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Christchurch City Council
Co No.: N/A

AECOM

Ōtautahi Christchurch Greenhouse Gas Emissions Inventory, FY23

(1st July 2022 – 30th June 2023)

01-Feb-2024

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Prepared by

AECOM New Zealand,

01-Feb-2024

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1	20-Nov-2023	Draft	Anthony Hume Associate Director - Practice Leader Sustainability & Resilience	
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Executive Summary

This report details the Greenhouse Gas (GHG) emissions produced within the Christchurch City Council's geographic boundary, which incorporates Ōtautahi Christchurch and Te Pātaka-o-Rākaihautū Banks Peninsula (referred to hereafter as Christchurch for ease). The GHG emissions presented here have been measured and reported using the production-based Global Protocol for Community-Scale Greenhouse Gas Emissions Inventory (GPC) methodology. This document reports GHG emissions produced in or resulting from activity or consumption for the FY23 government financial year (1st July 2022 to 30th June 2023). This document also examines the changes in GHG emissions produced in Christchurch between FY19 and FY23. The FY19 GHG inventory for Christchurch has been updated to align with the data and methodology used for the FY20 to FY23 inventories. The FY17 inventory has also been updated but this only covers updated emission factors and global warming potential values and not updates to data.

Greenhouse gas emissions are generally reported in this document in units of carbon dioxide equivalents (CO_2e) and are referred to as 'emissions'.

Major findings of this report include:

Emissions Inventory FY23

- **Total gross emissions** produced in Christchurch were 2,507,475 tCO_2e.
- **Transport** (e.g., emissions resulting from road, air, and marine freight journeys) represented 54% of Christchurch's total gross emissions[1]. On-road petrol and diesel use represented 38% of total gross emissions.
- **Stationary Energy** (e.g., emissions relating to electricity and coal consumption) produced 21% of total gross emissions, with electricity use representing 37% of Stationary energy emissions.
- **Agriculture** represented 16% of total gross emissions, with 60% of agricultural emissions related to cattle (dairy and non-dairy).
- **Industrial Processes and Product Use** (IPPU) (e.g., emissions from refrigerant gasses and aerosols) represented 5% of total gross emissions.
- **Waste** (e.g., emissions from landfill and wastewater treatment) represented 5% of total gross emissions.
- **Net Forestry** emissions totalled -247,610 tCO_2e. This represents that in this year carbon sequestrated (carbon captured and stored in plants or soil by forests) was greater than emissions from forest harvesting (e.g., the release of carbon from timber, roots, and organic matter following harvesting). Net forestry emissions are not included in total gross emissions but in total net emissions. Therefore, the **total net emissions** (gross emissions plus forestry) in Christchurch were 2,259,865 tCO_2e.

Table 1 Ōtautahi Christchurch total gross emissions for FY23

Total Emissions	Emissions (tCO_2e)
Transportation	1,348,345
Stationary Energy	521,927
Agriculture	390,638
IPPU	128,603
Waste	117,962
Total Gross Emissions	**2,507,475**

[1] Air travel and marine freight emissions have been split between the districts in Canterbury based on relative population size as the benefits of these journeys are considered to be regional. This is consistent with other major transport nodes in Aotearoa New Zealand.

Changes in Annual Emissions, FY19 to FY23

- Between FY19 and FY23, **Total Gross Emissions** in Christchurch decreased by 12% (-336,823 tCO_2e), largely due to a reduction in stationary energy and transport emissions.
- **Per Capita Gross Emissions** decreased by 14%, from 7.4 to 6.3 tCO_2e per person per year due to total gross emissions decreasing by a greater proportion (12%) than population growth (3%).
- **Stationary Energy** emissions decreased by 25% (-170,881 tCO_2e), mainly due to decreased use of fossil fuel electricity generation in the national grid reducing electricity emissions by 51% per unit of consumption. The electricity grid emissions intensity contains significant variability year-to-year with particularly low emissions intensity in FY23.
- Emissions from **Transport** decreased by 11% (-162,485 tCO_2e), driven by a reduction in air travel emissions, likely driven by the impacts of COVID-19.
- Emissions from **Agriculture** increased by 4% (14,545 tCO_2e) due to an increase in sheep and non-dairy cattle numbers.
- Emissions from **Waste** decreased by 12% (-16,031 tCO_2e) driven by a reduction in annual emissions from closed landfill sites.
- **Net Forestry** sequestration increased by 7% driven by a reduction in harvesting emissions. Net forestry emissions can be extremely variable year-to-year depending on harvesting activity.

