Australian Government
Department of Climate Change

AUSTRALIA'S NATIONAL GREENHOUSE ACCOUNTS

National Greenhouse Gas Inventory

accounting for the KYOTO target **May 2009**

thinkchange

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The Australian National Greenhouse Accounts are available on the Internet at the following address: http://www.climatechange.gov.au/inventory.

Suggestions and comments would be appreciated.
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May 2009

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1. Australia's National Inventory: Update

1.1 Quarterly Estimates of Australia's National Inventory: December quarter 2008

- 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.
- Under the Kyoto Protocol, the national inventory comprises four sources of emissions – the IPCC classifications *Energy*, *Industrial Processes*, *Agriculture* and *Waste* (Annex A sectors). Within the *Energy* sector, there are *Fuel Combustion* and *Fugitive emissions* (mainly from the extraction fuels) sources. In addition, countries must account for Article 3.3 *Land Use, Land Use Change and Forestry* activities – these are deforestation, afforestation and reforestation.
- Over the four quarters through to the December quarter of 2008, Australia's national inventory was an estimated 553 Mt CO_2-e (million tonnes of carbon dioxide equivalent).
- This is an increase of 1.1 per cent compared with the corresponding period for the previous year (Table 1).

Table 1: National Inventory estimates for the four quarters through to the December quarter 2008

Category	Annual emissions through to the December quarter Mt CO_2-e [a]		Per cent change in annual emissions [d]
	2007 December quarter [c]	2008 December quarter [c]	
National Inventory – Annex A sectors			
Energy – fuel combustion	374	377	1.0%
Energy – fugitive emissions	39	39	-0.3%
Industrial processes	31	32	2.3%
Waste	15	15	0.7%
Agriculture	89	91	1.7%
National Inventory total [b]	**547**	**553**	**1.1%**

Source: Department of Climate Change preliminary estimates.

Notes: a) Carbon dioxide equivalent, CO_2-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 the 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).

- In Figure 1, the year-on-year growth rates of emissions over time shows that emissions have continued to grow in the second half of 2008.
  - Nonetheless, the rate of emissions growth in the four quarters through to the end of the December quarter has slowed somewhat since the high point of 2006.
- In the December quarter 2008, the average quarterly emissions estimate for the previous four quarters was 138 Mt (Figure 2) and emissions have grown at an average annual growth rate of 1.5 per cent over the last three years.

Figure 1: National Inventory, year on year emissions growth rate, by quarter – July quarter 2006 to December quarter 2008

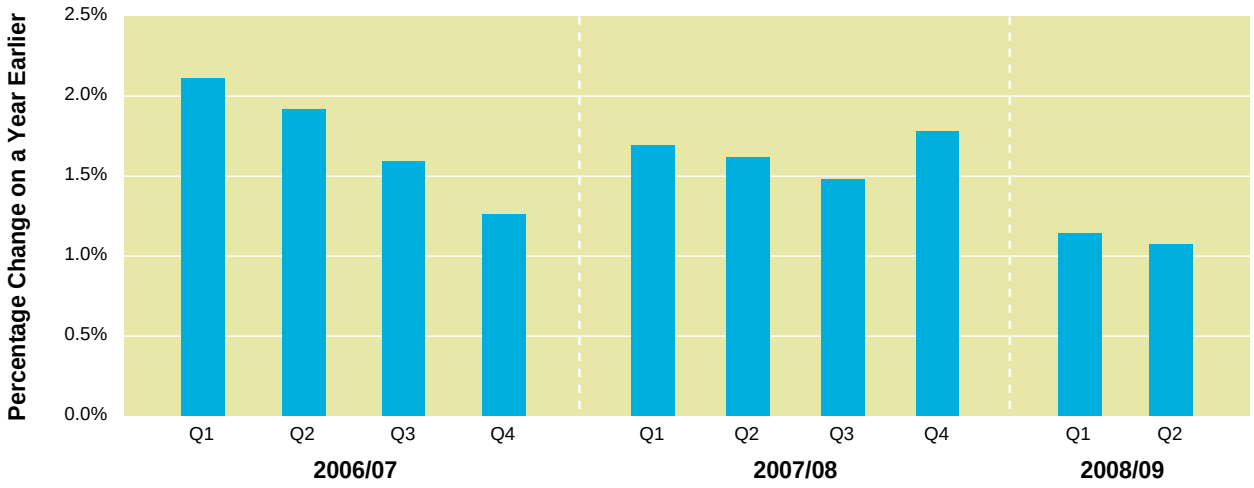
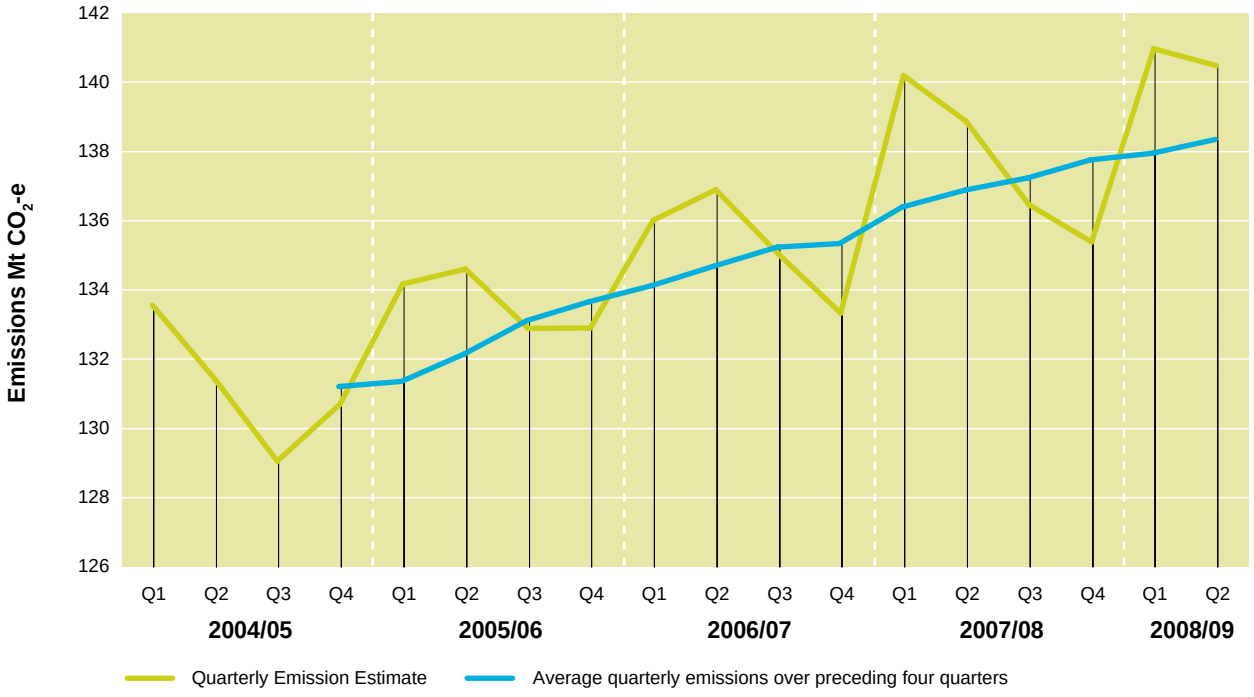


Figure 2: National Inventory, average quarterly emissions and actuals – July quarter 2004 to December quarter 2008



Note: Emission estimates have been compiled by the Department of Climate Change using the estimation methodologies incorporated in the Australian Greenhouse Emissions Information System (AGEIS) and preliminary activity data obtained from a range of publicly available sources – principally from ABARE, the ABS, the National Electricity Market and the Department of Innovation, Industry, Science and Research. As 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 these estimates of emissions revised before submission to the UN. The Department's assessment is that the 90 per cent confidence interval for the current 2008 estimates for the national inventory (before taking account of article 3.3 activities) is ±1 per cent (ie there is a 90 per cent probability that future revisions will be limited to ±1 per cent of the current estimate). The Department plans to update these quarterly estimates at regular intervals in the future.

1.2 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 projections of the amount of Australia's Kyoto Protocol units available for the first 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 2008 of 8 Mt of Kyoto Protocol units – or around 1 per cent of the Kyoto Target.
- Equivalently, Australia's emissions, including from Article 3.3 *Land Use, Land Use Change and Forestry* activities, were 107 per cent of the 1990 base period.

Table 2: Accounting for Australia's Kyoto Target – Australia's National Inventory, 2008

		Emissions Mt CO_2-e 2008
National Inventory – Annex A sectors		
	Energy – fuel combustion	376
	Energy – fugitive emissions	39
	Industrial processes	31
	Waste	15
	Agriculture	91
1	**National Inventory total**	**551** [(a)]
Kyoto Protocol units		
2	Assigned amount per year under the Kyoto Protocol [(b)]	592
3	Projected net credits from Article 3.3 LULUCF activities – Deforestation, afforestation and reforestation [(c)]	-33
	Kyoto protocol units – domestic sources total	559
4	Net purchases of credits from international sources under Articles 6, 12 and 17 [(d)]	0
5	**Kyoto Protocol units – national total (2)+(3)+(4)**	**559**
	Net balance (5) – (1) [(e)]	**8**

Source: Department of Climate Change preliminary estimates.

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. Consequently, for this table, national inventory estimates for 2008 are based on 2007-08, financial year data. 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 2007 were estimated at 541 Mt CO_2-e, as reported in the *National Inventory Report 2007*, which is the Australian Government's annual submission prepared by the Department of Climate Change 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 2007 are detailed in that publication. The estimates presented for 2008 are preliminary and will be revised when reference data sources become available;

b) Australia's *Initial Report under the Kyoto Protocol*, revised submission, October 2008;

c) Source: Department of Climate Change, Tracking to Kyoto 2009 (forthcoming). The estimates for article 3.3 activities are interim 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. This source is not yet available for Australia. The Government's position on purchases is set out in the *Carbon Pollution Reduction Scheme: Australia's low pollution future, White Paper*;

e) The year 2008 is the first year of the first commitment period under the Kyoto Protocol, which 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 first year may be used to cover any deficits arising from growth of emissions in the remainder of the commitment period.

