ACT State of the Environment Report 2011

THEME: Climate

Indicator cluster: Emissions

The indicators for this cluster are:

- *Atmospheric concentration of carbon dioxide* in parts per million (ppm) (C);
- *Atmospheric concentration of methane* in parts per billion (ppb) (C);
- *Atmospheric concentration of nitrous oxide* in parts per billion (ppb) (C);
- *Energy use* (P) - energy use by type and by sector, energy use per $1000 GDP, and discussion of trends;
- *Carbon dioxide emissions* (P) - CO_2 emissions per year, per sector and per person;
- *Methane emissions* (P) - including from landfill sites and water bodies;
- *Nitrous oxide emissions* (P); and
- *Ozone layer* (I) - Extent of the ozone layer and impacts.

Condition indicators (C) present data that tell us the state of the environment at any particular time.

Pressure indicators (P) present data about the main human activities that could potentially adversely affect the condition of the environment.

Impact indicators (I) present data on the effect that environmental changes have on environmental or human health.

Response indicators (R) present data about the main things we are doing to alleviate pressures, or to improve the condition of the environment.

Summary

Globally, atmospheric concentrations of greenhouse gases, emitted both via human activities and from natural sources, continue to increase, and the trend is generally reflected in the ACT. The calculated annual greenhouse gas emissions for the ACT totalled approximately 4.18 megatonnes (Mt) of CO_2-e in 2009, including emissions removal through land use, land-use change and forestry (LULUCF) as required under the Kyoto protocol.

The burning of fossil fuels to produce electricity is the largest contributor to greenhouse gas emissions, followed by use of natural gas and petrol. It is clear that emission reduction efforts need to focus on these sectors.

Carbon dioxide made up 95% of the ACT's total greenhouse gas emissions in 2008. Methane emissions in the ACT were reported to be 149 kilotonnes (kt) in 2008. These emissions were

attributed to the energy, agriculture and waste sectors, with the waste sector contributing 64% of total emissions. Nitrous oxide emissions for the ACT amounted to 49 kt in 2008.

Introduction

This paper provides an overall assessment of emissions generated by various sectors in the ACT throughout the 2007-2011 reporting period, within the context of global and historical emissions.

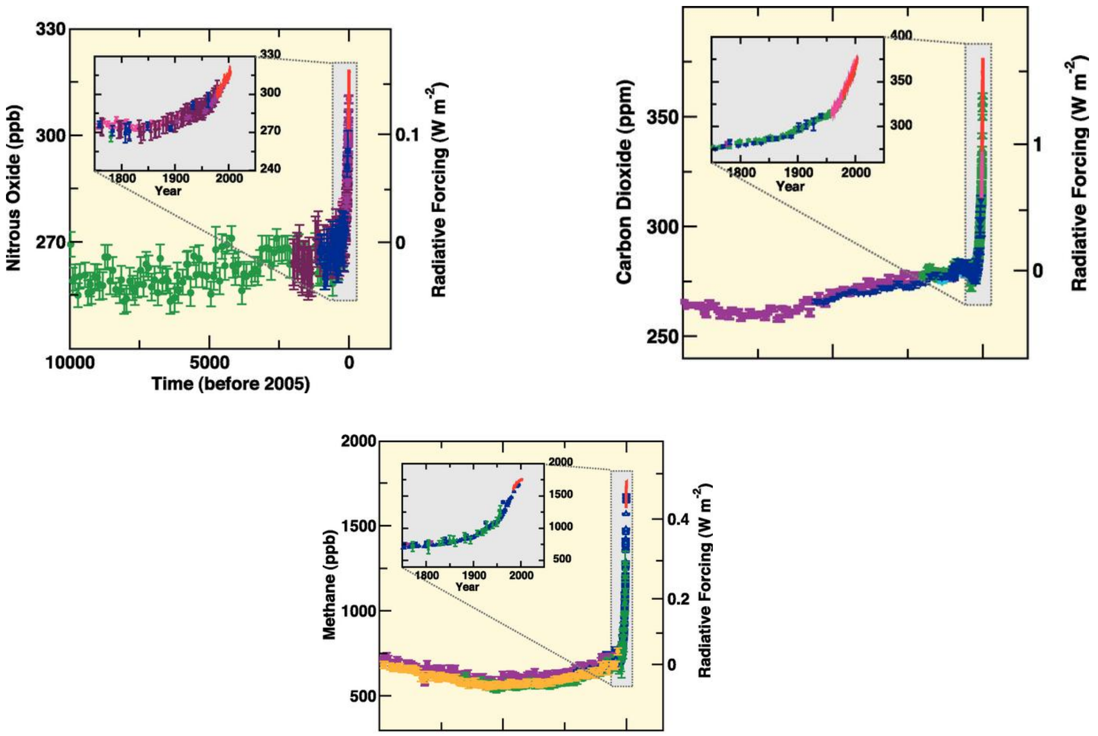
Condition indicators

Global greenhouse gas emissions

Measurements and calculations of atmospheric concentrations of greenhouse gas emissions add to understanding of current atmospheric conditions and potential future climate change. Carbon dioxide, methane and nitrous oxide are the three principal greenhouse gases, and their concentrations have been directly affected by human activity.

