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Annual Greenhouse Gas Emissions in Canterbury, 2018 and 2021

Prepared for the Canterbury Regional Council by:
Enviser Limited and
Emission Impossible Limited

Contents

Executive Summary

This report summarises the results of a greenhouse gas emissions inventory for Canterbury, for 2018 and 2021. This is the first such inventory made for Canterbury and has been undertaken in general accordance with the Global Protocol for Community-Scale Greenhouse Gas Inventories. The inventory is reported to BASIC+ level and includes Scope 1,2 and 3 emissions.

The overall gross GHG emissions in Canterbury are shown in Figure ES1 and were:

13,006 kilotonnes (thousand tonnes) carbon dioxide equivalent (CO_2e) per year in 2018 and

13,176 kilotonnes CO_2e per year in 2021.

Regional per capita emissions were:

20.9 tonnes per person in 2018 and

20.3 tonnes per person in 2021.

The Agriculture, Forestry and Other Land Use (AFOLU) sector is the dominant contributor of emissions. The transport and energy sectors are secondary sources, with discharges from the industrial process and product use (IPPU) and waste sectors being relatively small.

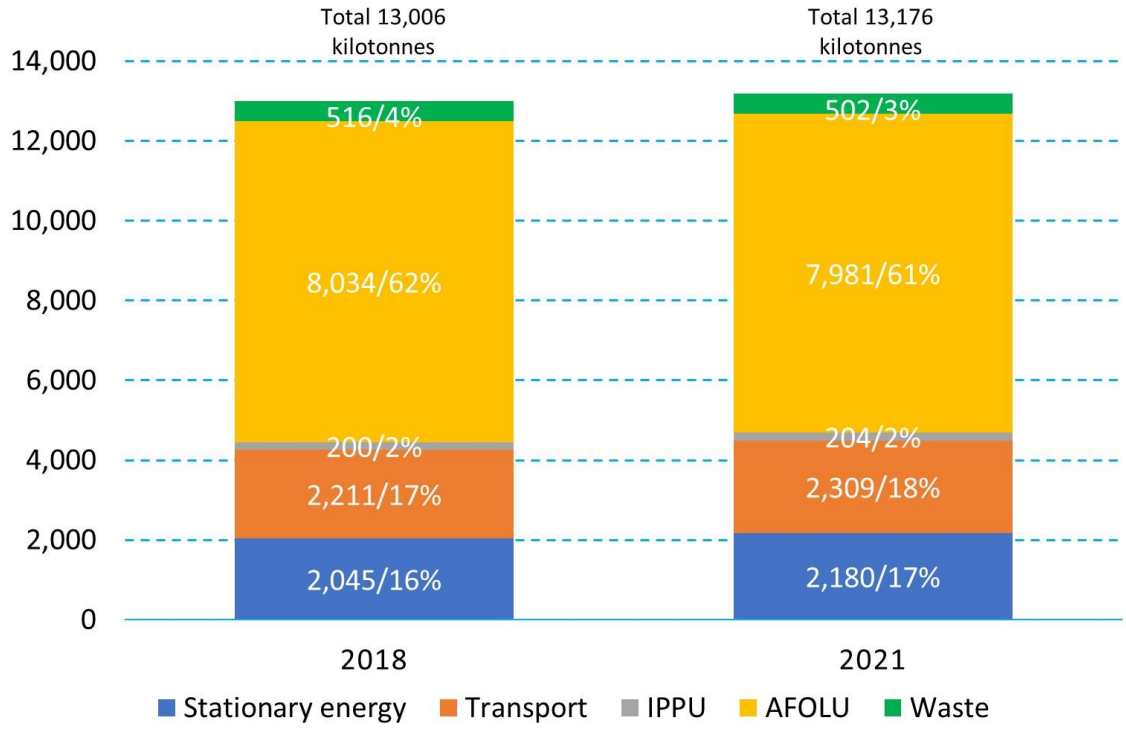


Figure ES1: Regional emissions by sector (kilotonnes CO_2e per year)

Stationary energy sources and transport are the dominant emitters of carbon dioxide (CO_2) but discharge negligible quantities of the other gases. IPPU emissions are dominated by fluorinated (F) gases but this sector's absolute contribution to the regional total CO_2e emission is not substantial. Methane (CH_4) from AFOLU sources is the largest single GHG emission, and the AFOLU sector also contributes a substantial quantity of nitrous oxide (N_2O). The waste sector makes a relatively small contribution dominated by methane.

The contributions of types of gases to the individual sectors in 2021 are shown in Figure ES2 (there is very little difference between the two reporting years).

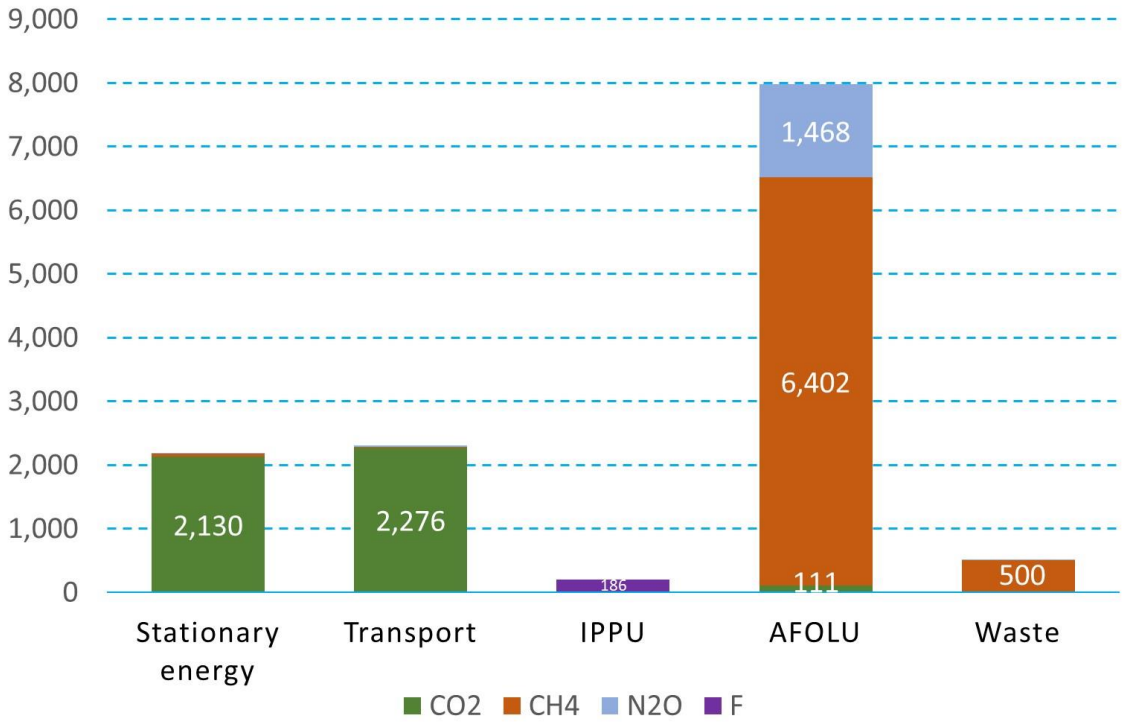


Figure ES2: Gas species emitted by sector, 2021 (kilotonnes CO_2e per year). The numbers on the chart refer to the main gases visible, and are not totals for the sector

Within the sectors:

In the stationary energy sector, emissions are predominantly from the provision of public electricity and heat, and industrial energy production.

In the transport sector, emissions from on road vehicles are the primary source, with a secondary contribution from off road sources.

In the IPPU sector (which excludes combustion), emissions are dominated by the refrigerants sub sector, the discharges from which are mainly F gases.

In the agriculture, forestry and other land use sector, CH_4 emissions from livestock are the dominant source.

In the waste sector, solid waste disposal is the main source, consisting primarily of CH_4.

Within the territorial local authorities:

The emissions from the territorial local authorities (TLAs) in 2021 were distributed as shown in Figure ES2. Other than in the Christchurch City Council (CCC) area, emissions are dominated by those from the AFOLU sector with secondary peaks from transport and/or stationary energy. In the CCC area, emissions from stationary energy are the largest single contributor with a substantial secondary contribution from transport sources.

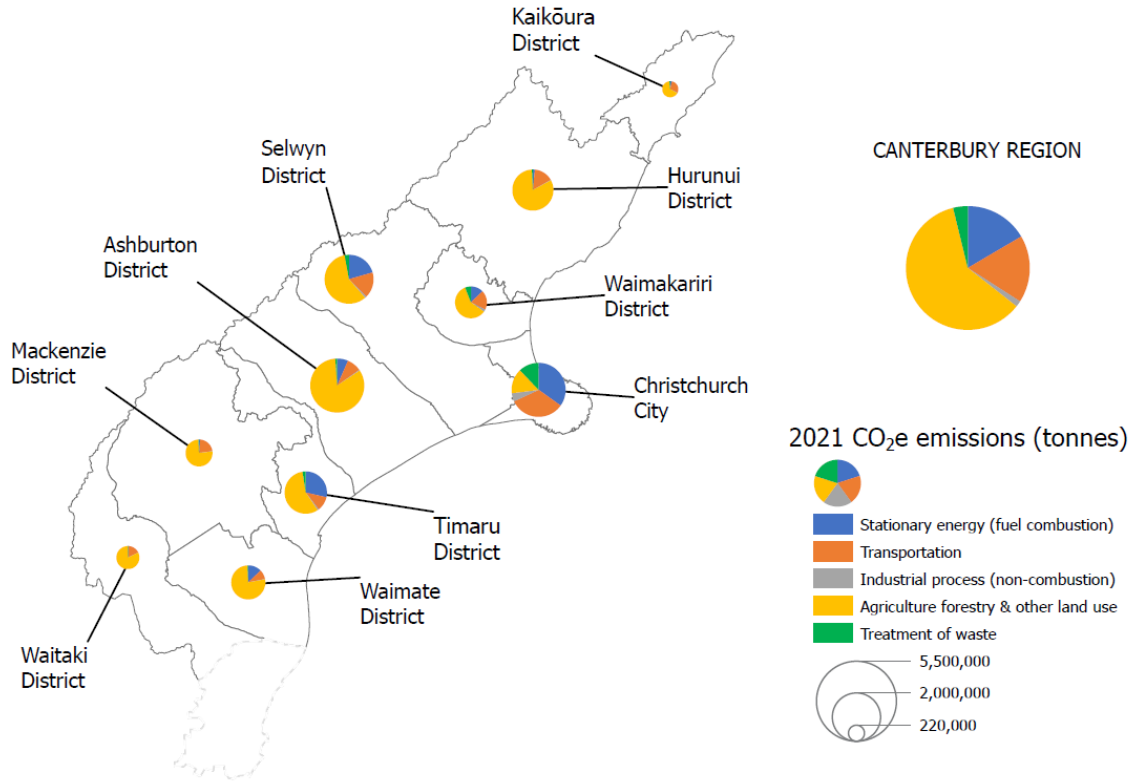


Figure ES3: Sector emissions by TLA, 2021 (tonnes CO_2e per year)

The types of gases emitted, by TLA, are shown in Figure ES4. The more rural TLAs with no large urban centres and/or industrial sources generally have higher proportions of CH_4 and N_2O to as opposed to CO_2 which is released in higher amounts from urban activities and dominates emissions from Christchurch City. F gases are more noticeable in districts that have larger amounts of industry.

