Strategy. Policy. Research.

Making the business case for sustainability

ACT Greenhouse Gas Inventory 2018–19

Prepared for the Environment, Planning and Sustainable Development Directorate
ACT Government

November 2019

BRW. CLIENT CHOICE AWARDS 2010

Table of Contents

Index of Figures

Index of Tables

1. Total ACT Greenhouse Gas Emissions

The estimate of total greenhouse gas emissions for the ACT in 2018-19 is 2,568 kilotonnes of carbon dioxide equivalent (kt CO_2-e).

This total includes the net impact of both emissions and removals of CO_2 in the Land Use, Land-Use Change and Forestry (LULUCF) sector; as well as emissions from all other emission sources occurring in the ACT; plus scope 2 emissions arising from electricity consumed in the ACT; all expressed in terms of CO_2-e.

Table 1 shows the results for 2018-19 and earlier years, including the current and, where necessary, revised values (the top row) and the values as stated last year (the bottom row). The main reasons for the changes in past values are recalculations in the most recent National Greenhouse Gas Inventory (for 2016-17) of emissions arising from 'Product used as substitutes for Ozone Depleting Substances' (which means synthetic refrigerant gases) and LULUCF. For these two emission source categories, the ACT Greenhouse Gas Inventory methodology uses estimates of emissions attributable to individual states and territories as prepared and published by the Commonwealth Department of the Environment and Energy. More detail on the changes is provided in sections 2.2.6 and 2.2.8 below.

Table 1: Total ACT greenhouse gas emissions summary (kt CO_2-e)

	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Current	3,926	3,884	3,980	3,857	3,678	3,129	2,568
Previous	4,041.5	3,934.5	4,063.2	4,102.4	3,927.8	3,367.5	NA

Table 2 shows per capita emissions for the same years as reported in Table 1. Per capita emissions rose between 2013-14 and 2014-15 but have fallen each year since then. Factors contributing to the reduction in emissions in 2018-19 are discussed later in this report. During the past three years, as the ACT's commitment to achieving zero emissions electricity has been progressively implemented, total emissions have fallen steadily. Despite a rising population, emissions per capita continue to reduce.

Table 2: ACT population, total greenhouse gas emissions and emissions per capita

Year	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Population (at 31 December)	379,812	386,318	391,981	398,874	407,489	415,874	423,309
Emissions (kt CO_2-e)	3,926	3,884	3,980	3,857	3,678	3,129	2,568
Emissions per capita (t CO_2-e)	10.34	10.05	10.15	9.67	9.03	7.52	6.07
Previous emissions per capita (t CO_2-e)	10.64	10.18	10.37	10.28	9.64	8.10	

2. Emissions by Source

2.1 Overview of sectoral totals 2018-19

The ACT differs from all other Australian states and territories in having no grid-scale electricity generators located within its borders. Most of the electricity consumed in the ACT is imported from the NSW grid, and most of the imported electricity is generated at power stations located either within NSW, or, by way of flows through inter-connectors between state grids, Queensland or Victoria. Consequently, a conventional jurisdictional greenhouse gas inventory following IPCC Guidelines, reporting only emissions from sources located within the jurisdictional boundary, would greatly under-estimate the emissions arising from consumption of electricity in the ACT. For this reason, the ACT emissions inventory has always reported scope 2 emissions for electricity consumption. To calculate these emissions, it uses its own version of what is termed, in the *Global Protocol for Community-Scale Greenhouse Gas Emissions*, the market-based method for calculating electricity related emissions (adoption and specification of this approach by the ACT actually pre-dates by some years the publication of the *Protocol*). All other emissions reported in the ACT GGI are scope 1 emissions, arising within the ACT.

Table 3 provides a sectoral breakdown of emissions in 2018-19, and Figure 1 shows the trend in emissions since 2012-13. One of the most striking features of the emissions reported this year is the large negative emissions arising from LULUCF. This represents an important change from the emissions reported in 2018 and affects previously reported emissions for a number of earlier years. The reasons for this change are explained later in this report. However, the size of these negative emissions makes it rather hard to understand the contribution of other source categories, and their trends, if these emissions are reported as shares of the total net emissions. In the following discussion, therefore, emissions from energy combustion and other sources are first described in terms of their contribution to total emissions, excluding the net CO_2 removals from LULUCF activities.