Figure 1 shows that the recent rate of change in atmospheric greenhouse gas concentration since the mid 1900s is both dramatic and unprecedented. Until the industrial era, the range of atmospheric concentrations of CO_2 increased by only 10 ppm (275-285 ppm). Since industrialisation however, atmospheric concentrations have increased by approximately 100 ppm - ten times the pre-industrial era variations - and in the 17 years to 2007 atmospheric CO_2 concentrations have increased by 30 ppm (Denman et al. 2007).

Figure 1. Atmospheric concentration of three greenhouse gases over time



Source: Denman et al. 2007

Over the reporting period 2007-2011, global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have continued to increase. Average annual atmospheric concentrations for the reporting period are shown in Table 1.

Table 1. Global atmospheric concentration of greenhouse gas emissions

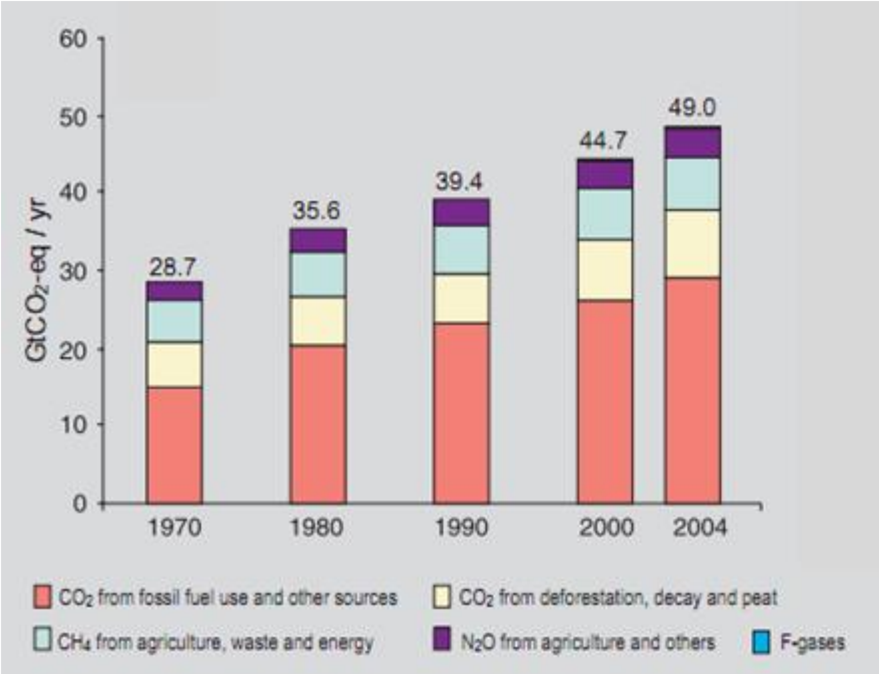
Annual average	CO_2 (ppm)	Increase from previous year average CO_2 (ppm)	Methane (ppb)	Nitrous oxide (ppb)
2007	380.57	1.87	1733.11	319.52
2008	382.69	2.12	1741.53	320.76
2009	384.26	1.57	1743.92	321.41
2010	386.09	1.83	1750.52	322.44

Source: BOM . (Note: Cape Grim, on Tasmania's west coast, is one of the three premier Baseline Air Pollution Stations in the World Meteorological Organization-Global Atmosphere Watch (WMO-GAW) network. Baseline stations are defined by the WMO to meet a specific set of criteria for measuring greenhouse and ozone depleting gases and aerosols in clean air environments.)

Each of these gases has a different potential to trap heat, and each remains in the atmosphere for a different period of time. Global warming potential expresses the heat-trapping power of a gas relative to carbon dioxide over a particular time period. For example, over a 100-year period, a methane molecule has 25 times the warming potential of a carbon dioxide molecule, while a nitrous oxide molecule has 298 times the warming potential of a carbon dioxide molecule. Other gases are hundreds or thousands of times more powerful. However, carbon dioxide is a more stable molecule and lasts longer in the atmosphere than most of the other greenhouse gases (McKeown 2009). It is also emitted in much higher quantities than any other greenhouse gas. As Figure 2 shows, despite the higher global warming potential of methane and nitrous dioxide, most by far of global warming potential from emissions is due to carbon dioxide.

A standardised measure called carbon dioxide equivalents (CO_2-e) is often used to measure total greenhouse gas emissions, with global warming potential commonly calculated for a 100-year time period (McKeown 2009). CO_2-e expresses the global warming potential of all greenhouse gases as a single figure based on the potential warming of carbon dioxide, allowing for a quick understanding of the threat presented by particular emission levels.

Figure 2. Global greenhouse gas emissions by sector 1970-2004



Source: Metz et al. 2007

Note. Emissions called F-gases are too small to appear.CO2 from fossil fuel use and other sources (bottom segment in each bar) contributes the most gigatonnes of CO_2-e per year.)