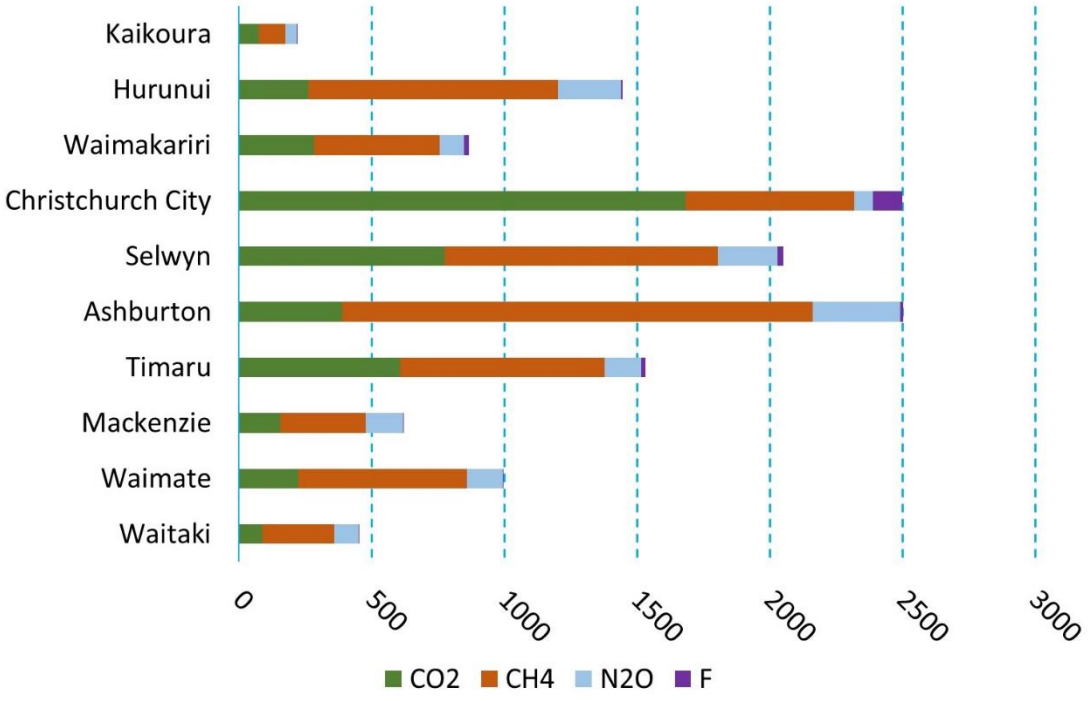


Figure ES4: Emissions of gas species by TLA, 2021 (kilotonnes CO_2e per year)

1 Introduction

1.1 Background

Environment Canterbury (ECan) engaged Emission Impossible Limited (EIL) to undertake an inventory of greenhouse gas (GHG) emissions in the Canterbury region. EIL gathered and collated the emissions data, M&P Consulting Limited made geospatial analyses, and Enviser Limited has been engaged to prepare this report of the key results based on that work. Emissions are reported for the calendar years 2018 and 2021.

This is the first regional GHG inventory prepared for Canterbury. Until now, the only regional GHG estimates have been those produced annually by Statistics NZ (Stats NZ). The Stats NZ inventories make regional GHG emission estimates, based on the United Nations System of Environmental-Economic Accounting (SEEA) framework. However, these are high-level estimates, and they are not likely to be accurate or detailed enough for tracking the impact of government policy targeting specific sources on emissions in our region.

The Climate Change Response (Zero Carbon) Amendment Act 2019 sets the following GHG emissions reduction targets in section 5Q:

> *(a)*
> *net accounting emissions of greenhouse gases in a calendar year, other than biogenic methane, are zero by the calendar year beginning on 1 January 2050 and for each subsequent calendar year; and*
> *(b)*
> *emissions of biogenic methane in a calendar year—*
> *(i)*
> *are 10% less than 2017 emissions by the calendar year beginning on 1 January 2030; and*
> *(ii)*
> *are 24% to 47% less than 2017 emissions by the calendar year beginning on 1 January 2050 and for each subsequent calendar year.*

To manage these reductions, the Government has implemented a multi-year "budget" approach with emission limits set for 2022-2025, 2026-2030 and 2031-2035. ECan is currently developing a Climate Change Action Plan which may include emissions targets and pathways for Canterbury. This inventory will inform this plan, as well as supporting future work such as tracking temporal changes in emissions, assessing mitigation options and evaluating the effect of central and local government policies on regional emissions.

1.2 Relationship to other reporting

This inventory included sources of the following local air pollutants (i.e. pollutants that have effects primarily at local scales):

- Particulate matter with a diameter less than ten microns[1] (PM_{10})
- Particulate matter with a diameter less than 2.5 microns ($PM_{2.5}$)
- Sulphur dioxide (SO_2)
- Oxides of nitrogen (NO_x)
- Carbon monoxide (CO)

[1] One micron is 1/1000 of a millimetre

- Volatile organic compounds (VOCs) and
- Ammonia (NH_3).

A separate inventory report will be prepared for these pollutants, with a focus on urban areas where concentrations are typically elevated. More detailed emissions data at a greater source and spatial resolution are available on request.

1.3 Content of this report

This report:

1. Provides an overview of the method used to calculate GHG emissions (section 2).
2. Presents the total GHG emissions in Canterbury for 2018 and 2021, with emissions broken down by the five sectors, and by the four main greenhouse gas species (section 3.1).
3. Describes, for each sector, the specific methods used to calculate GHG emissions from each sub sector and the amounts of GHGs discharged by each sub sector (section 3.2).
4. Summarises the emissions from TLAs overall, per capita, by sector and by gas type (section 4).

2 Overview of method

This inventory has been undertaken in general accordance with the Global Protocol for Community-Scale Greenhouse Gas Inventories (the GPC - World Resources Institute et al 2021). The GPC offers cities and local governments a robust, transparent and globally-accepted framework to consistently identify, calculate and report on city greenhouse gases. This includes emissions released within city boundaries as well as those occurring outside them as a result of activities taking place within the city. Its use enables consistency with other inventories already undertaken in New Zealand and overseas.

A wide variety of methods can be used to meet GPC requirements. This makes it difficult to directly compare one inventory with another and it is important that readers keep these methodological differences in mind when assessing the results.

The general GPC approach involves:

- Defining the inventory boundary and emissions sources (section 2.1) and
- Categorising the emissions (see section 2.2)

This inventory is of gross GHG emissions and does not account for CO_2 storage in vegetation. Owing to data limitations, some of the sources that make up the five sectors were not able to be estimated for this inventory and the likely impacts of these omissions are discussed in section 2.3.The specific activity data sources and emission factors used to estimate the sector emissions are described in more detail in section 3.2.

This inventory is based on the best information available. However, it is planned to review and update the inventory to include more up-to-date information and methods. New inventories will re-calculate emissions for previous years to ensure comparability between years and supersede older inventories.

2.1 Inventory boundary

In GPC terminology, the "inventory boundary" identifies the geographic area covered by the inventory, the gases assessed, emission sources and inventory time span.

2.1.1 Geographic area

The overall inventory boundary is the entire area in which emissions are generated that can be accounted for by the inventory. In this case, this includes emissions from electricity generated outside the Canterbury Region, but used within it. This is discussed in more detail later in this report.

The geographic boundary is that of the discrete area for which emissions are being inventoried (Figure 1). In this case, the geographic boundary is the Canterbury Region. However, data have been collected at a sufficiently high resolution that analyses can be made at a number of different scales, and for this report, analyses have been made both of discharges across the entire region, and those from individual territorial local authorities (TLAs).

2.1.2 Gases

This inventory quantifies the following discharges, consistent with the GPC:

- Carbon dioxide (CO_2)
- Methane (NH_4)
- Nitrous oxide (N_2O) and
- Fluorinated gases (F gases).

These gases vary in their global warming potential (GWP), and to account for their impact on global warming over a 100 year period the emissions are reported corrected to equivalent amounts of CO_2 (CO_2e) as discussed later in this report.

2.1.3 Biogenic CO_2 emissions

The GPC defines biogenic CO_2 emissions as:

"…those that result from the combustion of biomass materials that store and sequester CO_2 , including materials used to make biofuels (e.g. trees, crops, vegetable oils, or animal fats)" (GPC p 43).

The GPC specifies that the discharges of CO_2 from the combustion or decomposition of materials of biogenic origin are to be reported separately rather than included in the totals. In this case, biogenic emissions are from the industrial, commercial and residential combustion of wood products for energy, and the burning of rural garden waste.

A discussion and summary table of biogenic emissions is provided in Appendix A.

2.1.4 Emission sources

The GPC covers the following source sectors:

1. Stationary energy.
2. Transportation.
3. Industrial production and product use (IPPU).
4. Agriculture, forestry and other land use (AFOLU).
5. Waste.

2.1.5 Time span

This inventory reports on annual emissions for the calendar years 2018 and 2021.

2.2 Estimating and reporting emissions

"Scope" has a specific meaning in the GPC, referring to where emissions occur in relation to the geographic area. The GPC identifies three scopes:

1. Scope 1 emissions - those generated and discharged entirely within the geographic boundary.
2. Scope 2 emissions - those resulting from the use of grid-supplied electricity, heat, steam and/or cooling within the geographic boundary.
3. Scope 3 emissions - those occurring outside a geographic boundary but resulting from activities taking place within it (for example, waste sent out of a city, or transmission and distribution losses from electricity supplied by the grid but used within the city).

The scopes are shown below in Figure 1.

