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ACT Greenhouse Gas Inventory for 2019-20

Prepared for:	**Environment, Planning and Sustainable Development Directorate, ACT Government**
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1. Total ACT Greenhouse Gas Emissions

The estimate of total greenhouse gas emissions for the ACT in 2019-20 is 1,684 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 2019-20 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 2017-18) of emissions arising from 'Product used as substitutes for Ozone Depleting Substances' (which means synthetic refrigerant gases) and emissions/removals arising from the Land Use, Land Use Change, and Forestry (LULUCF) sector. 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.

A further major change has been made through the use of offsets available from Large Renewable Energy Certificates (RECs) earned by the ACT from its contracts with wind and solar wind farms.

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	2019-20
Current	4,143	4,120	4,204	4,158	4,169	3,967	3,924	1,684
Previous	3,926	3,884	3,980	3,857	3,678	3,129	2,568	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. A rising population has also contributed to reducing emissions per capita.

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	2019-20
Population (at 31 December)	379,812	386,318	391,981	398,874	407,489	415,874	423,229	427,419
Emissions (kt CO_2-e)	4,143	4,120	4,204	4,158	4,169	3,967	3,924	1,684
Emissions per capita (t CO_2-e)	10.91	10.66	10.73	10.42	10.23	9.54	9.27	3.94
Previous emissions per capita (t CO_2-e)	10.34	10.05	10.15	9.67	9.03	7.52	6.07	

2. Emissions by Source

2.1 Overview of sectoral totals 2019-20

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 borders of the ACT.

Table 3 provides a sectoral breakdown of emissions in 2019-20, and Figure 1 shows the trend in emissions since 2012-13. However, the size of the negative emissions from LULUCF 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.

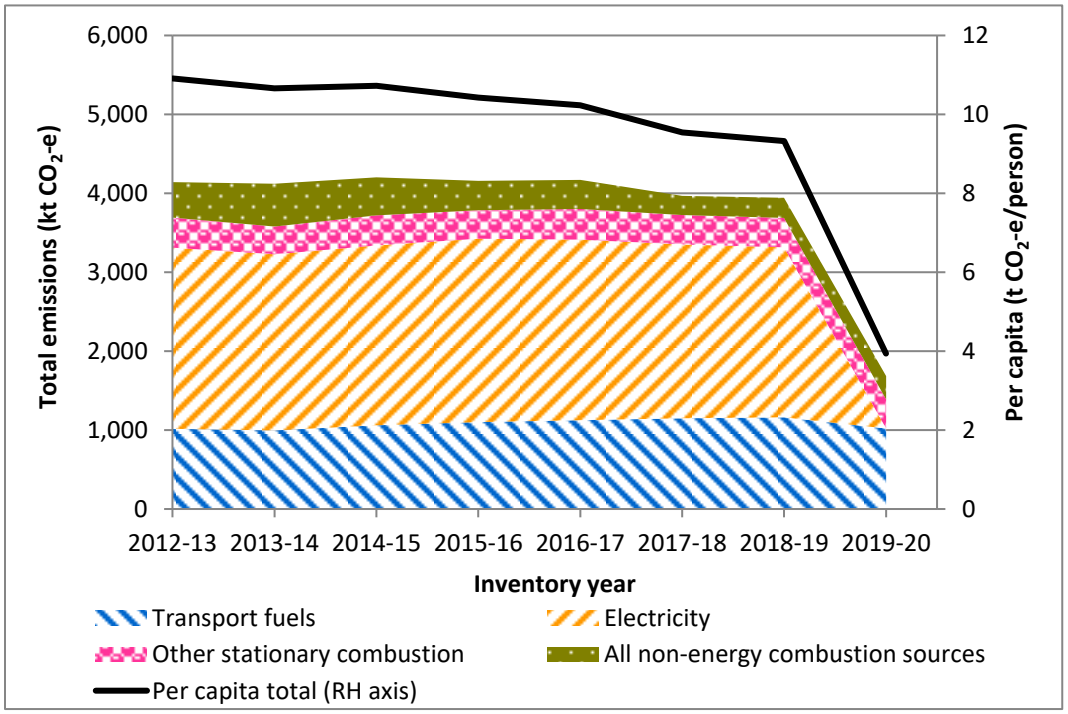
Until 2019-20, stationary energy consumption was the largest source of emissions in the ACT, as it had always been. However, with the achievement of zero emission electricity supply this year, through the ACT government policy to purchase renewable electricity from wind and solar farms, the share of stationary energy consumption is much smaller. Stationary energy use was responsible for emissions equal to 21 per cent of total emissions excluding LULUCF in 2019-20.