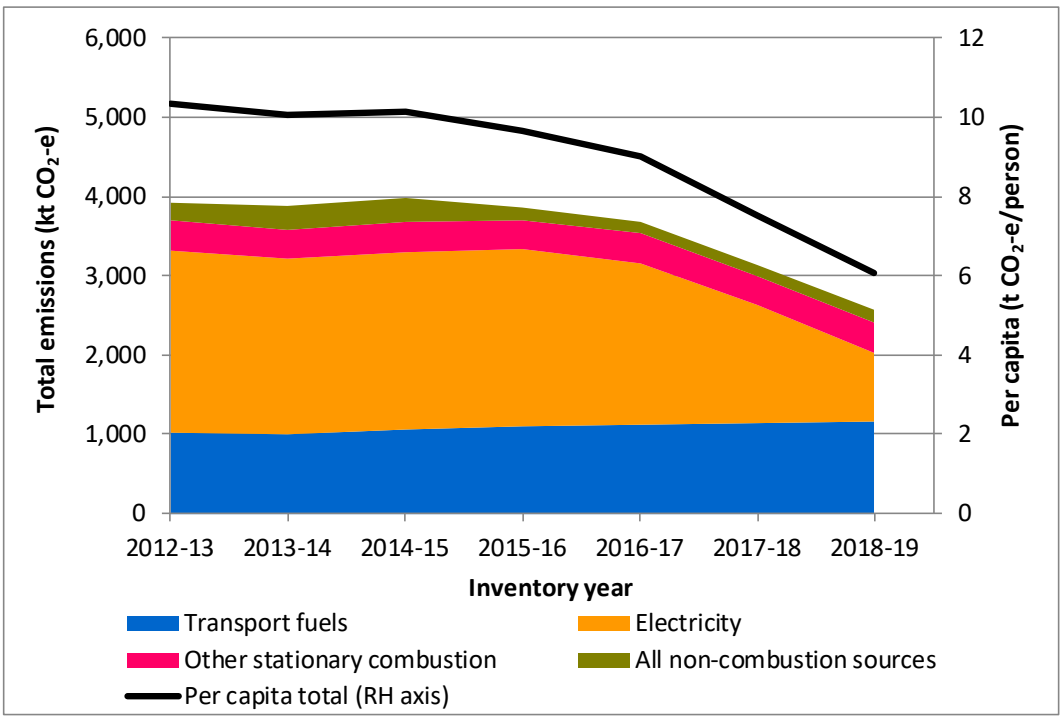
Stationary energy consumption remains the largest source of emissions in the ACT, as it has always been. Until 2013-14 it was responsible for over two-thirds of the CO_2-e emissions that were attributable to the ACT. Since then, however, its share has declined, at first slowly, mainly because consumption of electricity and gas grew more slowly than consumption of petroleum fuels for transport, and since 2016-17 because of ACT government policy to purchase renewable electricity from wind and solar farms. This has resulted in a marked reduction in the emissions intensity of electricity consumed in the ACT. Stationary energy use was responsible for emissions equal to 44 per cent of total emissions excluding LULUCF in 2018-19, down from 55 per cent in 2017-18.

Table 3: ACT Greenhouse emissions 2018-19 by source

Emissions Source	Emissions in 2018-19, kilo tonnes CO_2-e	Share of total emissions excluding LULUCF	Share of total emissions including LULUCF
Electricity	863.0	30.8%	33.6%
Other stationary energy	379.0	13.5%	14.8%
Transport	1,169.1	41.8%	45.5%
Fugitive emissions	33.3	1.2%	1.3%
Industrial processes	242.4	8.7%	9.4%
Agriculture	23.9	0.9%	0.9%
Waste	88.1	3.1%	3.4%
Sub Total (excl. LULUCF)	2,799	100.0%	109.0%
LULUCF	-231	-8.3%	-9.0%
TOTAL including LULUCF	2,568	91.7%	100.0%

NOTE: Figures may not reconcile exactly with those in Table 4, because of rounding errors.

Figure 1: Emission trends in the ACT since 2012-13



The transport sector is also very important, with emissions equal to 42 per cent of total emissions, excluding LULUCF, coming from petroleum-based fuels (and some natural gas) used in transport vehicles. Industrial processes, waste, and fugitive emissions related to the leakage from the gas distribution system account for most of the remaining emissions. Overall emissions relating to some form of energy use accounted for 87 per cent of emissions excluding LULUCF in 2018-19. However, as previously explained, emissions from these sources are significantly offset by CO_2 removals in the LULUCF sector, equal to 8.3 per cent of total emissions from all other sources. In addition to the major change in estimated emissions from LULUCF, there has also been a smaller, but by no means negligible, reduction in estimated emissions from Industrial Process activities, also explained below.

2.2 Discussion of individual source categories

2.2.1 Introduction

Table 4, on the next page, shows a more detailed breakdown of ACT greenhouse gas emissions. The remainder of this section of the report provides more information about most of the individual emission numbers shown in this Table.

Table 4: Detailed ACT emissions sources 2018-19

Emissions Source	Emissions (kt CO_2-e)		
Energy			2,444.4
A. Fuel combustion activities		2,411.4	
Electricity	863.0		
Natural gas	367.8		
Transport fuels	1,169.1		
Other use of petroleum fuels	11.1		
Fuel wood	0.3		
B. Fugitive emissions from fuels		33.3	
Natural gas leakage	33.3		
Industrial processes			242.4
Consumption of halocarbons and SF6	232.4		
Other activities	9.9		
Agriculture			23.9
Enteric fermentation	21.1		
Manure management	0		
Agricultural soils	2.8		
Land use, land-use change and forestry			-231
Forest Land	-247		
Cropland	0		
Grassland	-2		
Wetland	0		
Settlements	4		
Harvested wood products	14		
Waste			88.1
Solid Waste Disposal on Land	76.2		
Wastewater Handling	11.9		
Total emissions including net CO_2-e from LULUCF			2,568
Total emissions excluding net CO_2-e from LULUCF			2,799

2.2.2 Electricity

In 2018-19, for the first time, ACT electricity emissions were less than transport emissions. This significant milestone has been caused by the large increase in the share of ACT electricity consumption now being supplied, in market terms, by contracted wind farms. At the end of June 2019, six of the seven wind farms contracted by the ACT government were supplying under their

respective contracts. These wind farms are Coonooer Bridge and Ararat in Victoria, Hornsdale 1 and Hornsdale 2 in SA, and Sapphire 1 and Crookwell 2 in NSW. The seventh, Hornsdale 3, started supplying under contract on 1 October 2019. Table 5 shows the resultant decrease in the volume weighted average annual emissions intensity of electricity supplied to the ACT, and the renewable share of total supply, as calculated for the inventory. Note that this calculation also accounts for supply from contracted solar farms located within the ACT, and for the share of renewable generation under the Large Renewable Energy Target attributable to electricity purchased by ACT consumers.

