and enhanced methane recovery.

**Figure 5: Trends in CO<sub>2</sub>-e emissions by sector – change since 1990**



Australia's national inventory of greenhouse gas emissions, after accounting for *Land Use, Land Use Change and Forestry* activities, was 576.2 Mt CO<sub>2</sub>-e. In the *Land Use, Land Use Change and Forestry* activities, there has been a strong decline of 79.8% (104.9 Mt CO<sub>2</sub>-e) in net emissions and, in particular, reductions in emissions from deforestation.

Trends in emissions from each sector are discussed in the following chapters. Emissions data for all years 1990 to 2008 are provided in Appendix 3.

<sup>1</sup> The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

## 4.2 Energy

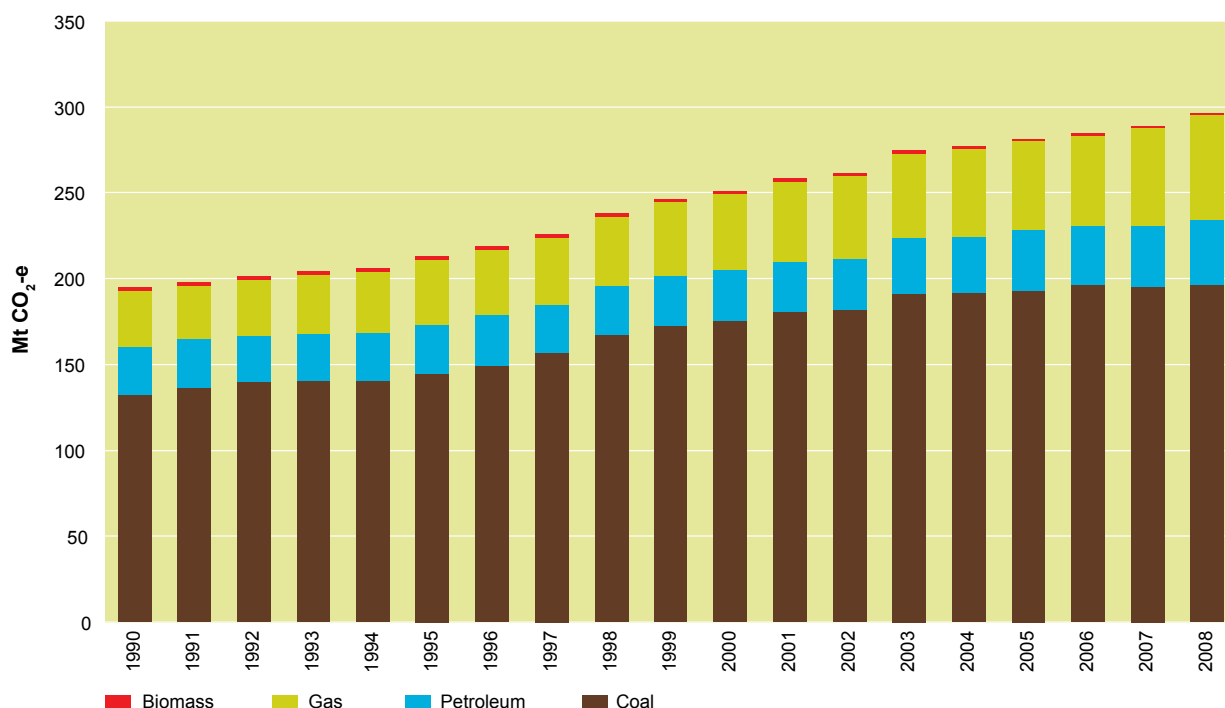
### Emissions estimates and trends 1990 to 2008

The entire *Energy* sector was the source of 416.6 Mt CO<sub>2</sub>-e or 75.8% of Australia's national inventory of emissions in 2008<sup>2</sup>. Of this, 296.4 Mt of emissions were from *Stationary Energy*, 80.2 Mt from *Transport* and 39.9 Mt from *Fugitive emissions*. In 2008, *Energy* sector emissions were 2.0% (8.2 Mt) higher than in 2007 and 44.0% (127.3 Mt) higher than in 1990. Preliminary estimates for 2009 indicate that *Energy* emissions have decreased by 0.4% (1.7 Mt) since 2008 principally due to decreased emissions from manufacturing and transport.

### Stationary energy

Estimated emissions from fuel combustion in the *stationary energy* sector were 296.4 Mt CO<sub>2</sub>-e in 2008, equal to 53.9% of national inventory emissions. Emissions from *stationary energy* increased by 52.1% (101.5 Mt) between 1990 and 2008 (Figure 6). An increase in emissions from the combustion of coal accounted for 63.4% of the overall increase in emissions while combustion of gas accounted for 27.5% and oil 9.8% of the increase. These increases were slightly offset by a decrease in emissions from non-fossil fuels. Preliminary estimates for 2009 indicate that stationary energy emissions have decreased by 0.1% (0.2 Mt) since 2008.

Figure 6: Total CO<sub>2</sub>-e emissions from stationary energy combustion by fuel, 1990–2008



### Energy production

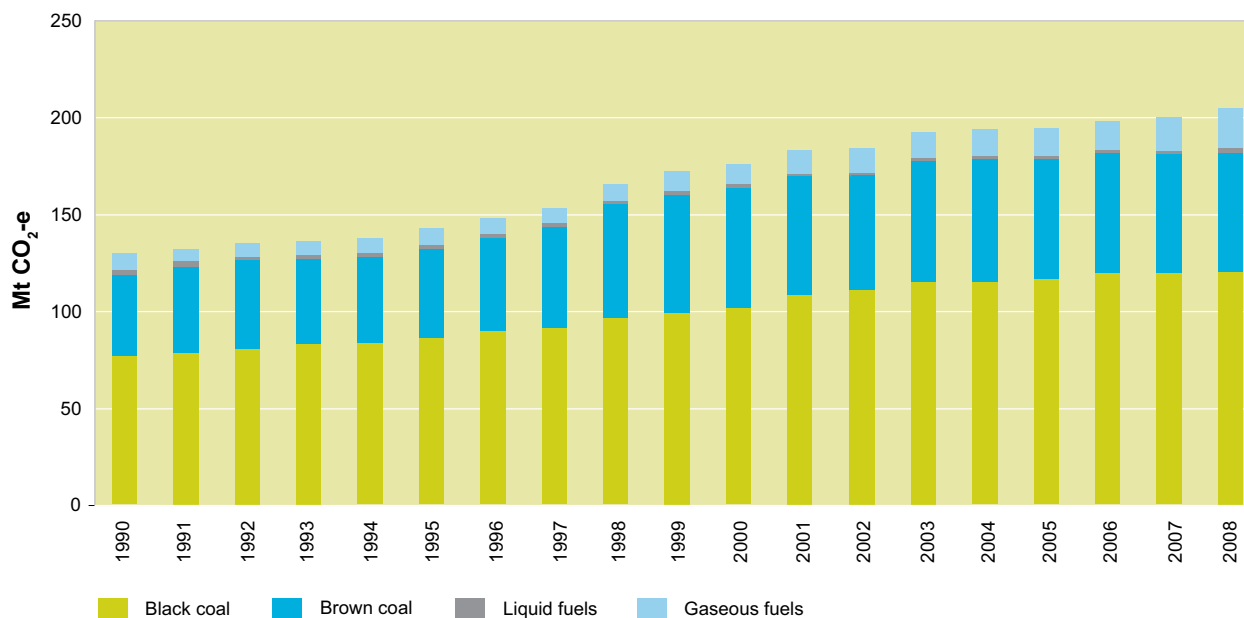
The largest contribution to *Stationary Energy* emissions comes from the generation of electricity (68.9%). Electricity generation accounted for 204.3 Mt or 37.2% of national emissions in 2008. Electricity generation emissions increased by 4.3 Mt (2.2%) from 2007 to 2008, and by 74.8 Mt (57.8%) from 1990 to 2008 (Figure 7). The 2007 to 2008 electricity generation emissions increase (2.2%) was less than the increase in fuel use (4.1%). The black coal share of energy use decreased by 1.5% to 54.5% while the brown coal share decreased by 0.7% to 27.4%.

<sup>2</sup> The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

The share of fuel use contributed by gaseous fossil fuels increased 1.9% to 16.3% while liquid fuels increased by 0.2% to 1.4%. The remaining 0.5% of energy use is from biogenic fuels. Preliminary estimates indicate that electricity generation emissions have increased by a further 1.1% (2.2 Mt) in 2009.

Other energy industries are, by comparison, small contributors: – petroleum refining contributed 5.6 Mt and the remainder contributed 16.4 Mt of emissions in 2008.

**Figure 7: CO<sub>2</sub>-e emissions from electricity generation by fossil fuels, 1990–2008**



### Other fuel combustion<sup>3</sup>

Fuel combustion in mining non-energy commodities, manufacturing and construction industries accounted for 8.9% (48.7 Mt) of national emissions in 2008. Emissions from these industries have increased 35.0% (12.6 Mt) between 1990 and 2008. However preliminary estimates for 2009 indicate that emissions have decreased from these sources by 5.1% (2.5 Mt) since 2008. The largest contributor to this decrease was the iron and steel sector.

Fuel combustion in the residential, commercial and institutional sectors, together with fuel use by agricultural, fisheries and forestry equipment, contributed 19.8 Mt or 3.6% of national greenhouse gas emissions in 2008. This is 34.0% more than the 14.7 Mt of emissions in 1990.

The remaining sources, military vehicles and combustion of lubricants, were only small contributors with estimated emissions of 1.6 Mt in 2008.