2. Australia's National Inventory: Analysis of Trends: 1990-2007

2.1 Overview

In 2007, Australia's national inventory of greenhouse gas emissions[1] was 541.2 Mt CO_2-e. The *Energy* sector was the largest source of emissions comprising 75.4 per cent of the national inventory total (408.2 Mt CO_2-e). The second largest source was the *Agriculture* sector (16.3 per cent). Relatively minor sources of emissions included *Industrial Processes* (5.6 per cent) and *Waste* (2.7 per cent).

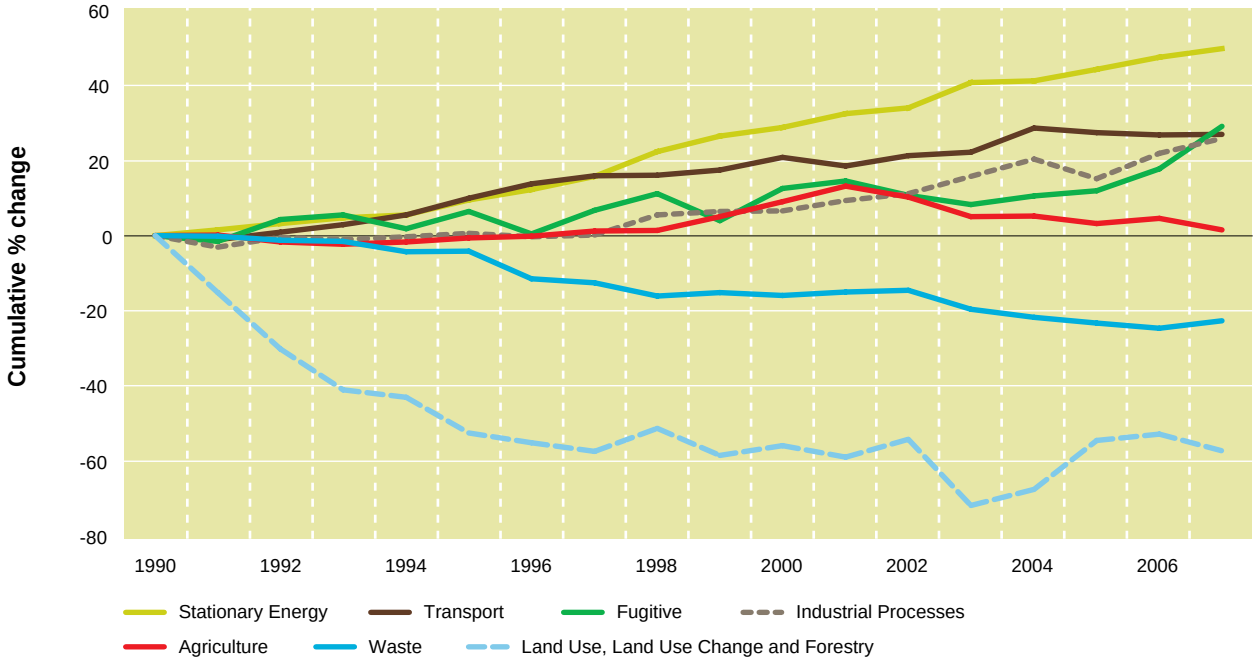
The individual sources of emissions exhibit differing characteristics in terms of trends. The largest increase in emissions over the 1990 to 2007 period, of 49.5 per cent (96.6 Mt CO_2-e), occurred in the *Stationary Energy* sector (Figure 3). Other sources of growth include *Fugitive emissions*, which is the next largest growth sector with an increase of 28.9 per cent (8.4 Mt CO_2-e); the *Transport* sector, with an increase of 26.9 per cent (16.7 Mt CO_2-e) and the *Industrial Processes*, which increased 25.7 per cent (6.2 Mt CO_2-e).

The *Agriculture* sector is largely a steady source of emissions, showing a slight increase of 1.5 per cent over the period.

Australia's national inventory of greenhouse gas emissions, after accounting for *Land Use, Land Use Change and Forestry* activities, was 597.2 Mt CO_2-e. In the *Land Use, Land Use Change and Forestry* activities, there has been a strong decline of 57.0 per cent (74.1 Mt CO_2-e) in net emissions and, in particular, reductions in emissions from deforestation. The *Waste* sector also showed a strong decline of 22.5 per cent (4.2 Mt CO_2-e), driven mainly by increasing patterns of recycling and enhanced methane recovery.

Trends in emissions from each sector are discussed in the following chapters. Emissions data for all years 1990 to 2007 are provided in Appendix 3.

Figure 3: Trends in CO_2-e emissions by sector – change since 1990



[1] The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

2.2 Energy

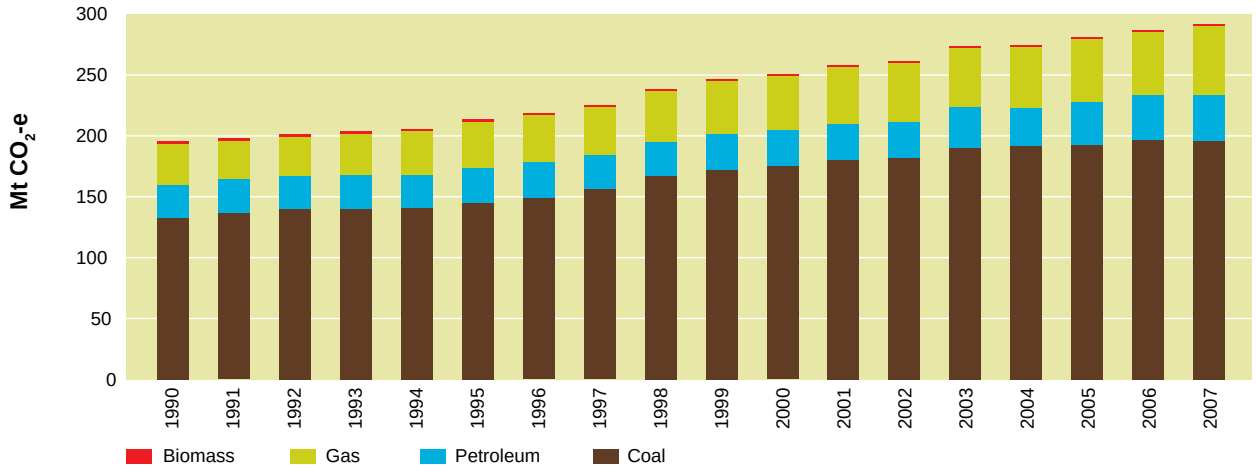
Emissions estimates and trends 1990 to 2007

The entire *Energy* sector was the source of 408.2 Mt CO_2-e or 75.4 per cent of Australia's national inventory of emissions in 2007[2]. Of this, 291.7 Mt of emissions were from *Stationary Energy*, 78.8 Mt from *Transport* and 37.7 Mt from *Fugitive emissions*. In 2007, *Energy* sector emissions were 2.0 per cent (8.1 Mt) higher than in 2006 and 42.5 per cent (121.7 Mt) higher than in 1990. Preliminary estimates for 2008 indicate that *Energy* emissions have increased by 1.5 per cent (6.0 Mt) since 2007 due to increased emissions from transport, manufacturing and energy industries.

Stationary energy

Estimated emissions from stationary energy combustion were 291.7 Mt CO_2-e in 2007, equal to 53.9 per cent of national inventory emissions. Emissions from stationary energy increased by 49.5 per cent (96.6 Mt) between 1990 and 2007 (Figure 4). An increase in emissions from the combustion of coal accounted for 66.1 per cent of the overall increase in emissions. Combustion of gas accounted for 24.9 per cent and oil 9.2 per cent. Preliminary estimates for 2008 indicate that stationary energy emissions have increased by 1.2 per cent (3.4 Mt) since 2007.

Figure 4: Total CO_2-e emissions from stationary energy combustion by fuel, 1990–2007



Energy production

The largest contribution to *Stationary Energy* emissions comes from the generation of electricity (68.4 per cent). Electricity generation accounted for 199.5 Mt or 36.9 per cent of national emissions in 2007. Electricity generation emissions increased by 1.6 Mt (0.8 per cent) from 2006 to 2007, and by 70.1 Mt (54.1 per cent) from 1990 to 2007 (Figure 5). The 2006 to 2007 electricity generation emissions increase (0.8 per cent) was less than the increase in fuel use (2.1 per cent). The black coal share of energy use increased by 0.9 per cent to 56.2 per cent while the brown coal share decreased by 0.9 per cent to 28.2 per cent. The share of fuel use contributed by gaseous fuels increased 2.0 per cent to 14.5 per cent while liquid fuels remained nearly the same at 1.1 per cent. Preliminary estimates for 2008 indicate that electricity generation emissions have increased by 0.4 per cent (0.8 Mt) since 2007.

Other energy industries are, by comparison, small contributors: – petroleum refining contributed 5.7 Mt and the remainder contributed 16.6 Mt of emissions in 2007.