Table 3: ACT Greenhouse emissions 2019-20 by source

Emissions Source	Emissions in 2019-20, kilo tonnes CO_2-e	Share of total emissions including LULUCF	Share of total emissions excluding LULUCF
Electricity	0	0%	0%
Other stationary energy	367.7	21.8%	20.6%
Transport	1,018.5	60.5%	57.2%
Fugitive emissions	41.1	2.40%	2.3%
Industrial processes	213.5	12.7%	12.0%
Agriculture	21.7	1.3%	1.2%
Waste	118.2	7.0%	6.6%
Sub Total (excl. LULUCF)	1,781	105.8%	100.0%
LULUCF	-97	-5.8%	NA
TOTAL including LULUCF	1,684	100.0%	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 now the most important source of ACT emissions, responsible for 57.2 per cent of total emissions, excluding LULUCF. Most transport emissions come 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 80 per cent of emissions excluding LULUCF in 2019-20. However, as previously explained, emissions from these sources are offset by CO_2 removals in the LULUCF sector, equal to 5.5 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 2019-20

Emissions Source	Emissions (kt CO_2-e)		
Energy			1,427.3
A. Fuel combustion activities		1,386.2	
Electricity	0		
Natural gas	362.3		
Transport fuels	1,018.5		
Other use of petroleum fuels	5.0		
Fuel wood	0.3		
B. Fugitive emissions from fuels		41.1	
Natural gas leakage	41.1		
Industrial processes			213.5
Consumption of halocarbons and SF6	202.7		
Other activities	10.7		
Agriculture			21.7
Enteric fermentation	18.2		
Manure management	1.0		
Agricultural soils	2.4		
Land use, land-use change and forestry			-97
Forest Land	-106		
Cropland	0		
Grassland	-12		
Wetland	8		
Settlements	1		
Harvested wood products	12		
Waste			118
Solid Waste Disposal on Land	106		
Wastewater Handling	12.0		
Total emissions including net CO_2-e from LULUCF			1,684
Total emissions excluding net CO_2-e from LULUCF			1,781

2.2.2 Electricity

With the continued growth in supply from contracted wind and solar farms, the fall in emissions from electricity generation continued in 2019-20. Pursuant to a change in methodology introduced earlier this year, residual emissions were offset by allocating Renewable Energy Certificates (RECs), acquired by the ACT under these contracts, against residual fossil fuel generation in 2019-20. This offset increased renewable supply in 2019-20 to 100 per cent of total electricity supplied to consumers, and the emissions intensity of electricity to zero. This was offset by reducing the volume of renewable generation deemed to be supplied in the years 2014-15 to 2017-18, with a consequent modest increase in electricity sector emissions in each of those years. The resultant year by year average emissions intensity and renewable shares are shown in Table 5.

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 offset, in market terms, by Renewable Energy Certificates acquired by the ACT through its contracts with 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	2019-20
Emissions intensity (t CO_2-e/MWh)	0.763	0.753	0.764	0.772	0.750	0.734	0.713	0.000
Renewable share	17.3%	18.6%	17.8%	17.0%	19.7%	20.71%	23.4%	100.0%

2.2.3 Other stationary energy

Use of natural gas accounts for almost 99 per cent of other stationary combustion emissions. The remaining small fraction 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. However, the figure for non-auto LPG is an under-estimate of

the true total, because only one of the three main suppliers operating in the ACT provided annual sales data. Reported emissions for 2019-20 cannot therefore be directly compared with those for the previous year, for which the corresponding data, although not complete, were less incomplete. Data for fuel oil represent only emissions from consumption by Icon Water; as in previous years, it is not known whether any other organisations in the ACT use fuel oil. Icon Water has advised that during the year it converted its furnace operations from use of fuel oil to use of natural gas; fuel oil emissions were therefore lower than in 2018-19, and, presumably, will be zero in 2020-21. All that said, it is clear that emissions from stationary combustion of petroleum products are so small as to have no material effect of total emissions.