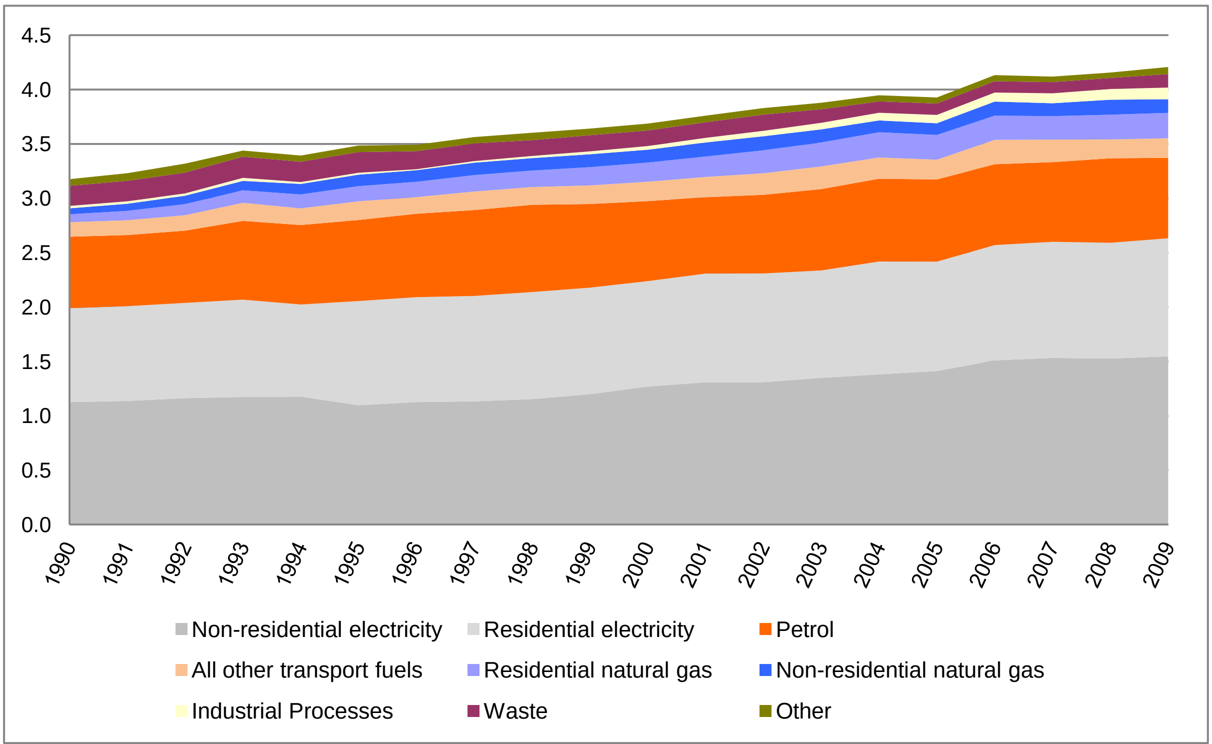
In 2005, global carbon dioxide concentrations were 379 parts per million (ppm), methane concentrations were around 1774 parts per billion (ppb) and nitrous oxide 319 ppb (Denman et al. 2007) (Figure 1). From the most recent calculations, global atmospheric carbon dioxide occupies more than 385 ppm of air, which is 38% more than the highest value recorded in the last 800,000 years (NOAA 2011).

The fifth Assessment Report by the Intergovernmental Panel on Climate Change, due to be completed in 2013-14, will provide an updated assessment of global scientific, technical and socio-economic information about climate change, its potential effects, and options for adaptation and mitigation.

ACT greenhouse gas emissions

Since 1990, ACT greenhouse gas emissions have also increased (Figure 3).

Figure 3: ACT greenhouse gas emissions in megatonnes of carbon dioxide equivalents, 1990-2009



Source: ICRC 2011

The calculated annual greenhouse gas emissions for the ACT totalled approximately 4.18 Mt of CO_2-e in 2009, including emissions removal through land use, land-use change and forestry (LULUCF) as required under the Kyoto protocol (ICRC 2011).