Table 5: Average emissions intensity and renewable share of electricity supplied in the ACT

Year	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Emissions intensity (t CO_2-e/MWh)	0.762	0.753	0.753	0.743	0.663	0.492	0.286
Renewable share	17.3%	18.6%	19.0%	20.0%	29.1%	46.8%	68.7%

The calculation of electricity emissions in 2018-19 uses a change in the methodology for one of the smaller components of renewable electricity. The affected component is the ACT share of the total supply into the NSW NEM region of below LRET baseline renewable generation (meaning, in practice, below baseline generation at the five Snowy Hydro power stations supplying the NSW region, together with the NSW share of Hume Dam power station output). For previous inventories that share has been calculated as the ACT share of total NSW region operational demand, minus transmission losses, over the inventory year. However, for 2018-19, the required data are no longer publicly available. Therefore, for the 2018-19 emissions inventory, the share is calculated as the average value of the share over the six preceding years, i.e. from six years from 2012-13 to 2017-18 inclusive. This is reasonable given that the ACT's share has not varied greatly over that period; the highest value was 4.77 per cent in 2012-13 and the lowest 4.17 per cent in 2017-18. The average is 4.51 per cent.

2.2.3 Other stationary energy

Use of natural gas accounts for 97 per cent of other stationary combustion emissions. The remaining 3 per cent arises from small volumes of non-auto LPG, used by some consumers where reticulated natural gas is either not available or not connected, heating oil and fuel oil, which is used by Icon Water at LMWQCC, and fuel wood, for which only emissions of methane and nitrous oxide are counted as anthropogenic. It is not known whether any other organisations in the ACT use fuel oil. Data on consumption of non-auto LPG was unavailable in previous years and the 2018-19 data is understood to be partly incomplete. Inclusion of emissions from this source therefore results in a discontinuity in the time series, but emissions are so small as to have no material impact of the emissions trend.

Table 6: Total and per capita consumption of natural gas

Year	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Total consumption (TJ)	7,343	6,837	7,297	6,945	7,515	7,226	7,137
Consumption per capita (GJ)	19.33	17.70	18.62	17.41	18.44	17.38	16.86

Table 6 shows trends in consumption of natural gas, in both total and per capita terms. Consumption per capita shows a generally downward trend over the last few years, though there have been some ups and downs. These are probably associated with year to year variations in winter weather, because the major use of natural gas in Canberra is as a space heating fuel.

2.2.4 Transport

As implied above, transport is now the largest single source of ACT emissions, and the overwhelming majority of this arises from road transport. Petroleum products, mainly petrol (mogas) and diesel, with some auto-LPG and ethanol blends (E10), are the source of the great majority of transport energy. Compressed natural gas (CNG) is an important fuel for the ACTION bus fleet. There is negligible consumption of fuels for other transport modes. Emissions are calculated from retail sales volume data, which is collected annually by the ACT government through a survey of all service stations, plus ACTION bus depots.

Table 7 shows trends in consumption of road transport fuels, as identified by the survey. The first two rows show a strong shift away from petrol and LPG and towards diesel; a similar trend is seen in all parts of Australia. The third row of the table uses the respective calorific values (energy per unit volume) to convert consumption to energy units. This is needed to place all the different fuels on a common basis, because diesel has a higher calorific value than petrol and LPG. It can be seen that, apart from a dip between 2012-13 and 2013-14, road transport fuel consumption has been steadily increasing. When expressed in per capita terms, as is done in the fourth table row, this converts to per capita fuel energy consumption which is virtually unchanged over the six year period.

The change in the third row from 2012-13 to 2018-19 is equivalent to an increase of 12 per cent. This compares with an increase in the corresponding greenhouse gas emissions of 14 per cent over the same period. The difference arises from the fact that diesel has a higher carbon content than either petrol or LPG, and therefore a higher greenhouse gas emissions factor. What this comparison shows is that either, firstly, the greater efficiency of diesel engines compared with petrol (spark ignition) engines is insufficient to offset the higher specific emissions of diesel fuel, or, secondly, vehicles are on average are becoming larger and less fuel efficient, so that the average fuel efficiency of the fleet has deteriorated, notwithstanding the switch to diesel. It is likely that both factors are contributing.

Table 7: Total and per capita consumption of road transport fuels

Year	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Petrol. E10, E85, LPG (ML)	352.6	332.8	326.6	331.8	330.4	328.5	326.6
Diesel (ML)	85.1	91.4	117.2	128.3	137.1	146.3	155.0
Total consumption (PJ)	15.27	14.84	15.63	16.23	16.53	16.82	17.09
Total emissions (kt CO_2-e)	1,042	1,014	1,069	1,111	1,131	1,150	1,169
Consumption per capita (GJ)	40.2	38.4	39.9	40.7	40.6	40.4	40.4

The fuel use survey does not cover petroleum fuels (almost exclusively diesel) that are delivered in bulk to consumers, such as private bus fleet operators, ready mixed concrete suppliers, construction equipment operators, and some farmers. Some of this fuel, such as that used by buses and ready mixed concrete delivery, is used for road transport, while the remainder is used in off-road equipment. Given the small size of the ACT and the absence of activities, such as mining and broad acre cropping, which use large amounts of diesel, this "missing" diesel consumption is likely to be small, though not negligible, relative to the reported diesel consumption. The missing data do, however, represent an under-estimate of total ACT greenhouse gas emissions.