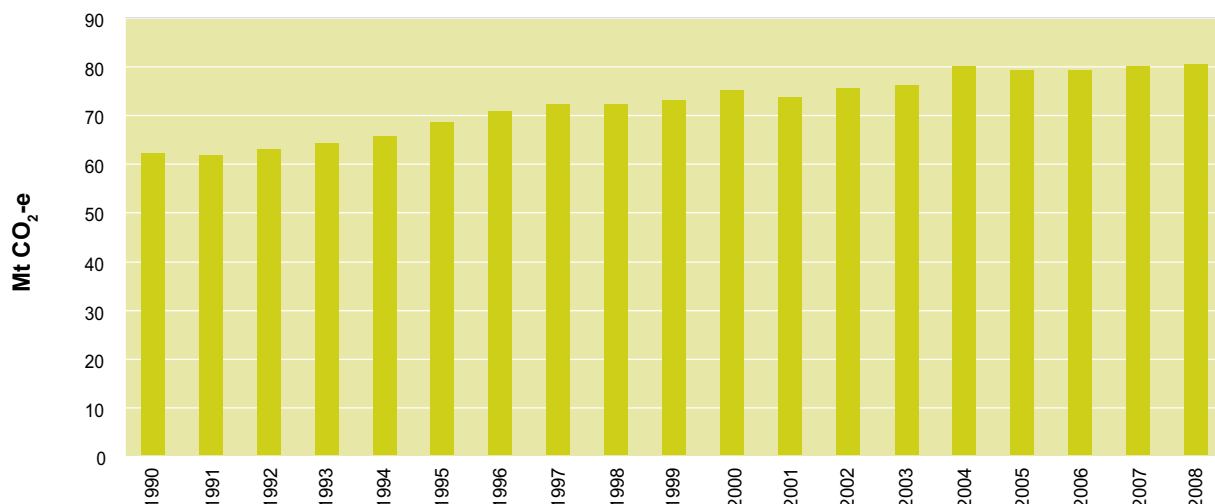
### Transport

In 2008 *Transport* contributed 80.2 Mt CO<sub>2</sub>-e or 14.6% of Australia’s national inventory<sup>4</sup> emissions. *Transport* emissions are one of the strongest sources of emissions growth in Australia. Emissions from this sector were 29.2% higher in 2008 than in 1990, and have increased by about 1.4% annually on average (Figure 8). Between 2007 and 2008, *Transport* emissions increased by 0.7%. Preliminary estimates for indicate that *Transport* emissions have decreased by 1.5% (1.2 Mt) in 2009.

<sup>3</sup> The National Inventory accounts for emissions from electricity at the point where the emissions occur, which means the power station where electricity is produced, not the point where the electricity is used. Therefore, emissions associated with electricity used in the industry, residential and commercial sectors are included under energy production. For information on the allocation of emissions from electricity to end uses, see *National Inventory by Economic Sector 2008*.

<sup>4</sup> The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

**Figure 8: Total transport emissions, 1990–2008**



### Road transport

*Road transport* was the main source of transport emissions and accounted for 86.3% (69.2 Mt) of 2008 transport emissions. Emissions from *Road transport* increased by 27.5% (14.9 Mt) between 1990 and 2008.

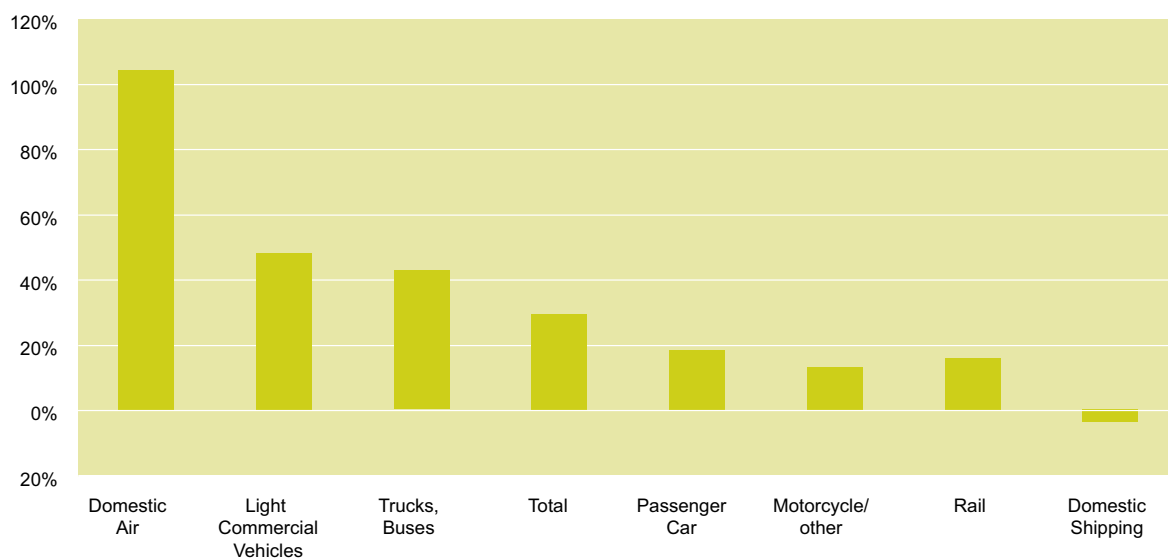
Passenger cars were the largest transport source contributing 41.6 Mt. Emissions from passenger cars increased by 18.2% (6.4 Mt) between 1990 and 2008. Emissions from trucks (increase of 4.8 Mt) and light commercial vehicles (increase of 3.6 Mt) have also grown strongly.

### Other modes of transport

Other transport sources are smaller contributors to total transport emissions: – civil aviation contributed 7.4% (6.0 Mt), domestic shipping 3.7% (2.9 Mt), and railways 2.5% (2.0 Mt).

*Domestic air transport* emissions were 104.0% (3.0 Mt) higher than the 1990 level. Emissions have grown strongly in this sector, particularly in the early 1990s, although emissions in 1990 were unusually low because of extensive airline disruptions in that year and this has contributed to the magnitude of the change. Emissions from rail have risen by 15.9% while *Domestic shipping* emissions have fallen by 3.9%, reflecting improved productivity and changes in activity (Figure 9).

**Figure 9: Comparison of growth in transport emissions by subcategory, 1990–2008**

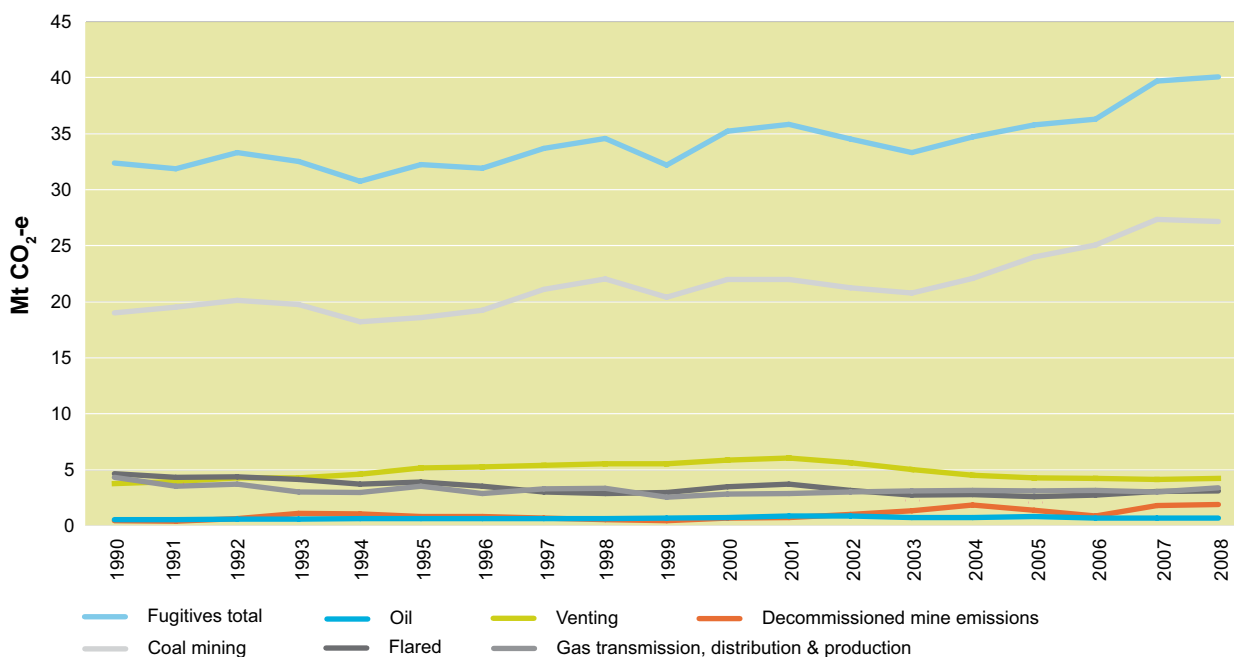


## Fugitive emissions

Total estimated *Fugitive Emissions* for 2008 were 39.9 Mt CO<sub>2</sub>-e, representing 7.3% of national inventory emissions<sup>5</sup>. Net emissions associated with coal mining and handling and decommissioned mines contributed 72.3% (28.9 Mt) of *Fugitive emissions*. Oil and natural gas production, processing and distribution account for the remaining 27.7% (11.1 Mt).

Overall, *Fugitive Emissions* increased by 23.8% (7.7 Mt) between 1990 and 2008, and by 0.9% (0.4 Mt) from 2007 to 2008 (Figure 10). Preliminary estimates indicate that fugitive emissions decreased by 0.9% (0.4 Mt) in 2009.