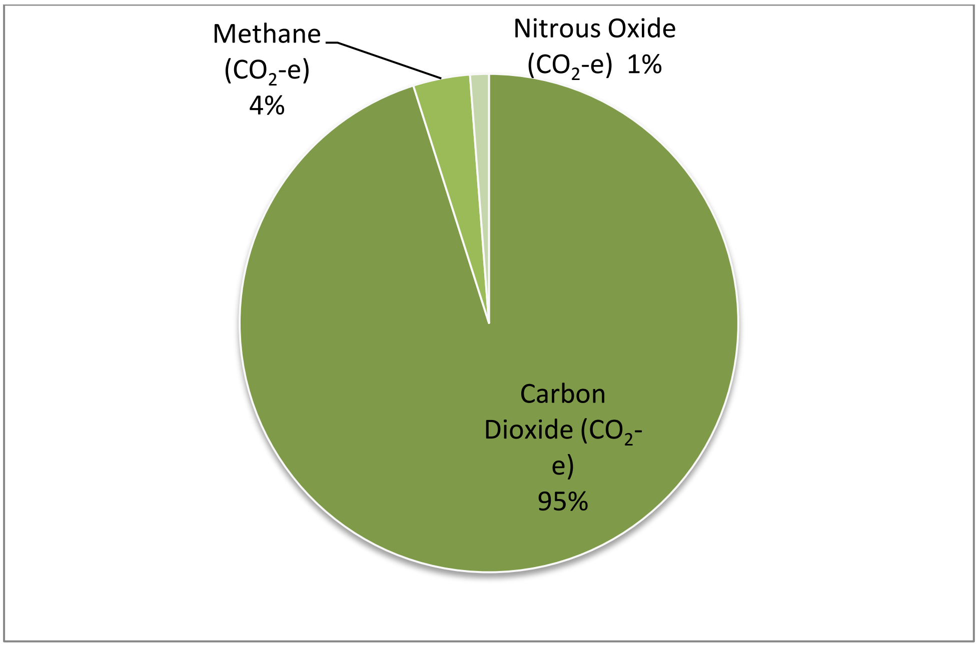
When measured on a per capita basis, emissions in Australia have stabilised and slightly decreased over the last decade, while per capita emissions in the ACT have only begun to decrease more recently (DECCEW 2010). Emissions per person in ACT were calculated at 11.2 t CO_2-e in 2009, while in the same year Australia's per capita CO_2-e emissions were calculated at 24.9 t (ICRC 2011 and unpublished). This large disparity reflects the contribution from industries such as energy generation, mining and agriculture occurring across the country, of which there is minimal activity in the ACT. However, Canberrans import and consume goods and services produced by these sectors. The ACT Government accepts accountability for emissions from stationary energy (electricity) generated elsewhere for use within its borders (ICRC 2011) and the data here include those additional emissions.

Pressure indicators

Greenhouse gas emissions by type

Carbon dioxide made up 95% of the ACT's total greenhouse gas emissions as CO_2-e in 2008 (Figure 4).

Figure 4. ACT greenhouse gas emissions by type for 2008



Source: Based on data from DECCEW 2010

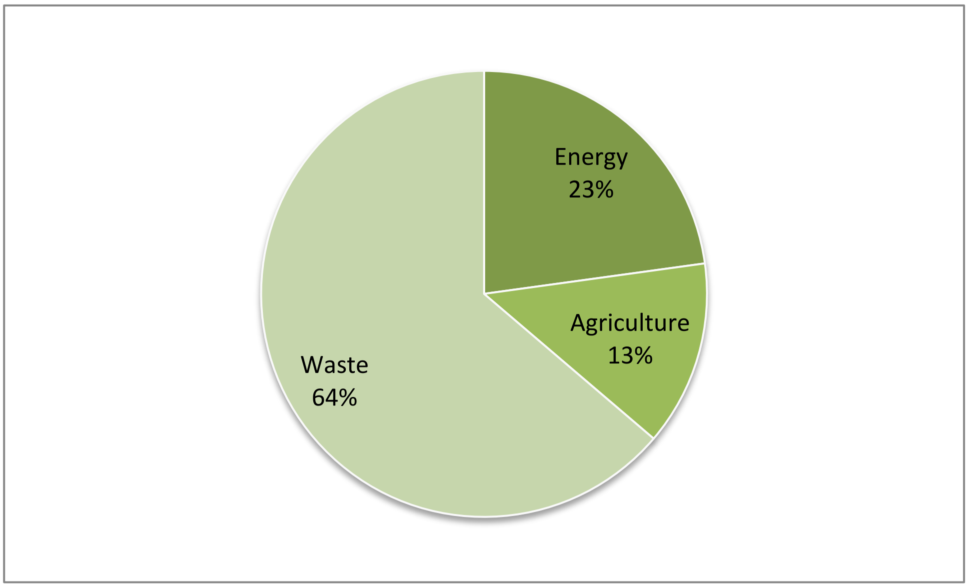
Carbon dioxide emissions

In the ACT, almost all carbon dioxide is emitted during use of energy, predominantly as electricity, in heating, cooling and lighting buildings. Petrol used in transport emits the second largest amounts of CO_2.

Methane emissions

Methane, as previously discussed, is a naturally occurring atmospheric gas that has been increasing in abundance in the atmosphere, particularly since the industrial revolution (Figure 1) (IPCC 2007). At a global scale, methane largely comes from particular land-use practices, such as irrigated rice cultivation and cattle production and landfill sites. In Australia, the digestive processes of livestock (enteric fermentation) and fugitive emissions from coal mining together account for more than two-thirds of methane emissions (ABS 2010).