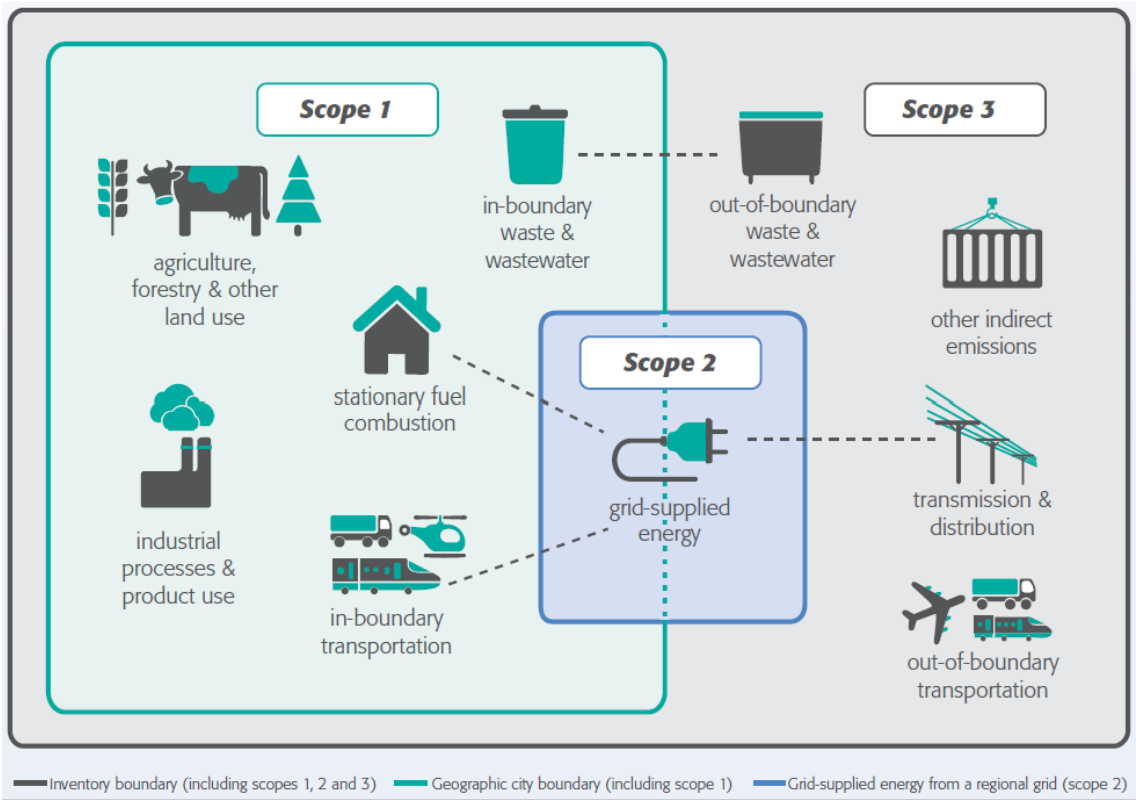


Figure 1 Inventory boundaries and scopes (Source: GPC Figure 1)

This inventory includes emissions from all three scopes. However, Scope 3 emissions have been calculated only for grid-supplied electricity losses.

2.2.1 Sector and sub-sector emissions by scope

This inventory reports emissions from the sectors and sub sectors summarised in Table 1.

Table 1: Sectors and sub sectors reported in this study, and their applicable scopes

Sector	Sub sector	Scope
Stationary energy	Public electricity/heat generated within the geographic boundary	1
	The use of public electricity generated outside the geographic boundary	2
	Transmission and distribution losses from electricity generated outside the geographic boundary but used within it	3
	Manufacturing (iron and steel, non ferrous metals, chemicals, pulp/paper/print, food and beverages, "other industry").	1
	Commercial/institutional	1
	Residential home heating	1
	Other residential uses	1
Transport	Aviation	1
	Road transport	1
	Rail	1
	Shipping	1
	Offroad uses (vehicles and equipment)	1
IPPU	Industrial non-combustion processes	1
	Products use (lubricants, aerosols, medical products, refrigerants)	1
AFOLU	Livestock including animal housings	1
	Crops	1
	Fertiliser use	1
Waste	Solid waste disposal	1
	Waste incineration	1
	Rural burning	1
	Wastewater treatment and disposal	1

2.2.2 BASIC and BASIC+ reporting

The GPC allows for reporting at one of two levels: BASIC or BASIC+. BASIC reporting includes scope 1 and 2 energy and transport emissions, and scope 1 and 3 waste emissions. BASIC+ includes those sources and also includes IPPU, AFOLU and transboundary transport emissions.

This inventory largely fulfils the requirements of BASIC+, with the exception of transboundary transport as discussed later in this report.

2.2.3 Emissions calculation

Three main methods have been used to calculate GHG emissions for this inventory.

In most cases, activity data were gathered for use parameters such as amount of fuel burnt. The activity data figures were then multiplied by emission factors (for example kg of CO_2 per litre of fuel) to estimate total emissions for the sub sector.

For on road vehicle emissions, emissions data were obtained directly from mapping and modelling tools held by Waka Kotahi New Zealand Transport Agency.

In some cases, regional emissions estimates expressed in CO_2e were obtained from Stats NZ Tatauranga Aotearoa (Stats NZ). These were used directly and broken down as required to provide estimates on a TLA basis.

The specific methods and data sources used for each sub sector are discussed in detail in section 3.2, with the data sources summarised in Appendix B.

2.2.4 Global warming potentials

For ease of comparison, the non-CO_2 gases - CH_4 and N_2O – are converted to CO_2e using global warming potentials (GWPs). GWP values are published by the IPCC in their assessment reports. Most New Zealand GHG reporting still uses GWP values from the 4th assessment report (AR4) but some reporting is undertaken using the values from the 5th assessment report (AR5). The GWP values are shown in Table 2 below.

Table 2: GWP conversion values (multipliers to obtain CO_2e from gas emissions)

	AR4	**AR5**
CH_4	298	265
N_2O	25	28

This report has been prepared using AR5 values, unless identified otherwise (this is mainly in relation to data provided by Stats NZ, which are already converted to CO_2e using AR4. The values are all for a 100 year period.

As per the GPC, the discharges of biogenic CO_2 are not included in the GHG emission totals but are reported separately, in Appendix A.

2.3 Omissions

It is intended that where possible the following omissions will be included in the next inventory update.

2.3.1 Land use, land use change and forestry

These sub-sectors could not be calculated for this inventory as it was not possible to source suitable data within the project timeframe (particularly with regard to forest areas and types, harvested areas and changes to forested land).

The main potential effect of this omission relates to the offsetting effect that would be gained from carbon retention in forested areas which would lessen the overall AFOLU footprint. This means that the reported figures in this study are gross, rather than net values.

2.3.2 Industrial permitted activities

Industrial sources were identified and located using ECan consent records, consistent with ECan's methods for undertaking other emission inventories. Smaller industrial activities which are permitted by plan rules are largely unrecorded and not monitored, although some have been identified in a previous study and are included here.

The actual emissions from industrial sources are therefore likely to be slightly higher than those reported here, but the permitted sources are small and their discharges are unlikely to be substantial.

2.3.3 Aircraft and shipping cruise emissions

These have not been calculated as it was not possible to source suitable data, particularly at the TLA level, within the project timeframe.

Aviation and shipping emissions are both likely to be higher than reported here, but the magnitude of this cannot be calculated robustly.

2.3.4 Scope 3 waste

It is possible that some waste material from outside the region is disposed of in Canterbury's landfills.

Data are not readily available. However, the amount is unlikely to be substantial.

3 Region-wide emissions

3.1 Overall emissions

3.1.1 Canterbury total and per capita emissions

The overall gross GHG emissions in Canterbury were:

13,006 kilotonnes (thousand tonnes) CO_2e per year in 2018 and

13,176 kilotonnes CO_2e per year in 2021.

Total emissions increased between 2018 and 2021 by 70 kilotonnes, (1% of the 2018 value).

Per capita emissions were:

- 20.9 tonnes per person in 2018 and
- 20.3 tonnes per person in 2021.

Per capita emissions decreased by 0.62 tonnes per person (-3% of the 2018 value).

The total population of Canterbury was:

- 622,800 in 2018 and
- 650,200 in 2021.

This is an increase of 27,400 people, (4.4% of the 2018 value).

3.1.2 Sector contributions to Canterbury total

Region wide sector totals are shown in Figure 2 below. A full data table is provided in Appendix C, Table C1.

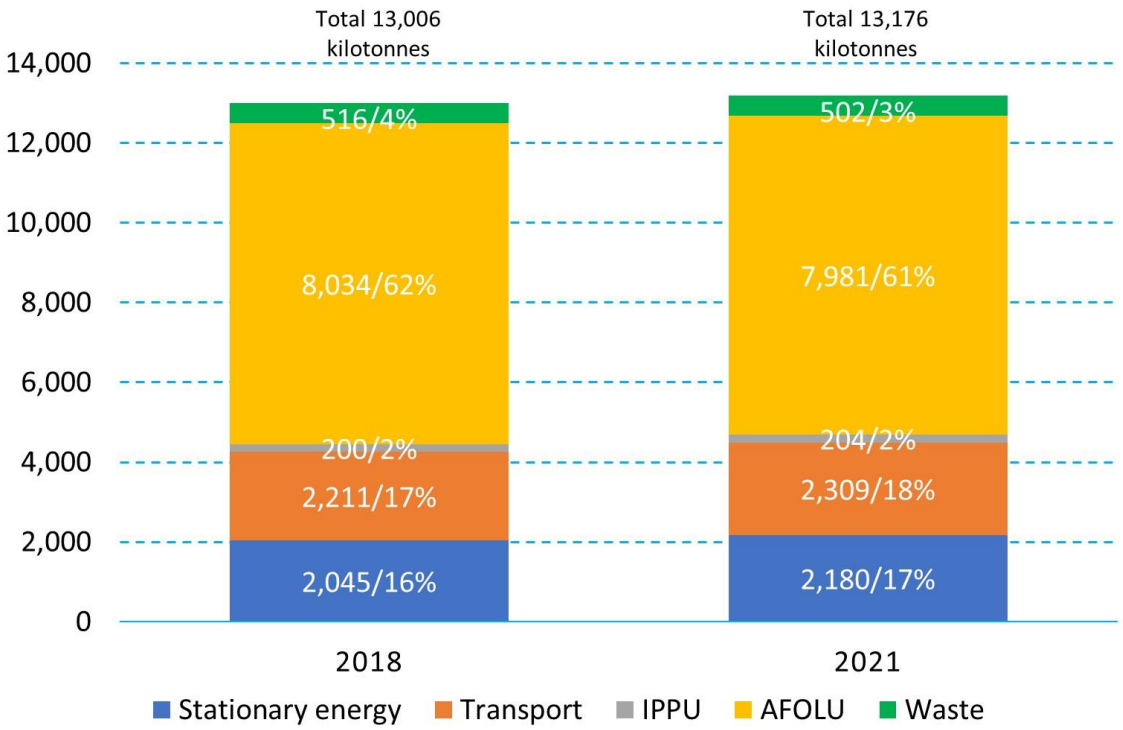


Figure 2: Regional emissions by sector (kilotonnes CO_2e per year)

The AFOLU sector is the dominant contributor of emissions. The transport and energy sectors are the secondary source, with discharges from the industrial process and waste sectors being relatively small contributions.

3.1.3 GHG species contributions to sector totals

Figure 3 below shows the contribution of each gas species or species group, by sector, for 2021, in kilotonnes of CO_2e per year. No figure is provided for 2018 as the distribution is almost identical. Numerical values are only provided for the most substantial contributors.