**Figure 10: CO<sub>2</sub>-e fugitive emissions by category, 1990–2008**



Fugitive emissions from *Solid fuels* decreased by 0.5% (0.1 Mt) between 2007 and 2008. Underground mine emissions fell by 1.7% (0.3 Mt), driven by a 14% decrease in production from the gassiest region – the southern coalfields. This was largely offset by production increases in the less gassy coalfields of Queensland and western New South Wales. Emissions from surface mines increased by 1.4% (0.1 Mt) between 2007 and 2008. Emissions from decommissioned mines have increased 4.1% (0.1 Mt) between 2007 and 2008.

Mine production of coal has increased from 241.0 Mt in 1990 to 481.2 Mt in 2008, an increase of 99.7%. Methane emissions have not grown as fast as activity principally because, since 1998, there has been an increasing trend in activity from surface mines compared to that of underground mines (Figure 11) and, within underground mines, a decreasing share of production from the gassiest southern New South Wales coalfield (Figure 12). In addition, technologies to recover and utilise or flare CH<sub>4</sub> have been increasingly adopted in underground mining.

<sup>5</sup> The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

Figure 11: Fugitive CO<sub>2</sub>-e emissions from coal mining, 1990–2008

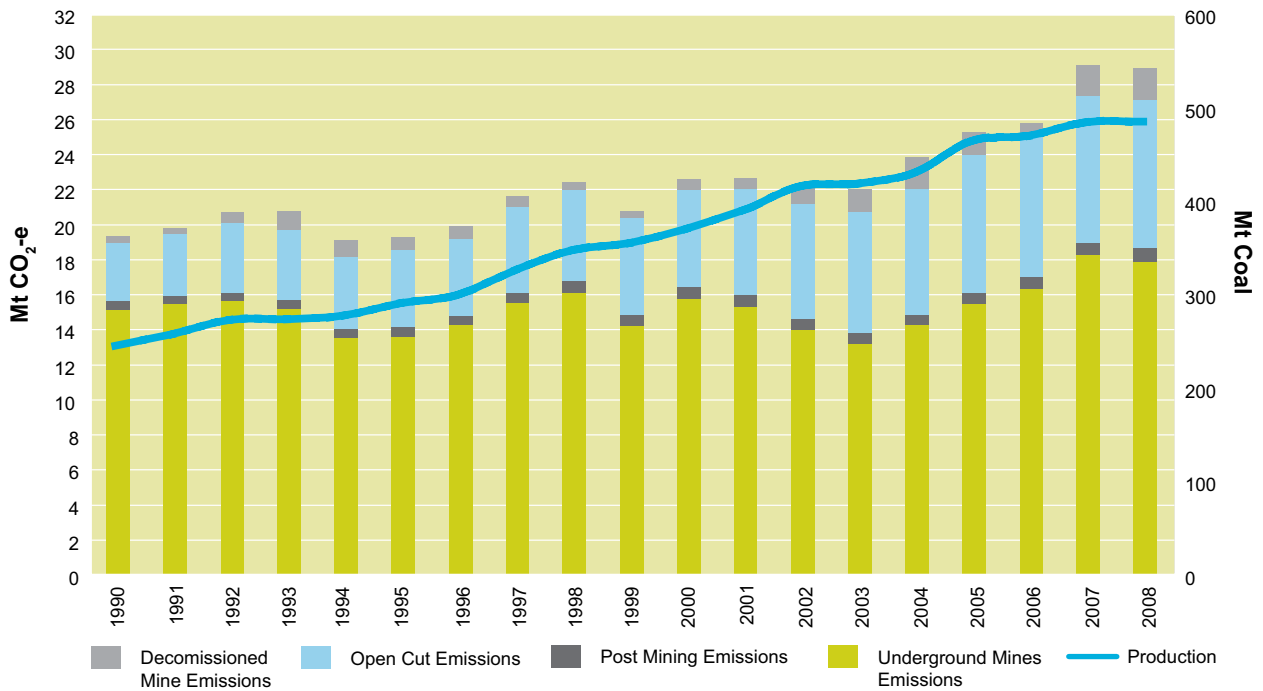
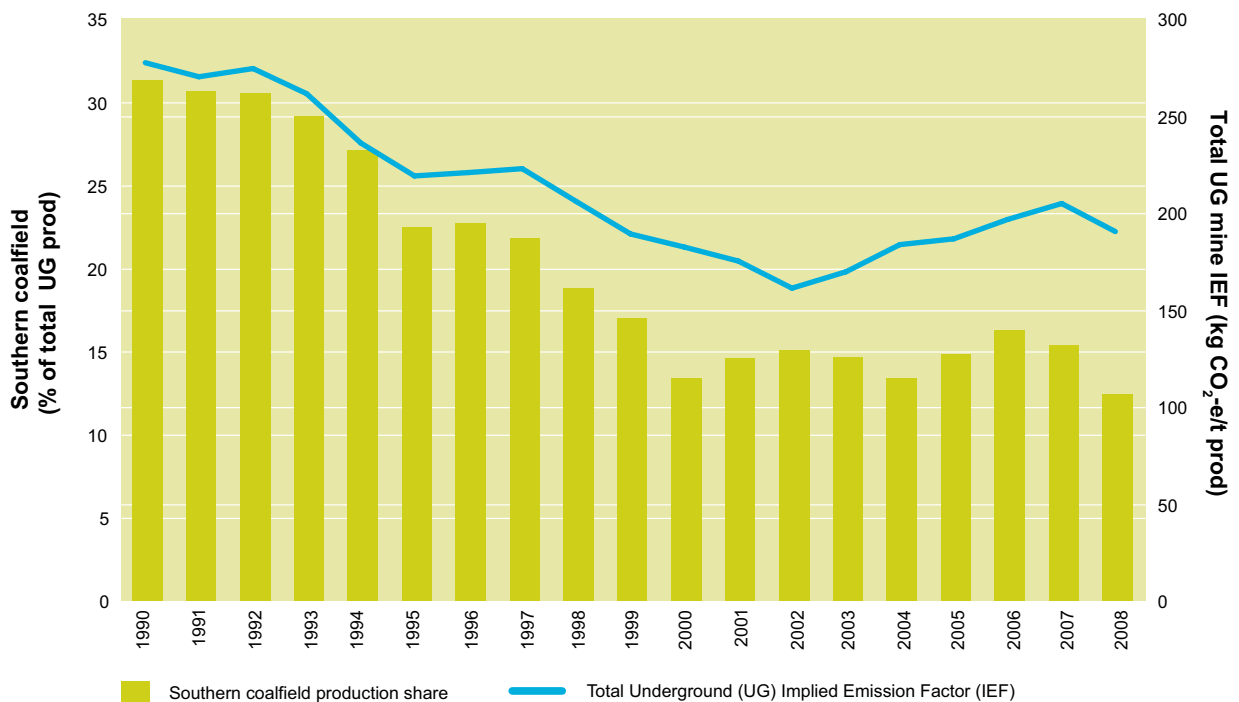
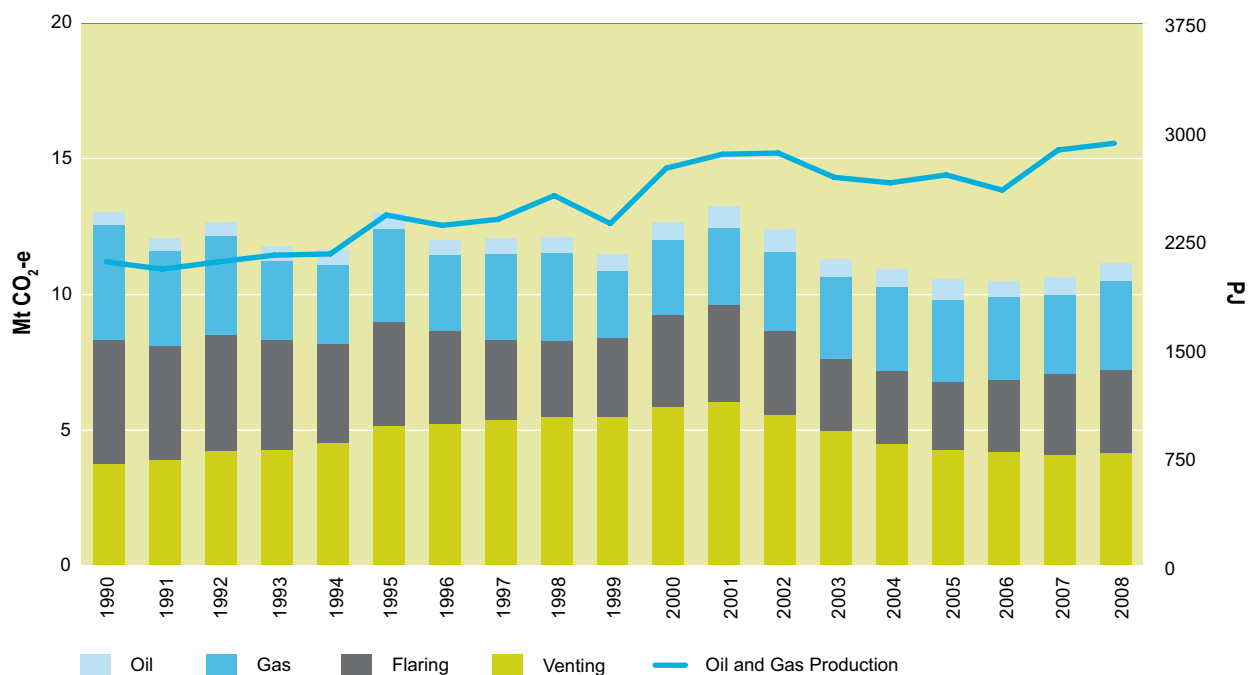


Figure 12: Decline of the overall underground coal mine implied emission factor compared with the fall in production from the high gas content Southern Coalfield



Oil and natural gas fugitive emissions decreased by 14.6% (1.9 Mt) between 1990 and 2008 (Figure 13). This compares with a 39.5% increase in production activity. The decrease in emissions relative to the increase in activity is largely the result of improvements in gas distribution and a reduction in the emissions from flaring. Between 2007 and 2008, emissions from oil-related activities decreased by 1.7% (0.01 Mt) and emissions from gas-related activities increased by 12.5% (0.4 Mt). Emissions from venting increased by 2.2% (0.1 Mt) from 2007 to 2008 and were 11.8% (0.4 Mt) higher than in 1990. Flaring-related emissions increased by 1.5% (0.04 Mt) from 2007 to 2008, although emissions in 2008 were lower than 1990 levels by 33.9% (1.6 Mt).