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	2019-20
Total consumption (TJ)	7,343	6,837	7,297	6,945	7,515	7,226	7,137	7,032
Consumption per capita (GJ)	19.33	17.70	18.62	17.41	18.44	17.38	16.86	16.61

Table 6 shows trends in consumption of natural gas, in both total and per capita terms. Both total consumption and per capita consumption have gradually declined over the past three years. The overall decline since 2016-17 has been 6.4 per cent in total and 9.9 per cent per capita. The great majority of natural gas consumed in the ACT is used for space heating in residential and commercial/institutional buildings, and much of the remainder is used for water heating. The gradual decline in natural gas consumption is being driven by gradually increasing energy efficiency of all types of building, coupled with the shift from gas to reverse cycle air conditioning for space heating.

Finally, it should be noted that data on natural gas supply and consumption provided by EvoEnergy cover the whole of their distribution area, which includes Queanbeyan and Bungendore, as well as the ACT. EvoEnergy have never been able to advise exactly how much of the total volume supplied to consumers through their distribution network is delivered to addresses in the ACT, and have always advised us of 90 per cent as a “rule of thumb” approximation.

2.2.4 Transport

As was the case last year, transport is the largest single source of ACT emissions, and the overwhelming majority of these emissions arise from road transport. Petroleum products, mainly petrol 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, though apparently gradually decreasing, source of fuel for the ACTION bus fleet. The inventory includes negligible emissions from consumption of fuels for other transport modes. Rail locomotives ceased re-fuelling in

Canberra some years ago. Until the last few years, jet aircraft also did not re-fuel in Canberra. However, it is understood that there is now a re-fuelling facility for large commercial aircraft at Canberra Airport, but information on the volume of fuel supplied through the facility is currently not available. There is a very small consumption of avgas by light aircraft. Transport fuel-related 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 three rows show reported annual consumption of the various fuels, expressed in the units in which they are normally sold, i.e. volumetric units for petroleum products and energy content units for gas. The most distinctive feature is the sharp fall in annual consumption in 2019-20, compared with 2018-19, equal to 12% for petrol (mogas) and 8% for diesel. The cause of these falls in consumption is of course the impact on road transport, particularly the use of private cars, of the COVID pandemic. National data on retail sales of petrol, as published in *Australia Petroleum Statistics*, show a similar, though smaller, reduction of 10%. The fourth row of the table uses the respective calorific values (energy per unit volume) to convert consumption to energy units. The corresponding reduction in total greenhouse gas emissions, including emissions of methane and nitrous oxide from combustion, is 10.7%. Prior to 2020, combined total annual consumption of petrol and diesel in the ACT had been steadily growing, while per capita consumption had been roughly constant since 2015-16. It seems likely that once the economic slow-down ends, road transport emissions will start growing again, unless there is a decisive change in trend, such as an accelerated uptake of electric vehicles.

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	2019-20
Petrol. E10, E85, LPG (ML)	352.6	332.8	326.6	331.8	330.4	328.5	318.0	279.5
Diesel (ML)	85.1	91.4	117.2	128.3	137.1	146.3	151.2	138.6
CNG used by ACTION (GJ)			102.0	95.0	82.1	85.3	80.6	74.5
Total consumption (PJ)	15.27	14.84	15.63	16.23	16.53	16.82	16.70	14.91
Total emissions (kt CO_2-e)	1,017	994	1,058	1,102	1,124	1,150	1,140	1,019
Consumption per capita (GJ)	40.2	38.4	39.9	40.7	40.6	40.4	39.5	34.9

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. In previous years, much of this consumption was supplied

through petroleum distributors, all located adjacent to the railway in Fyshwick. All but one of these distributors has now closed following the decision of the major national petroleum companies to cease transporting bulk petroleum products to Canberra by rail. Most bulk customers are now supplied direct from Sydney, using road tankers. Some of this bulk 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 the two gas transmission pipelines to which the local gas distribution network is connected, 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. It should be noted that gas supply and consumption data provided by EvoEnergy showed that in 2019-20 UAG was 2.6% of gas supplied, representing a significant increase on the level of 2.1% reported in 2018-19 and in several years prior to that.