[2] The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

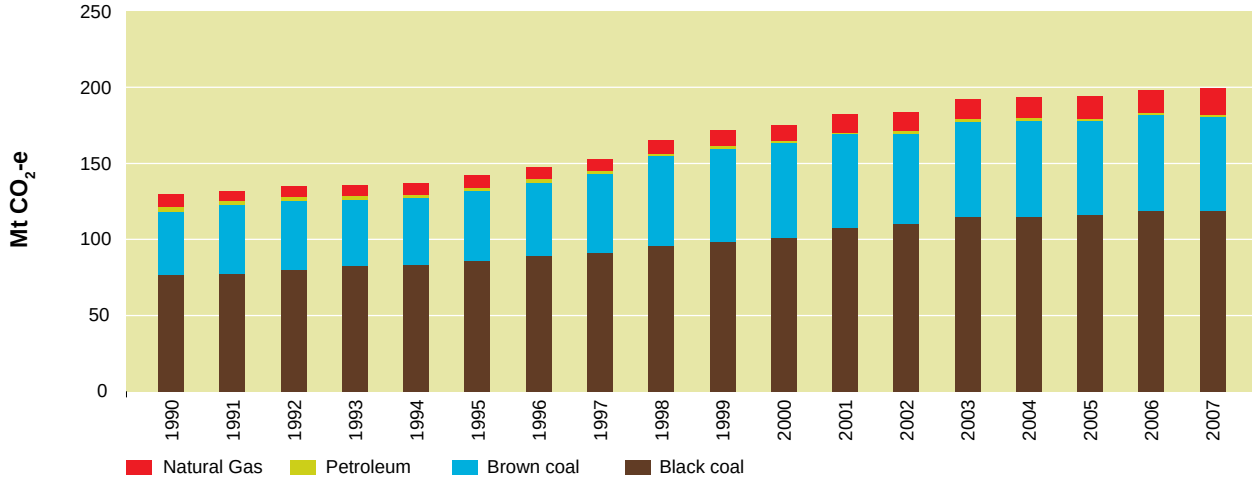
Other fuel combustion[3]

Fuel combustion in mining non-energy commodities, manufacturing and construction industries accounted for 9.0 per cent (48.7 Mt) of national emissions in 2007. Emissions from these industries have increased 34.1 per cent (12.4 Mt) between 1990 and 2007. Preliminary estimates for 2008 indicate that emissions have increased by 2.7 per cent (1.3 Mt) since 2007.

Fuel combustion in the residential, commercial and institutional sectors, together with fuel use by agricultural, fisheries and forestry equipment, contributed 19.7 Mt or 3.6 per cent of national greenhouse gas emissions in 2007. This is 33.4 per cent 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 2007.

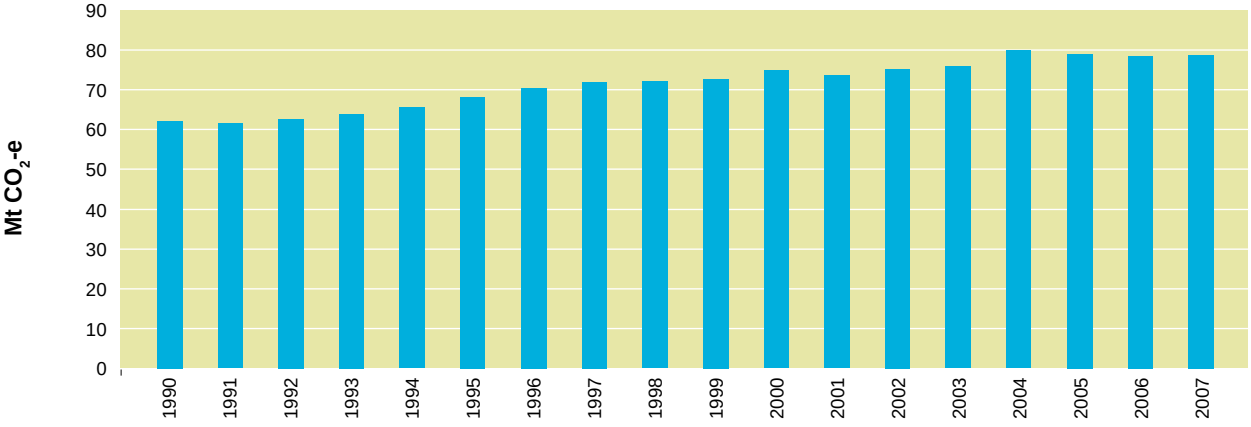
Figure 5: CO_2-e emissions from electricity generation by fossil fuels, 1990–2007



Transport

In 2007 *Transport* contributed 78.8 Mt CO_2-e or 14.6 per cent of Australia's national inventory[4] emissions. *Transport* emissions are one of the strongest sources of emissions growth in Australia. Emissions from this sector were 26.9 per cent higher in 2007 than in 1990, and have increased by about 1.5 per cent annually on average (Figure 6). Between 2006 and 2007, transport emissions increased by 0.2 per cent. Preliminary estimates for 2008 indicate that transport emissions have increased by 2.2 per cent (1.7 Mt) since 2007.

Figure 6: Total transport emissions, 1990–2007



[3] 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 2007.*

[4] The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

Road transport

Road transport was the main source of transport emissions and accounted for 87 per cent (68.5 Mt) of 2007 transport emissions. Emissions from road transport increased by 26.1 per cent (14.2 Mt) between 1990 and 2007.

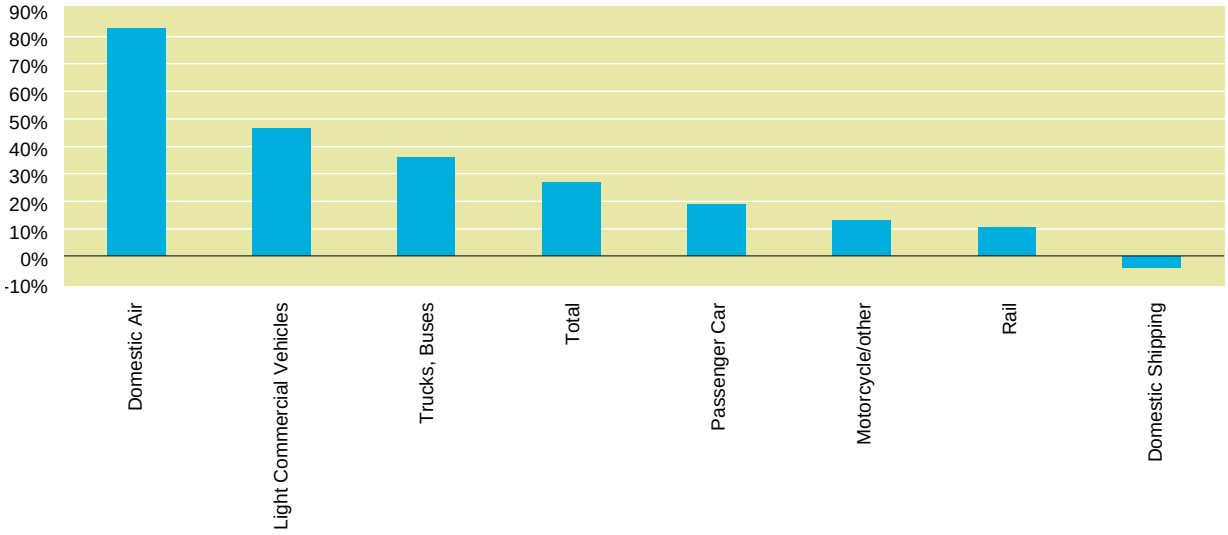
Passenger cars were the largest transport source contributing 41.9 Mt. Emissions from passenger cars increased by 18.8 per cent (6.6 Mt) between 1990 and 2007. Emissions from Light Commercial Vehicles (LCVs) and trucks have also grown strongly.

Other modes of transport

Other transport sources are smaller contributors to total transport emissions: – civil aviation contributed 6.8 per cent (5.3 Mt), domestic shipping 3.7 per cent (2.9 Mt), and railways 2.5 per cent (1.9 Mt).

Domestic air transport emissions were 82.8 per cent (2.4 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 10.7 per cent while domestic shipping emissions have fallen by 4.2 per cent, reflecting improved productivity and changes in activity (Figure 7).

Figure 7: Comparison of growth in transport emissions by subcategory, 1990–2007



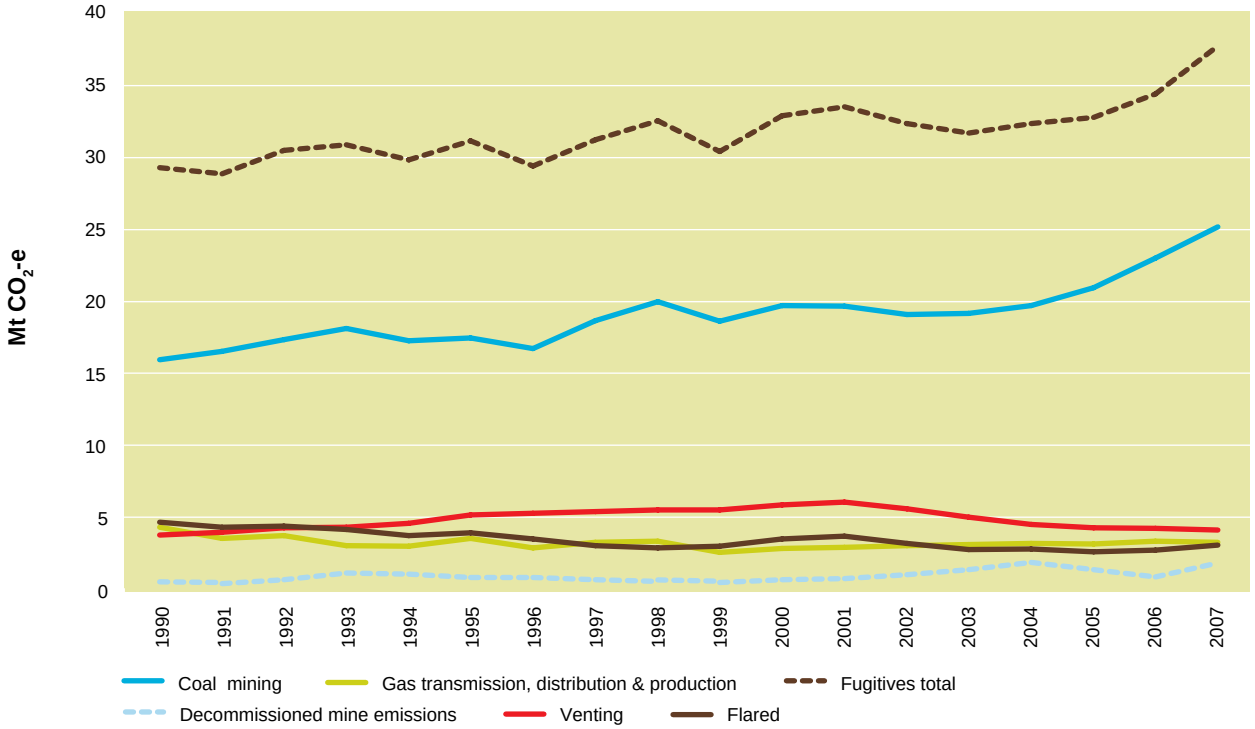
Fugitive emissions

Total estimated *Fugitive Emissions* for 2007 were 37.7 Mt CO_2-e, representing 7.0 per cent of national inventory emissions[5]. Net emissions associated with coal mining and handling and decommissioned mines contributed 71.3 per cent (26.8 Mt) of fugitive emissions. Oil and natural gas production, processing and distribution account for the remaining 28.7 per cent (10.8 Mt) of fugitive emissions.