Figure 13: Fugitive CO<sub>2</sub>-e emissions from oil and gas production, 1990–2008



## NOTES

The *Energy* sector includes emissions from the following sources:

**Stationary combustion**—emissions from fuel combustion to provide energy in the following areas:

- *Energy industries*—electricity generation, petroleum refining, gas processing and solid fuel manufacturing.
- *Manufacturing industries and construction*—direct emissions from combustion of fuel to provide energy used in manufacturing such as steel, non ferrous metals, pulp and paper and food processing.
- *Other sectors*—energy use by the commercial, institutional, residential sectors as well as fuel use by agricultural, fishery and forestry equipment and all remaining fuel combustion emissions including those produced by combustion of engine lubricating oil and military fuel use.

**Transport**—emissions from road, rail and domestic air and water transport:

- *Road transport*—passenger vehicles, light commercial vehicles, trucks, buses and motorcycles.
- *Domestic air transport*—commercial passenger and light aircraft on domestic routes using either aviation gasoline or jet kerosene; international air transport is reported but not included in Australia's total emissions in line with international guidelines.
- *Coastal shipping*—domestic shipping and small craft; international shipping is reported but not included in Australia's total emissions in line with international guidelines.
- *Rail transport*—railways, but not electric rail, which is covered under electricity generation.

**Fugitive emissions**—emissions, other than those attributable to energy use, from:

- *Solid fuels*—Coal mining and handling and decommissioned mines.
- *Oil and natural gas*—production, processing and transportation.

## 4.3 Industrial Processes

### Emissions estimates and trends from 1990 to 2008

Emissions from the *Industrial Processes* sector were 31.1 Mt CO<sub>2</sub>-e in 2008, which is equivalent to 5.7% of national inventory emissions<sup>6</sup>. Emissions were 6.8 Mt (27.7%)<sup>1</sup> higher than in 1990 (Figure 14). The increase in emissions observed over the longer term are principally due to growth in emissions associated with the consumption of halocarbons and the chemical industry.

### Mineral products

*Mineral products* contribute 20.9% of *Industrial Processes* emissions. In 2008, emissions from mineral products were 6.5 Mt. Cement clinker contributed 3.9 Mt (59.8%) of mineral product emissions and lime production contributed 1.1 Mt (17.2%). The limestone and dolomite use sub-sector generated 1.5 Mt (23.0%) of emissions, this sub-sector includes emissions related to iron and steel production, glass production, magnesia production and soda ash production and use.

Net emissions from *Mineral products* increased by 1.1 Mt (20.3%) from 1990 to 2008 mainly due to increased production of lime and cement clinker. From 2007 to 2008, net emissions increased by 0.03 Mt (0.4%).

### Chemical industry

Emissions from the *Chemical Industry* totaled 7.2 Mt in 2008 and included emissions from nitric acid production, ammonia production, acetylene use, production of polymer and other chemicals, production of titanium dioxide and synthetic rutile and the use of N<sub>2</sub>O in aerosols and anesthesia. These emissions increased by 5.0 Mt (229.5%) between 1990 and 2008, although emissions decreased by 0.5 Mt (6.3%) from 2007 to 2008.

### Metal production

*Metal production* generated 11.0 Mt of emissions in 2008. The emissions are due to iron and steel production (7.5 Mt) and aluminium smelting (3.5 Mt). *Metal production* emissions declined by 4.0 Mt (26.7%) from 1990 to 2008. This was due to a 2.5 Mt (41.3%) reduction in emissions from aluminium smelting, and a 1.6 Mt (17.1%) fall in emissions from crude steel production, largely as a result of the closures of the Newcastle Steelworks in 2000 and the Boodarie Iron hot briquetted iron plant in Western Australia in 2005.

### Other Production

Emissions of CO<sub>2</sub> from the food and drink industry accounted for 0.1 Mt, a 59.8% increase on 1990.

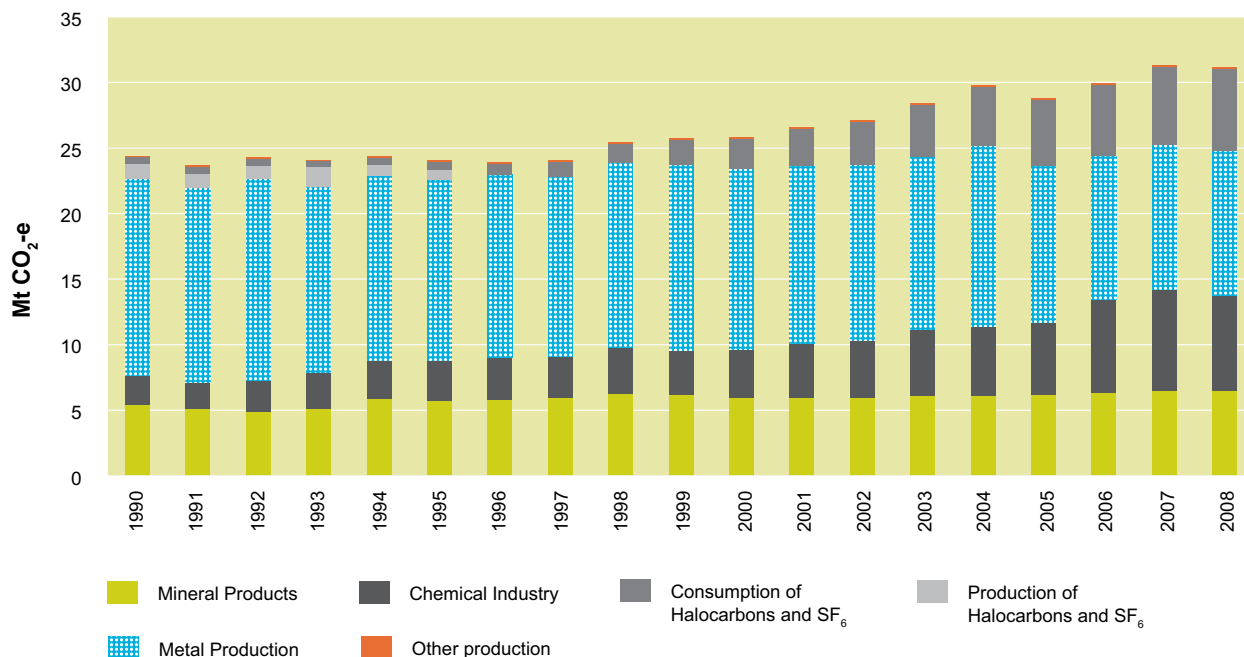
### Consumption and production of halocarbons

Emissions from the *Consumption of halocarbons* and SF<sub>6</sub> were estimated to be 6.3 Mt CO<sub>2</sub>-e in 2008. The main halocarbons emitted are HFC-125, HFC-134a, and HFC-143a. These substances were not used in 1990, but have been increasingly used since then as a replacement for CFCs and other substances phased out under the Montreal Protocol. The increasing use of HFC refrigerants reflects this transition from the use of CFCs together with growing stocks of equipment (principally refrigerators and air-conditioners) charged with these gases. Production of halocarbons in Australia ceased in 1995, removing a source of fugitive emissions of HFC-23 that was 1.1 Mt CO<sub>2</sub>-e in 1990.

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<sup>6</sup> The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

Figure 14: Trend in emissions from industrial processes from 1990 to 2008



NOTES

Greenhouse gas emissions from the *Industrial Processes* sector are primarily by-products of production, and they vary with the process technology used and the level of industrial output. These emissions arise from non-energy related sources. For example, high temperature processing of calcium carbonate to produce quicklime releases carbon dioxide emissions. Technological change in production processes can affect the greenhouse intensity of industrial processes.

Greenhouse gas emissions from industrial processes are mostly carbon dioxide. Smaller quantities of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF<sub>6</sub>), nitrous oxide and methane are emitted. The sources of Industrial Process emissions include:

- *Mineral products*—carbon dioxide from cement clinker and lime production; the use of limestone and dolomite in industrial smelting processes; soda ash use; and magnesia production.
- *Metal production*—carbon dioxide and PFCs from aluminium smelting; and carbon dioxide, methane and nitrous oxide from iron and steel production.
- *Chemical industry*—includes nitrous oxide from the production of nitric acid; carbon dioxide emissions from ammonia production; and methane from polymers and other chemicals.
- *Other production*—carbon dioxide from the consumption of CO<sub>2</sub> in the food and drink industry, the use of sodium bicarbonate and ethylene oxide production.
- *Consumption of halocarbons*—HFCs, PFCs and SF<sub>6</sub> from refrigeration and airconditioning equipment; foam blowing; metered dose inhalers; fire extinguishers; solvent use; and, electrical equipment.

## 4.4 Agriculture

### Emissions estimates and trends from 1990 to 2008

*Agriculture* produced an estimated 87.4 Mt CO<sub>2</sub>-e emissions or 15.9% of national inventory emissions in 2008<sup>7</sup>. The *Agriculture* sector is the dominant national source of both methane and nitrous oxide - accounting for 67.1 Mt CO<sub>2</sub>-e (58.0%) and 20.3 Mt CO<sub>2</sub>-e (75.5%) respectively of the net national emissions for these two gases.