2.2.5 Fugitive energy

Fugitive energy emissions are all emissions which arise from the use of fossil fuels, other than emissions from combustion of fuels to supply useful energy. Overall, in Australia, fugitive emissions arise from a wide variety of activities related to the extraction, processing and transport of all types of fossil fuels, including coal, petroleum and gas. In the ACT, however, the only significant source of fugitive emissions is the leakage of natural gas, i.e. methane, from the gas distribution network. Emissions are calculated as a share of what the gas industry terms unaccounted for gas (UAG), which is the difference between the volume of gas received into the distribution network from gas transmission pipeline, and the total metered volume of gas supplied to consumers supplied from the distribution network. Both of these figures are provided by Evoenergy, and in recent years the difference has averaged around 2 per cent of gas received. The national methodology, which is used for the ACT emissions inventory, then assumes that 55 per cent of UAG is leaked as unburnt natural gas.

For the 2017-18 inventory, a different approach was used. A distinction was made between UAG and gas network losses, and a figure of slightly lower figure of 1.96 per cent was used for losses, taken from a 2016 regulatory submission by Evoenergy. This year it was decided to revert to the previously used method of calculating UAG, resulting in a very small increase in estimated fugitive emissions, despite the small reduction in gas consumption.

2.2.6 Industrial Processes

The Industrial Processes source category covers a large number of different greenhouse gases, emitted from a diverse array of mainly manufacturing related activities, other than fossil fuel combustion. As with other source categories, the range of greenhouse gas emitting activities occurring in the ACT is much narrower than in Australia as a whole.

In the ACT by far the largest component is what is termed "Product used as substitutes for ozone depleting substances". In practice, this means synthetic hydrofluorocarbon (HFC) gases used mainly as the working fluid in refrigeration and air conditioning equipment, and also, in much smaller quantities, as propellants in equipment such as fire extinguishers and metered dose inhalers.

Estimates are based on the Commonwealth Department of Environment and Energy's estimates of the ACT share of national emissions, as available through the Australian Greenhouse Emissions Information System (AGEIS). Since the National Greenhouse Gas Inventory extends only to 2016-17, estimates are required for the two most recent years. It has been consistently found that the trend of historic ACT emissions approximates very closely to a straight line. The formal ACT emissions inventory methodology therefore uses linear extrapolation of the line of best fit to values up to 2016-17 to estimate emissions in 2017-18 and 2018-19.

In the 2016-17 NGGI, estimates of emissions from this source category were recalculated to lower values right across the board. The 2019 *National Inventory Report* states that the main reasons for the recalculation are:

> "the calibration of annual leakage rates for HFC emitting equipment from 2006 onwards, and the correction to the unit charge of split systems from 2006 onwards." (p. 262, Volume 1)

Industrial Process emissions for the ACT, as estimated by the Commonwealth, also include very small emission volumes in two other generic industrial process sub-sectors, namely Chemical industry and Other product manufacture and use. The source or sources of Chemical industry emissions are unidentified, for reasons of commercial confidentiality. The principal source of emissions from Other product manufacture and use is understood to be leakage of sulfur hexafluoride (SF_6), which is used in the electrical transmission and distribution industry.

It is assumed, in the absence of more recent national data, that emissions from these sources in 2017-18 and 2018-19 were the same as in 2016-17. Small changes can be expected to be made in the 2017-18 NGGI, which is likely to be published before the 2019-20 ACT GGI is prepared.

2.2.7 Agriculture

The agriculture emissions source category covers a diverse range of activities, all of which are related to agricultural production. By far the largest sources, in Australia and in the ACT, are activities related to livestock rearing, most importantly enteric fermentation in ruminant animals, including both cattle and sheep. Given the limited scope of agricultural activities in the ACT, these are a very small source of emissions. The share of national emissions allocated to the ACT by the Commonwealth Department of the Environment and Energy for 2016-17 is used for ACT emissions in the year, and the two subsequent years, including 2018-19.

2.2.8 Land Use, Land-Use Change and Forestry (LULUCF)

This source category also covers a wide range of processes and activities, all of which affect the fluxes of CO_2 between the atmosphere and biomass, mainly in trees, but also including shrubs, grasses and soil carbon. As with agriculture, Commonwealth estimates of ACT emissions are used in the ACT emissions inventory. The 2016-17 NGGI contains a recalculation of ACT emissions from this source category which is very large relative to total ACT emissions.

Unlike the recalculation of industrial process emissions, this recalculation affects only the ACT (and NSW). The recalculation affects the source sub-category Forest Land and arises from removals of CO_2 from the atmosphere by growing trees. The Department of the Environment and Energy has advised that the reason for this change is that access to satellite imagery data at higher resolution, not previously available, has revealed that part of the border between the ACT and NSW had been incorrectly located on the maps used in the emissions estimation model. Correcting this error resulted in an appreciable area of managed plantation forest being re-allocated from NSW to the ACT.