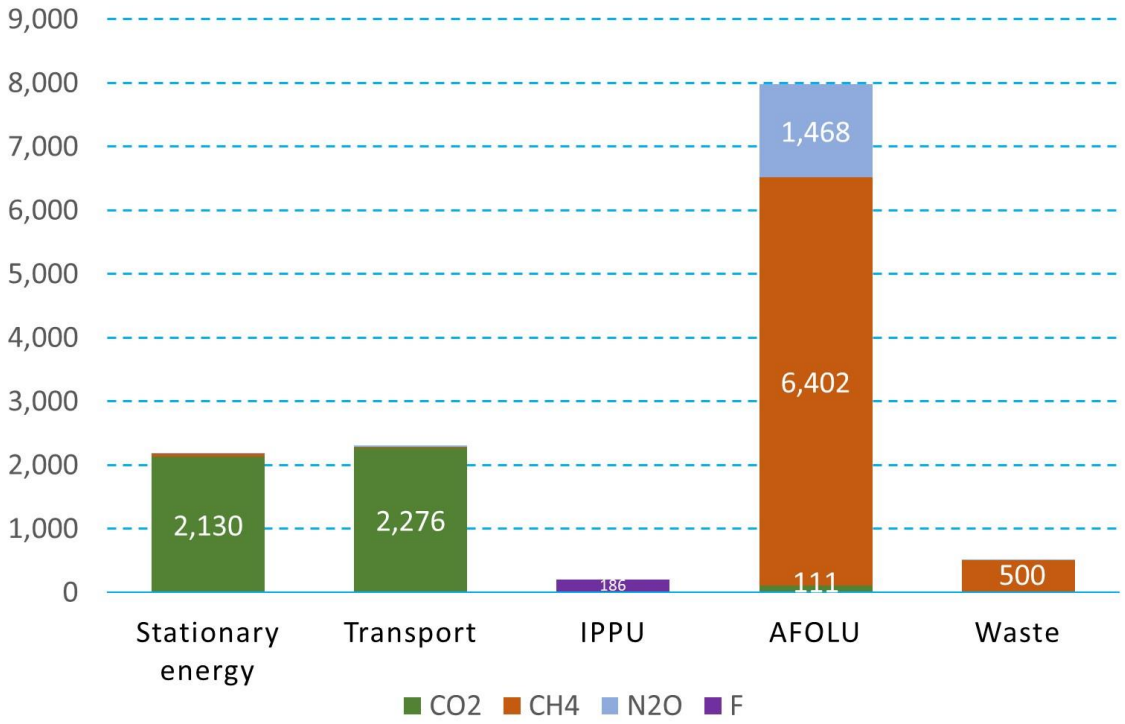


Figure 3: Gas species emitted by sector, 2021 (kilotonnes CO_2e per year). The numbers on the chart refer to the main gases visible, and are not totals for the sector.

Stationary energy sources and transport are the dominant emitters of CO_2 but discharge negligible quantities of the other gases. IPPU emissions are dominated by F gases but this sector's absolute contribution to the regional total CO_2e emission is not substantial. Methane from AFOLU sources is the largest single GHG emission, and the AFOLU sector also contributes a substantial quantity of N_2O. The waste sector makes a relatively small contribution dominated by CH_4.

3.2 Sector emissions

This section describes how the emissions were calculated and presents results for each sub-sector. Each section describes the method, presents results for both inventory years in a column chart, and provides a very brief summary of the key results.

To set the scene, a summary table is provided below that shows the emissions from each sub sector. This table will assist in interpreting the subsequent charts and provides overall context by summarising the contribution each sub sector makes to the annual emissions total (sector contributions to the total are presented above in Figure 2).

Table 3: Summary of regional GHG emissions by sub sector

Sector	Sub sector	Kilotonnes CO_2e 2018	Percent of total 2018	Kilotonnes CO_2e 2021	Percent of total 2021
Stationary energy	Public electricity/heat	895	7%	1,046	8%
	Manufacturing/ construction	1,016	8%	1,007	8%
	Commercial/ institutional	91	1%	82	1%
	Residential home heating	10	0%	11	0%
	Residential other	33	0%	33	0%
Sector total		***2,045***		***2,180***	
Transport	Aviation	55	0%	48	0%
	Road	1,660	13%	1,713	13%
	Rail	17	0%	18	0%
	Shipping	6	0%	6	0%
	Offroad	473	4%	524	4%
Sector total		***2,211***		***2,309***	
IPPU	Other manufacturing	2	0%	2	0%
	Lubricants and aerosols	12	0%	10	0%
	Medical	20	0%	20	0%
	Refrigerants	166	1%	173	1%
Sector total		***200***		***204***	
AFOLU	Livestock/ animal housing	7,240	56%	7,240	55%
	Crops	110	1%	111	1%
	Fertiliser	685	5%	630	5%
Sector total		***8,034***		***7,981***	
Waste	Solid waste disposal	457	4%	441	3%
	Waste incineration	2	0%	2	0%
	Open burning	2	0%	2	0%
	Wastewater treatment and discharge	55	0%	57	0%
Sector total		***516***		***502***	
Canterbury region		13,006		13,176	

3.2.1 Stationary energy sector

In the energy sector, the sub-sectors are:

- Public electricity/heating
- Iron and steel manufacturing
- Non-ferrous metals
- Chemical manufacturing
- Pulp, paper and print
- Food and beverages
- "Other industry" (spray coating, blasting, etc)
- Commercial/institutional (education, hospital, crematoria, other general industries and activities)
- Residential home heating and
- Residential other uses (small scale domestic fuel use).

3.2.1.1 Emission calculation methods

Public electricity/heating

This is the only sub sector for which emissions are reported at all three scope levels.

Scope 1 emissions (i.e., those generated and used in the geographic boundary) occur from one distributed heat energy site in the Timaru district. Activity data for this source, and for the other industrial combustion sources discussed in the next section, were obtained from site resource consent/s, an online survey that consent holders were asked to fill out, and follow-up communications as necessary to obtain the data needed. Those data include some or all of the following depending on the information source:

- Appliance types
- Fuel types
- Fuel consumption rates and
- Hours of operation.

In cases where the data were not provided, these were inferred from previous emission inventories for other pollutants, or assumptions were made based on consented limits.

Emissions were calculated using emission factors published in Ministry for the Environment (MfE 2022).

Scope 2 emissions for energy use are those associated with electricity purchased from the national grid for use inside the geographic boundary. Activity data were sourced from The Electricity Authority Te Mana Hiko's (EA's) "residential consumption trends" web data source (EA 2023), and emissions were calculated using MfE 2022 emission factors.

Scope 3 emissions for energy use are those associated with losses during the transmission and distribution of electricity purchased from the national grid for use inside the geographic boundary. These losses were assumed to be 10% of Scope 2 emissions.

All other industrial/commercial energy/heat production

Activity data were sourced using the method described in the previous section, and emissions were calculated using MfE 2022 emission factors. The emissions were allocated to the relevant TLA and summed for regional totals. Where applicable, biogenic emissions (from wood combustion) were calculated and then subtracted from the totals for the sector. These values are reported in Appendix A.

Residential home heating

Activity data were sourced from the ECan's wood burner records (based on TLA building permits and resource consents, and ECan resource consents) and census data. Emissions were calculated using MfE 2022 emission factors. The activity data do not include the use of LPG for home heating, which is included in the following sub-sector. The emissions were calculated by TLA and summed for regional totals.

Biogenic CO_2 emissions from wood combustion were calculated and then subtracted from the totals for the sector. Given that wood is the dominant home heating fuel used in Canterbury, the residual emissions (of CH_4 and N_2O, and of CO_2 from the combustion of coal) are relatively low. The biogenic emission values are reported in Appendix A.

Other residential uses

This category includes domestic use of LPG for cooking, space heating and water heating, and of petrol for domestic uses not included in off road fuel use discussed in the transport section of this report. Activity data were sourced from the Energy Efficiency and Conservation Authority Te Tari Tiaki Pūngao (EECA) Energy End Use Database (EECA 2023), and emissions were calculated using MfE 2022 emission factors.

3.2.1.2 Results

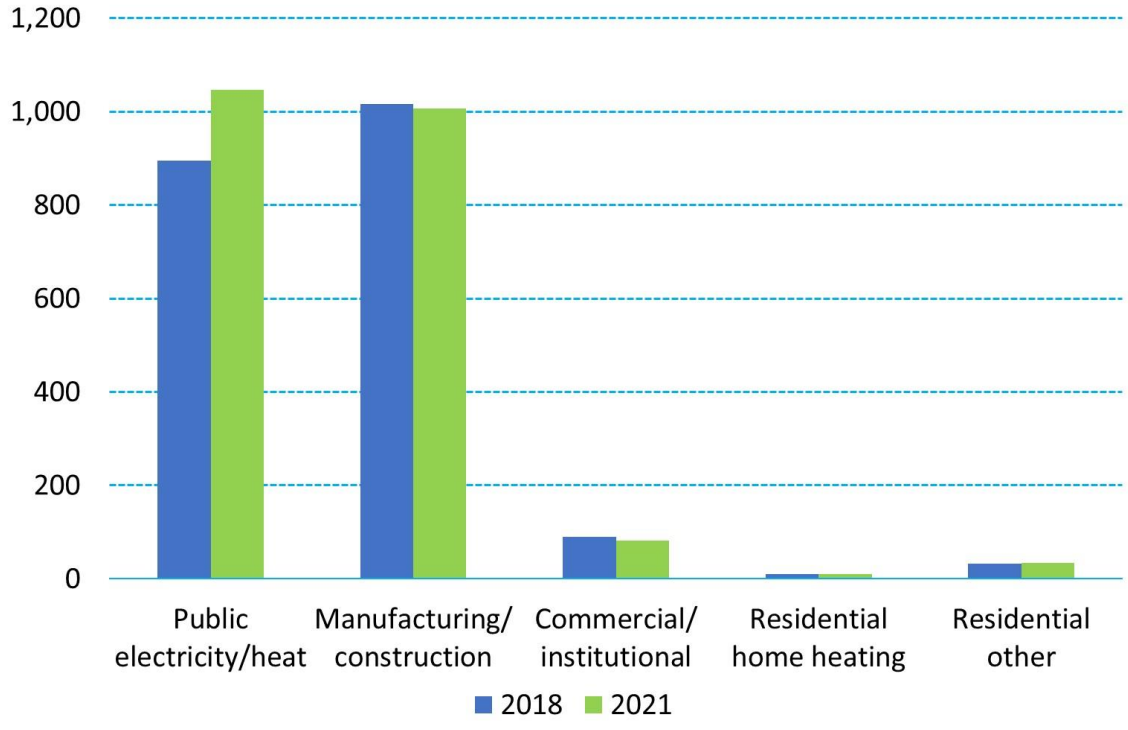


Figure 4: Sub-sector emissions from the stationary energy sector (kilotonnes CO_2e per year)

The emissions from this sector are predominantly from the provision of public electricity and heat, and industrial energy production.

3.2.2 Transport sector

The transport sub-sectors are:

- Aviation
- Road transport
- Rail
- Shipping (domestic only) and
- Offroad.

All emissions calculations are scope 1 only. Scope 2 emissions are not applicable, and scope 3 emissions were not estimated.

3.2.2.1 Emission calculation methods

Aviation

Activity data were sourced from Airways Limited (Airways Limited 2022). They were available only for Christchurch International Airport and cover domestic landing and take-off cycles (LTOs), which include final approach, landing, taxiing, take-off and initial ascent. Emissions from aircraft in flight prior to final approach or after take-off are not included due to insufficient local data and, at the TLA level, uncertainty about apportioning the emissions. LTO data were converted to fuel use and the emissions were calculated using MfE 2022 emission factors.