Figure 5. Sources of methane emissions in the ACT in 2008



Source: Based on data from DECCEW 2010

Methane emissions in the ACT were reported to be 149 kt in 2008 (DECCEW 2010). These emissions were attributed to the energy, agriculture and waste sectors, with the waste sector contributing 64% of total emissions (Figure 5).

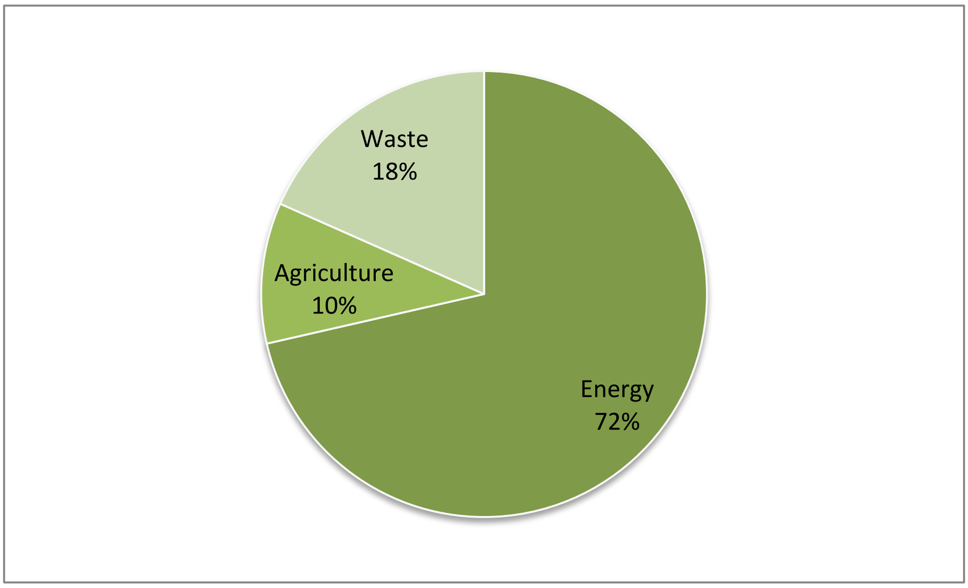
The ACT incorporates a number of artificial lakes, such as Lake Burley Griffin, as well as stormwater control ponds and wetlands. At times, these water bodies may cause an increase in the Territory's methane emissions as a result of decomposing materials, methane-producing algae and anaerobic conditions. This contribution will need to be considered in future State of the Environment reports, but there are insufficient data on methane production from water bodies at present for comment to be made in the current report.

Nitrous oxide emissions

Globally there has been a dramatic rise in atmospheric concentrations of nitrous oxide since the 1750s (IPCC 2007) (Figure 1). Nitrous oxide is of concern because it is a very stable gas and in the atmosphere it is 310 times more effective at trapping heat than carbon dioxide in a given time period (US EPA 2011).

Reporting of ACT emissions of nitrous oxide for the current period is limited to the information contained in the 2008 ACT Greenhouse Gas Inventory (released in 2010; DECCEW 2010). The inventory reports that 49 kt of nitrous oxide were added to the atmosphere in 2008 as a result of activity in the ACT. Most of the ACT's nitrous oxide emissions came from energy production, and some were attributable to the agricultural and waste sectors (Figure 6).

Figure 6. Sources of nitrous oxide emissions for the ACT in 2008

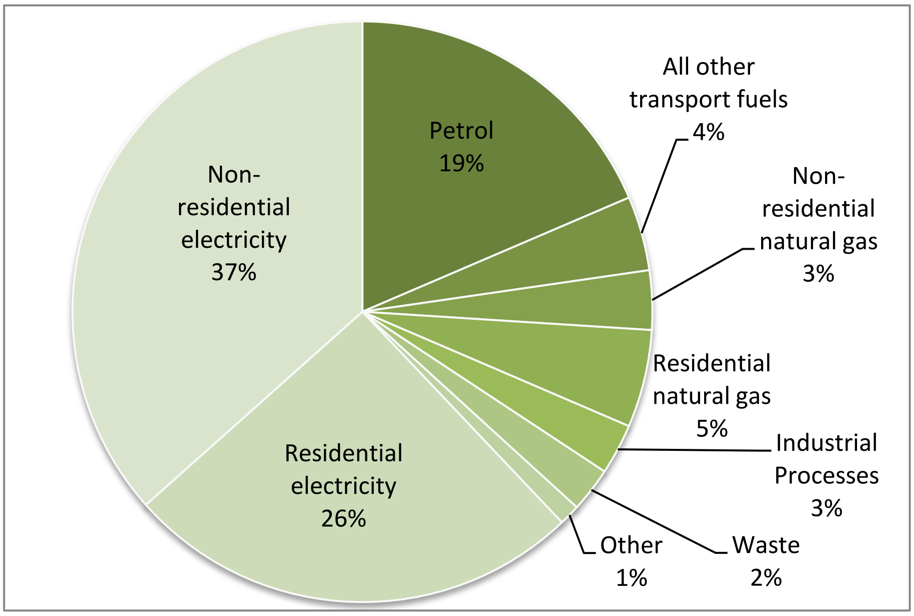


Source: Based on DECCEW 2010

ACT greenhouse gas emissions by sector

Greenhouse gases are released into the atmosphere by activities such as burning of fossil fuels for energy production, broadscale land clearing and land-use changes (indirect impacts) (Figure 7).