Overall, *Fugitive Emissions* increased by 28.9 per cent (8.4 Mt) between 1990 and 2007, and by 9.6 per cent (3.3 Mt) from 2006 to 2007. Preliminary estimates for 2008 indicate that fugitive emissions have increased by 2.3 per cent (0.9 Mt) since 2007 (Figure 7).

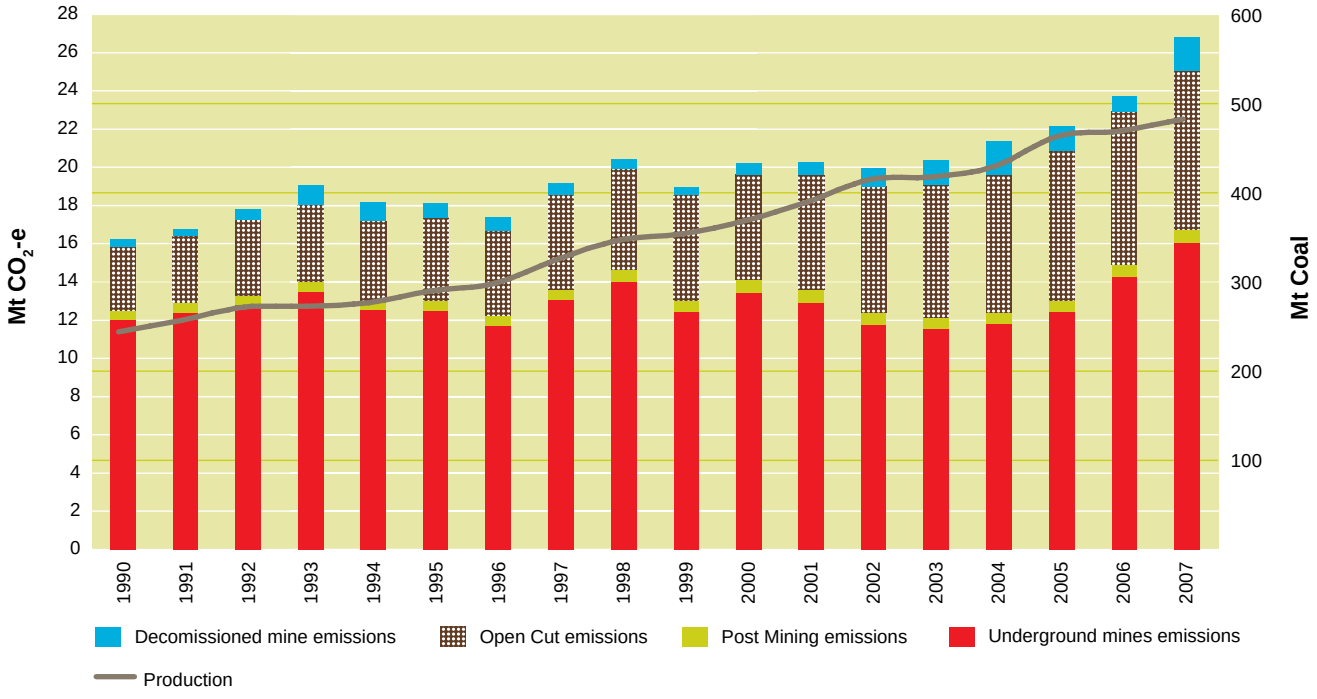
[5] The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

Figure 8: CO_2-e fugitive emissions by category, 1990–2007



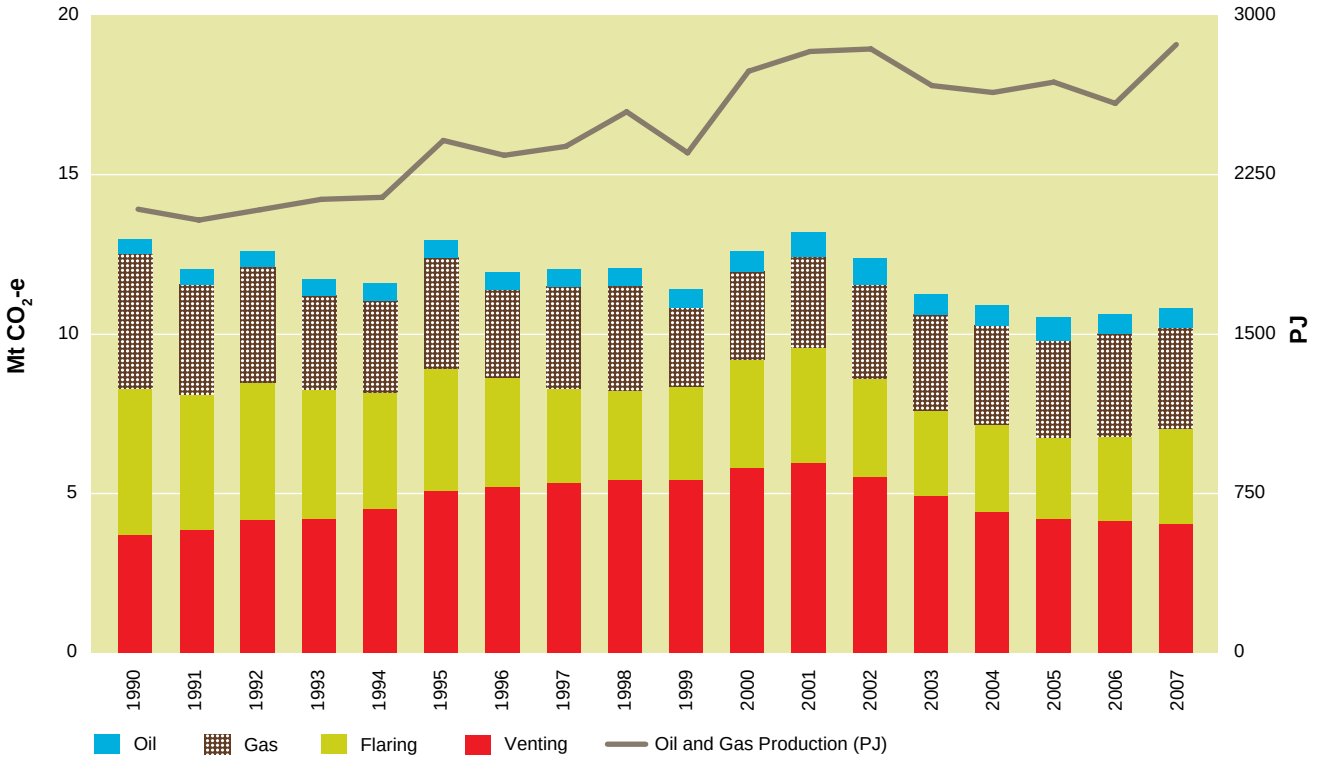
Solid fuel emissions increased by 13.1 per cent (3.1 Mt) between 2006 and 2007, driven by an 8.5 per cent increase in coal production from gassy underground mines. Emissions tend to fluctuate from year to year, depending on the volume of coal mined and the share of gassy underground mines in total production. Decommissioned mine emissions also contributed to the overall increase due to the closure of several large gassy mines. Mine production of coal has increased from 241 Mt in 1990 to 480.9 Mt in 2007, an increase of 99.5 per cent. Since 1990, methane emissions have not grown as fast as activity principally because, since 1998, there has been a decreasing trend in activity from gassy mines while there has been growth in non-gassy mines and surface mines (Figure 9). In addition, technologies to recover and utilise or flare CH_4 have been increasingly adopted. Emissions from decommissioned mines have increased 1.4 Mt between 1990 and 2007.

Figure 9: Fugitive CO_2-e emissions from coal mining, 1990–2007



Oil and natural gas fugitive emissions decreased by 16.6 per cent (2.2 Mt) between 1990 and 2007 (Figure 10). This compares with a 37.4 per cent increase in production activity. The decrease in emissions relative to the increase in activity is largely the results of improvements in gas distribution and a reduction in the emissions from flaring. Between 2006 and 2007, emissions from oil-related activities increased by 3.8 per cent (0.02 Mt) and emissions from gas-related activities decreased by 2.2 per cent (0.1 Mt). Emissions from venting decreased by 2.4 per cent (0.1 Mt) from 2006 to 2007 although, compared with 1990, emissions were higher by 9.4 per cent (0.3 Mt). Flaring-related emissions increased by 13.0 per cent (0.3 Mt) from 2006 to 2007, although emissions in 2007 were lower than 1990 levels by 34.9 per cent (1.6 Mt).

Figure 10: Fugitive CO_2-e emissions from oil and gas production, 1990–2007



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.

2.3 Industrial Processes

Emissions estimates and trends from 1990 to 2007

Emissions from the *Industrial Processes* sector were 30.3 Mt CO_2-e in 2007, which is equivalent to 5.6 per cent of national inventory emissions[6]. Emissions were 6.2 Mt (25.7 per cent) higher than in 1990 (Figure 11). 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 industries.

Mineral products

Mineral products contribute 19.3 per cent of *Industrial Process* emissions. In 2007, emissions from mineral products were 5.9 Mt. Cement clinker contributed 3.9 Mt (66.4 per cent) of mineral product emissions and lime contributed 1.0 Mt (17.2 per cent). Limestone and dolomite use generated 1.0 Mt (16.4 per cent) of emissions from the subsector.