Road transport

Vehicle emissions were obtained for all road segments in Canterbury, using the National Vehicle Emissions Dataset (NVED) (Waka Kotahi New Zealand Transport Agency 2023a and 2023b). The daily emissions are based on traffic counts, road gradients and speed, and an annual temperature of 11.8°C (which is needed to estimate cold start emissions). These emissions were then aggregated to TLA and regional level.

Rail

Activity data in litres of diesel per year were calculated using known diesel consumption for a base year of 2018/2019 (Kuschel et al 2023) and scaled for 2018 and 2021 using published freight tonnages in the Te Manatū Waka Ministry of Transport (MoT) Freight Information Gathering System (FIGS) (MoT 2023). Fuel consumption was calculated per TLA using rail network lengths within the TAs.

Emissions were calculated using MfE 2022 emission factors. TLA data were aggregated for regional total.

Shipping

Activity data in litres per year of heavy fuel oil were obtained from FIGS and Kuschel et al 2023. Emissions were calculated using MfE 2022 emission factors.

Emissions have been calculated only for container, bulk cargo and tanker ships berthed at the ports of Lyttelton and Timaru. Emissions from ships at sea are not included, nor are smaller craft such as fishing vessels. Recreational boat use is included in the off road vehicle category discussed below.

Offroad

Offroad sources include trucks, lighter vehicles such as utilities and quad bikes, equipment such as chainsaws, and recreational boats. Activity data in terms of fuel consumption were sourced from EECA 2021, and emissions were calculated using MfE 2022 emission factors.

Activity data were scaled down from a national total to regional total, and then to TLA sub totals based on population statistics. Emissions were calculated by TLA and then summed for the regional total.

3.2.2.2 Results

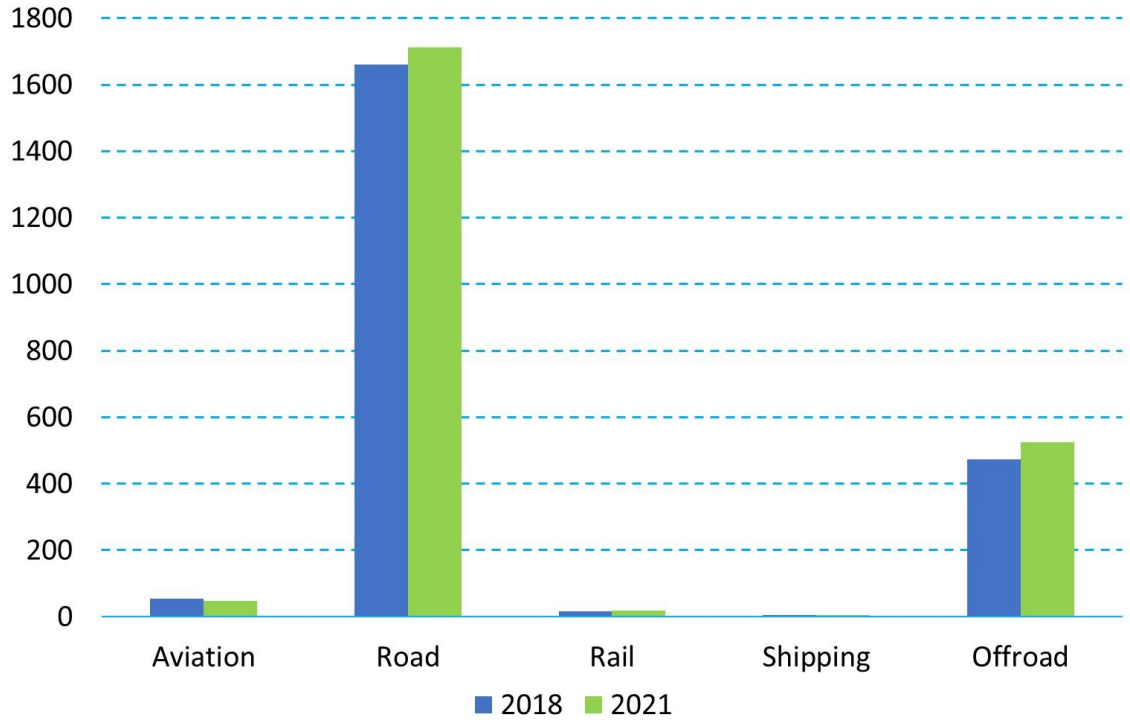


Figure 5: Sub-sector emissions from the transport sector (kilotonnes CO2e per year)

Emissions from on road vehicles are the primary source in this sector, with a secondary contribution from off road sources.

As stated earlier in this report, aviation and shipping emissions are likely to be underestimated due to the lack of data for "cruise" activities. However, a recent inventory carried out for the Auckland region (Xie 2020), indicates that aviation is a relatively small contribution to that region's transport sector, forming 7.1% of the sector total.

3.2.3 Industrial processes and product use sector

IPPU emissions are those from processes other than combustion that are discharged from industries or other institutional uses. The IPPU sector includes a very wide range of industrial and commercial activities that could discharge non-combustion GHGs. The potential list is long but includes activities such as dry cleaning, printing, coating application, chemical manufacture/storage and manufacturing processes. For data acquisition, the source groups in this sub-sector are:

- "Other manufacturing" (a generic heading encompassing many different processes)
- Lubricant and aerosol use

- Medical applications and
- Refrigerants.

3.2.3.1 Emission calculation methods

Activity data for "other manufacturing" sources and other industrial IPPU sources were obtained from site resource consent/s, an online survey that consent holders were asked to fill out, and follow-up communications as necessary to obtain the data needed. In cases where the data were not provided, these were inferred from previous emission inventories for other pollutants, or assumptions were made based on consented limits. Emissions were calculated using specific emission factors provided to EIL by ECan. These include generic emission factors, limits set by resource consents, and specific information in consent files.

Emissions from the remaining three groups were obtained direct from Stats NZ, reported in tonnes per year of CO_2e (Stats NZ 2023). The data are region-wide and were split into TLA sub totals using population statistics. The "medical applications" sub sector includes the use of metered-dose inhalers.

All Stats NZ data used for this study use AR4 GWP conversion values.

3.2.3.2 Results

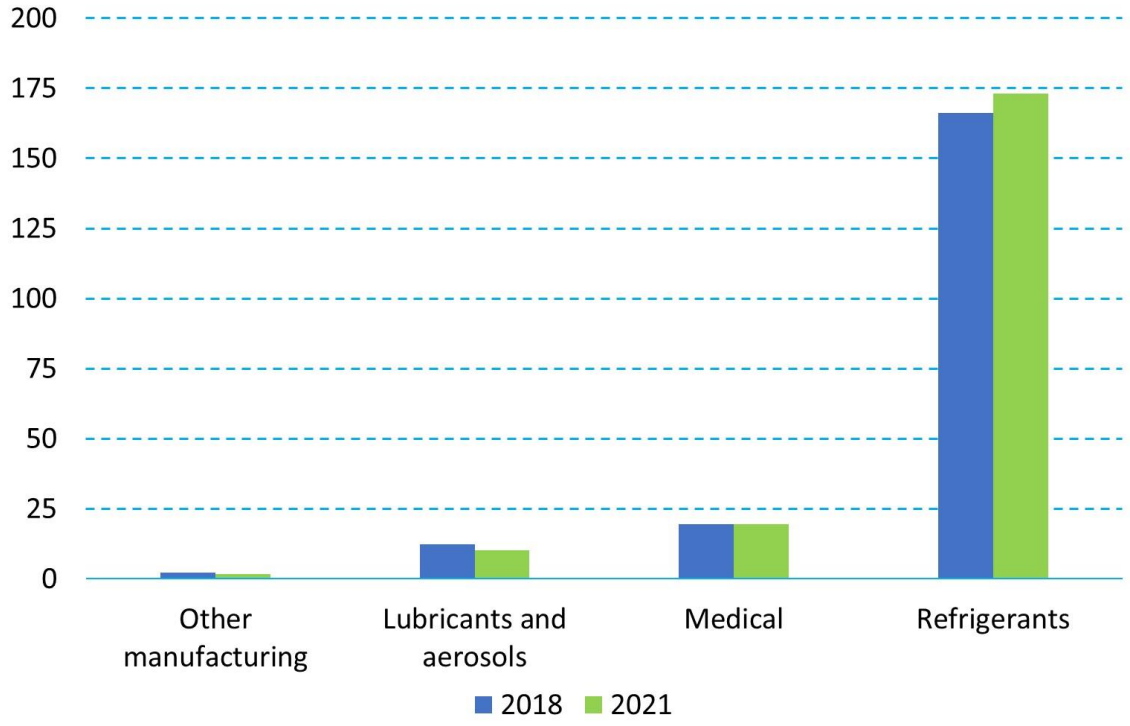


Figure 6: Sub-sector emissions from the IPPU sector (kilotonnes CO_2e per year)

These emissions are clearly dominated by the refrigerants sub sector, the discharges from which are mainly F gases with high GWP.

3.2.4 Agriculture, forestry and other land use sector

The AFOLU sector includes the following sub-sectors:

- Livestock including animal housings
- Crops and

- Fertiliser use.

3.2.4.1 Emission calculation methods

Livestock including animal housing

This sub sector includes enteric fermentation, manure management, animal housings and discharges from agricultural soils due to livestock.

Activity data in terms of animal numbers were obtained from the following sources:

- For ruminants, the MfE's online GIS service (MfE, 2023)
- For pigs, Stats NZ 2019 and
- For chickens, Metcalfe & Sridhar 2018.

Emissions data were obtained from MfE 2022.

Crops

These emissions were obtained direct from Stats NZ (Stats NZ 2023), reported in tonnes per year of CO_2e. The data are region-wide and were split into TLA sub totals using population statistics. These data include some emissions from crop residue burning.

Fertiliser

These emissions were obtained direct from Stats NZ (Stats NZ 2023), reported in tonnes per year of CO_2e. The data are region-wide and were split into TLA sub totals using population statistics. They were calculated using AR4 GWP values. It is assumed that all the CO_2e is N_2O.