Table 2 Change in Ōtautahi Christchurch total gross emissions from FY19 to FY23

	FY19 (tCO_2e)	FY20 (tCO_2e)	FY21 (tCO_2e)	FY22 (tCO_2e)	FY23 (tCO_2e)	% Change (FY19 to FY23)
Total Gross Emissions (excluding Forestry)	2,844,298	2,691,532	2,846,874	2,621,110	2,507,475	-12%

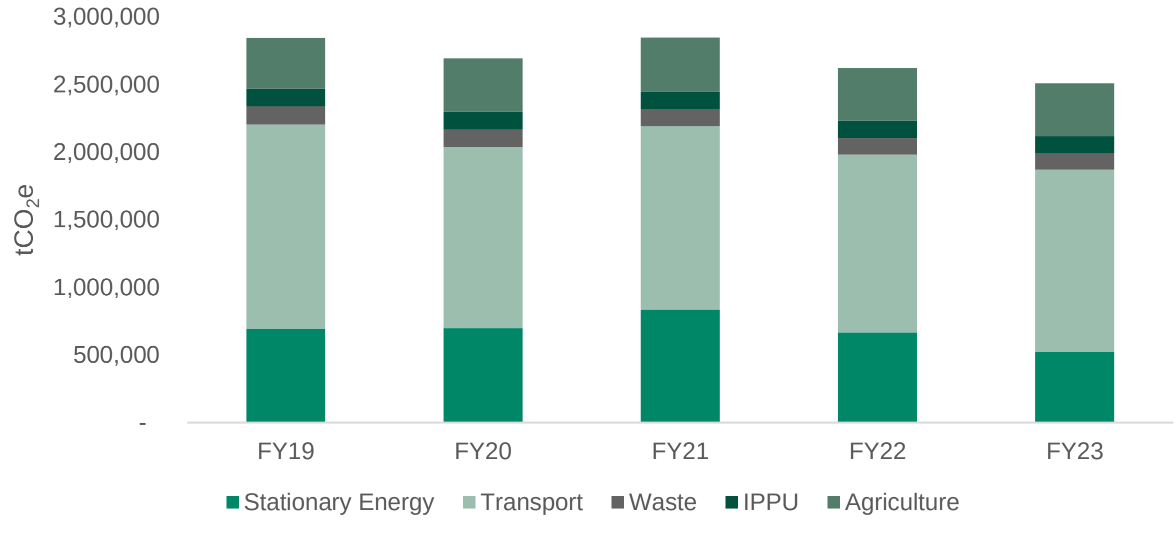

Figure 1 Change in Ōtautahi Christchurch total gross emissions from FY19 to FY23

Changes in Annual Emissions, FY17 to FY23

- Emissions from some sources for FY17 are not directly comparable to the FY19 to FY23 results due to differences in the data used. This is particularly the case for coal, electricity, and rail emissions where different data sources have been used. It is however possible to use these results to identify general trends and assess progress towards emission reduction targets.
- Between FY17 and FY23, **Total Gross Emissions** in Christchurch decreased by 1% (-28,260 tCO_2e), largely due to a reduction in transport emissions (particularly air travel). Significantly, emissions from electricity consumption, closed landfill sites, and on-road transport also decreased while emissions from agriculture and other sources increased.