The recalculation affects all past years, as well as 2016-17. For example, the previous estimate for 2015-16 was for CO_2 net removals from the atmosphere of 6.5 kt. The recalculated figure is removals of 230 kt CO_2. Most importantly, the recalculation extends right back to 1990, which has particularly important implications for the ACT.

The Commonwealth has been compiling and publishing state/territory allocations of national greenhouse gas emission since 2008, and since 2015 these have extended back from the most recent year to 1990. For the ACT, estimates of both current year and 1990 net emissions have varied somewhat over the years since 2015, but only in a narrow band of less than ±50 kt CO_2, i.e. between net annual emissions and net annual removals of less than 50 kt CO_2. It is for this reason that estimated LULUCF emissions have remained set at zero in the formal 1990 base ACT emissions inventory. It is important to note that this inventory was established many years before the Commonwealth published state and territory emissions estimates for LULUCF. However, the 2017 LULUCF recalculation by the Commonwealth has amended 1990 ACT net emissions to net removals of 257 kt CO2. The effect of this change on assessment of the ACT's progress towards its 2020 emissions reduction target is discussed in Chapter 4.

Given the large size of the recalculated (negative) emissions from this source, it would be ideal if there were some means of extrapolating the data up to 2016-17 forward to 2018-19. Unlike synthetic gas emissions, however, LULUCF emissions do not follow a predictable year to year trend, because they are affected by a range of largely unpredictable factors, such as weather (e.g. rainfall and temperature), human activities (plantation timber harvesting, land clearing), and bushfires. It is therefore provisionally assumed, as with the several other sectors previously discussed, that emissions are the same in 2017-18 and 2018-19 as they were in 2016-17. That said, since the large recalculation made for 2016-17 has been caused by correcting an error in locating the ACT border, it is unlikely that another large change will occur in the 2017-18 NGGI.

It is important to note that two different accounting approaches are used to estimate emissions from the LULUCF sector. Until the 2015 national inventory, the Department of the Environment and Energy used Kyoto Protocol accounting to report LULUCF emissions in its annual *State and Territory*

Greenhouse Gas Inventories reports. However, in the 2016 national inventory it switched to UNFCCC accounting, which, for the ACT, results in slightly smaller estimates of net removals. State and Territory data available through the on-line *Australian Greenhouse Emissions Information System* (AGEIS) continues to be based on Kyoto accounting. However, the Department of the Environment and Energy has provided informal advice that it is in the process of switching AGEIS over to UNFCCC accounting and expects to use UNFCCC accounting in its inventory work from now on. The figures for the ACT quoted above are taken from Table 11, in Appendix 4, of the *State and Territory Greenhouse Gas Inventories 2017* report.

2.2.9 Waste

Waste related emissions fall into two separate sub-categories – methane emissions from the breakdown of organic materials in solid waste sent to landfill, and emissions of methane and/or nitrous oxide from the treatment of wastewater.

In the ACT, solid waste emissions arise from the currently active Mugga Lane landfill site and the relatively recently closed Belconnen site. Because the breakdown of organic solid wastes in landfill sites is very slow, most of the methane emissions arise from legacy waste, sent to landfill as long as thirty or forty years ago. ACT emissions are estimated using the Solid Waste Calculator workbook, built by the Clean Energy Regulator for use as a reporting tool by organisations required to report under the National Greenhouse and Energy Reporting Scheme. Several years ago, the model was populated with annual disposal data provided by ACT NoWaste, extending back to 1975. Estimates for each successive year are made by adding, at the appropriate place in the model, the reported volume of waste sent to landfill during the year, and the volume of waste captured and either used in engines to generate electricity, or flared, as reported by Energy Developments Ltd.

For a given waste stream composition, landfill gas emissions, net of capture and flaring, are a complex function of several factors, which include the quantity of waste to landfill during the inventory year, the year on year profile of quantities sent in past years, extending back as much as two or more decades, the volume of gas captured and flared during the inventory year, and the year on year profile of capture and flaring in past years. The overall outcome is that estimated emissions have varied somewhat from year to year. In the last two years they have been lower than in any of the previous five years, in part because a larger volume of gas has been captured and flared.

Emissions of nitrous oxide arising from the denitrification stage of the aerobic digestion treatment process used at the Lower Molonglo Wastewater Quality Control Centre are provided each year by Icon Water. These emissions, which are very small, are a function of the quantity of organic solids processed each year. Consequently, they usually show a gradual year on year increase and that is the case for 2018-19, with estimated emissions 0.24 kt CO2-e, equivalent to about 2 per cent, higher in 2018-19 than in 2017-18.

Waste is a relatively small but consistent source of emissions in the ACT, which in the last few years has varied up and down from year to year, but has not shown any consistent trend, either up or down. It is currently, however, markedly lower than it was prior to the recent period. Emissions from wastewater treatment are largely proportional to population.

2.3 Recalculations

As described above, the 2018-19 inventory includes major changes to the LULUCF sector, and a significant change to the Industrial Processes sector, both of which affect previously published estimates of emissions in earlier years.

The change in LULUCF emissions, since it is caused by correcting an error in the assumed location of the ACT border, will affect emissions in all earlier years. Similarly, the changes made to the Commonwealth's modelling of synthetic gas emissions will also affect all earlier years. Table 8 shows the effect of these changes in estimated emissions in the two sectors concerned, and the resultant change in total ACT emissions in all years back to 2012-13.