Net emissions from mineral products increased by 0.7 Mt (14.5 per cent) from 1990 to 2007 due to increased production of lime and cement. From 2006 to 2007, net emissions increased by 0.02 Mt (0.3 per cent).

Chemical industry and other

Emissions from the chemical industry, soda ash production and use, magnesia production, nitric acid production, ammonia production, acetylene use and the use of N_2O in aerosols and anesthesia were 7.7 Mt in 2007. These emissions increased by 5.4 Mt (235.2 per cent) between 1990 and 2006, and by 0.4 Mt (5.2 per cent) from 2006 to 2007 due to increased production.

Metal production

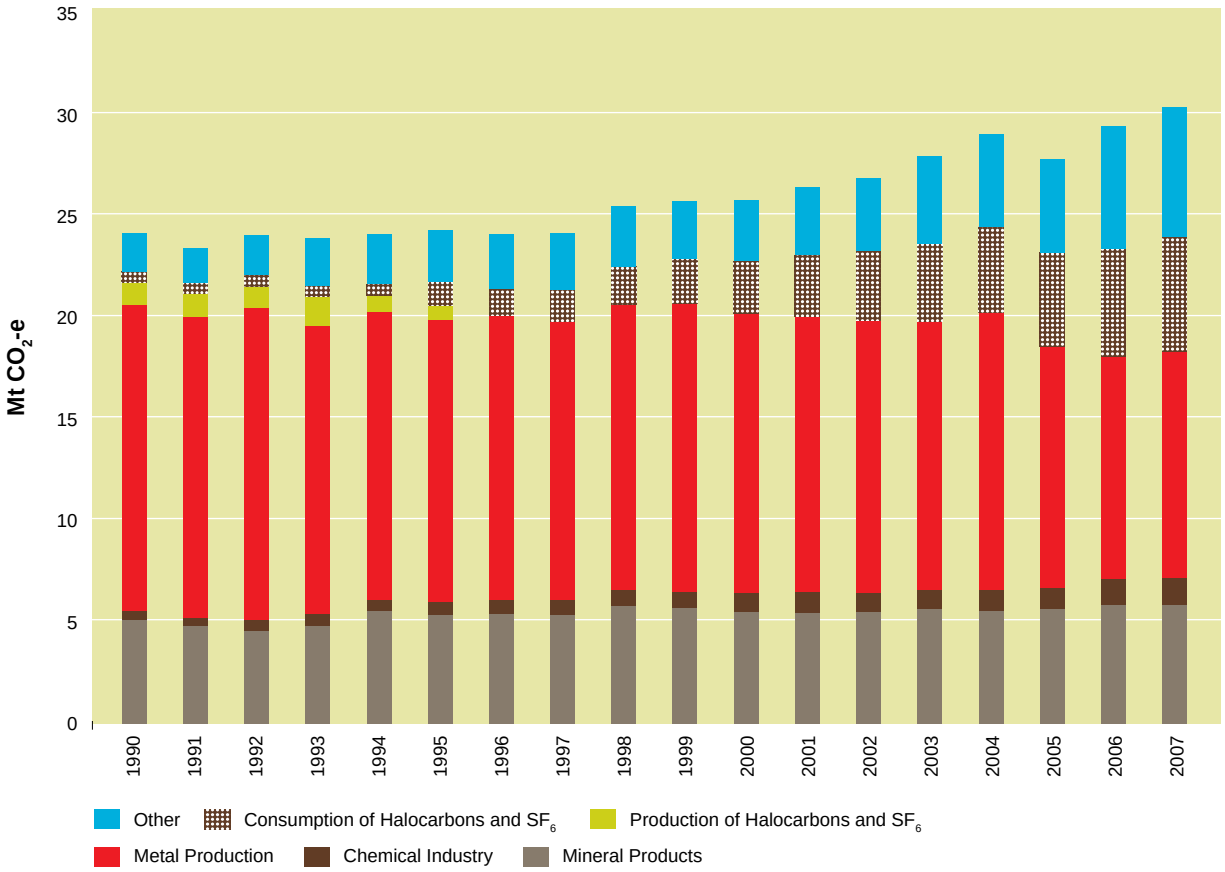
In 2007, metal production generated 11.1 Mt of emissions. The emissions are mostly due to iron and steel production (7.4 Mt) and aluminium smelting (3.7 Mt). Metal production emissions declined by 3.9 Mt (26.2 per cent) from 1990 to 2007. This was due to a 2.3 Mt (38.1 per cent) reduction in emissions from aluminium smelting, and a 1.7 Mt (18.4 per cent) 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.

Consumption and production of halocarbons

In 2007, emissions from the consumption of halocarbons and SF_6 were estimated to be 5.6 Mt CO_2-e. 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_2-e in 1990.

[6] The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

Figure 11: Trend in emissions from industrial processes from 1990 to 2007



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_6), 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.
- *Chemical industry*—nitrous oxide from the production of nitric acid; carbon dioxide emissions from ammonia production; and methane from polymers and other chemicals.
- *Consumption of halocarbons*—HFCs, PFCs and SF_6 from refrigeration and airconditioning equipment; foam blowing; metered dose inhalers; fire extinguishers; solvent use; and, electrical equipment.

2.4 Agriculture

Emissions estimates and trends from 1990 to 2007

Agriculture produced an estimated 88.1 Mt CO_2-e emissions or 16.3 per cent of national inventory emissions in 2007[7]. The *Agriculture* sector is the dominant national source of both methane and nitrous oxide – accounting for 67.9 Mt CO_2-e (58.9 per cent) and 20.2 Mt CO_2-e (85.9 per cent) respectively of the net national emissions for these two gases.

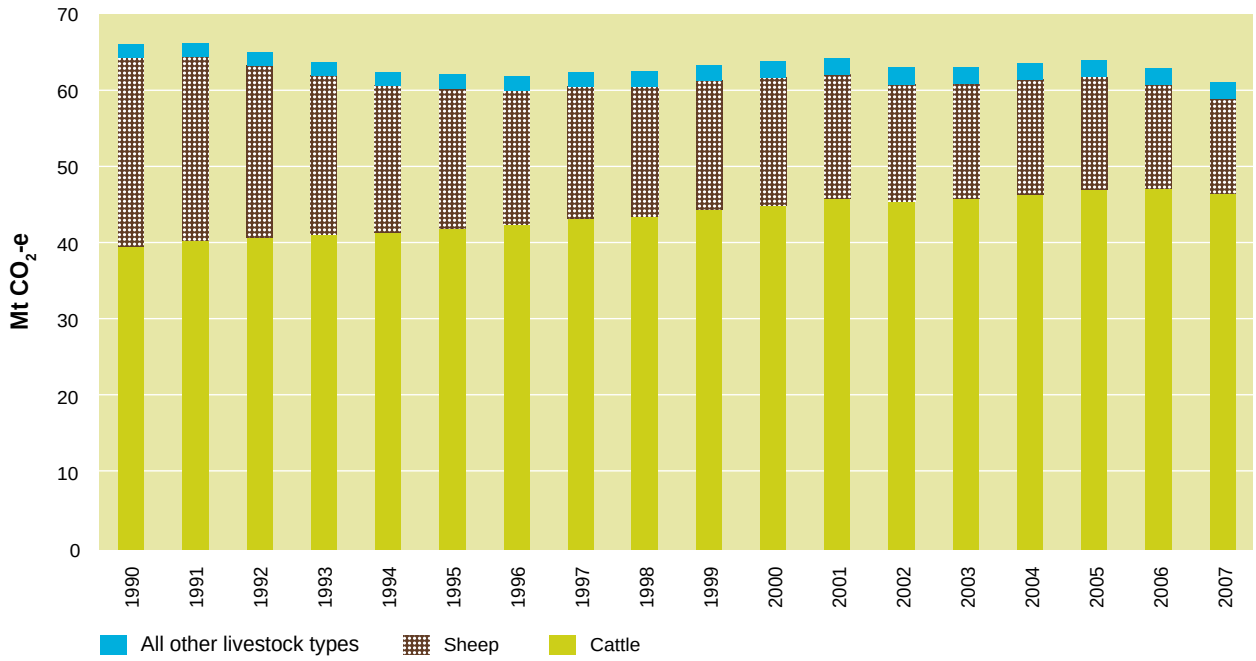
Greenhouse gas emissions from *Agriculture* increased by 1.5 per cent (1.3 Mt) between 1990 and 2007, and decreased by 3.0 per cent (2.7 Mt) from 2006 to 2007. Preliminary estimates for 2008 indicate that Agriculture emissions have increased by 3.0 per cent (2.6 Mt) since 2007 due to increased emissions from savanna burning.

Livestock

Greenhouse gas emissions from livestock are the sum of the enteric fermentation (57.6 Mt) and manure management (3.5 Mt) sub-sectors. Livestock emissions were 61.0 Mt CO_2-e in 2007, which represents 69.3 per cent of the Agriculture sector's emissions.

Livestock related emissions have declined by 7.5 per cent (4.9 Mt) between 1990 and 2007 (Figure 12). The decline in emissions has principally been driven by a 50.7 per cent fall in sheep numbers, although partially offset by a 13.9 per cent rise in beef cattle numbers, reflecting changing relative returns to each industry. Preliminary estimates for 2008 indicate that livestock emissions have declined by 1.9 per cent (1.2 Mt) since 2007.