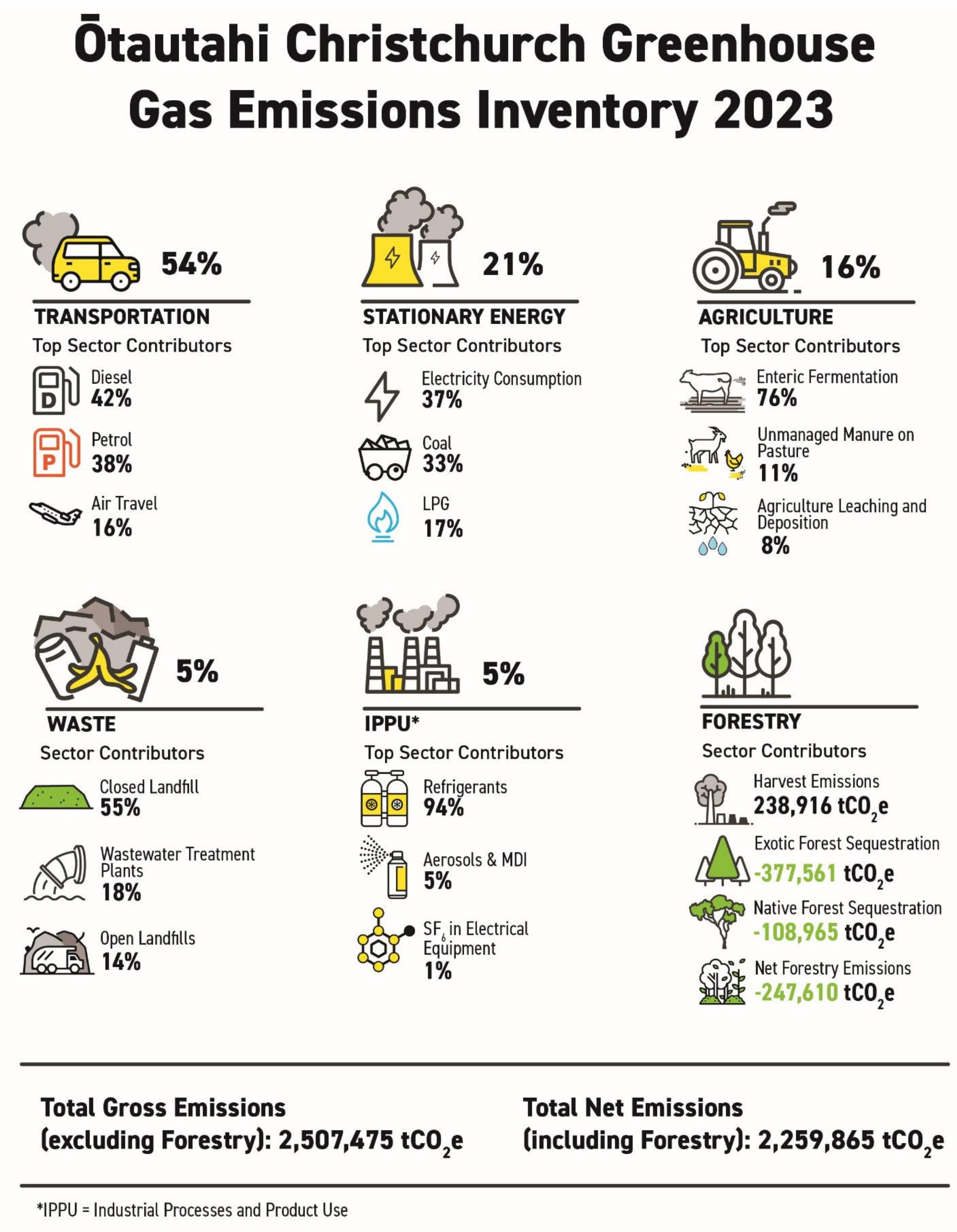

Figure 2: Ōtautahi Christchurch Greenhouse Gas Emissions Inventory FY23

1.0 Introduction

Christchurch City Council commissioned AECOM New Zealand Limited (AECOM) to assist in developing a production-based community-scale greenhouse gas (GHG) emissions footprint for Ōtautahi Christchurch and Te Pātaka-o-Rākaihautū Banks Peninsula for the FY21 and FY23 financial years. The FY23 financial year spans from 1st July 2022 to 30th June 2023. As part of this work, AECOM recalculated emissions for the FY19 financial year, previously calculated by AECOM, using current best-practice methods, updated data, and additional emission sources to enable direct comparison to the other reported years. GHG emissions produced in FY20 and FY21 have been calculated based on a combination of collected data and the FY19, FY21 and FY23 inventories. This report focusses discussion on the changes and trends since Christchurch's last full GHG emissions inventory (for FY19). The Ōtautahi Christchurch FY17 GHG emissions inventory has also been updated as part of this work to align with the updated emission factors and global warming potential values used in this inventory. This enables a consistent baseline for emission tracking.

The study boundary incorporates the jurisdiction of Christchurch City Council (Ōtautahi Christchurch and Te Pātaka-o-Rākaihautū Banks Peninsula), hereafter referred to as Christchurch for ease. The geographic area includes both urban and rural areas, with over 65% of the land area zoned as rural.

This inventory forms part of Christchurch City Council's climate action plan regarding the measuring of Ōtautahi Christchurch's emissions and tracking progress towards the district's targets[2]:

- Net zero greenhouse gas emissions by 2045, and a 50% reduction from the baseline financial year 2016/2017 levels, by 2030 (excluding methane);
- At least a 25% reduction in methane emissions by 2030, and 50% reduction from the baseline financial year 2016/2017, by 2045.

For these targets, the FY17 (2016/17) greenhouse gas emissions inventory acts as a baseline year against which to track this progress.

The purpose of the Ōtautahi Christchurch GHG Emissions Inventory for FY23 is to estimate the relative scale of GHG emissions produced in Ōtautahi Christchurch and Te Pātaka-o-Rākaihautū Banks Peninsula and the relative contribution of different emission sources to the area's total emissions. The results of this inventory can be used to assess trends and changes in the emissions produced over time.

2.0 Approach

The methodological approach used to calculate emissions follows the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventory v1.1[3] (GPC) published by the World Resources Institute (WRI) 2021. The GPC methodology follows a production-based approach and allocates emissions to industries as opposed to final users. Production-based approaches exclude global emissions relating to consumption (i.e., embodied emissions relating to products produced elsewhere but consumed within the geographic area, such as imported food products, cars, phones, clothes etc.).

This emissions footprint assesses both direct and indirect emissions sources. Direct emissions are production-based and occur within the geographic area (Scope 1 in the GPC reporting framework). Indirect emissions are produced outside the geographic boundary (Scope 2 and 3) but are allocated to the consumption location. An example of indirect emissions is those associated with electricity consumption, which is supplied by the national grid (Scope 2). All other indirect emissions, such as cross-boundary travel (e.g., flights) and energy transmission and distribution losses, are Scope 3.

The inventory is based on data and reporting guidance available at the time of calculation, using reasonable assumptions in line with the GPC reporting guidance, and may need to be updated in the future to account for changes in data availability or changes to reporting guidance.