Figure 7. Sources of greenhouse gas emissions in the ACT for 2009



Source: ICRC 2011

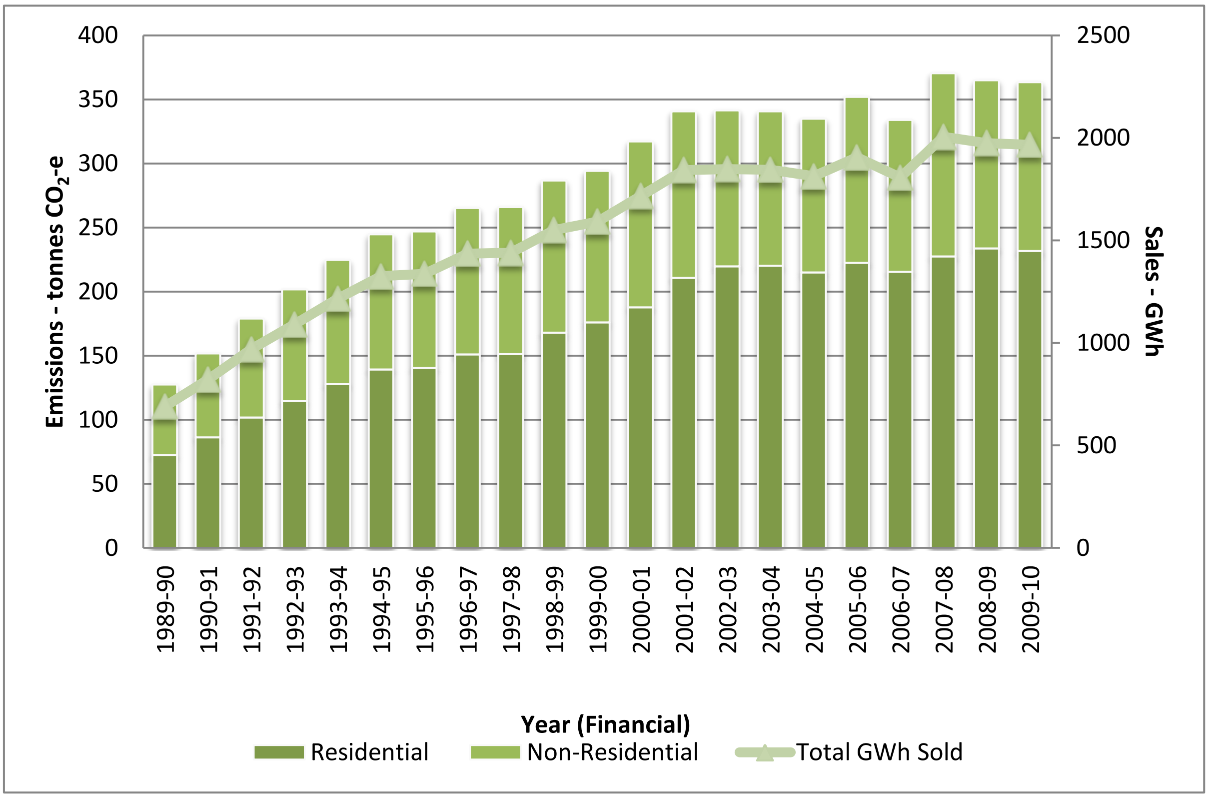
Electricity and gas

Electricity accounts for 62.6% of the Territory's greenhouse gas emissions (Figure 7), but less than 2% of the electricity consumed within the ACT is generated within the ACT itself (ICRC 2009, Engineers Australia 2010).

Stationary energy use contributes over two thirds of the ACT's greenhouse gas emissions; it comes from electricity and gas use for lighting and heating (Figure 7). A significant reduction in the emissions from the stationary energy and transport sectors will be needed if the ACT is to meet its greenhouse gas reduction targets without heavy reliance on offset strategies.

For more information on emissions reduction see the *Mitigation* indicator cluster.

Figure 8. Natural gas emissions and purchasing trends in the ACT



Source: ICRC unpublished 2010 and DECCEW 2010

Over the reporting period, total gas use and emissions decreased slightly. However, total emissions in 2009-10 were more than double those in 1990. Most emissions attributable to the natural gas sector come from household use of energy, which has increased much more over the last few decades than use in the non-residential sector (Figure 8).

Natural gas is a fossil fuel energy source but it produces significantly less emissions than other non-renewable sources of energy, particularly coal (DECCEW 2010). Given the significantly higher share of emissions attributable to the electricity sector in the ACT, choosing electricity generated from gas instead of coal may be beneficial for overall emissions reduction in the short to medium term.