Table 8: Effect of recalculating estimated emissions in years from 2012-13 to 2017-18

Year	Previous/ recalculated	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Industrial processes	Recalculated	170.7	186.8	204.6	208.4	215.9	231.6
	Previous	198.3	210.9	221.8	228.1	246.6	259.5
LULUCF	Recalculated	-94	-39	-79	-220	-231	-231
	Previous	-6.4	-7.9	-7.9	-9.8	-9.8	-9.8
Total ACT emissions	Recalculated	3,926	3,884	3,980	3,857	3,678	3,128
	Previous	4,042	3,935	4,063	4,102	3,928	3,368

Another very much smaller change was the adoption of an improved method for calculating emissions of methane and nitrous oxide from internal combustion engines used in road vehicles, by using emission factors applicable to the vintage of the vehicle fleet. For light vehicles this means using lower emission factors for methane, but higher emission factors for nitrous oxide in post 2004 vehicles. For heavy road vehicles the change meant distinguishing between Euro I, Euro II and Euro IV compliant vehicles. Making these changes required preparing estimates of the distance travelled, and hence fuel consumed, by vehicles of different vintages, which was done using the most recent ABS Survey of Motor Vehicle Use, Cat. No. 9208.0, and ACT vehicle registration data. The net effect of the improved methodology was a small increase in estimated emissions of about 4 kt CO2-e, equivalent to roughly 0.12 per cent of total 2018-19 emissions. Recalculations of estimates of earlier years have not be undertaken, both because the effect would be so negligible and because additional year by year data on the vintage by vehicle type of the entire registered ACT motor vehicle fleet would be required for each recalculated year.

3. Changes in Greenhouse Gas Emissions between 2017-18 and 2018-19

3.1 Electricity

Emissions from electricity decreased from 1,468 kt CO_2-e in 2017-18 to 863 kt CO_2-e in 2018-19, a decrease of 41 per cent. The main factor producing this outcome was the continuing large increase in the volume of electricity acquired by the ACT government from contracted renewable generators. Contracts with two large windfarms, Sapphire 1 and Hornsdale 2, each contracted at a capacity of 100 MW, started in the earlier part of 2018-19. As a result, the share of total electrical energy flow within the ACT being supplied, in contractual terms, by large windfarms, increased from 23 per cent to 43 per cent.

Other factors affecting Scope 2 emissions from electricity generation were as follows:

1. Total electricity supplied through the meter to consumers increased by 1.2 per cent.
2. The emissions intensity of the remaining 31 per cent of electricity, sourced from fossil fuel generators supplying the NSW region pool, decreased slightly, because of a modest decrease in the volume of more emissions intensive electricity imported into the NSW NEM region from Victoria.

The total share of renewable electricity in supply to the ACT increased from 47 per cent to 69 per cent.

3.2 Natural gas

Emissions from natural gas decreased for the second successive year, by a modest 1.1 per cent between 2017-18 and 2018-19. As noted in previous inventory reports, lack of more detailed data on gas consumption by different customer categories makes it very difficult to determine the reasons for reduced consumption. We suggest that Evoenergy be asked to use individual meter data to estimate annual gas consumption separated, as a minimum, into residential and non-residential consumers. In addition, irrespective of whether or not disaggregated consumption data are available, it might be useful to calculate heating degree days at the Canberra Airport weather station over, say, the past eight years, to see if this correlates to any extent with variations in gas consumption.

3.3 Transport

Emissions from fuels used for transport continued to increase, as they have for many years past. The increase was just under 19 kt CO_2-e, equivalent to 1.6 per cent, which was a slightly slower increase than in 2017-18. Consumption of petrol (auto gasoline, including E10) was almost unchanged, while consumption of diesel increased by almost 6 per cent, an almost identical increase to that seen between 2016-17 and 2017-18. The discussion in section 2.2.3 suggested that lower fleet average efficiency, because of larger average vehicle size, may be contributing to this trend. That conclusion is not inconsistent with data for the ACT in the *ABS Survey of Motor Vehicle Usage*, though the small sample size (a couple of hundred only on a pro-rata basis) means that most

individual data points have relatively high standard errors, making it difficult to draw firm conclusions. It is, however, fairly unequivocal that the average annual distance travelled per registered vehicle has been decreasing for both passenger and light commercial vehicles, which are the two main vehicle types. It may be useful to consider policies which encourage the use of vehicles which are smaller, as well as more inherently efficient.

3.4 Fugitive energy

In 2017-18 an Unaccounted for Gas (UAG) factor of 1.96% was used to calculate gas leakage. As earlier explained, for the 2018-19 inventory it was decided it would be better to revert to the previous methodology, which gave a slightly higher value of 2.10% for UAG in 2018-19. The outcome was a small increase in fugitive emissions. In future years, however, unless there is some reason to change the methodology again, fugitive emissions will tend to be proportional to gas consumption, though this relationship will not be a rigid one, as some other factor may affect losses from the gas distribution system.

3.5 Waste

After decreasing in 2017-18, emissions from solid waste disposal in 2018-19 were about 25 per cent higher than in 2017-18, mainly because of a decrease in the volume of landfill gas emissions from legacy waste captured and burnt at the Mugga Lane and Belconnen landfill sites, as advised by Energy Developments Ltd. This followed a significant increase in the previous year as well. The volume of landfill gas captured and flared mainly affects the estimates of emissions from legacy waste. For the second year in succession, there was a substantial increase in the volume of commercial and residential waste going to landfill, as advised by ACT NoWaste. Changes in current volumes of waste to landfill will affect emissions in future years.