Greenhouse gas emissions from *Agriculture* increased by 0.7% (0.6 Mt) between 1990 and 2008, and decreased by 0.2% (0.2 Mt) from 2007 to 2008. Preliminary estimates for 2009 indicate that *Agriculture* emissions have decreased by 2.7% (2.3 Mt) since 2008 due to decreased stock numbers.

### Livestock

Greenhouse gas emissions from livestock are the sum of the *Enteric fermentation* (55.6 Mt) and *Manure management* (3.3 Mt) sub-sectors. Livestock emissions were 58.9 Mt CO<sub>2</sub>-e in 2008, which represents 67.4% of the *Agriculture* sector's emissions.

Livestock related emissions have declined by 10.7% (7.1 Mt) between 1990 and 2008 (Figure 15). The decline in emissions has principally been driven by a 55.7% fall in sheep numbers, although partially offset by a 11.3% rise in beef cattle numbers, reflecting changing relative returns to each industry. Preliminary estimates for 2009 indicate that livestock emissions have declined by 2.4% (1.4 Mt) since 2008.

Figure 15: Trends in CO<sub>2</sub>-e emissions from livestock



### Crops, soil and fire-related emissions

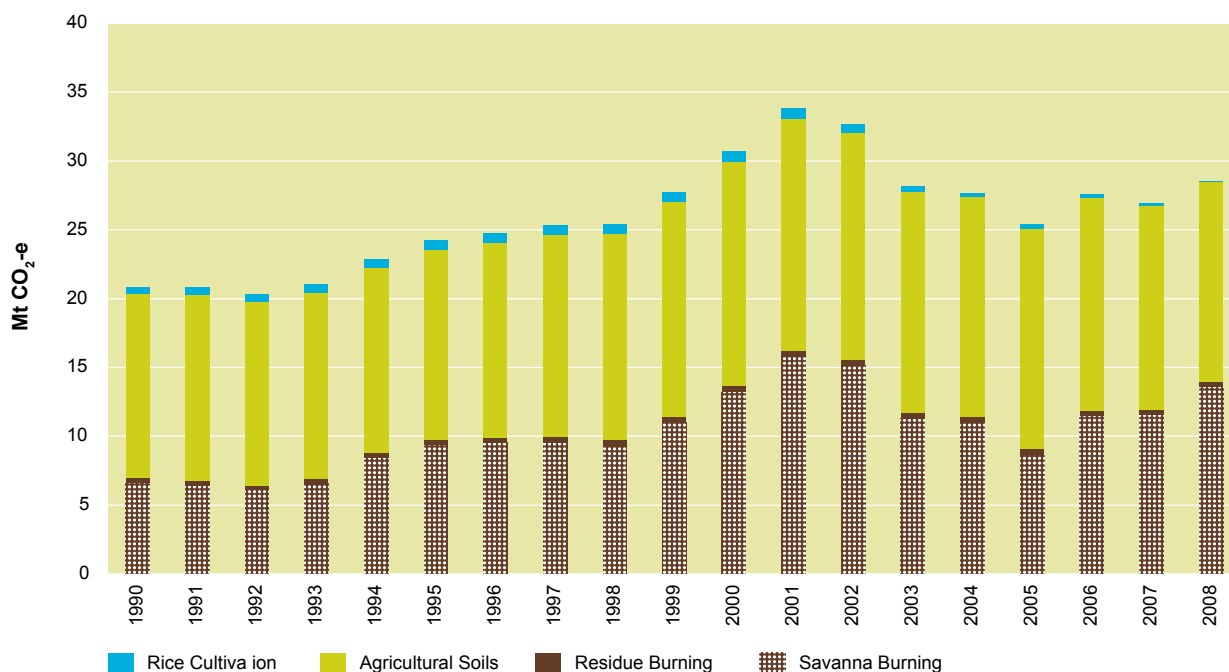
The estimated emissions from the other *Agriculture* sub-sectors in 2008 were:

- 0.04 Mt from *Rice cultivation*, a 91.2% (0.4 Mt) decrease since 1990;
- 14.6 Mt from *Agricultural soils*, an 8.3% (1.1 Mt) increase since 1990;
- 13.6 Mt from *Prescribed burning of savannas*, a 106.0% (7.0 Mt) increase since 1990; and
- 0.3 Mt from *Field burning of agricultural residues*, a 3.3% (0.01 Mt) increase since 1990.

<sup>7</sup> The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

Emissions from the other agriculture sub-sectors, with the exception of savanna burning, declined between 2007 and 2008. Preliminary estimates for 2009 indicate an increase in *Field burning of agricultural residues*, a decrease in savanna burning and relatively flat emissions growth in the other sub-sectors.

**Figure 16: Trends in CO<sub>2</sub>-e emissions from the crop, soil and fire related subsectors**



## NOTES

Emissions of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) are produced when living and dead biomass is consumed, decays or is burnt. These emissions are modified by human activities including cultivation, addition of fertilisers, deliberate burning, flooding and by the introduction of ruminant animals. The sources of Agriculture emissions are:

- *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 N 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 and other crop stubble, and the emissions from burning sugar cane prior to harvest.

## 4.5 Waste

### Emissions estimates and trends from 1990 to 2008

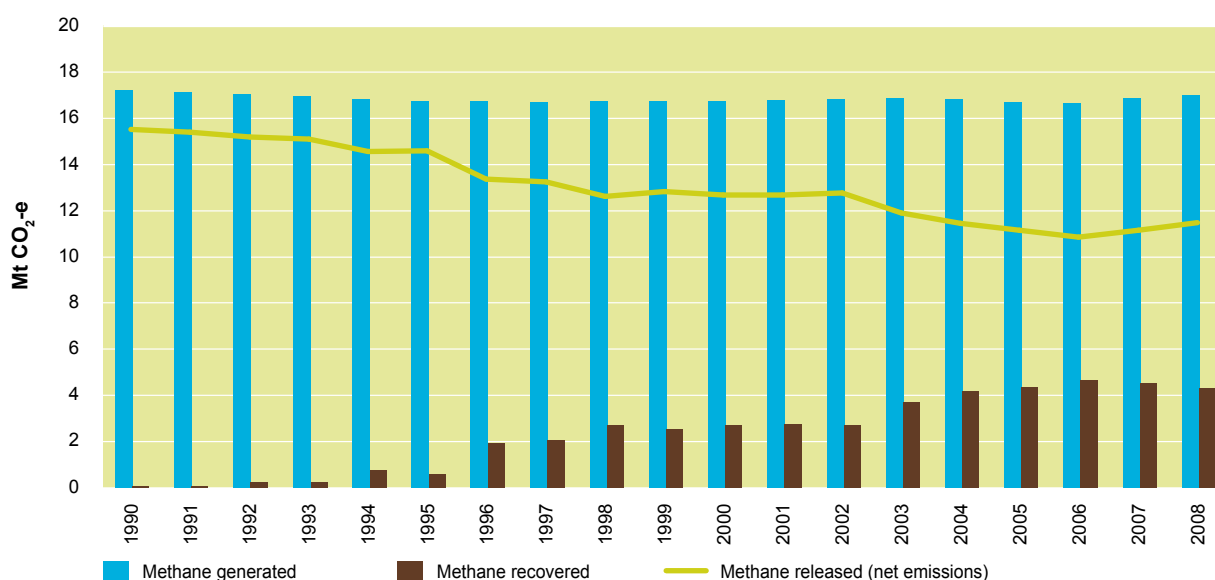
Net *Waste* emissions were 14.4 Mt CO<sub>2</sub>-e in 2008, an increase of 0.4 Mt (3.0%) since 2007 and a decrease of 3.5 Mt (19.6%) since 1990. Preliminary estimates for 2009 indicate that *Waste* emissions have increased by 1.5% (0.2 Mt) since 2008.

### Solid waste

Methane emissions from *Solid waste* disposal on land were 11.1 Mt CO<sub>2</sub>-e in 2008. Estimated emissions from *Solid waste* disposal decreased by 3.1 Mt (22.1%) during the period 1990–2008 reflecting changing patterns of disposal, particularly higher rates of recycling, and from an increase in methane recovery (Figure 17). Net emissions from *Solid waste* are estimated to have increased by 0.4 Mt (3.4%) in 2008 compared with 2007.

Rates of methane recovery from *Solid waste* have improved substantially since 1990, increasing from a negligible amount to 4.3 Mt CO<sub>2</sub>-e of methane in 2008.

Figure 17: Emissions from solid waste disposal on land, 1990–2008



### Wastewater

Methane is generated by anaerobic decomposition of organic matter in sewerage facilities during treatment and disposal of wastewater, and on-site sewage treatment systems such as septic tanks. Human sewage is also a source of nitrous oxide emissions. Emissions from *Wastewater* amounted to 3.3 Mt CO<sub>2</sub>-e in 2008.

Methane and nitrous oxide emissions from *Wastewater* decreased by 0.3 Mt CO<sub>2</sub>-e or 8.4% during the period 1990–2008, largely as a result of reductions in the quantities of industrial wastewater generated and changes to the processes employed to treat this wastewater.

### Incineration

Emissions of CO<sub>2</sub> occur as a result of the incineration of solvents, clinical and municipal solid waste. Emissions of CO<sub>2</sub> from *Incineration* were 0.03 Mt in 2008. These emissions decreased by 0.06 Mt (65.7%) during the period 1990–2008.