3.2.4.2 Results

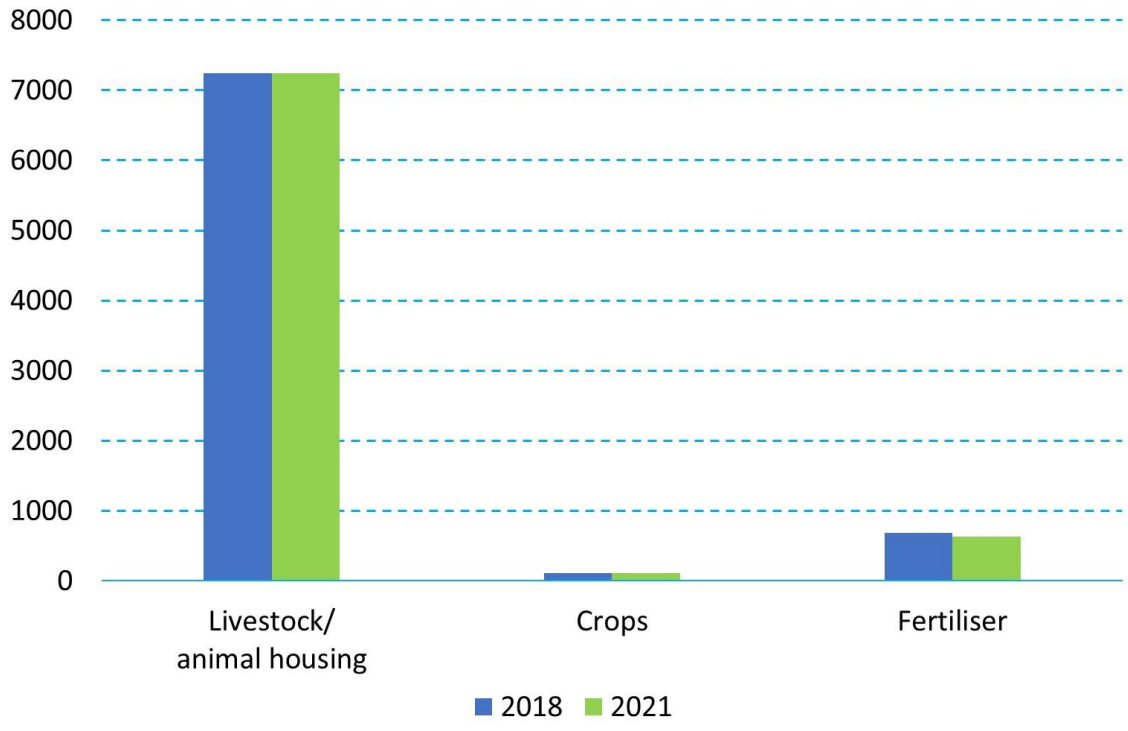


Figure 7: Sub-sector emissions from the AFOLU sector (kilotonnes CO2e per year)

The emissions from the overall AFOLU sector are largely methane (Figure 3), and they are dominated by those from the livestock and animal housing sub sector. The data summarised in Table 3 show that this sub sector is the largest single contributor to Canterbury's GHG inventory for both years, with the 2021 sub sector emission being 7,981 kilotonnes (57% of the total 14,469 kilotonnes discharged).

3.2.5 Waste sector

The waste sub-sector includes the following groups:

- Solid waste disposal
- Waste incineration (actually LFG flaring)
- Open burning (garden waste in rural areas) and
- Wastewater treatment and discharge.

3.2.5.1 Emission calculation methods

Solid waste disposal

These emissions were obtained direct from Stats NZ (Stats NZ 2023), reported in tonnes per year of CO_2e (with the GWP conversion using AR4 values). The data are region-wide and were split into TLA sub totals using population statistics.

Incineration

This category only includes one source, the combustion of landfill gas for biosolids drying at the Christchurch wastewater treatment plant. Activity data were sourced from ECan consent records, and emission estimates were made using specific emission factors provided to EIL by ECan.

Open burning

This category includes the open burning of rural garden waste. Activity data expressed in tonnes per year of waste burned per rural household were calculated from a national total for 2015 in Metcalfe and Sridhar 2018. These were then multiplied by rural household numbers for 2018 and 2021.

Emissions data were obtained from MfE 2022.

These discharges are dominated by biogenic CO_2 and the residual emissions of CH_4 and N_2O are relatively low. The biogenic emission values are reported separately in Appendix A.

Wastewater

These emissions were obtained direct from Stats NZ (Stats NZ 2023), reported in tonnes per year of CO_2e (with the GWP conversion using AR4 values). The data are region-wide and were split into TLA sub totals using population statistics.

3.2.5.2 Results

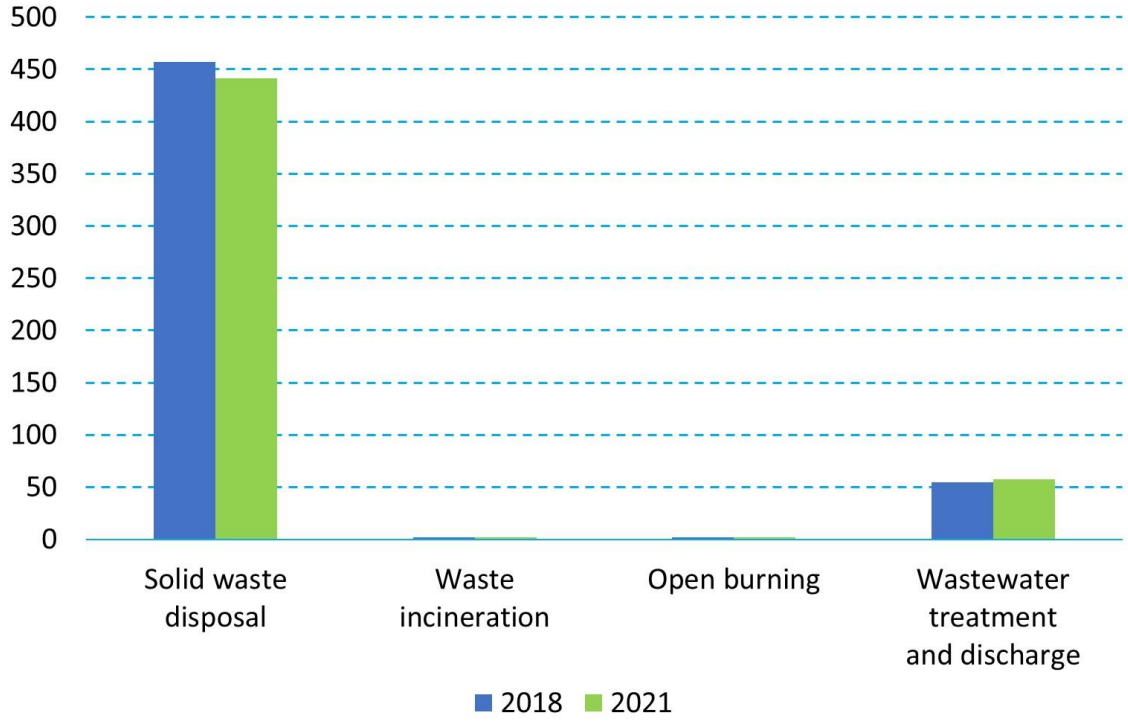


Figure 8: Sub-sector emissions from the waste sector (kilotonnes CO_2e per year)

The emissions from the overall waste sector are largely methane (Figure 3), and they are dominated by those from the solid waste disposal sub sector.

4 Emissions by Territorial Local Authority

4.1 Overall emissions

Figure 9 shows the total GHG emissions in tonnes CO_2e per year, for each TLA (a full data table is provided in Appendix C, Table C2). The Waitaki District is partly in Otago, and emissions were calculated for the Canterbury component only.

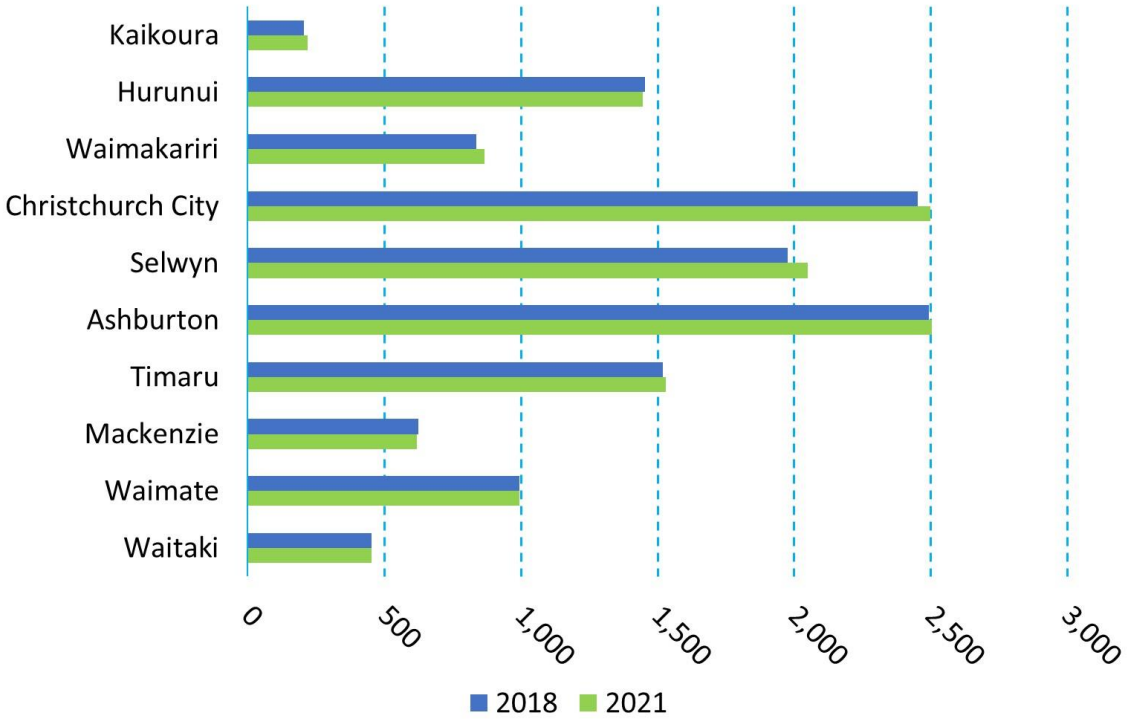


Figure 9: Total TLA emissions (kilotonnes CO_2e per year)

4.2 Per capita emissions

Overall TLA emissions per capita are shown in Table 4. A general decrease is apparent from 2018 to 2021, other than in the Kaikoura and Waitaki districts, and Christchurch City.

Table 4: TLA emissions per capita (tonnes CO_2e per year)

	Emissions per person 2018	Emissions per person 2021	Change	per capita emissions change (%)
Kaikoura	50.9	52.7	1.8	3.5%
Hurunui	112.2	106.6	-5.6	-5.0%
Waimakariri	13.6	13.0	-0.6	-4.6%
Christchurch City	6.4	6.41	0.02	0.3%
Selwyn	31.2	27.1	-4.1	-13.3%
Ashburton	72.1	69.3	-2.8	-3.8%
Timaru	31.9	31.6	-0.3	-1.1%
Mackenzie	122.2	114.1	-8.1	-6.7%
Waimate	122.3	119.9	-2.4	-2.0%
Waitaki	230.4	241.7	11.3	4.9%
Canterbury	**20.9**	**20.3**	**-0.6**	**-3%**

4.3 Emissions by sector

Emissions by sector for each TLA are presented in Figure 10 below (a full data table is provided in Appendix C, Table C4). Given the small change between 2018 and 2021, only the results for 2021 are presented and discussed in this section.

Emissions by sub sector for each TLA are presented in Appendix D.

The source contributions vary widely and – as may be expected given its dominantly urban demographic - those from Christchurch city are markedly different from the other TLAs in having a high contribution from energy and transport sources and a small contribution from the AFOLU sector. All other TLA emissions are dominated by those from the AFOLU sector.