There was almost no change in the quantities of nitrous oxide arising from the denitrification process at the Lower Molonglo Water Quality Control Centre (LMWQCC).

3.6 Industrial Processes

As noted earlier, the National Greenhouse Gas Inventory (NGGI) for 2016-17 reported a significant decrease in the estimate of emissions from synthetic fluorinated hydrocarbon gases in the ACT in that and several previous years. This was a marked change from the previous year, when a significant increase was reported. Consequently, as previously mentioned, the estimate of ACT emissions using the linear extrapolation methodology showed a significant decrease in previously estimated emissions for each of the past three years. Emissions are continuing to increase, but more slowly than had previously been estimated.

3.7 Agriculture and Land Use, Land-Use Change and Forestry (LULUCF)

The very large change in estimated CO_2 removals in the forest management sector of LULUCF, compared with the emission reported in last year's inventory, is discussed above. It of course remains to be seen what the trend in actual emissions in 2018-19, compared with its actual

preceding year, will be. As also previously mentioned, many, if not most of the factors affecting year to year levels of LULUCF emissions are largely uncontrollable, and many are also unknowable.

4. Progress towards the 2020 emission reduction target

Some years ago, the ACT set a legislated target for 2020 emissions, equal to a reduction of 40 per cent below emissions in 1990. Translating the 40 per cent reduction into a level of emissions to be achieved in 2020 requires that the level of emissions in 1990 be established. An inventory of emissions for all sources other than LULUCF was undertaken around the same time as the target was legislated, using methodologies broadly the same as those used today, though with less detailed activity data for some sectors. For the LULUCF sector, however, there was no data at all, because it was not until 2015 that the Commonwealth first published estimates of state and territory LULUCF emissions for years prior to 2008. Discussions with ACT government agencies established that LULUCF sector emissions sources and sinks which are very important elsewhere in Australia, such as land clearing and reforestation on private land, are of minor importance in the ACT. The major source of LULUCF CO_2 emissions and removals in the ACT is management of public lands and, in particular, the ACT plantation forest estate. ACT Forests were unable at that time to provide comprehensive and detailed records of the kind now available from satellite data (and what records that did exist were all destroyed in the 2003 bushfire). The agency advised that it managed the forest estate over the long term on a sustainable basis, and for that reason, net LULUCF emissions were set at zero, i.e., with CO_2 removals from tree growth equal to CO_2 emissions from harvesting, thinning and other processes affecting the forest estate.

This approach resulted in an estimate of 3,197 kt CO_2-e for total ACT emissions in 1990, inclusive of LULUCF. A reduction of 40 per cent below this level would correspond to emissions in 2020 of 1,918 kt CO_2-e. This is the target figure which has been used until this year.

However, the major recalculation undertaken for the 2019 NGGI, described above, extended to all prior years, back to 1990. Given the recent availability of these figures (only available since 2015, as mentioned above), up to now they have not been adopted, and a figure of 3,197 kt CO_2-e in 1989-90 has been retained. (Parenthetically, it can be noted that failure to change the 1989-90 estimate before now is probably fortunate, given the size of the recalculation and the fact that its source in a misinterpretation of satellite data is not one which is likely to recur.) ACT LULUCF emissions in 1989-90 are now, in the most recent (2017) NGGI estimated to have been -257 kt CO_2, that is net removals of CO_2 from the atmosphere of 257 kt.

Adding the new estimates for emissions in 1990 from LULUCF, compared with the previous values of zero, results in a revised level of 1989-90 baseline emission of 2,940 kt CO_2-e. This makes the 40 per cent reduction target 1,764 kt CO_2-e. On this basis, emissions in 2018-19 were 13 per cent lower than in 1989-90, rather than 20 per cent lower, which would have been the case using the previous estimate of LULUCF emissions in 1989-90.

5. Trends for the future

Table 9 shows emissions in 1989-90, and in each year since 2012-13, both inclusive and exclusive of net LULUCF emissions. As previously noted, most emissions and removals from LULUCF activities in the ACT arise from the management of forested lands. This sector is in most years a significant source of CO_2 removals through natural forest growth, on which government policies have very little impact over the short to medium term. In many other parts of Australia, these removals are offset by emissions from land clearing, but that is negligible in the ACT. It follows that the trend in emissions influenced by government policies and programs is better demonstrated by the trend in emissions exclusive of LULUCF. This trend is shown in Figure 2.

In 2018-19 emissions inclusive of LULUCF were lower than in 1989-90 by 14 per cent. Emissions exclusive of LULUCF were 13 per cent lower. The corresponding changes for total Australian emissions between 1989-90 and 2016-17 (the most recent national inventory year) are also a reduction of 13 per cent if LULUCF is included, but national emissions exclusive of LULUCF have increased by 32 per cent. The ACT has therefore been much more successful than Australia, taken as a whole, at reducing its emissions from non-LULUCF activities.