## NOTES

Waste emissions are predominantly methane. Small amounts of carbon dioxide and nitrous oxide are generated through incineration and the decomposition of human wastes respectively. The main sources of waste emissions are:

- *Solid waste*—emissions resulting from anaerobic decomposition of organic matter in landfills.
- *Wastewater*—emissions resulting from anaerobic decomposition of organic matter in sewerage facilities (including on-site systems such as septic tanks) during treatment and disposal of wastewater.
- *Incineration*—emissions resulting from the incineration of solvents and clinical waste.

## 4.6 Article 3.3 Land Use, Land Use Change and Forestry Activities

### Emissions estimates and trends from 1990 to 2008

The net emissions from the *Land Use, Land Use Change and Forestry* activities were 26.6 Mt CO<sub>2</sub>-e in 2008.

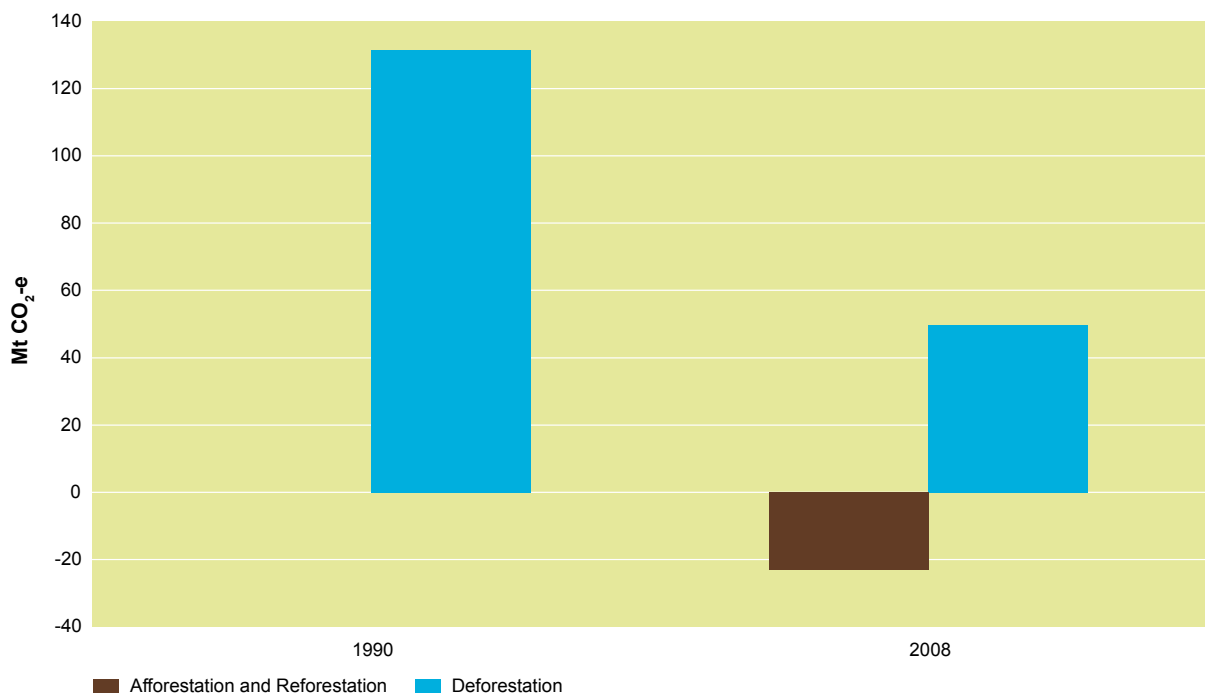
### Afforestation and Reforestation

In 2008, removals associated with *Afforestation and reforestation* activities (sequestration of carbon dioxide in plantations established since 31 December 1989) were estimated to be 23.0 Mt of CO<sub>2</sub>-e.

### Deforestation

Net emissions from *Deforestation* in 2008 were estimated to be 49.7 Mt CO<sub>2</sub>-e (see notes for more explanation). This amounts to a decline of 81.9 Mt (62.3%) on 1990. Annual rates of land use change have decreased substantially since 1990 with consequent reductions in estimated emissions from burning and decay of aboveground biomass and below ground carbon.

**Figure 18: Net land use, land use change and forestry emissions from 1990 and 2008**



## NOTES

Under the UNFCCC, all carbon dioxide emissions from the human use of the land are reported in the *Land Use, Land Use Change and Forestry* (LULUCF) sector. In contrast, under the Kyoto Protocol (Article 3.3) accounting provisions, emissions from this sector for the commitment period 2008–2012 are limited to:

- *Afforestation and Reforestation*—emissions and removals (that is sinks) from forests established on agricultural land since 1990.
- *Deforestation*—emissions and removals from the direct human-induced removal of forest and replacement with pasture, crops or other uses on land that was forest on 1 January 1990.

Emissions arise from the burning and decay of aboveground biomass, and changes in soil carbon from current and past events. Growth of the forests and regrowth on cleared lands provides a carbon sink. Emissions also arise from the application of lime based products to these lands (CO<sub>2</sub>) and from soil disturbance on the cleared lands (N<sub>2</sub>O).

Estimates of the emissions and removals from the Article 3.3 LULUCF activities are only provided for 1990 and for the commitment period (2008–2012). Unlike other sectors, the accounting rules for Article 3.3 LULUCF activities differ between the initial assigned amount calculations and the commitment period. It is, therefore, not possible to present a consistent time-series of emissions and removals for these activities.

The 1990 estimate presented here for LULUCF, is the ‘base year’ estimate used to calculate the initial assigned amount. This includes land use change (or forest conversion) as reported under the UNFCCC inventory and no emissions or removals due to forestry.

- *Land use change* under the UNFCCC includes emissions and removals from all forest lands cleared in a given year as well as ongoing emissions from the loss of biomass and soil carbon on lands previously cleared. As the carbon in these pools can take greater than 20 years to reach a new equilibrium after forest clearing the land use change estimate for 2008 includes emissions and removal on lands cleared prior to 1990. *Deforestation* as agreed under the Kyoto Protocol only includes emissions and removals from land that was forest on 1 January 1990 and which has been cleared since 1990.

The estimates presented here for afforestation/reforestation are the accounting quantity taking into consideration the harvested forest sub-rule of the Kyoto Protocol. Under this accounting rule “debits resulting from harvesting during the first commitment period following afforestation and reforestation since 1990 shall not be greater than credits accounted for on that unit of land”. In other words, whenever emissions on harvested land units are greater than the removals on those land units, a net balance of zero is assumed for those units of land.

# APPENDIX 1 – NOTES

## Australian National Greenhouse Accounts

In conjunction with this *Report*, the Department of Climate Change and Energy Efficiency (DCCEE) publishes a range of supporting emission estimates that, together, constitute the *Australian National Greenhouse Accounts*. In addition to the *National Greenhouse Gas Inventory*, the DCCEE also prepares:

- a summary of *State and Territory Greenhouse Gas Inventories*;
- the *National Inventory by Economic Sector*, comprising emission estimates by economic sector rather than by IPCC sectors as in this report; and
- the *National Inventory Report 2008*, prepared under the reporting provisions applicable to the United Nations Framework Convention on Climate Change.

These documents are available on the DCCEE website <http://www.climatechange.gov.au/en/climate-change/emissions>. They provide additional information with respect to Australia's emissions on both a regional and industry basis, as well as with respect to Australia's domestic policy commitments.

## Australian Greenhouse Emissions Information System

The Australian Greenhouse Emissions Information System (AGEIS) provides on-line public access to emission estimates, background supporting data and time-series analyses that support the *National Greenhouse Accounts*. The dynamic interface allows users to select emissions data of interest and download the results in a format which allows for further analysis of the. The AGEIS can be accessed at <http://www.climatechange.gov.au/en/climate-change/emissions>.

## International Guidelines and Review

The *National Greenhouse Gas Inventory* has been prepared in accordance with the Intergovernmental Panel on Climate Change (IPCC) *Revised 1996 Guidelines for National Greenhouse Gas Inventories* and the principles of the IPCC (2000) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* and the IPCC (2003) *Good Practice Guidance for Land Use, Land Use Change and Forestry*. Where appropriate, elements of the 2006 *IPCC Guidelines for National Greenhouse Gas Inventories* are being progressively implemented. The national inventory undergoes annual independent international review.

## Kyoto accounting

- 'Kyoto accounting' is relevant to Australia's target under the Kyoto Protocol (established as an initial assigned amount of 592 Mt a year for each year of the first commitment period 2008–2012). See the Department of Climate Change and Energy Efficiency web site for more detail – <http://www.climatechange.gov.au/publications/international/unfccc-report.aspx>.
- The 'initial assigned amount' represents Australia's emissions target for the first commitment period of the Kyoto Protocol (before adjustments are made for purchases of net credits from international sources). The initial assigned amount is calculated as 108% of the base year emissions.
- The 'base year' emissions for Australia (547.7 Mt CO<sub>2</sub>-e) are the 1990 emissions for the Annex A sectors (Energy, Industrial Processes, Agriculture and Waste) and Land Use Change as submitted to the UNFCCC in Australia's Initial Report in October 2008.

## Greenhouse gases

- Consistent with the requirements of the Kyoto Protocol, the National Greenhouse Gas Inventory covers sources of greenhouse gas emissions and removals by sinks resulting from human (anthropogenic) activities for the major greenhouse gases – carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF<sub>6</sub>).
- Global Warming Potentials have been used for each of the major greenhouse gases to convert them to carbon dioxide equivalents (CO<sub>2</sub>-e). As greenhouse gases vary in their radiative activity and in their atmospheric residence time, converting emissions into CO<sub>2</sub>-e allows the integrated effect of emissions of the various gases to be compared. The GWPs used in this Report were the 100-year global warming potentials (GWPs) contained in the 1995 IPCC Second Assessment Report (IPCC 1996), as agreed for use under the Kyoto Protocol.