Figure 12: Trends in CO_2-e emissions from livestock



Crops, soil and fire-related emissions

The estimated emissions from the other agriculture sub-sectors in 2007 were:

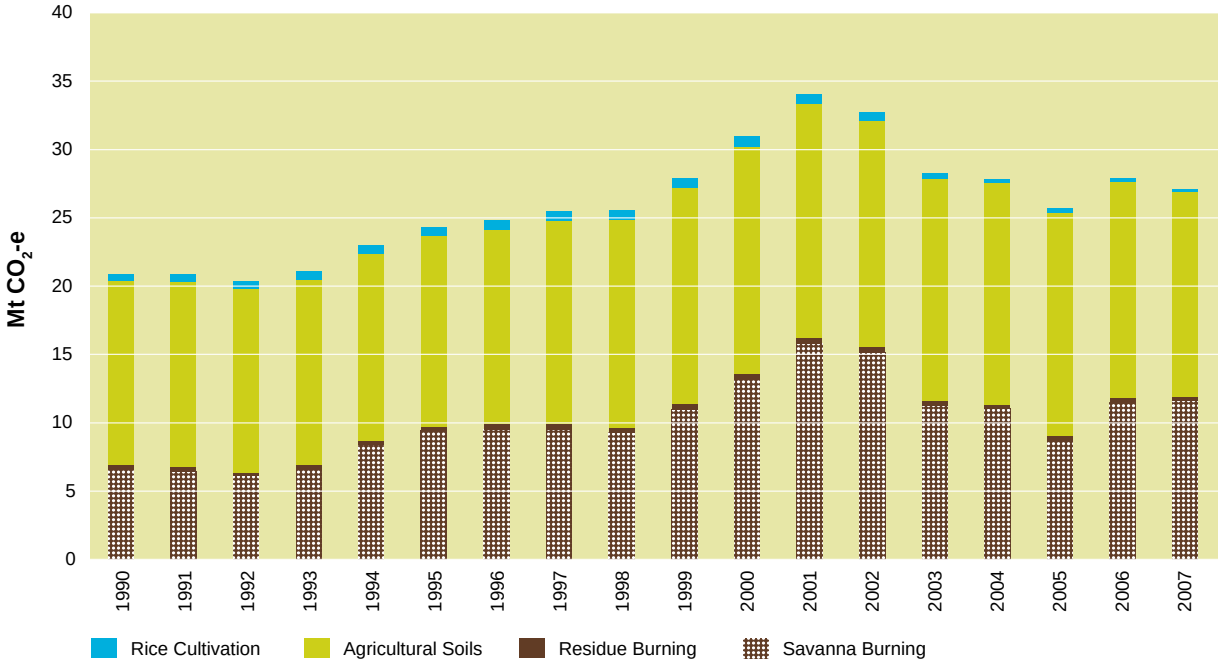
- 0.2 Mt from rice cultivation, a 60.0 per cent (0.3 Mt) decrease since 1990;
- 15.0 Mt from agricultural soils, an 11.2 per cent (1.5 Mt) increase since 1990;
- 11.6 Mt from prescribed burning of savannas, a 75.3 per cent (5.0 Mt) increase since 1990; and

[7] The national inventory, before accounting for Land Use, Land Use Change and Forestry activities, financial year data.

- 0.3 Mt from field burning of agricultural residues, a 5.8 per cent (0.02 Mt) increase since 1990.

Emissions from the other agriculture sub-sectors, with the exception of savanna burning, declined between 2006 and 2007. Preliminary estimates for 2008 indicate an ongoing decline in these sub-sectors since 2007 but an increase in savanna burning.

Figure 13: Trends in CO_2-e emissions from the crop, soil and fire related subsectors



NOTES

Emissions of methane (CH_4) and nitrous oxide (N_2O) 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.

2.5 Waste

Emissions estimates and trends from 1990 to 2007

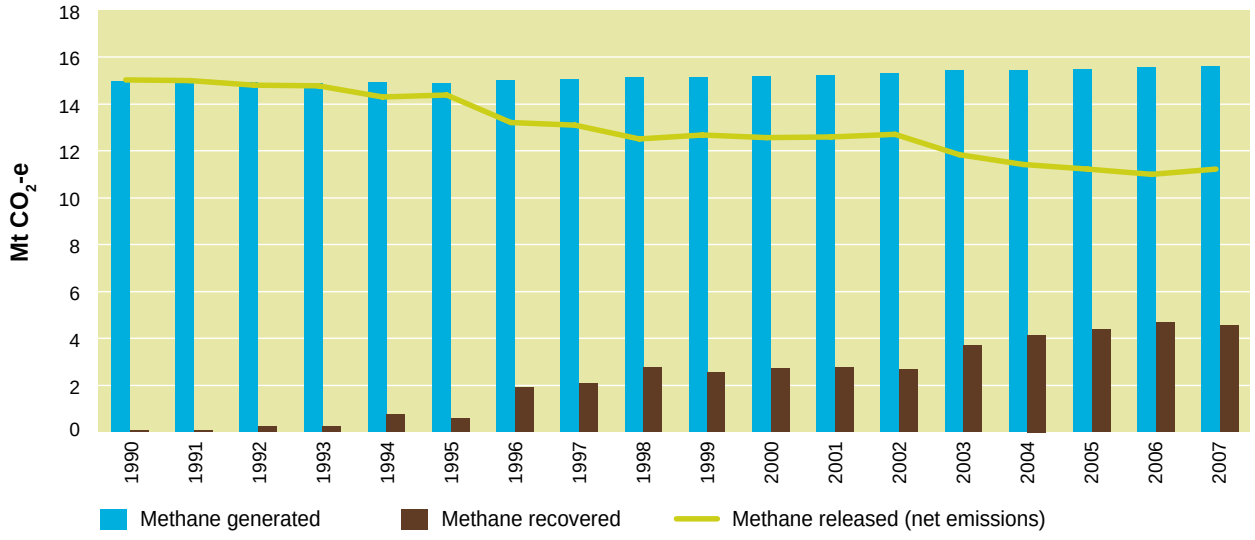
Net *Waste* emissions were 14.6 Mt CO_2-e in 2007, an increase of 0.4 Mt (2.7 per cent) since 2006 and a decrease of 4.2 Mt (22.5 per cent) since 1990. Preliminary estimates for 2008 indicate that waste emissions have increased by 0.8 per cent (0.1 Mt) since 2007.

Solid waste

Methane emissions from solid waste disposal on land were 11.1 Mt CO_2-e. Estimated emissions from solid waste disposal decreased by 3.8 Mt (25.5 per cent) during the period 1990–2007 reflecting changing patterns of disposal, particularly higher rates of recycling, and from an increase in methane recovery (Figure 14). Net emissions from solid waste are estimated to have increased by 0.2 Mt (2.0 per cent) in 2007 compared with 2006.

Rates of methane recovery from solid waste have improved substantially since 1990, increasing from a negligible amount to 4.5 Mt CO_2-e of methane in 2007.

Figure 14: Methane emissions from solid waste disposal



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 3.4 Mt CO_2-e.

Methane and nitrous oxide emissions from wastewater decreased by 0.4 Mt CO_2-e or 10.0 per cent during the period 1990–2007, 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_2 occur as a result of the incineration of solvents, clinical and municipal solid waste. Emissions of CO_2 from incineration were 0.03 Mt in 2007. These emissions decreased by 0.06 Mt (66.1 per cent) during the period 1990-2007.

NOTES
Waste emissions are predominantly methane. Small amounts of carbon dioxide and nitrous oxide are generated through the incineration of solvents 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.

2.6 Article 3.3 Land Use, Land Use Change and Forestry Activities

Emissions estimates and trends from 1990 to 2007

The net emissions from the *Land Use, Land Use Change and Forestry* activities were 56.0 Mt CO_2-e in 2007.

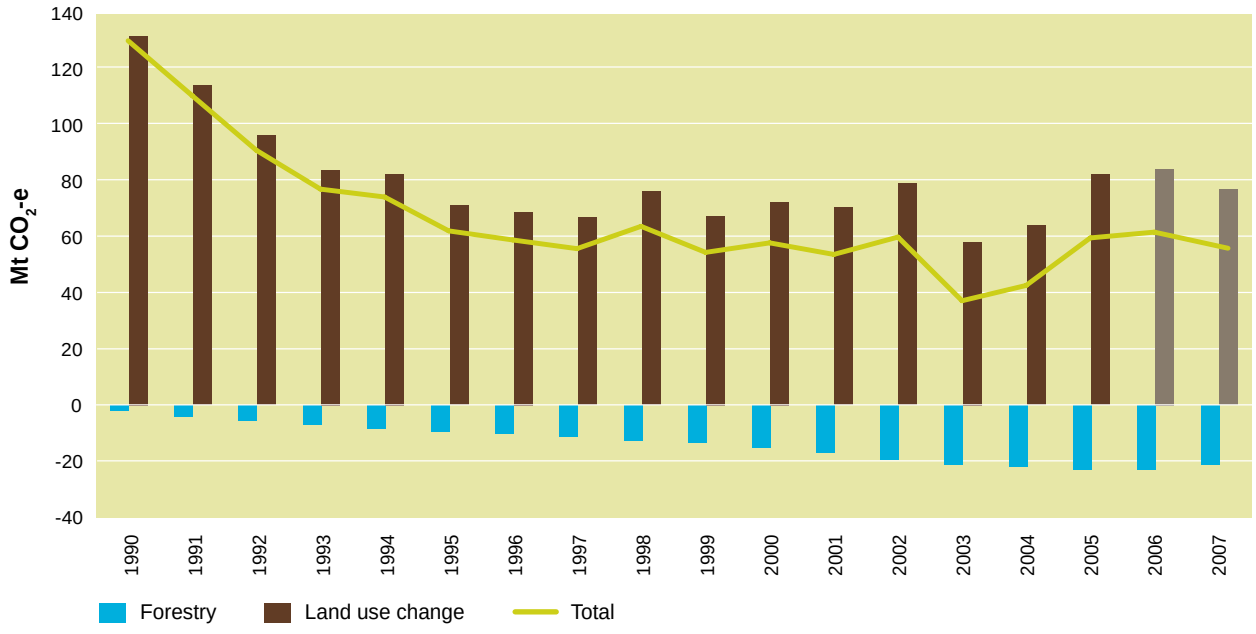
Forest plantings

In 2007, removals associated with afforestation and reforestation activities (sequestration of carbon dioxide in plantations established since 31 December 1989) were estimated to be 21.2 Mt of CO_2-e.