[2] https://ccc.govt.nz/environment/climateaction/whats-council-doing/
[3] http://www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

Greenhouse gas emissions are generally reported in this document in Carbon Dioxide Equivalent (CO_2e) units and are referred to as ‘emissions’.

Differences of note compared to previous inventories:

- This inventory uses global warming potentials from the IPCC 6th Assessment Report (2021).
- Emissions from electricity used for transportation activities (e.g. electric vehicles and electric buses) have been estimated with the emissions included in the Transport results, with the related electricity consumption removed from the stationary energy electricity consumption calculations.
- Emissions related to cruise ships have been estimated within this inventory. These have been reported separately from total gross emissions and total net emissions as this is the first-time emissions from this source have been estimated in New Zealand[4] and there are significant limitations of the data and method used for these calculations.
- Air travel emissions have been calculated and provided by Christchurch International Airport and have not been reviewed by AECOM.

Appendix A provides further information on the method and approach used, and outlines the assumptions made during data collection and analysis for each emissions source.

It is essential to consider the uncertainty associated with the results, particularly given the different datasets used. At the national level, New Zealand’s Greenhouse Gas Inventory the estimate of gross emissions uncertainty was ±8.8%, with a net emissions uncertainty estimate of ±26.9% (MfE, 2022).

2.1 Emissions Inventory Method

The purpose of the GPC methodology is to understand the relative scale of emissions produced in an area at a high level. The GPC provides an approach to calculating emissions which allows flexibility of data collection, assumptions, method, and conversion factors. This inventory represents a largely production-based inventory following the GPC guidance and reporting standards. AECOM follows this method as it is a commonly used framework designed for accounting and reporting city-wide greenhouse gas emissions both in New Zealand and internationally. It provides a robust method for the development of a comprehensive greenhouse gas inventory for the district, including establishing and updating the base year for the inventory, setting emissions reduction targets and tracking emissions over time.

AECOM are aware that Environment Canterbury are in the process of completing an integrated air pollution and GHG emissions assessment for the Canterbury region for the 2021 calendar year following the GPC methodology. It is likely that due to flexibility within the GPC guidance, the results of this inventory for FY21 (2021 financial year) and the Environment Canterbury inventory may differ. Differences in the Global Warming Potential (GWP) values used as well as the different reporting years (financial year used by AECOM vs calendar year used by Environment Canterbury) are key factors that may cause results between the two assessments to differ. Other reporting differences may also exist, such as reporting by industry or by fuel type. During the development of this inventory, Christchurch City Council, AECOM and Environment Canterbury collaborated to understand where methodologies and results may differ and to align the two inventories where possible.

[4] Within knowledge at time of writing

3.0 Ōtautahi Christchurch Emissions Inventory for FY23

3.1 Total Gross Emissions

Total emissions are reported as both gross emissions (excluding forestry harvesting and sequestration) and net emissions (including forestry harvesting and sequestration).

During FY23, Christchurch produced **total gross emissions** of 2,507,475 tCO_2e. Transport and stationary energy were Christchurch's most significant contributors to total gross emissions.

The population of Christchurch in FY23 was approximately 396,200 people, resulting in per capita gross emissions of 6.3 tCO_2e/person.

Table 3 Ōtautahi Christchurch total gross emissions for FY23

Total Emissions	Emissions (tCO_2e)
Total Gross Emissions (excluding Forestry)	2,507,475

Figure 3 and Table 4 illustrate the five different sectors that comprise the emissions inventory. A discussion of each sector follows in Sections 3.4 through Section 3.7. Due to rounding, there may be some discrepancy between totals and the sum of results in the tables.