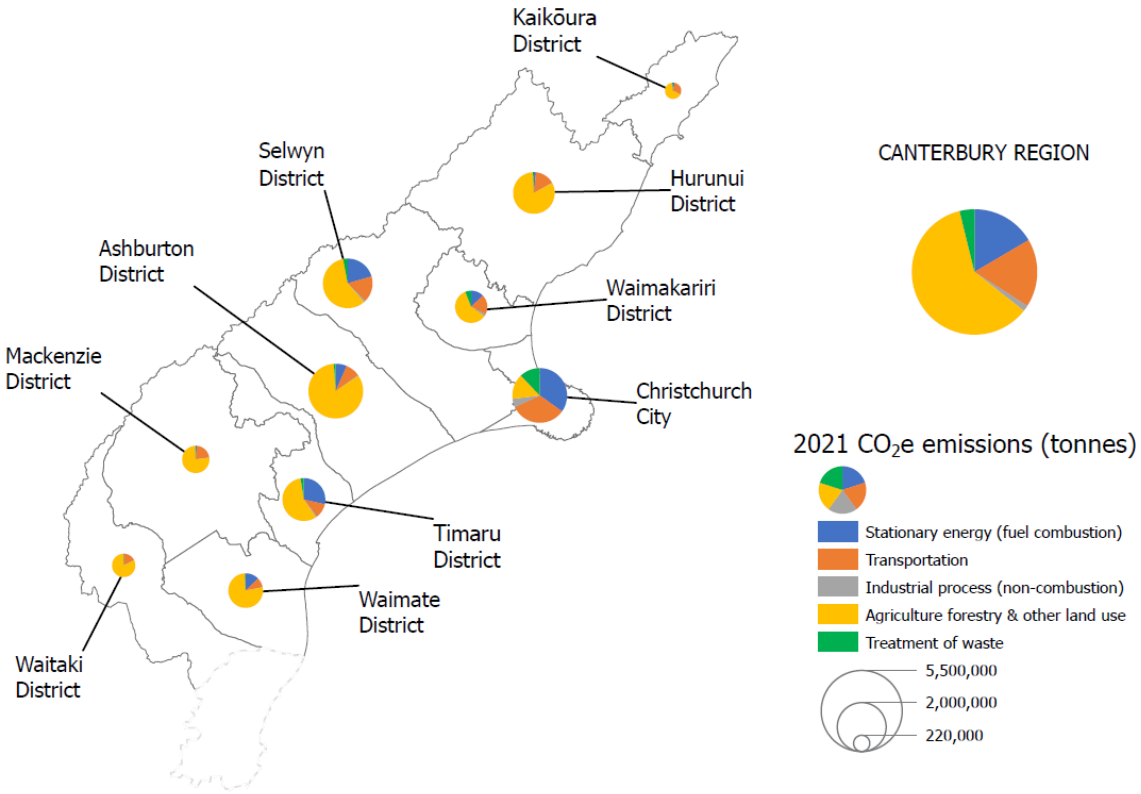


Figure 10: Sector emissions by territorial local authority, 2021 (tonnes CO_2e per year)

4.4 TLA Emissions by gas type

The emissions of each type of GHG from each TLA in 2021 are shown in Figure 11 below (a full data table is provided in Appendix C Table C4).

It is difficult to draw broad conclusions from these data as there is a complex interplay between land use, TLA area, population (both overall and how it is distributed) and urbanisation. However, the more rural TLAs with no large urban centres and/or industrial sources generally have a higher ratio of methane to other gases than Christchurch City, which is dominated by urban activities. Similarly, F gases, which do not form major proportions of any TLA discharges, are more noticeable in districts that have larger amounts of industry.

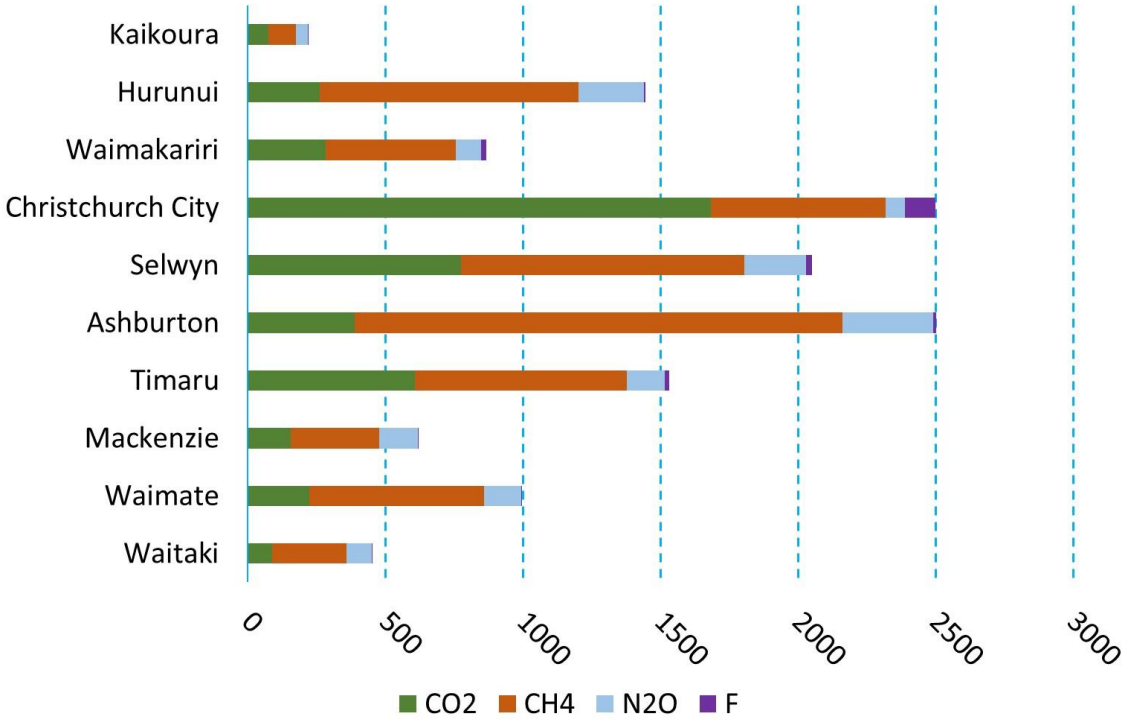


Figure 11: Emissions of gas species by TLA, 2021 (kilotonnes CO_2e per year)

5 References

Airways Ltd. 2022. *Air traffic movements January 2013 to June 2022*. https://www.airways.co.nz/assets/Movements2206-Stats.pdf (last accessed October 2023)

Electricity Authority Te Mana Hiko. 2023. *Residential consumption trends*. End user database: https://www.emi.ea.govt.nz/Retail/Reports/0YUCE0 (last accessed October 2023)

Energy Efficiency and Conservation Authority Te Tari Tiaki Pūngao. 2023. *Energy End Use Database*. https://www.eeca.govt.nz/insights/data-tools/energy-end-use-database/ (last accessed October 2023)

Energy Efficiency and Conservation Authority Te Tari Tiaki Pūngao. 2021. *Off-Road Liquid Fuel Insights - Research into the use of off-road diesel and petrol in New Zealand*. Report prepared by MartinJenkins for the Energy Efficiency and Conservation Authority, July 2021.

Energy End Use Database. https://www.eeca.govt.nz/insights/data-tools/energy-end-use-database/ (last accessed October 2023)

Kuschel et al. 2023. *Domestic Transport Costs and Charges Study: Air quality and greenhouse gas emissions (WP D4)*. Report prepared by G Kuschel, S Sridhar and J Metcalfe for Ministry of Transport, March 2023. https://www.transport.govt.nz/area-of-interest/freight-and-logistics/transport-costs-charges/domestic-transport-costs-and-charges-study-reports (last accessed October 2023)

Metcalfe & Sridhar. 2018. *National Air Emissions Inventory 2015*. Report prepared by J Metcalfe and S Sridhar for Ministry for the Environment, 29 March 2018.

Ministry for the Environment. 2022. *Measuring emissions: A guide for organisations: 2022 detailed guide.* Wellington: Ministry for the Environment.

Ministry for the Environment. 2021. *New Zealand's Greenhouse Gas Inventory 1990–2019*. Wellington: Ministry for the Environment.

Ministry for the Environment. 2023. *Online GIS data service*. https://data.mfe.govt.nz/data/category/environmental-reporting/land/land-use/ (last accessed October 2023)

Stats NZ Tatauranga Aotearoa. 2019. *Agricultural production statistics: June 2019 (final).* https://www.stats.govt.nz/information-releases/agricultural-production-statistics-june-2019-final (last accessed October 2023).

Stats NZ Tatauranga Aotearoa. 2023. *GPC and Industrial product use for Canterbury, 2007-2022.* Customised data request, supplied as CO_2e emissions by Adam Tipper, Stats NZ, November 2023.

Ministry of Transport Te Manatū Waka. 2023. *Freight Information Gathering System*. https://www.transport.govt.nz/statistics-and-insights/freight-and-logistics/sheet/trade-trends (last accessed October 2023)

Waka Kotahi NZ Transport Agency. 2023a. *Vehicle Emissions Mapping Tool*. (Note this is link is to information material only, the tool requires a log in). https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/environment-and-sustainability-in-our-operations/environmental-technical-areas/air-quality/vehicle-emissions-mapping-tool/ (last accessed October 2023)

Waka Kotahi NZ Transport Agency. 2023b. *Vehicle Emissions Prediction Model.* https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/environment-and-sustainability-in-our-operations/environmental-technical-areas/air-quality/vehicle-emissions-prediction-model/ (last accessed October 2023).

World Resources Institute, C40 Cities Climate Leadership Group and ICLEI – Local Governments for Sustainability (ICLEI). 2021. *Global Protocol for Community-Scale Greenhouse Gas Inventories. An Accounting and Reporting Standard for Cities Version 1.1*. https://ghgprotocol.org/ghg-protocol-cities (last accessed September 2023).

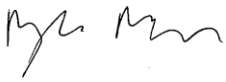
Xie, S. 2020. *Auckland's greenhouse gas inventory to 2018*. Auckland Council technical report, TR2020/026. https://knowledgeauckland.org.nz/media/2011/tr2020-026-aucklands-greenhouse-gas-inventory-to-2018.pdf (last accessed October 2023)

6 Applicability statement

Enviser Ltd has prepared this report for Environment Canterbury in accordance with the agreed scope. No other party, aside from Environment Canterbury, may rely on this report, or any conclusions or opinions within it, for any purpose without the express written permission of Enviser Ltd.

The opinions and conclusions within this report are based on the information that was viewed during preparation of the report.

Prepared for Enviser Ltd by:



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Appendix A: Biogenic emissions

Applicable biogenic emissions were calculated but are not included in the results summarised in the main report. The GPC requires that these be reported separately, and they are shown below along with the non-biogenic emission quantities for comparison. Emissions were calculated using the same methods as for non-biogenic discharges.