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. Leakage of these gases from operating equipment is by far the largest source of HFC emissions in Australia. Another much smaller source is use of HFCs as propellants in equipment such as fire extinguishers and metered dose inhalers. As the formal name for this emission source indicates, these gases were initially introduced as replacements for the ozone depleting HCFC refrigerants, pursuant to the Montreal

Protocol. Although HCFCs are also greenhouse gases, because their phase-out was covered by the Montreal Protocol, they were not covered under the UNFCCC, but HFCs are of course covered. As equipment which used HCFCs was gradually replaced by equipment using HFCs, leakage of HFCs, and consequent greenhouse gas emissions, increased year by year. The Commonwealth Department of Industry, Science, Energy and Resources (and its predecessor Departments) developed an HFC stock model which it has used for some years to estimate the volume of leakage for each successive National Greenhouse Gas Inventory (NGGI). It also established a method, based on relevant characteristics, for allocating national emissions to states and territories. The allocation to the ACT, as published in association with the National Greenhouse Gas Inventory, is used as the basis for calculating emissions for the ACT greenhouse gas inventory.

The nature of the replacement of HCFCs with HFCs meant that from 1999-2000 to about 2014-15 emissions grew at an almost exactly linear fashion, making it feasible to use extrapolation of a linear regression to estimate ACT emissions in the relevant inventory year, i.e. two years ahead of the NGGI figure for ACT emissions.

Australia is a party to the Kigali Amendment to the Montreal Protocol. This Amendment is an international agreement to gradually phase out the use of HFCs as a refrigerant. The principal means by which Australia is implementing the Kigali Accord is legislation which progressively reduces the volume of HFCs allowed to be imported each year, starting on 1 January 2018. Since HFCs are not manufactured in Australia, this will make it difficult for local manufacturers of refrigeration and air conditioning equipment to continue making equipment which requires HFC refrigerants. It will also make it progressively more difficult, and presumably more expensive, to replenish leakage from previously installed HFC-using equipment. Finally, while importation of pre-charged HFC-equipment is not prohibited, international equipment manufacturers are redesigning equipment to progressively replace HFC with other refrigerants which are not greenhouse gases. The obvious intent of these measures to is to first stabilise, and then progressively reduce the stock of HFCs in equipment in Australia, and thus first stabilise, and then reduce annual emissions.

In the 2016-17 NGGI, estimates of emissions from HFCs 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)

This national recalculation resulted in a reduction of previously estimated ACT emissions for 2017-18 and earlier years to be revised down by between 10 and 20 per cent (varying somewhat between years). In the 2017-18 NGGI there was no significant further revision. However, there was almost no increase in total emissions. This meant that there were now four successive years, from 2014-15 to 2017-18, with almost no increase in HFC emissions, and that the overall trend of annual emissions since 1999-2000 exhibited a clear break in trend in 2014-15. Consequently, it was decided to calculate a second regression, covering those four years, and to use the extrapolation of that line to estimate ACT emissions in 2018-19 and 2019-20. The overall effect of this recalculation has been

a downward revision, equal to about 10 per cent, of previously estimated ACT emissions for 2017-18 and 2018-19, together with a much lower than expected figure for 2019-20.

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 2018-19 and 2019-20 were the same as in 2017-18.

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 2017-18 is used for ACT emissions in the year, and the two subsequent years, including 2019-20.

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

This source category 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. As was the case in 2019 (with respect to the 2016-17 NGGI), the 2017-18 NGGI again contains a recalculation of ACT emissions from this source category which is relatively large relative to total ACT emissions. However, unlike 2019, the most recent recalculation has the effect of increasing, not decreasing, total ACT emissions in 2017-18, and also in 1989-90.