Unlike natural gas, sources of electricity vary in emissions intensity and as over 98% of the ACT's electricity is sourced from NSW estimates have to be made based on the composition of the NSW power sector. An additional variable is the increasing quantity of renewable energy being both purchased and produced by ACT customers, which is further discussed in the Mitigation indicator cluster paper.

Figure 9. Electricity emissions and purchasing trends in the ACT

Source: ICRC unpublished 2010 and DECCEW 2010

Estimates of the emissions from electricity use in the ACT are shown in Figure 9. While emissions due to the ACT's electricity consumption have remained at 8.3 t of CO_2-e per person over the reporting period (ICRC unpublished), it is the total emissions caused by the ACT as a whole that contribute to climate change, irrespective of population size. Note that the reduction in emissions observed early in the last reporting period has since reversed, with electricity sector emissions increasing again (Figure 9).

Household use of electricity per person in the ACT remains well above the national average (ACT Government 2007). Conversely, total average energy consumption (residential and non-residential) is low relative to other States because of the small amount of industry in the ACT. The high residential consumption has been attributed to Canberra's relatively cold winters and to the high disposable incomes of Canberrans (Engineers Australia 2010).

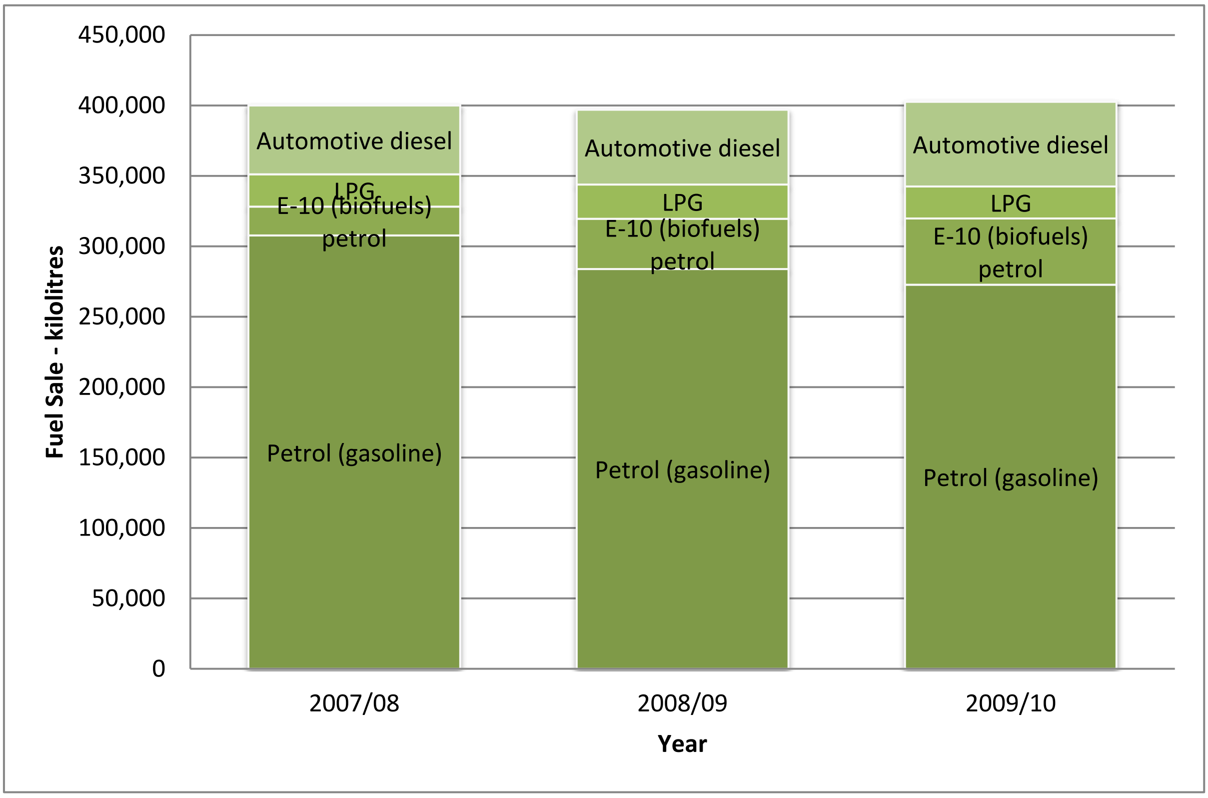
Transport

Based on available data for Australia, the ACT's energy consumption in road transport was the lowest per capita (averaging just over 40 gigajoules) when compared with other Australian States and Territories. However, as with other emissions, the ACT's total footprint for transport emissions is larger. The ACT has limited industry and imports most of its goods (and services) from interstate. Reported ACT transport emissions do not really include the emissions generated in transporting these goods because energy use by the sector was calculated from purchases of fuel by type and from consumption of fuel in terajoules.

Transport fuel use has varied slightly over the reporting period: with an increase in total sales from 399,855 kL in 2007-08 to 402,547 kL in 2009-10 (TAMS).