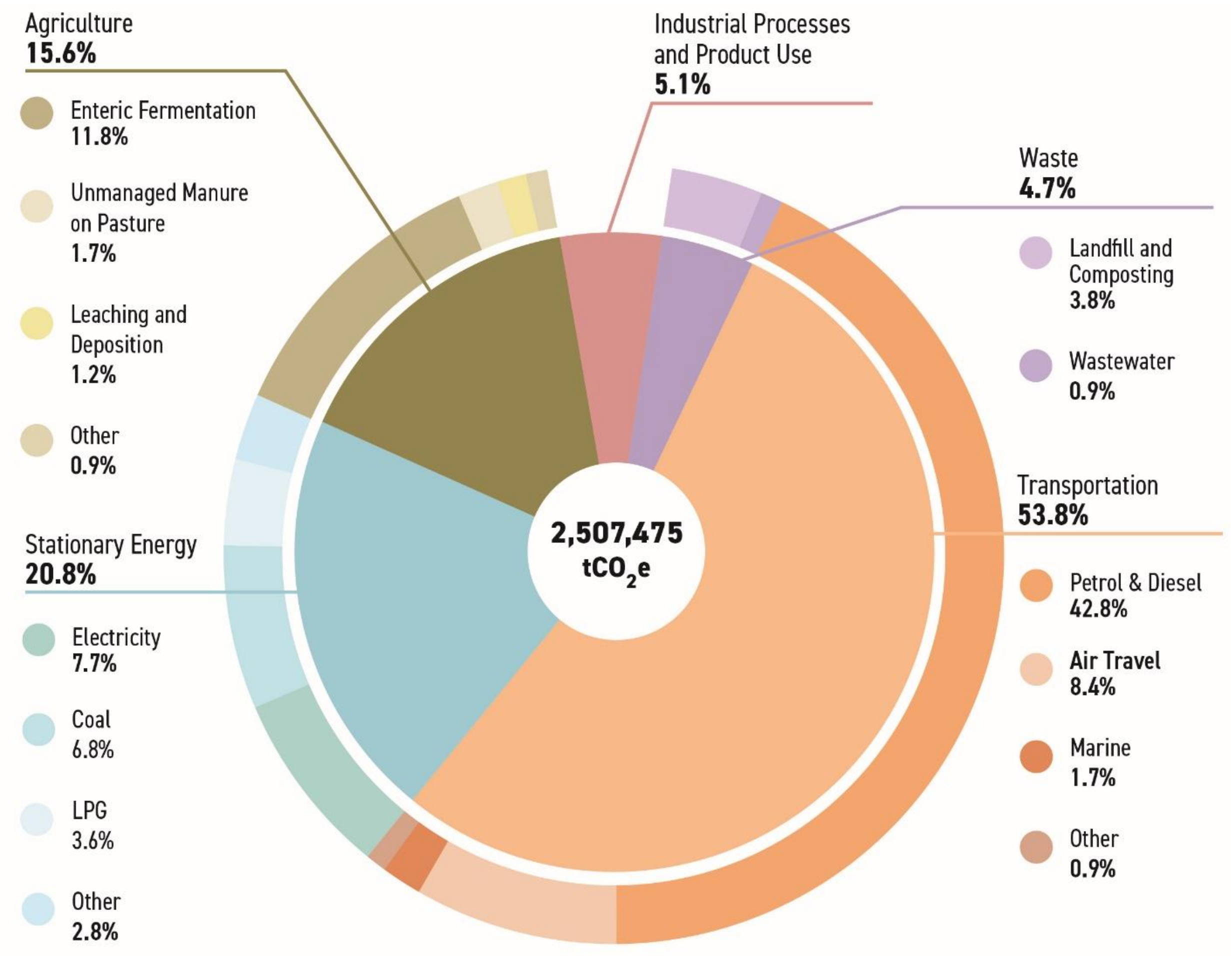

Figure 3: Ōtautahi Christchurch's total gross GHG emissions for FY23, split by sector and source (tCO_2e)

Table 4 Ōtautahi Christchurch FY23 emissions by sector

Emissions Source	Emissions (tCO_2e)	Percentage of Total Gross Emissions (%)
Transportation	1,348,345	53.8%
Stationary Energy	521,927	20.8%
Agriculture	390,638	15.6%
IPPU	128,603	5.1%
Waste	117,962	4.7%
Total Gross Emissions	**2,507,475**	**100%**

Table 3 shows the emission sources from largest to lowest emission source. Full breakdowns of emissions are presented in **Appendix B.**

Table 5 Ōtautahi Christchurch FY23 emissions by source

Emissions Source	Emissions (tCO_2e)	Percentage of Total Gross Emissions (%)
On-Road Transport	961,459	38%
Enteric Fermentation from Livestock	296,141	12%
Air Travel (Domestic and International)	211,779	8%
Electricity Consumption	192,972	8%
Coal	170,272	7%
Refrigerant and Air Conditioning Gasses	120,684	5%
Off-Road Transport	116,156	5%
LPG (Stationary)	89,513	4%
Solid Waste (Landfill)	81,377	3%
Stationary Diesel and Petrol Use	63,750	3%
Marine Freight and Port Operational Vessels	44,185	2%
Unmanaged Manure on Pasture	42,446	2%
Agricultural Leaching and Deposition (Manure, Urine, and Fertiliser)	29,646	1%
Wastewater	22,779	1%
Other Agriculture Emissions	22,405	1%
Rail	14,766	1%
Composting (Green Waste)	13,807	1%
Other Industrial Gasses	7,919	<1%
Biofuel and Biogas	5,420	<1%
Total Gross Emissions	**2,507,475**	**100%**

3.2 Transport

Transport was the highest emitting sector in Christchurch, representing 54% of total gross emissions.

Petrol and diesel use represented 80% of the transport emissions in Christchurch. Diesel and petrol transport emissions are split into on-road and off-road use. On-road transport (e.g. cars, trucks and buses used on roads) was responsible for 39% of total gross emissions and 71% of transport emissions. Off-road transport was responsible for 9% of transport emissions. Off-road transport consists of all fuel used for off-road vehicles (e.g. agricultural, forestry, and construction vehicles and equipment, and includes recreational marine use). A further breakdown of on-road emissions by vehicle type and class is included as Appendix C.