## Uncertainty Analysis

Uncertainty is inherent within any kind of estimation. Uncertainty assessments at a sectoral level are reported in the National Inventory Report. Overall, at the national level, the uncertainty of the national inventory excluding LULUCF emission estimates has been assessed at around  $\pm 2\%$ .

## Ongoing Improvements of estimates

Due to refinements to the emissions estimation methodologies, which have been applied to all years for which emissions have been estimated, the estimates presented in this document supersede all previously published estimates for the National Greenhouse Gas Inventory and caution should be exercised before comparing directly with the estimates of previous publications.

Copies of the other *Australian National Greenhouse Accounts* documents

*National Inventory by Economic Sector 2008*

*State and Territory Greenhouse Gas Inventories 2008*

*National Inventory Report 2008*

can be obtained from the Department of Climate Change and Energy Efficiency website

**<http://www.climatechange.gov.au/en/climate-change/emissions.aspx>**

On-line access to emissions results—Australian Greenhouse Emissions Information System (AGEIS) – also available at **<http://ageis.climatechange.gov.au>**

## Appendix 2 – Sectoral Emissions 2008

**Table 1: Overview of Australia's national inventory by sector (Kyoto accounting), 2008**

Sector and Subsector	Emissions Mt CO <sub>2</sub> -e				
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFCs/PFCs/SF <sub>6</sub>	Total
All energy (combustion + fugitive)	379.4	34.5	2.7	NA	416.6
Stationary energy	294.2	1.2	1.0	NA	296.4
Transport	78.0	0.6	1.7	NA	80.2
Fugitive emissions	7.2	32.7	0.03	NA	39.9
Industrial Processes	21.0	0.1	3.4	6.7	31.1
Agriculture	NA	67.1	20.3	NA	87.4
Waste	0.03	13.9	0.4	NA	14.4
<b>National Inventory</b>	<b>400.4</b>	<b>115.7</b>	<b>26.8</b>	<b>6.7</b>	<b>549.5</b>
Article 3.3 LULUCF activities	24.6	1.3	0.6	NA	26.6
<b>National Inventory including Article 3.3 LULUCF activities</b>	<b>425.0</b>	<b>117.0</b>	<b>27.5</b>	<b>6.7</b>	<b>576.2</b>

NA = not applicable, IE = included elsewhere

**Table 2: Energy sector CO<sub>2</sub>-e emissions, 2008**

Greenhouse gas source and sink categories	CO <sub>2</sub> -e emissions (Mt)			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Total
<b>1 ENERGY</b>	379.4	34.5	2.7	416.6
<b>A. Fuel combustion activities</b>	372.2	1.8	2.7	376.7
1 Energy industries	225.4	0.2	0.7	226.4
A Electricity generation	203.5	0.2	0.6	204.3
B Petroleum refining	5.6	0.002	0.01	5.6
C Manufacture of solid fuels	16.4	0.04	0.02	16.4
2 Manufacturing industries and construction	48.4	0.06	0.3	48.7
3 Transport	78.0	0.6	1.7	80.2
A Civil aviation	5.9	0.001	0.06	6.0
B Road transportation	67.2	0.5	1.6	69.2
C Railways	2.0	0.002	0.02	2.0
D Navigation (domestic)	2.8	0.1	0.02	2.9
E Other transportation	0.04	0.0004	0.0002	0.04
4 Other sectors	18.7	1.0	0.07	19.8
5 Other	1.6	0.002	0.01	1.6
A Lubricants	0.5	NA	NA	0.5
B Mobile (military)	1.1	0.002	0.01	1.2
<b>B. Fugitive emissions from fuels</b>	7.2	32.7	0.03	39.9
1 Solid fuels	1.0	27.9	NA	28.9
2 Oil and natural gas	6.3	4.8	0.03	11.1

**Table 3: Industrial processes sector CO<sub>2</sub>-e emissions, 2008**

Greenhouse gas source and sink categories	CO <sub>2</sub> -e emissions (Mt)				
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFC/PFC/SF <sub>6</sub>	Total
<b>2 INDUSTRIAL PROCESSES</b>	21.0	0.1	3.43	6.7	31.1
A Mineral products	6.5	NA	NA	NA	6.5
B Chemical industry	3.8	0.01	3.41	NA	7.2
C Metal production	10.6	0.1	0.02	0.4	11.0
D Other production	0.1	NA	NA	NA	0.1
E Production of halocarbons and sulphur hexafluoride	NO	NO	NO	NO	NO
F Consumption of Halocarbons and sulphur hexafluoride	NA	NA	NA	6.3	6.3

**Table 4: Agriculture sector CO<sub>2</sub>-e emissions, 2008**

Greenhouse gas source and sink categories	CO <sub>2</sub> -e emissions (Mt)			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Total
<b>4 AGRICULTURE</b>	NA	67.1	20.3	87.4
A Enteric fermentation	NA	55.6	NA	55.6
B Manure management	NA	1.8	1.5	3.3
C Rice cultivation	NA	0.04	NA	0.04
D Agricultural soils	NA	NA	14.6	14.6
E Prescribed burning of savannas	NA	9.5	4.1	13.6
F Field burning of agricultural residues	NA	0.2	0.1	0.3

**Table 5: Waste CO<sub>2</sub>-e emissions, 2008**

Greenhouse gas source and sink categories	CO <sub>2</sub> -e emissions (Mt)			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Total
<b>6 WASTE</b>	0.03	13.9	0.4	14.4
A Solid waste disposal on land	NA	11.1	NE	11.1
B Wastewater handling	NA	2.9	0.430	3.3
C Waste incineration	0.03	NA	NE	0.03
D Other waste	NA	NA	NA	NA

**Table 6: Land use, land use change and forestry net CO<sub>2</sub>-e emissions, 2008**

Greenhouse gas source and sink categories	CO <sub>2</sub> -e emissions (Mt)			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Total
<b>LAND USE, LAND USE CHANGE AND FORESTRY</b>	24.6	1.3	0.6	26.6
Afforestation and reforestation <sup>(a)</sup>	-23.0	NA	NA	-23.0
Land use change (deforestation)	47.7	1.3	0.6	49.7

Note: (a) A negative sign denotes a sink.

**Table 7: National Inventory, quarterly emissions estimates, Mt CO<sub>2</sub>-e**

Year		Energy – Electricity Generation	Energy – Stationary energy excluding electricity	Energy – Transport	Energy – Fugitives	Agriculture	Industrial Processes and Waste	National Inventory Total	Average quarterly emissions over four quarters to end of quarter
2004/05	Q1	50	22	20	9	22	11	135	NA
	Q2	48	22	20	9	22	11	132	NA
	Q3	48	21	19	9	22	10	129	NA
	Q4	48	22	20	9	22	11	132	132
2005/06	Q1	50	22	19	9	23	11	134	132
	Q2	48	22	21	9	23	11	134	132
	Q3	50	21	20	8	22	11	131	133
	Q4	50	22	19	9	23	11	134	133
2006/07	Q1	51	22	20	10	22	11	137	134
	Q2	50	23	20	10	22	11	137	135
	Q3	51	22	20	9	22	11	134	135
	Q4	48	22	20	10	22	11	134	135
2007/08	Q1	53	23	20	11	22	12	141	136
	Q2	50	23	21	10	22	11	137	136
	Q3	51	22	20	9	22	11	135	137
	Q4	50	23	20	10	22	11	137	137
2008/09	Q1	54	24	20	10	21	12	141	137
	Q2	51	23	20	10	21	11	138	138
	Q3	51	21	19	9	21	10	131	137
	Q4	50	22	20	10	21	10	133	136
2009/10	Q1	51	23	20	11	21	11	136	135
	Q2	50	23	21	11	21	11	137	134

Note: The national inventory total does not include estimates of emissions from article 3.3 Land Use, Land Use Change and Forestry activities.