Volume 2 of the *National Inventory Report 2018* includes a very extensive account for the many improvements which were made in the estimation of national LULUCF emissions in 2017-18. By far the largest source of LULUCF emissions and/or removals of CO_2 in the ACT is the Forest land source category. In the 2017 NGGI this source was estimated to remove 247 kt CO_2-e in the ACT during 2016-17, and this figure was used also for the 2017-18 and 2018-19 ACT emission inventories. The corresponding estimate in the 2018 NGGI is removals of just 17 kt CO_2-e in 2016-17, and removals of 106 kt CO_2-e in 2017-18. This is the figure now being used for the 2019-20 ACT emissions inventory.

It appears that the main source of these changes is two methodological changes. One relates to managed plantation forests, and is described in the *National Inventory Report 2018* in the following terms:

> "Building on last year's enhancement to Tier 3, Approach 3 spatial simulation by incorporating satellite-imagery based forest cover change data to more accurately model the timing of harvesting and replanting."

The other methodological change relates to native forests which are not harvested for timber, (referred to as "Other native forests"); the changes consist of including in the inventory for the first time the effects of forest fires and subsequent vegetation regrowth; the changes are described as follows.

> "Spatial simulation of fires using FullCAM; carbon stock changes from the combustion and subsequent recovery of live biomass from wildfires." (p. 350)

Note that theses recalculations affect all past years, as well as 2017-18, and extend right back to 1990, for which LULUCF emissions change from -257 kt CO_2-e, as calculated for the 2019 ACT GGI, to -127 kt CO_2-e, used in this Inventory.

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 now 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 landfill gas captured and either used in engines to generate electricity, or flared. In past years, this information has been provided by Energy Developments Ltd., the company which owned and operated the electricity generation facilities at the two sites. During 2019-20 the two plants were sold to another company, called LGI (Landfill Gas Industries). Data on gas captured and burnt over whole year has therefore been provided by both companies.

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 2019-20 emissions from landfill gas were significantly higher than in the preceding years, because the volume of gas captured and flared was lower.

Data on 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 2019-20, with estimated emissions 0.4 kt CO_2-e, equivalent to just over 3 per cent, higher in 2019-20 than in 2018-19.

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 2016-17. Emissions from wastewater treatment are largely proportional to population.

2.3 Recalculations

As described above, the 2019-20 inventory includes changes affecting the LULUCF and Industrial Processes sectors, both of which affect previously published estimates of emissions in years prior to 2019-20. The Industrial Process changes affect all years back to 2006 and the LULUCF changes affect all years back to the 1990 base year. 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. The electricity emissions offsets, described in Section 2.2.2 above, affect reported emissions in every year since 2014-15, with the exception of 2018-19.

The overall effect, as can be seen, is to significantly increase estimated emissions in every past year since 2012-13.

Table 8: Effect of recalculating estimated emissions in years from 2012-13 to 2018-19 (kt CO_2-e)

Year		2012-13	2013–14	2014-15	2015-16	2016–17	2017–18	2018-19
Industrial processes	Recalculated	170.6	186.7	204.5	208.4	206.6	212.3	212.3
	Previous	170.7	186.8	204.6	208.4	215.9	231.6	242.4
LULUCF	Recalculated	122	196	109	-9	2	-97	-97
	Previous	-94	-39	-79	-220	-231	-231	-231
Electricity	Recalculated	2,295	2,231	2,284	2,323	2,288	2,201	2,153
	Previous	2,295	2,231	2,248	2,235	2,023	1,475	883
Total ACT emissions	Recalculated	4,143	4,120	4,204	4,158	4,169	3,967	3,924
	Previous	3,926	3,884	3,980	3,857	3,678	3,129	2,568

3. Changes in Greenhouse Gas Emissions between 2018-19 and 2019-20

3.1 Electricity

The new methodology for calculating emissions attributable to electricity supplied in the ACT resulted in a very large decrease in emissions, from 2,153 kt CO_2-e in 2018-19 to zero in 2019-20. By voluntarily surrendering some of the stock of Renewable Energy Certificates acquired under its contracts with wind and solar farms, starting in 2014-15, the ACT has been able to offset all emissions related to its consumption of electricity , and will be able to do so for every year into the future, provided that expiring contracts with renewable generators are either rolled over or replaced as required.