The next largest emission source in the transport sector was domestic and international air travel, representing 8% of total gross emissions and 16% of transport emissions[5]. Air travel emissions are determined by calculating the emissions from the fuel consumed by aircraft journeys to and from Christchurch. As Christchurch Airport is treated as a regional airport, the emissions to and from Christchurch have been allocated across the Canterbury Region based on the relative population of districts in the region. The same method and approach have been used for marine freight transport. It is recognised that flights to and from Christchurch, and marine freight to and from Christchurch serve a wider area than just the region, however a regional approach has been taken to ensure that these emissions are captured in community-level emissions inventories and in alignment with the approach taken for other major transport hubs such as Wellington Airport, and Tauranga Port.

Marine transport emissions (from freight journeys, and port operational vessel fuel use) produced 2% of total gross emissions and 3% of transport emissions. Marine freight represented 95% of marine transport emissions. Emissions related to cruise ships visiting Christchurch have been calculated separately (see section 3.2.1.).

Rail transport represented 1% of transport emissions, this represents emissions from fuel used to move freight which is loaded or unloaded in Christchurch.

3.2.1 Cruise Ships

Cruise ship emissions have previously not been included in Ōtautahi Christchurch's GHG emission's inventory. This is due to the limited data and information available to estimate emissions from this source. Using a new method, emissions from this source have been estimated for the first time but not included in the reported total gross emissions or total net emissions as sources of reliable data are limited. The reported cruise ship emissions are based on estimates of fuel used during the journeys to and from Christchurch (with emissions split equally between the origin and destination) and fuel use while stationary in Christchurch. Unlike marine freight, where emissions are allocated across the Canterbury region, cruise ship emissions are 100% allocated to Christchurch, where the benefits are experienced. This method enables a simplified way to estimate emissions from this source.

It is estimated cruise ships produced 54,302 tCO_2e in FY23, equivalent to approximately 2% of Christchurch's total gross emissions, and 4% of transport emissions. Cruise ship emissions could account for up to 55% of marine transport emissions related to Christchurch. The method and limitations of this calculation are detailed in the appendix.

3.3 Stationary Energy

Stationary energy represented 21% of Christchurch's total gross emissions in FY23.

Electricity consumption (including transmission and distribution losses) accounted for 8% of Christchurch's total gross emissions and 37% of stationary energy emissions. Electricity consumption emissions depend upon the amount of consumption (in kWh), and the emissions intensity of the national grid (tCO_2e/kWh), which changes annually. The emissions intensity of the grid was low in FY23 relative to recent years due to particularly high generation from hydropower and low coal and gas generation, resulting in lower than usual emissions from this source regardless of consumption.

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[5] Air travel emissions for flights to/from Christchurch have been calculated and provided by Christchurch International Airport and have not been reviewed by AECOM

Coal accounted for 7% of Christchurch's total gross emissions and produced 33% of stationary energy emissions. The estimate of emissions from coal were calculated from national per capita use for residential, commercial, and industrial uses of coal. Local information suggests that this approach may overestimate coal use in Christchurch. Bottom-up data collected from users in Christchurch rather than estimating coal emissions from national data may improve the understanding of emissions from this source.

LPG represented 17% of stationary energy emissions. This is relatively high in Aotearoa New Zealand but reflects the lack of a reticulated natural gas network in Christchurch. The use of diesel, petrol, biofuels, and biogas used for energy generation, produced the remaining stationary energy emissions.

Biogenic CO_2 emissions from biofuels and biogas combustion have not been included in these totals and are reported separately in section 3.10.

3.4 Agriculture

Agricultural emissions represented 16% of Christchurch's total gross emissions in FY23. Agriculture emissions relate to the greenhouse gas emissions (mainly methane and nitrous oxide) produced directly or indirectly by livestock, crops and fertiliser within the study boundary. Christchurch includes a large proportion of rural area, with over 65% of the land area zoned as rural.

- Enteric fermentation represented 76% of agricultural emissions. Enteric fermentation is the methane (CH_4) released from the digestive process of livestock.
- Nitrous oxide (N_2O) from unmanaged manure deposited directly on land by grazing animals on pasture represented 11% of agricultural emissions.
- Agricultural leaching and deposition (i.e. N_2O produced through the runoff and volatilisation of applied nitrogen inputs such as fertilisers, as well as animal excrements) were responsible for 8% of agricultural emissions.
- Fertilisers on land (i.e. CH_4 and N_2O produced by liming and dolomite use, fertiliser application for horticulture, and crop residues) and methane and nitrous oxide from managed manure (typically stored in piles or disposed of in tanks or lagoons) represented the remaining agricultural emissions.

Agriculture Emissions by Emission Source

Livestock was responsible for the majority of the agriculture sector's GHG emissions. Dairy cattle accounted for 36% of agricultural emissions in Christchurch with sheep accounting for 33%. In FY23, there were an estimated 42,819 dairy cattle and 306,754 sheep in Christchurch[6].