# Appendix 3 – Emission Trends

**Table 1: Emission trends (CO<sub>2</sub>-e)**

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
<b>1. Energy</b>	<b>289272</b>	<b>291087</b>	<b>297150</b>	<b>300428</b>	<b>301932</b>	<b>313656</b>	<b>321010</b>	<b>331234</b>	<b>344672</b>
A. Fuel Combustion (Sectoral Approach)	257008	259323	263944	268000	271263	281501	289187	297640	310210
1. Energy Industries	143097	146375	149726	151517	152438	158304	163006	169632	182224
2. Manufacturing Industries and Construction	36062	35606	35231	35727	36504	37395	37544	37716	37564
3. Transport	62092	61463	62641	63921	65528	68229	70588	71958	72049
4. Other Sectors	14744	14884	15300	15762	15669	16318	16680	16931	17077
5. Other	1012	996	1046	1073	1123	1255	1369	1403	1296
B. Fugitive Emissions from Fuels	32264	31764	33207	32427	30670	32155	31823	33594	34462
1. Solid Fuels	19287	19730	20600	20692	19074	19207	19874	21569	22393
2. Oil and Natural Gas	12978	12034	12606	11735	11596	12948	11948	12024	12069
<b>2. Industrial Processes</b>	<b>24379</b>	<b>23653</b>	<b>24273</b>	<b>24099</b>	<b>24314</b>	<b>24073</b>	<b>23911</b>	<b>24070</b>	<b>25424</b>
A. Mineral Products	5410	5076	4889	5113	5904	5735	5814	5883	6268
B. Chemical Industry	2187	2033	2369	2796	2859	3027	3196	3200	3521
C. Metal Production	15070	14832	15376	14158	14154	13856	13953	13742	14052
D. Other Production	64	64	64	64	64	109	106	107	103
E. Production of Halocarbons and SF <sub>6</sub>	1126	1126	1054	1447	812	719	NO	NO	NO
F. Consumption of Halocarbons and SF <sub>6</sub>	521	521	521	521	522	629	842	1139	1481
<b>3. Solvent and Other Product Use</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>
<b>4. Agriculture</b>	<b>86812</b>	<b>86957</b>	<b>85254</b>	<b>84736</b>	<b>85257</b>	<b>86190</b>	<b>86487</b>	<b>87696</b>	<b>87895</b>
A. Enteric Fermentation	63919	64038	62730	61319	59859	59342	59105	59539	59484
B. Manure Management	2064	2123	2239	2394	2531	2626	2647	2823	2985
C. Rice Cultivation	490	524	540	602	606	649	705	723	725
D. Agricultural Soils	13438	13528	13377	13515	13537	13868	14151	14706	15017
E. Prescribed Burning of Savannas	6608	6460	6075	6590	8414	9382	9533	9515	9280
F. Field Burning of Agricultural Residues	292	286	293	315	311	324	347	390	405
<b>5. Land Use, Land-Use Change and Forestry</b>	<b>131545</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
A. Afforestation and reforestation									
B. Land use change (deforestation)	131545								
<b>6. Waste</b>	<b>17909</b>	<b>17850</b>	<b>17671</b>	<b>17601</b>	<b>17071</b>	<b>17095</b>	<b>15723</b>	<b>15567</b>	<b>14967</b>
A. Solid Waste Disposal on Land	14216	14151	13991	13955	13442	13525	12349	12274	11725
B. Waste-water Handling	3608	3613	3594	3561	3543	3479	3309	3265	3214
C. Waste Incineration	85	85	85	85	86	91	66	28	28
<b>Total CO<sub>2</sub> emissions including net CO<sub>2</sub> from LULUCF</b>	<b>549917</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>
<b>Total CO<sub>2</sub> emissions excluding net CO<sub>2</sub> from LULUCF</b>	<b>418372</b>	<b>419547</b>	<b>424348</b>	<b>426863</b>	<b>428575</b>	<b>441015</b>	<b>447132</b>	<b>458567</b>	<b>472959</b>
<b>Memo Items:</b>									
<b>International Bunkers</b>	<b>6457</b>	<b>6433</b>	<b>6642</b>	<b>7046</b>	<b>7427</b>	<b>8609</b>	<b>9109</b>	<b>9137</b>	<b>9530</b>
Aviation	4380	4556	4834	5241	5393	5905	6362	6592	7291
Marine	2077	1877	1808	1805	2034	2704	2746	2545	2239
<b>Multilateral Operations</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>
<b>CO<sub>2</sub> Emissions from Biomass</b>	<b>14976</b>	<b>14858</b>	<b>13574</b>	<b>15206</b>	<b>16142</b>	<b>16918</b>	<b>17931</b>	<b>18785</b>	<b>19083</b>

Notes: The Kyoto Protocol accounting rules for LULUCF activities differ between the 1990 base year and the commitment period (2008-2012), as such, it is not possible to present a consistent time-series of emissions and removals for these activities.

In the appendices emissions are expressed in gigagrams (Gg) to avoid loss of detail.

Gigagram (Gg) = 1,000 tonnes = 1 kilotonne

Megatonne (Mt) = 1,000,000 tonnes = 1000 Gg

In the tables, the following indicators are used

NA = not applicable NE = not estimated NO = not occurring C = confidential IE = included elsewhere

Greenhouse gas source and sink categories	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Change from base to latest reported year %
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	
<b>1. Energy</b>	<b>351298</b>	<b>360827</b>	<b>367425</b>	<b>370835</b>	<b>383513</b>	<b>391148</b>	<b>396047</b>	<b>399596</b>	<b>408437</b>	<b>416604</b>	<b>44.0</b>
A. Fuel Combustion (Sectoral Approach)	319193	325715	331679	336397	350292	356525	360372	363407	368848	376656	46.6
1. Energy Industries	189582	192610	199883	201299	211522	213056	214566	218339	221802	226359	58.2
2. Manufacturing Industries and Construction	38347	39303	38542	40027	41534	43139	45981	45392	46372	48687	35.0
3. Transport	72851	74905	73540	75256	75897	79811	78876	79080	79659	80213	29.2
4. Other Sectors	17206	17650	18451	18585	20111	19212	19581	19424	19454	19764	34.0
5. Other	1208	1248	1263	1229	1228	1306	1368	1171	1560	1633	61.2
B. Fugitive Emissions from Fuels	32105	35111	35746	34438	33221	34623	35675	36189	39589	39948	23.8
1. Solid Fuels	20694	22502	22561	22079	21957	23746	25178	25720	29003	28870	49.7
2. Oil and Natural Gas	11411	12609	13185	12360	11265	10877	10497	10469	10586	11078	-14.6
<b>2. Industrial Processes</b>	<b>25736</b>	<b>25835</b>	<b>26592</b>	<b>27142</b>	<b>28380</b>	<b>29752</b>	<b>28813</b>	<b>29967</b>	<b>31315</b>	<b>31137</b>	<b>27.7</b>
A. Mineral Products	6141	5952	5940	5991	6124	6082	6171	6373	6480	6508	20.3
B. Chemical Industry	3434	3713	4156	4308	5079	5306	5488	7103	7691	7207	229.5
C. Metal Production	14173	13753	13555	13400	13153	13745	11938	10913	11075	11046	-26.7
D. Other Production	102	103	103	102	102	102	102	102	102	102	59.8
E. Production of Halocarbons and SF <sub>6</sub>	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NA
F. Consumption of Halocarbons and SF <sub>6</sub>	1885	2315	2838	3341	3922	4517	5114	5476	5968	6273	1103.9
<b>3. Solvent and Other Product Use</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>IE</b>	<b>NA</b>
<b>4. Agriculture</b>	<b>91028</b>	<b>94476</b>	<b>98042</b>	<b>95530</b>	<b>91096</b>	<b>90926</b>	<b>89080</b>	<b>90274</b>	<b>87586</b>	<b>87395</b>	<b>0.7</b>
A. Enteric Fermentation	60156	60442	60849	59523	59555	59834	60124	59082	57185	55552	-13.1
B. Manure Management	3191	3297	3358	3386	3384	3438	3549	3594	3488	3346	62.1
C. Rice Cultivation	671	741	738	589	399	237	341	265	196	43	-91.2
D. Agricultural Soils	15630	16384	16903	16511	16131	16064	16007	15517	14823	14557	8.3
E. Prescribed Burning of Savannas	10977	13202	15772	15165	11262	11018	8650	11478	11581	13615	106.0
F. Field Burning of Agricultural Residues	403	410	422	357	365	335	407	339	313	282	-3.3
<b>5. Land Use, Land-Use Change and Forestry</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>26618</b>	<b>-79.8</b>
A. Afforestation and reforestation										-23033	NA
B. Land use change (deforestation)										49651	-62.3
<b>6. Waste</b>	<b>15178</b>	<b>15047</b>	<b>15260</b>	<b>15369</b>	<b>14505</b>	<b>14129</b>	<b>13803</b>	<b>13499</b>	<b>13986</b>	<b>14405</b>	<b>-19.6</b>
A. Solid Waste Disposal on Land	11971	11873	11944	12089	11289	10885	10650	10381	10707	11071	-22.1
B. Waste-water Handling	3177	3146	3289	3253	3187	3216	3124	3089	3249	3305	-8.4
C. Waste Incineration	29	28	28	28	28	28	28	29	29	29	-65.7
<b>Total CO<sub>2</sub> emissions including net CO<sub>2</sub> from LULUCF</b>	<b>NA</b>	<b>(a)</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>NA</b>	<b>576158</b>	<b>4.8</b>
<b>Total CO<sub>2</sub> emissions excluding net CO<sub>2</sub> from LULUCF</b>	<b>483240</b>	<b>496185</b>	<b>507319</b>	<b>508876</b>	<b>517494</b>	<b>525955</b>	<b>527743</b>	<b>533336</b>	<b>541323</b>	<b>549540</b>	<b>31.4</b>
<b>Memo Items:</b>											<b>NA</b>
<b>International Bunkers</b>	<b>9801</b>	<b>10187</b>	<b>10483</b>	<b>9615</b>	<b>8766</b>	<b>9983</b>	<b>10942</b>	<b>11527</b>	<b>11897</b>	<b>12175</b>	<b>88.6</b>
Aviation	7326	7390	7856	6748	5971	7165	8287	8382	9348	9265	111.5
Marine	2475	2797	2627	2867	2795	2818	2655	3145	2549	2910	40.1
<b>Multilateral Operations</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NE</b>	<b>NA</b>
<b>CO<sub>2</sub> Emissions from Biomass</b>	<b>18827</b>	<b>19008</b>	<b>18209</b>	<b>16343</b>	<b>17592</b>	<b>17469</b>	<b>17643</b>	<b>17648</b>	<b>18066</b>	<b>18520</b>	<b>23.7</b>

Notes: The Kyoto Protocol accounting rules for LULUCF activities differ between the 1990 base year and the commitment period (2008-2012), as such, it is not possible to present a consistent time-series of emissions and removals for these activities.

(a) The Government has specified emission reduction targets based on 2000 emission levels. Using previous technical assumptions, the estimate is 557.9 Mt CO<sub>2</sub>-e. This comprises the national inventory total for emission sources listed under Annex A of the Kyoto Protocol (496.2 Mt CO<sub>2</sub>-e) and specified LULUCF activities (61.7 Mt CO<sub>2</sub>-e). Specified LULUCF activities comprise emissions from land use change (72.4 Mt CO<sub>2</sub>-e) and afforestation and reforestation since 1990 (-10.8 Mt CO<sub>2</sub>-e), consistent with approaches used under the Kyoto Protocol. Definitions and accounting issues for future targets and base years, such as in relation to 2020, are subject to international negotiation.

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