Scope 2 emissions from electricity generation were also affected, to a much lesser extent, by a 1.1 per cent drop in electricity supplied through the meter to consumers, attributable to a combination of:

1. more efficient use of electricity,
2. growth in behind the meter consumption form rooftop solar on both residential and commercial buildings, partly offset by,
3. a gradual shift from gas to reverse cycle air conditioning for residential space heating, and a small uptake of electric vehicles.

Nationally, 2020 is the year in which the Large Renewable Energy Target (LRET) scheme reaches its target level, which is 33,000 GWh of accredited renewable generation. Because, the scheme works of calendar rather than financial years, that will mean a small increase in the ACT's share of the national target in 2020-21, and thereafter no further increase in the LRET component of ACT renewable electricity supply.

3.2 Natural gas

Emissions from natural gas decreased for the third successive year, by 1.5 per cent between 2018-19 and 2019-20, which is larger than the 1.2 per cent increase in 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 with any certainty the reasons for reduced consumption, although, as noted above, increased building energy efficiency, combined with a shift from gas to electricity as the energy source for heating, are likely to be the most important causes. There is no sign in the annual consumption data of any significant effect of the economic slow-down on gas consumption, and in this respect the ACT does not differ from the rest of Australia. The ACT is second only to Victoria in the share of residential space heating supplied by gas consumption. Given that the main economic impact fell during the winter months, it is possible that increased use of gas for residential space heating was offset by reduced consumption by commercial gas consumers.

Unfortunately, the inability of EvoEnergy to provide data which separates residential from other consumption means that it is not possible to test this hypothesis.

As in the 2018-19 inventory report, 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 decreased in 2019-20, almost certainly because of the impact of the pandemic on economic activity and personal travel. It seems certain that this effect will also be seen in 2020-21. These unique circumstances mean that the experience of 2019-20 provides no useful guidance as to the longer term trend in ACT transport emissions. That said, if the dip in road transport fuel consumption is put aside, the data in Table 7 show that both consumption of road transport fuels and the resultant greenhouse gas emissions have increased in every year since 2013-14, while fuel consumption per capita has been effectively constant since 2014-15. This is a marked contrast with stationary energy, where total quantities of both electricity and gas supplied to consumers have been falling steadily for several years; per capita consumption has been falling correspondingly faster.

3.4 Fugitive energy

As previously noted, Unaccounted for Gas was higher in 2019-20 than in 2018-19, but it is not possible to say why this was so. That said, gas lost in distribution can be expected to remain a small fraction of total gas consumption and, if and when natural gas consumption starts to fall on a more consistent basis, fugitive emissions form gas distribution will also fall.

3.5 Waste

Emissions from solid waste disposal in 2019-20, which increased in 2018-19, increased again in 2019-20, by nearly 40 per cent. The detailed model used to estimate landfill gas emissions calculates that gross emissions from the two main landfill sites, Mugga Lane and West Belconnen (which has been closed as an operating waste disposal site but continues to emit methane) increased by about 2 per cent in 2019-20, reflecting rapid growth in disposal of putrescible waste several decades ago. However, the main reason for the higher net emissions in 2019-20 was the much lower volume of landfill gas captured and flared during the year. During the year, Landfill Gas Industries (LGI) replaced Energy Development Limited (EDL) as owner and operator of the electricity generators and flares at the two sites, but there is nothing in the data to suggest that this change in ownership had any impact of the volume of gas captured. For the third successive year, the total volume of waste

going to landfill, as advised by ACT NoWaste, also increased. All else being equal, this will increase the volume of landfill gas released several decades from now.

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

The reasons for the significant reduction, compared with previous emissions inventories, in estimated emissions from use of HFC gases have been described above in considerable detail. It follows from that explanation that, over the next few years, emissions from this source can be expected to show very little growth and, subsequently, to start a gradual decline.