Table 6 Ōtautahi Christchurch's Agriculture emissions by emission source, FY23

Sector / Emissions Source	tCO_2e	% of Total Gross Emissions	% of Sector Total
Dairy Cattle	141,360	6%	36%
Sheep	128,771	5%	33%
Non-Dairy Cattle	91,265	4%	23%
Fertiliser	22,391	1%	6%
Other livestock	6,851	<1%	2%
Total	**390,638**	**15%**	**100%**

Following the GPC guidance, agricultural results do not include emissions related to the consumption of agricultural products supplied to Ōtautahi Christchurch from outside the area.

[6] Livestock numbers taken from the StatsNZ Agricultural Production Statistics Year to June 2022 (https://www.stats.govt.nz/information-releases/agricultural-production-statistics-year-to-june-2022-final/). This dataset presents robust on-farm livestock numbers for the Christchurch District area.

3.5 Waste

Waste processed in Christchurch (solid waste, wastewater, and compost) represented 5% of Christchurch's total gross emissions.

Solid waste produced the bulk of waste emissions making up 69% of total waste emissions. Solid waste emissions include emissions from open (operating) landfill sites (16,506 tCO_2e) and closed landfill sites (64,871 tCO_2e). Both open and closed landfills emit landfill (methane) gas from the breakdown of organic materials disposed of in the landfill for many years after waste enters the landfill. The reported emissions here relate to the emissions produced in FY23 from all waste produced in Christchurch that has entered landfill sites over the last 50+ years[7].

Open landfill emissions relate to emissions from waste produced in Christchurch and sent to Kate Valley Landfill in Canterbury. Both Kate Valley Landfill and Burwood Landfill (closed) have landfill gas capture systems that reduce emissions being released into the atmosphere. Owing to the lack of gas capture systems at the majority of closed landfill sites, emissions from closed landfill sites were greater than those from the currently open sites. Annual emissions from closed landfill sites will decrease over time as no new waste enters these sites.

Wastewater treatment (both treatment plants and individual septic tanks) accounted for 19% of total waste emissions with centralised wastewater treatment plants accounting for 18% of total waste emissions (21,388 tCO_2e[8]). Households which are not connected to centralised wastewater treatment plants (i.e., using individual septic tanks) produced 1,390 tCO_2e in wastewater emissions.

Waste diverted from landfill for composting in Christchurch includes horticultural, animal waste products, green waste, bark, and sawdust. Composting of this organic waste produces lower emissions than if sent to a landfill.

3.6 Industrial Processes and Product Use (IPPU)

IPPU includes emissions associated with the consumption of industrial products and synthetic gases containing GHGs for refrigerants, foam blowing, fire extinguishers, aerosols, metered dose inhalers and Sulphur Hexafluoride for electrical insulation and equipment production. No known industrial processes (as defined in the GPC requirements) are present in Christchurch (e.g., aluminium manufacture).

IPPU contributed 5% to total gross emissions. The most significant contributor to IPPU emissions was refrigerant gasses, which produced 94% of IPPU emissions.

IPPU emissions do not include energy use for industrial manufacturing, which is included in the relevant stationary energy sub-category (e.g., coal, electricity and/or petrol and diesel). These emissions are based on nationally reported IPPU emissions and apportioned based on population due to the difficulty of allocating emissions to geographic locations.

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[7] Annual emissions inventory methods are often used by organisations and may differ from the method discussed here.
[8] Wastewater treatment emissions have been calculated and provided by Christchurch City Council and have not been reviewed by AECOM

3.7 Forestry (Net Emissions)

Net forestry emissions include:

- Sequestration of carbon from the atmosphere which native forests (e.g., mānuka and kānuka) and exotic forests (e.g., pine) sequester (capture) while the trees are growing to maturity and,
- emissions released due to harvesting of forests via the release of carbon from organic matter and soils following harvesting.

Native forests (e.g., mānuka and kānuka) and exotic forests (e.g., pine) sequester (capture) carbon from the atmosphere while the trees are growing to maturity. Harvesting of forests emits emissions via the release of carbon from organic matter and soils following harvesting. When forest sequestration exceeds emissions from harvesting in a particular year, forestry is a net-negative source of emissions which results in the area's total net emissions being lower than their total gross emissions. Conversely, when emissions from harvesting exceed the amount of carbon sequestered by native and exotic forests, then forestry is a net-positive source of emissions which results in the area's total net emissions being higher than their total gross emissions. Harvesting of exotic forests can be cyclical in nature. Some years will have higher sequestration, and some years will have higher harvesting emissions determined by the age of forests, commercial operators, and the global market.

In FY23, forestry in Christchurch was a net negative source of emissions.

Table Ōtautahi Christchurch Forestry emissions by emission source (including sequestration), FY23

Sector / Emissions Source	tCO_2e
Harvest Emissions	238,916
Native Forest Sequestration	-108,965
Exotic Forest Sequestration	-377,561
Total	**-247,610**

3.8 Total Net Emissions

Net emissions differ from gross emissions because they include emissions related to forestry activity (harvesting emissions and sequestration). The cyclical nature of harvesting and planting regimes influences the observed forestry emissions, which in FY23 were a net-negative source of emissions. During the FY23 reporting period, Christchurch produced total net emissions of 2,259,865 tCO_2e.