Petrol (Automotive Gasoline) was main fuel used, followed by Automotive Diesel Oil (ADO) and then LPG, as shown in Figure 10.

Figure 10. Fuels used by the transport sector in the ACT, 2007-2009



Source: TAMS

Impact indicators

Ozone layer

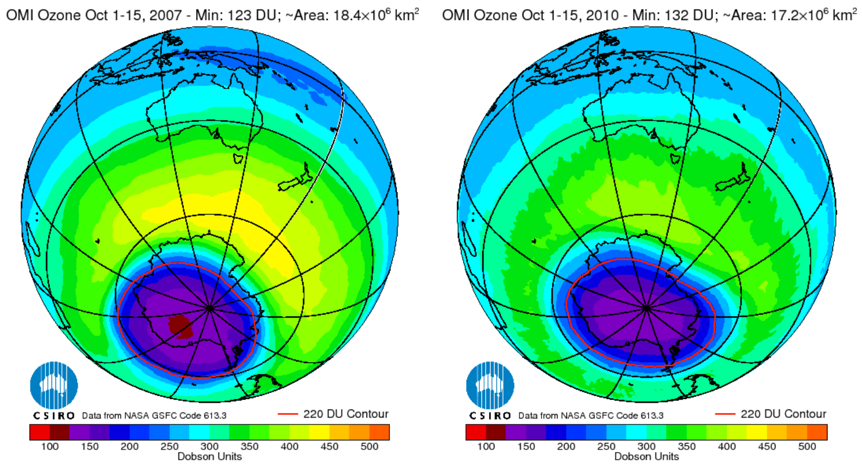
The *Ozone layer* impact indicator refers to ozone depletion in the upper layer (or stratospheric layer) of the atmosphere, acknowledged since measurements of the hole over Antarctica were first published in the early 1980s (Fahey 2006; UNEP 2011). The ozone layer is an indicator of impact rather than pressure because its condition results from human use of ozone-depleting gases and aerosols.

The ozone layer makes up a very small amount of the atmosphere but is vital for human well-being. Although local impacts relating to stratospheric ozone depletion are limited, the global issue of ozone depletion has the potential to dramatically change the earth's atmosphere.

A slight thinning of the ozone layer has also been observed over other regions of the globe, such as the Arctic and southern middle latitudes, including Australia. The area of the hole in the ozone layer fluctuates with atmospheric cycles and earth rotations, which are linked with seasonal changes. According to data from the WMO, the area of ozone-depleted atmosphere peaked in 2003 and 2006, when it extended over 28 million square kilometres. The ozone hole is still present during August-December in the southern hemisphere, although primarily located over Antarctica and the surrounding Southern Ocean. During the reporting period the ozone hole was always largest during August, September and October (WMO 2010).

Figure 11 demonstrates how the ozone hole (the area with darkest shading, purple and red, over Antarctica) has changed over 2007-2010.

Figure 11. Antarctic ozone hole maps for 2007 and 2010



Source: SEWPaC

The monitoring and management of the ozone layer is an example of world co-operation through the Montreal Protocol of 1987. The protocol is an international treaty establishing the phasing out of substances known to be ozone-depleting, such as chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs) (WMO 2010). Global agreements now have led to the production of CFCs and HCFCs being phased out in most countries across the globe, but we are still living with the legacy of past chemical and production practices.

There are no other impact indicators for this indicator cluster for the ACT. Impacts of climate change on the ACT are outlined and discussed in the *Climate vulnerability* indicator cluster.

The most likely future climate scenario for the ACT includes (Webb 2011):

- the strong likelihood of mean temperatures continuing to increase, along with more frequent and severe heatwaves for the ACT and region; and
- a high probability of changes in the pattern of rainfall from that observed during the period of instrumental records, with some risk of a decline in long-term average rainfall; and in addition, the likelihood of an increase in rainfall intensity with more extreme rainfall events.

Response indicators

There are no response indicators for this indicator cluster. It is clear that emission reduction efforts need to focus on improving efficiency in electricity and transport use and the sourcing of renewable energy for electricity and transport fuels.

Responses to greenhouse gas emissions and climate change in the ACT are outlined in the *Mitigation* and *Adaptation* indicator clusters.

Glossary

Stationary energy: Stationary energy includes emissions from fuel consumption for electricity generation, fuels consumed in the manufacturing, construction and commercial sectors, and other sources like domestic heating. The stationary energy sector makes up 53.9% of Australia's emissions. Electricity generation is by far the largest source of emissions in this sector, contributing close to 50% of all energy emissions. The remainder of emissions from stationary energy come from direct combustion of fuels.

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Other data sources

In addition to these published reports, data for this paper were also sourced from:

ACT Department of the Environment, Climate Change Energy and Water (DECCEW) - now Environment and Sustainable Development Directorate (ESDD)

Bureau of Meteorology - Atmospheric concentration of Greenhouse Gas emissions, Cape Grim (BOM)

Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), Antarctic ozone hole

ACT Department of Territory and Municipal Services (TAMS) – now Territory and Municipal Services Directorate (TAMSD)