Land use change

Net emissions from land use change in 2007 using UNFCCC accounting rules were estimated to be 77.1 Mt CO_2-e (see notes for more explanation). This amounts to a decline of 55.0 Mt (42.3 per cent) 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. After a rise in areas cleared in 2005 and 2006, preliminary data indicate areas cleared fell significantly in 2007. Nonetheless, emission estimates for 2006 and 2007 should be considered to be interim at this stage, and will change in the next update of the inventory when areas of land use change are confirmed in the next update of the inventory using the National Carbon Accounting System (NCAS). The estimate provided for 2007 has not been calculated using the NCAS but rather is based on recent trends and is subject to significant revision.

Figure 15: Net Land Use, Land Use Change and Forestry emissions from 1990 to 2007



Note: The results for land use change for 2006 and 2007 will be revised following the next update of the inventory. The land use change estimate for 2007 is based on an average of emissions in 2004-2006, financial year data.

NOTES

Under the UNFCCC, all carbon dioxide emissions from the human use of the land are accounted for 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—new forest plantings since 1990.
- Deforestation—the deliberate, human induced removal of forest cover and replacement with pasture, crops or other uses on land that was forest on 1 January 1990.

Unlike other sectors, the Kyoto Protocol accounting for LULUCF activities differs between the assigned amount calculations and the commitment period. The assigned amount includes emissions due to land use change (deforestation) as determined using UNFCCC accounting rules (which differ to those applied during the Kyoto commitment period) and do not include emissions or removals due to forestry.

As the Kyoto accounting rules that apply to the estimation of net emissions from LULUCF for the commitment period differ from those applied to the estimation of net emissions from the sector when used for the calculation of the assigned amount, it is not possible to provide a consistent post-1990 time-series comparison for tracking progress toward a Kyoto target. Notably, the 'Kyoto land' for which reporting is required is, as yet, only partially established and will not be fully established until the end of the commitment period.

However, by looking at the UNFCCC time-series trend in reductions of land areas deforested it is possible to gain some insight into trends. Even then, the period over which lands are accumulated means that the impact of reclearing cycles will become increasingly important in determining per hectare emissions during the commitment period. A comparison of the total areas cleared under the UNFCCC inventory in 1990 (561 kha) and the area entering the Kyoto deforestation account in 2006 (270 kha) provides some assistance in understanding current trends in deforestation emissions in relation to the Kyoto Target. A broadly indicative preliminary assessment has been conducted employing the framework of accounting rules that will apply during the Kyoto commitment period. This broad Kyoto rules type of assessment indicates deforestation emissions emissions in 2006 from the current Kyoto deforestation lands were 73.2 Mt CO_2-e. However, the progressively accumulating land area under the Kyoto accounting rules means that this estimate is subject to significant uncertainty.

For afforestation and reforestation, the time-series trend in areas entering the Kyoto account since 1990 provides insight into the age-class distribution of the current areas that are eligible under Article 3.3. When considering the emissions and removals from afforestation and reforestation it is important to consider the future impacts of both harvesting, which will become increasingly influential through the commitment period and increasing areas of land entering the account until the end of the commitment period.

Appendix 1 – Notes

Australian National Greenhouse Accounts

In conjunction with this *Report*, the Department of Climate Change (DCC) publishes a range of supporting emission estimates that, together, constitute the *Australian National Greenhouse Accounts*. In addition to the *National Greenhouse Gas Inventory*, the DCC 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 2007*, prepared under the reporting provisions applicable to the United Nations Framework Convention on Climate Change.

These documents are available on the DCC website http://www.climatechange.gov.au/inventory. 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 new dynamic interface allows users to select emissions data of interest and download the results in a format which allows for further analysis of the data on their own desktop. The AGEIS can be accessed at http://www.climatechange.gov.au/inventory.

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 an assigned amount of 592 Mt a year for each year of the first commitment period 2008-2012). See the Department of Climate Change web site at http://www.climatechange.gov.au for more detail.
- 'Assigned amount' is 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 assigned amount is calculated as 108% of the estimates for the 1990 base period for the Annex A sectors (Energy, Industrial Processes, Agriculture and Waste) and Land Use Change (deforestation) as submitted to the UNFCCC in Australia's Initial Report in October 2008.
- 'Deforestation' includes greenhouse gas emissions from the conversion of forests to grassland and cropland. Under the Kyoto Protocol the assigned amount is determined from the emissions and removals on lands cleared during the period 1972-1990, however, for the commitment period emissions and removals from land cleared since 1990 are reported.
- 'Forestry' activities includes carbon dioxide removals (that is, sinks) from plantations established on agricultural land since 1990, referred to as 'afforestation and reforestation' in the Kyoto Protocol. This is a narrower definition than the Forestry sub-sector under United Nations Framework Convention on Climate Change (UNFCCC) accounting provisions (See the *National Inventory Report 2007* for further details).

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_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6).
- Global Warming Potentials have been used used in this *Report* for each of the major greenhouse gases to convert them to carbon dioxide equivalents (CO_2-e). As greenhouse gases vary in their radiative activity and in their atmospheric residence time, converting emissions into CO_2-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 inventory level, the uncertainty of the emissions estimates has been assessed at ±3%.

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 2007

State and Territory Greenhouse Gas Inventories 2007

National Inventory Report 2007

can be obtained from the Department of Climate Change website **www.climatechange.gov.au/inventory**

On-line access to emissions results — Australian Greenhouse Emissions Information System (AGEIS) – also available at **www.climatechange.gov.au/inventory**

Appendix 2 – 2007 Sectoral Emissions

Table 1: Overview of Australia's national inventory by sector (Kyoto accounting), 2007

Sector and Subsector	Emissions Mt CO_2-e				
	CO_2	CH_4	N_2O	HFCs/PFCs/SF_6	Total
All energy (combustion + fugitive)	372.1	33.3	2.7	NA	408.2
Stationary energy	289.5	1.3	1.0	NA	291.7
Transport	76.5	0.6	1.7	NA	78.8
Fugitive emissions	6.2	31.5	0.0	NA	37.7
Industrial Processes	24.1[(a)]	0.1	0.0	6.1	30.3
Agriculture	NA	67.9	20.2	NA	88.1
Waste	0.0	13.9	0.6	NA	14.6
National Inventory	**396.3**	**115.3**	**23.5**	**6.1**	**541.2**
Article 3.3 LULUCF activities	52.6	2.4	1.0	NA	56.0
National Inventory including Article 3.3 LULUCF activities [(b)]	**448.9**	**117.7**	**24.5**	**6.1**	**597.2**

Notes: a) Emissions of methane and nitrous oxide are included under carbon dioxide for components of the Industrial Processes sector for reasons of confidentiality;

b) Strictly speaking the net credits from land use change and forestry activities should only be account for during the first commitment period (2008-2012).

NA = not applicable, IE = included elsewhere

Table 2: Energy sector CO_2-e emissions, 2007

Greenhouse gas source and sink categories	CO_2-e emissions (Mt)			
	CO_2	CH_4	N_2O	Total
1 ENERGY	372.1	33.3	2.7	408.2
A. Fuel combustion activities	366.0	1.9	2.7	370.5
1 Energy industries	221.0	0.2	0.6	221.8
A Electricity generation	198.7	0.2	0.6	199.5
B Petroleum refining	5.7	0.002	0.01	5.7
C Manufacture of solid fuels	16.5	0.04	0.02	16.6
2 Manufacturing industries and construction	48.3	0.05	0.3	48.7
3 Transport	76.5	0.59	1.7	78.8
A Civil aviation	5.3	0.001	0.05	5.3
B Road transportation	66.4	0.5	1.6	68.5
C Railways	1.9	0.002	0.02	1.9
D Navigation (domestic)	2.8	0.1	0.02	2.9
E Other transportation	0.04	0.0004	0.0002	0.0
4 Other sectors	18.6	1.0	0.07	19.7
5 Other	1.5	0.002	0.01	1.6
A Lubricants	0.5	NA	NA	0.5
B Mobile (military)	1.1	0.002	0.010	1.1
B. Fugitive emissions from fuels	6.2	31.5	0.03	37.7
1 Solid fuels	NE	26.8	NA	26.8
2 Oil and natural gas	6.2	4.6	0.03	10.8

Table 3: Industrial processes sector CO_2-e emissions, 2007

Greenhouse gas source and sink categories	CO_2-e emissions (Mt)				
	CO_2	CH_4	N_2O	HFC/PFC/SF_6	Total
2 INDUSTRIAL PROCESSES	24.1	0.1	0.02	6.1	30.3
A Mineral products	5.9	NA	NA	NA	5.9
B Chemical industry	1.3	0.01	IE	NA	1.3
C Metal production	10.5	0.1	0.02	0.5	11.1
D Other production	IE	NA	NA	NA	IE
E Production of halocarbons and sulphur hexafluoride	NO	NO	NO	NO	NO
F Consumption of Halocarbons and sulphur hexafluoride	NA	NA	NA	5.6	5.6
G Other [(a)]	C	C	C	NA	6.4

Table 4: Agriculture sector CO_2-e emissions, 2007

Greenhouse gas source and sink categories	CO_2-e emissions (Mt)			
	CO_2	CH_4	N_2O	Total
4 AGRICULTURE	NA	67.9	20.2	88.1
A Enteric fermentation	NA	57.6	NA	57.6
B Manure management	NA	1.9	1.6	3.5
C Rice cultivation	NA	0.2	NA	0.2
D Agricultural soils	NA	NA	15.0	15.0
E Prescribed burning of savannas	NA	8.1	3.5	11.6
F Field burning of agricultural residues	NA	0.2	0.1	0.3

Table 5: Waste CO_2-e emissions, 2007

Greenhouse gas source and sink categories	CO_2-e emissions (Mt)			
	CO_2	CH_4	N_2O	Total
6 WASTE	0.03	13.9	0.6	14.6
A Solid waste disposal on land	NA	11.1	NE	11.1
B Wastewater handling	NA	2.8	0.6	3.4
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_2-e emissions, 2007

Greenhouse gas source and sink categories	CO_2-e emissions (Mt)			
	CO_2	CH_4	N_2O	Total
LAND USE, LAND USE CHANGE AND FORESTRY [(a)]	52.6	2.4	1.0	56.0
Afforestation and reforestation	-21.2	NA	NA	-21.2
Land use change (deforestation) [(b)]	73.7	2.4	1.0	77.1

Notes: a) A negative sign denotes a sink;

b) The results for deforestation will be revised when areas of deforestation are confirmed following the next update of estimates using the National Carbon Accounting System.