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

2019-20 is the second successive inventory year for which large change in estimated CO_2 emissions and removals in the forest management sector of LULUCF have been reported. It is important to appreciate that the two year lag in the national inventory, compared with the ACT inventory, means that, should yet more major changes (improvements) in the national methodology be made, emissions for 2018-19 and 2019-20, as set out in this report, may change again. In addition, the observation made in the 2018-19 inventory report remains relevant and important: 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 emission reduction targets

Some years ago, the ACT set a legislated target for 2020 emissions, equal to a reduction of 40 per cent below emissions in 1990. The *ACT Greenhouse Gas Emissions Inventory* report for 2019 explains how the 1990 base value was revised, to take account of significant retrospective changes in national methodology for the Agriculture and LULUCF sectors. As explained above, further significant changes to the LULUCF methodology were introduced in the National Inventory for 2018. Incorporating the effect of these changes into the 1990 Base level emissions for the ACT makes the 1990 Base emissions 3,077 kt CO_2-e, which is an increase on the previous level of 2,940 kt CO_2-e.

The ACT has two other targets. One is 100 per cent renewable electricity supply by 2020 which, as explained above, has been achieved. The other concerns per capita emissions, which are required to have reached a maximum level in 2012-13. Table 9 shows progress since 2012-13 towards each of these three targets. It can be seen that all three have been achieved.

Table 9: Progress towards emissions reduction and renewable electricity supply targets

Year	1989-90	2012-13	2013–14	2014-15	2015-16	2016–17	2017–18	2018-19	2019-20
Total emissions (kt CO_2-e)	3,077	4,143	4,120	4,204	4,158	4,169	3,967	3,945	1,684
Change from 1989-90	0%	35%	34%	37%	35%	36%	29%	28%	-45%
Emissions per capita (kt CO_2-e)	11.0	10.9	10.7	10.7	10.4	10.2	9.5	9.3	3.9
Renewable share of electricity supply	NA	17.3%	18.6%	17.8%	17.0%	19.7%	20.7%	23.4%	100.0%

5. Trends for the future

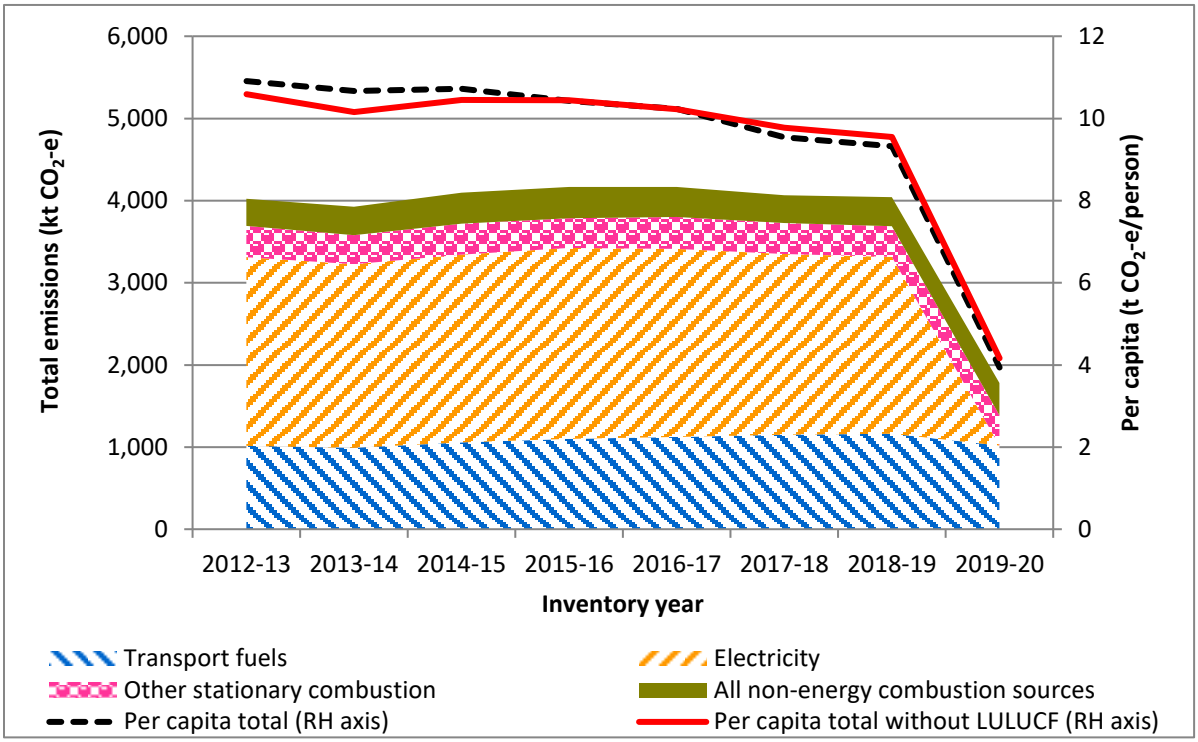
Table 9 shows that the ACT has succeeded in achieving its target of reducing its emissions to 40 per cent below the 1990 level by 2020. This was achieved by an explicit strategy of reducing emissions from the supply of electricity to zero. This result is that in 2019-20 transport accounted for 60 per cent of total Territory emissions and natural gas use for a further 22 per cent, which rises to 24 per cent if fugitive emissions from gas leakage from the distribution system is included.