The reason for the close similarity between the reduction in ACT emissions since 1989-90, with and without LULUCF, is that the ACT's net LULUCF emissions, i.e. removals, as calculated and reported by the Commonwealth, are much the same in the most recent year as in 1989-90. However, for years in which LULUCF sector removals are lower, as might occur, for example, in a drought year, because of reduced tree growth, the LULUCF sector would make a smaller contribution to offsetting continuing emissions from other sectors, and the year on year reduction in total emissions achieved would be reduced. This can be seen in Figure 2, for the years prior to 2016-17, when the level of CO_2 removals was lower, meaning that emissions excluding LULUCF fell more slowly. Since then, with the same LULUCF value assumed for each of the three most recent years, the estimated change of emissions has of course been identical in the two cases. It is important to bear in mind that, when the 2017-18 NGGI is published next year, it may well show reduced removals in the ACT, and hence a smaller reduction in total net emissions, compared with 2018-19.

It can be calculated from the estimated emissions for 2018-19, as presented in this report, that if electricity emissions fall to zero in 2019-20, and all other emissions, including LULUCF net removals, remain the same, then the ACT will just reach its overall emission reduction target of 40 percent below 1990 levels. However, as noted above, changes in LULUCF, such as reductions in the rate of growth of managed plantation forests because of drought, could put achieving the target at risk, as could continuing increases in transport emissions.

Figure 2: Emission trends in the ACT since 2012-13, with and without LULUCF emissions

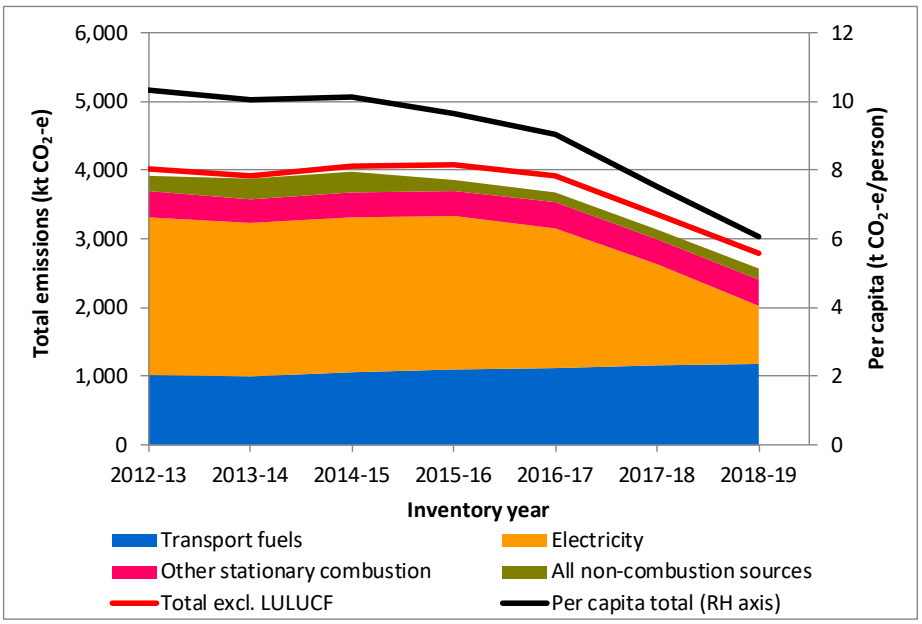


Table 9: Total and per capita greenhouse gas emissions, with and without LULUCF

Year	1989-90	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Emissions (kt CO_2-e)	2,940	3,926	3,884	3,980	3,857	3,678	3,129	2,568
Change relative to 1990 base		34%	32%	35%	31%	25%	6%	-13%
Absolute change from 1990 base (kt CO_2-e)		986	944	1,040	917	738	188	-372
Emissions per capita (t CO_2-e)	10.53	10.34	10.05	10.15	9.67	9.03	7.52	6.07
Change relative to 1990 base		-2%	-4%	-4%	-8%	-14%	-29%	-42%
Emissions excl. LULUCF (kt CO_2-e)	3,197	4,020	3,923	4,059	4,077	3,909	3,360	2,799
Change relative to 1990 base		26%	23%	27%	28%	22%	5%	-12%
Absolute change from 1990 base (kt CO_2-e)		824	727	862	880	713	163	-398
Emissions per capita excl. LULUCF (t CO_2-e)	11.45	10.59	10.16	10.35	10.22	9.59	8.08	6.61
Change relative to 1990 base		-8%	-11%	-10%	-11%	-16%	-29%	-42%

Figures 1 and 2 show, and the preceding discussion explains, that as electricity emissions continue to fall, the ACT's emissions profile will be dominated by emissions from road transport and consumption of natural gas. On present trends, there is a serious risk that, once electricity emissions reach zero, ACT emissions could start to increase again, albeit at a much lower level. At that point, road transport and natural gas emissions would almost certainly account for over 80 per cent of total ACT emissions, exclusive of LULUCF. The ACT's Climate Change Strategy 2019-2025 clearly acknowledges the challenges which transport and gas combustion emissions present. Continuing the decline in ACT emissions will depend on rapid implementation of the array of measures set out in the Strategy.

Most of the remaining non-LULUCF emissions will be coming from Industrial processes, meaning almost entirely HFC gases, and Waste. Unfortunately, the ACT has very few options to reduce emissions from either of these sources. Reduction in HFC emissions will be controlled by the Commonwealth government's HFC phase-down schedule, which extends out until 2036. Waste emissions are largely a function of the volume of legacy biodegradable waste, now buried in landfills. Landfill gas recovery currently reduces combined emissions from Mugga Lane and West Belconnen by about two thirds, meaning that there is very little prospect of further emissions reduction for that source. Diverting more biodegradable waste away from landfill will be very important for reducing landfill gas emissions in the medium to long term but have only a limited effect in the near term.