Table 7: National Inventory, quarterly emissions estimates, Mt CO_2-e

Year		Electricity	Stationary energy excluding electricity	Transport	Fugitives	Other sectors	Actual Emissions	Average quarterly emissions over four quarters to end of quarter
2004/05	Q1	50	22	20	8	33	134	NA
	Q2	48	22	20	9	33	131	NA
	Q3	48	21	19	8	32	129	NA
	Q4	48	22	20	8	33	131	131
2005/06	Q1	50	23	19	9	34	134	131
	Q2	48	23	21	9	34	135	132
	Q3	50	22	20	9	33	133	133
	Q4	50	22	20	8	34	133	134
2006/07	Q1	51	23	20	9	33	136	134
	Q2	50	24	20	10	34	137	135
	Q3	50	23	19	10	33	135	135
	Q4	48	23	20	9	33	133	135
2007/08	Q1	52	24	20	10	34	140	136
	Q2	49	24	21	10	34	139	137
	Q3	50	23	20	10	34	136	137
	Q4	49	24	20	9	34	135	138
2008/09	Q1	52	24	20	9	35	141	138
	Q2	50	24	20	11	35	140	138

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: Emissions Trends (CO_2-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)
Total CO_2-e emissions	**546328**	**528010**	**513444**	**503186**	**502915**	**503488**	**504859**	**513173**	**535907**
1. Energy	**286433**	**288302**	**294537**	**298927**	**301173**	**312795**	**318703**	**328978**	**342864**
A. Fuel Combustion (Sectoral Approach)	257226	259527	264108	268134	271418	281715	289372	297806	310405
1. Energy Industries	143097	146375	149726	151517	152438	158304	163006	169632	182224
2. Manufacturing Industries and Construction	36280	35810	35395	35860	36659	37609	37728	37881	37759
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	29207	28775	30429	30793	29755	31080	29331	31172	32458
1. Solid Fuels	**16230**	**16741**	**17822**	**19058**	**18159**	**18132**	**17383**	**19148**	**20389**
2. Oil and Natural Gas	12978	12034	12606	11735	11596	12948	11948	12024	12069
2. Industrial Processes	24141	23411	24040	23882	24070	24269	24080	24165	25443
A. Mineral Products	5123	4810	4606	4815	5567	5371	5437	5376	5809
B. Chemical Industry	416	406	503	600	561	660	687	695	776
C. Metal Production	15070	14832	15376	14158	14154	13856	13953	13742	14052
D. Other Production									
E. Production of Halocarbons and SF_6	1126	1126	1054	1447	812	719			
F. Consumption of Halocarbons and SF_6	521	521	521	521	522	1131	1319	1564	1858
G. Other	1885	1716	1980	2341	2455	2532	2683	2789	2948
3. Solvent and Other Product Use									
4. Agriculture	**86832**	**87001**	**85329**	**84846**	**85375**	**86333**	**86628**	**87848**	**88049**
A. Enteric Fermentation	63881	64018	62739	61355	59894	59387	59135	59568	59502
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	13496	13590	13443	13589	13619	13965	14261	14829	15152
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
G. Other									
5. Land Use, Land Use Change and Forestry	**130114**	**110509**	**90959**	**77023**	**74299**	**62052**	**58798**	**55741**	**63753**
A. Afforestation and reforestation	-2046	-3927	-5578	-7100	-8541	-9359	-10322	-11329	-12751
B. Land use change (deforestation)	132159	114437	96537	84123	82840	71410	69121	67070	76504
6. Waste	**18807**	**18787**	**18580**	**18508**	**17999**	**18040**	**16650**	**16441**	**15799**
A. Solid Waste Disposal on Land	14909	14887	14704	14669	14183	14288	13098	12976	12390
B. Waste-water Handling	3813	3815	3791	3753	3730	3660	3486	3437	3381
C. Waste Incineration	85	85	85	85	86	91	66	28	28
D. Other									
7. Other (as specified in Summary 1.A)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total CO_2 emissions including net CO_2 from LULUCF	**546328**	**528010**	**513444**	**503186**	**502915**	**503488**	**504859**	**513173**	**535907**
Total CO_2 emissions excluding net CO_2 from LULUCF	**416214**	**417500**	**422485**	**426163**	**428616**	**441437**	**446061**	**457432**	**472154**
Memo Items:									
International Bunkers	**6457**	**6433**	**6642**	**7046**	**7427**	**8609**	**9109**	**9137**	**9530**
Aviation	4380	4556	4834	5241	5393	5905	6362	6592	7291
Marine	2077	1877	1808	1805	2034	2704	2746	2545	2239
Multilateral Operations									
CO_2 Emissions from Biomass	14976	14858	13574	15206	16142	16918	17931	18785	19083

Notes: 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 estimates
NO = not occurring
C = confidential
IE = included elsewhere

Greenhouse gas source and sink categories	1999	2000	2001	2002	2003	2004	2005	2006	2007	Change from base to latest reported year
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	%
Total CO_2-e emissions	**537015**	**552680**	**559496**	**567038**	**553057**	**564697**	**584232**	**596140**	**597157**	**9.3**
1. Energy	**349717**	**358623**	**365124**	**368640**	**381635**	**387040**	**392830**	**400104**	**408163**	**42.5**
A. Fuel Combustion (Sectoral Approach)	319368	325794	331694	336344	350017	354755	360138	365757	370510	44.0
1. Energy Industries	189582	192610	199883	201299	211795	212399	214784	218980	221844	55.0
2. Manufacturing Industries and Construction	38522	39381	38556	39974	40637	41755	45274	47347	48661	34.1
3. Transport	72851	74905	73540	75256	75828	79793	79003	78643	78774	26.9
4. Other Sectors	17206	17650	18451	18585	20529	19539	19697	19414	19672	33.4
5. Other	1208	1248	1263	1229	1228	1269	1380	1374	1559	54.0
B. Fugitive Emissions from Fuels	30349	32829	33430	32296	31618	32285	32692	34347	37653	28.9
1. Solid Fuels	18938	20220	20245	19937	20351	21393	22163	23720	26832	65.3
2. Oil and Natural Gas	11411	12609	13185	12360	11267	10892	10529	10627	10821	-16.6
2. Industrial Processes	**25691**	**25731**	**26381**	**26831**	**27937**	**29019**	**27793**	**29387**	**30343**	**25.7**
A. Mineral Products	5706	5526	5472	5490	5641	5593	5641	5849	5867	14.5
B. Chemical Industry	793	911	1035	963	979	986	1065	1313	1326	218.8
C. Metal Production	14173	13753	13555	13400	13137	13674	11836	10913	11124	-26.2
D. Other Production										NA
E. Production of Halocarbons and SF_6										NA
F. Consumption of Halocarbons and SF_6	2176	2566	2983	3406	3862	4229	4622	5292	5639	982.2
G. Other	2842	2974	3336	3572	4318	4536	4629	6019	6388	238.8
3. Solvent and Other Product Use										**NA**
4. Agriculture	**91226**	**94677**	**98236**	**95646**	**91230**	**91287**	**89571**	**90798**	**88106**	**1.5**
A. Enteric Fermentation	60160	60435	60847	59551	59587	60033	60339	59291	57561	-9.9
B. Manure Management	3191	3297	3358	3386	3384	3438	3548	3593	3453	67.3
C. Rice Cultivation	671	741	738	589	399	237	341	265	196	-60.0
D. Agricultural Soils	15824	16592	17098	16598	16234	16226	16285	15828	15002	11.2
E. Prescribed Burning of Savannas	10977	13202	15772	15165	11262	11018	8650	11481	11585	75.3
F. Field Burning of Agricultural Residues	403	410	422	357	365	335	407	339	309	5.8
G. Other										NA
5. Land Use, Land Use Change and Forestry	**54423**	**57826**	**53758**	**59848**	**37129**	**42613**	**59596**	**61669**	**55978**	**-57.0**
A. Afforestation and reforestation	-13287	-15001	-17146	-19605	-21252	-21753	-22960	-22794	-21150	933.9
B. Land use change (deforestation)	67710	72827	70904	79453	58381	64365	82556	84463	77128	-41.6
6. Waste	**15959**	**15824**	**15996**	**16072**	**15126**	**14740**	**14441**	**14182**	**14567**	**-22.5**
A. Solid Waste Disposal on Land	12581	12469	12497	12604	11738	11316	11110	10892	11106	-25.5
B. Waste-water Handling	3349	3327	3472	3441	3360	3395	3303	3261	3432	-10.0
C. Waste Incineration	29	28	28	28	28	28	28	29	29	-66.1
D. Other										NA
7. Other (as specified in Summary 1.A)	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**537015**	**552680**	**559496**	**567038**	**553057**	**564697**	**584232**	**596140**	**597157**	**9.3**
Total CO_2 emissions excluding net CO_2 from LULUCF	**482592**	**494855**	**505738**	**507190**	**515928**	**522085**	**524635**	**534471**	**541179**	**30.0**
Memo Items:										NA
International Bunkers	**9801**	**10187**	**10483**	**9615**	**8766**	**8852**	**9556**	**10775**	**11994**	**85.8**
Aviation	7326	7390	7856	6748	5971	6034	6901	8125	9348	113.4
Marine	2475	2797	2627	2867	2795	2818	2655	2650	2646	27.4
Multilateral Operations										**NA**
CO_2 Emissions from Biomass	**18827**	**19008**	**18209**	**16343**	**17120**	**17469**	**16976**	**17037**	**18050**	**20.5**

Notes: 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 estimates
NO = not occurring
C = confidential
IE = included elsewhere