The compilation of the 2019-20 emissions inventory included a large change in estimated emissions from the LULUCF sector, affecting all past years, including the 1990 base year. The 2018-19 inventory included an even larger change in LULUCF estimates, also affecting all years. These changes arise form improvements in the level of detail available in satellite data and improvements in the complex analytical processes which link satellite observations to measured vegetation density on the ground. These estimates involve complex science, undertaken by a team of university, CSIRO and other government scientists; it is by no means impossible that there will be further changes before the 2020-21 ACT inventory. These changes, which are entirely outside the ACT's control, make it very difficult if not impossible, given their size, to establish a consistent trend from year to year in ACT total emissions. Table 10 shows emissions in 1989-90, and in each year since 2012-13, both inclusive and exclusive of net LULUCF emissions. As noted in the ACT emissions inventory report for 2018-19, 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.

Table 10: Total greenhouse gas emissions, with and without LULUCF

Year	1989-90	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Including LULUCF									
Emissions (kt CO_2-e)	3,077	4,143	4,120	4,204	4,158	4,169	3,967	3,946	1,684
Change relative to 1990 base	0%	35%	34%	37%	35%	36%	29%	28%	-45%
Absolute change from 1990 base (kt CO_2-e)	0	1,066	1,043	1,127	1,081	1,092	890	868	-1,393
Excluding LULUCF									
Emissions (kt CO_2-e)	3,204	4,022	3,924	4,096	4,167	4,167	4,064	4,042	1,781
Change relative to 1990 base	0%	26%	22%	28%	30%	30%	27%	26%	-44%
Absolute change from 1990 base (kt CO_2-e)	0	817	720	891	962	963	860	838	-1,424

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



The ACT now has a further target of reducing its emissions to net zero by 2045, with interim targets for 2025, 2030 and 2040. To achieve any of these targets it will be essential to substantially reduce emissions from both transport and natural gas use. Note also, as previously explained, that estimates of emissions from both of these sources are incomplete because of lack of data relating to some smaller, but non-negligible sources; these sources include use of LPG and diesel for non-transport activities, some use of diesel in freight and bus transport, and jet fuel supplied at Canberra Airport.

Most of the remaining non-LULUCF emissions will be coming from Industrial processes, meaning almost entirely HFC gases, and Waste. As previously explained, from now on emissions from HFC gases can be expected to gradually decrease each year, driven by national policy over which the ACT has effectively no control. Waste emissions are largely a function of the volume of legacy biodegradable waste, now buried in landfills. Landfill gas recovery currently significantly reduces combined emissions from Mugga Lane and West Belconnen, though the volume of gas captured in 2019-20 was significantly less than in recent years. This suggests that by about two thirds, meaning that there may be little prospect of further emissions reduction from legacy waste. Diverting more biodegradable food waste and green 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.

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