Non-biogenic and biogenic CO_2 emissions (kilotonnes per year)

	2018			**2021**		
	Sector non biogenic	**Sector biogenic**	**Biogenic percent of total**	**Sector non biogenic**	**Sector biogenic**	**Biogenic percent of total**
Stationary energy	2,045	162	7.3%	2,180	171	7.3%
Transport	2,211	0	0.0%	2,309	0	0.0%
IPPU	200	0	0.0%	204	0	0.0%
AFOLU	8,034	0	0.0%	7,981	0	0.0%
Waste	516	28	5.1%	502	29	5.4%
Total	**13,006**	**190**	**1.4%**	**13,176**	**199**	**1.5%**

Appendix B: Summary of emissions calculation data sources

Sub sector	Activity data source	Emission factor source	CO_2e calculation
Public electricity/heating Scope 1	Environment Canterbury's 2021 Industrial activity survey	MfE 2022	AR5
Public electricity/heating Scope 2	EA 2023	MfE 2022	AR5
Public electricity/heating Scope 3	Scaled from above		AR5
Manufacturing energy generation	Environment Canterbury's 2021 Industrial activity survey/CRC resource consents	MfE 2022	AR5
Commercial/institutional	Environment Canterbury's 2021 Industrial activity survey/CRC resource consents	MfE 2022	AR5
Residential home heating	CRC wood burner permit database/2018 NZ census	MfE 2022	AR5
Other residential uses	EECA 2023	MfE 2022	AR5
Aviation	Airways Limited 2022	MfE 2022	AR5
Road	NZTA 2023a (NVED)	Waka Kotahi NZ Transport Agency 2023b (VEPM)	AR5
Rail	Kuschel et al 2023; MoT 2023	MfE 2022	AR5
Shipping	Kuschel et al 2023; MoT 2023	MfE 2022	AR5
Offroad	EECA 2021	MfE 2022	AR5
Industrial non-combustion	Environment Canterbury's 2021 Industrial activity survey/CRC resource consents	CRC data	AR5
Product use	Stats NZ 2023		AR4
Solid waste disposal	Stats NZ 2023		AR4
Waste incineration	Environment Canterbury's 2021 Industrial activity survey/CRC resource consents	CRC data	
Wastewater	Stats NZ 2023		AR4
Open burning	Metcalfe and Sridhar 2018	MfE 2022	AR5
Wastewater	Stats NZ 2023		AR4
Livestock/animal housings	MfE 2023 Stats NZ 2019 Metcalf and Sridhar 2015	MfE 2022	AR5
Crops	Stats NZ 2023		AR4
Fertiliser use	Stats NZ 2023		AR4

Appendix C: Data tables

Table C1: Regional emissions by sector (kilotonnes CO_2e per year)

Sector	CO_2e 2018	Sector percent of total 2018	CO_2e 2021	Sector percent of total 2021	CO_2e Change 2018 - 2021	Percent change 2018 – 2021
Stationary energy	2045	16%	2180	17%	135	7%
Transport	2211	17%	2309	18%	98	4%
IPPU	200	2%	204	2%	4	2%
AFOLU	8034	62%	7981	61%	-53	-1%
Waste	516	4%	502	4%	-13	-3%
Canterbury region	**13006**		**13176**		**170**	**1%**

Table C2: Total TLA emissions (kilotonnes CO_2e per year)

Territorial Local Authority	2018	2021	Change 2018 - 2021	Change 2018 – 2021 percent
Kaikoura	207	219	12	6%
Hurunui	1,453	1,445	-8	-1%
Waimakariri	835	865	30	4%
Christchurch City	2,452	2,499	47	2%
Selwyn	1,977	2,050	74	4%
Ashburton	2,493	2,502	9	0%
Timaru	1,518	1,530	12	1%
Mackenzie	623	618	-5	-1%
Waimate	993	995	2	0%
Waitaki	454	452	-2	0%
Canterbury region	**13,006**	**13,176**	**170**	**1%**

Table C3: TLA emissions by sector 2021 (kilotonnes CO_2e per year)

2021	Stationary energy	Transport	IPPU	AFOLU	Waste
Kaikoura	8	63	1	144	3
Hurunui	24	219	4	1187	11
Waimakariri	112	170	21	512	52
Christchurch City	872	829	123	374	301
Selwyn	421	348	24	1199	59
Ashburton	165	215	11	2084	28
Timaru	438	168	15	872	37
Mackenzie	9	132	2	471	4
Waimate	128	89	3	769	6
Waitaki	3	77	1	370	1

Table C4: Emissions of gas species by TLA 2021 (kilotonnes CO_2e per year)

	Carbon dioxide	Methane	Nitrous oxide	Fluorinated gases
Kaikoura	75	101	42	1
Hurunui	260	943	238	4
Waimakariri	282	475	90	19
Christchurch City	1683	634	70	111
Selwyn	775	1028	225	22
Ashburton	389	1773	330	10
Timaru	606	772	139	14
Mackenzie	156	321	140	2
Waimate	223	636	134	2
Waitaki	89	270	93	1

Appendix D: TLA emissions by sub sector

Table D1: TLA emissions from each sub sector, 2018 (kilotonnes CO_2e per year). Continued next page.

Sector	**Sub sector**	Kaikoura	Hurunui	Waimakariri	Christchurch City	Selwyn
Stationary energy	Public electricity/heat	6	18	87	544	90
	Manufacturing/ construction	0	1	0	174	289
	Commercial/ institutional	1	0	0	77	5
	Residential home heating	0	1	2	3	2
	Residential other	0	1	3	20	3
Sector total		***7***	***21***	***92***	***818***	***389***
Transport	Aviation	0	0	0	55	0
	Road	25	124	135	742	236
	Rail	2	4	0	1	5
	Shipping	0	0	0	5	0
	Offroad	22	92	24	15	68
Sector total		***49***	***220***	***159***	***817***	***308***
IPPU	Other manufacturing	0	0	0	2	0
	Lubricants and aerosols	0	0	1	8	1
	Medical	0	0	2	12	2
	Refrigerants	1	3	16	102	17
Sector total		***1***	***4***	***19***	***124***	***20***
AFOLU	Livestock/ animal housing	110	1,043	475	350	1,093
	Crops	5	21	5	3	16
	Fertiliser	31	133	34	22	98
Sector Total		***146***	***1,197***	***514***	***376***	***1,206***
Waste	Solid waste disposal	3	10	45	282	46
	Waste incineration	0	0	0	2	0
	Open burning	0	0	1	0	1
	Wastewater treatment and discharge	0	1	5	34	6
Sector total		***3***	***11***	***51***	***317***	***53***
TLA total		**207**	**1,453**	**835**	**2,452**	**1,977**

Table D1 continued

Sector	Sub sector	Ashburton	Timaru	Mackenzie	Waimate	Waitaki
Stationary energy	Public electricity/heat	49	80	7	12	3
	Manufacturing/ construction	102	335	0	114	0
	Commercial/ institutional	3	5	0	0	0
	Residential home heating	1	1	0	0	0
	Residential other	2	2	0	0	0
Sector total		***157***	***424***	***8***	***127***	***3***
Transport	Aviation	0	0	0	0	0
	Road	138	133	54	45	29
	Rail	2	2	0	1	0
	Shipping	0	1	0	0	0
	Offroad	66	29	76	38	45
Sector total		***206***	***165***	***130***	***84***	***74***
IPPU	Other manufacturing	0	0	0	0	0
	Lubricants and aerosols	1	1	0	0	0
	Medical	1	1	0	0	0
	Refrigerants	9	13	1	2	1
Sector total		***11***	***15***	***2***	***3***	***1***
AFOLU	Livestock/ animal housing	1,981	826	352	710	300
	Crops	15	7	18	9	10
	Fertiliser	95	42	110	55	65
Sector Total		***2,091***	***875***	***480***	***774***	***375***
Waste	Solid waste disposal	25	35	4	6	1
	Waste incineration	0	0	0	0	0
	Open burning	0	0	0	0	0
	Wastewater treatment and discharge	3	4	0	1	0
Sector total		***29***	***39***	***4***	***7***	***2***
TLA total		**2,493**	**1,518**	**623**	**993**	**454**

Table D2: TLA emissions from each sub sector, 2021 (kilotonnes CO_2e per year). Continued next page.

Sector	**Sub sector**	Kaikoura	Hurunui	Waimakariri	Christchurch City	Selwyn
Stationary energy	Public electricity/heat	7	22	106	623	121
	Manufacturing/ construction	0	1	0	155	289
	Commercial/ institutional	1	0	0	70	6
	Residential home heating	0	1	2	3	2
	Residential other	0	1	3	21	3
Sector total		***8***	***24***	***112***	***872***	***421***
Transport	Aviation	0	0	0	48	0
	Road	36	113	143	759	267
	Rail	2	4	0	1	5
	Shipping	0	0	0	4	0
	Offroad	24	102	26	17	75
Sector total		***63***	***219***	***170***	***829***	***348***
IPPU	Other manufacturing	0	0	0	1	0
	Lubricants and aerosols	0	0	1	6	1
	Medical	0	0	2	12	2
	Refrigerants	1	4	18	104	20
Sector total		***1***	***4***	***21***	***123***	***24***
AFOLU	Livestock/ animal housing	110	1,043	475	350	1,093
	Crops	5	22	6	4	16
	Fertiliser	29	122	31	20	90
Sector Total		***144***	***1,187***	***512***	***374***	***1,199***
Waste	Solid waste disposal	3	9	45	265	51
	Waste incineration	0	0	0	2	0
	Open burning	0	0	1	0	1
	Wastewater treatment and discharge	0	1	6	34	7
Sector total		***3***	***11***	***52***	***301***	***59***
TLA total		**219**	**1,445**	**865**	**2,499**	**2,050**

Table D2 continued

Sector	Sub sector	Ashburton	Timaru	Mackenzie	Waimate	Waitaki
Stationary energy	Public electricity/heat	58	85	9	13	3
	Manufacturing/ construction	102	345	0	114	0
	Commercial/ institutional	2	4	0	0	0
	Residential home heating	1	2	0	0	0
	Residential other	2	3	0	0	0
Sector total		***165***	***438***	***9***	***128***	***3***
Transport	Aviation	0	0	0	0	0
	Road	140	133	48	45	28
	Rail	2	2	0	1	0
	Shipping	0	1	0	0	0
	Offroad	73	32	84	42	49
Sector total		***215***	***168***	***132***	***89***	***77***
IPPU	Other manufacturing	0	0	0	0	0
	Lubricants and aerosols	1	1	0	0	0
	Medical	1	1	0	0	0
	Refrigerants	10	13	1	2	0
Sector total		***11***	***15***	***2***	***3***	***1***
AFOLU	Livestock/ animal housing	1,981	826	352	710	300
	Crops	15	7	18	9	10
	Fertiliser	88	39	101	50	59
Sector Total		***2,084***	***872***	***471***	***769***	***370***
Waste	Solid waste disposal	25	33	4	6	1
	Waste incineration	0	0	0	0	0
	Open burning	0	0	0	0	0
	Wastewater treatment and discharge	3	4	0	1	0
Sector total		***28***	***37***	***4***	***6***	***1***
TLA total		**2,502**	**1,530**	**618**	**995**	**452**