Figure 4 shows total gross emissions and total net emissions in FY23, and the difference from total gross emissions due to the impact of forestry sequestration and harvesting.

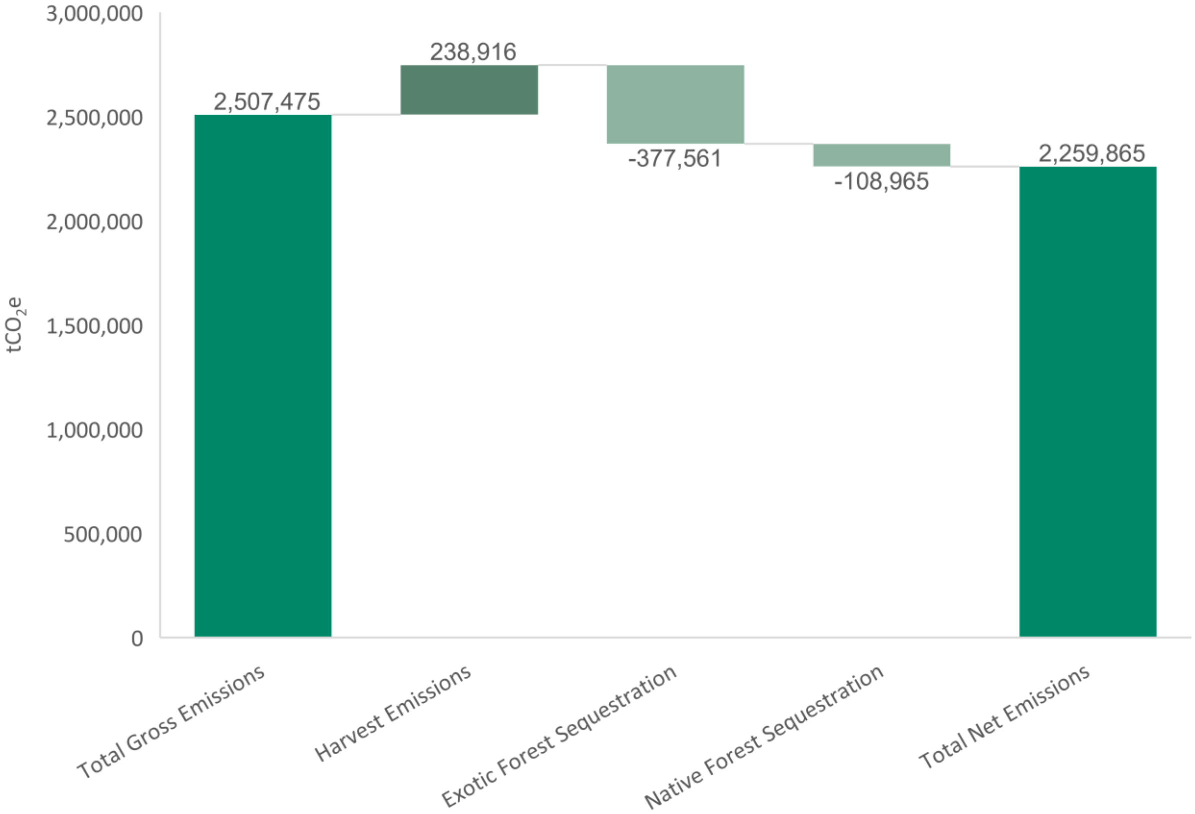

Figure 4: Contribution of gross emissions, forestry emissions, and forest sequestration to Ōtautahi Christchurch's total net emissions, FY23

3.9 Total Gross Emissions by Greenhouse Gas

Each greenhouse gas has a different level of impact on climate change, which is accounted for when converting quantities of each gas into units of carbon dioxide equivalent (CO_2e). This assessment uses conversion figures (i.e., global warming potential values) from the IPCC 6th Assessment Report (2021)[9].

Table 7: Ōtautahi Christchurch's total gross emissions by greenhouse gas, FY23

Greenhouse Gas	Tonnes	Global Warming Potential (GWP)	Tonnes of CO_2e
Carbon Dioxide (CO_2)	1,818,034	1	1,818,034
Biogenic Methane (CH_4) (non-fossil origin)	14,981	27.2	407,472
Non-biogenic Methane (CH4) (fossil origin)	651	29.8	19,396
Nitrous Oxide (N_2O)	484	273	132,226
Other / Unknown Gas (in CO_2e)	130,346	1	130,346
Total	**1,964,496**		**2,507,475**

3.10 Biogenic Emissions

Biogenic CH_4 emissions (e.g., produced by farmed cattle via enteric fermentation) are included in gross emissions due to their relatively large contribution to anthropogenic climate change, especially when compared to biogenic CO_2. Biogenic methane represented 0.8% of the total gross tonnage of GHG emissions in Christchurch but 16% of total gross GHG emissions when expressed in CO_2e. This is caused by the higher global warming impact of methane per tonne compared to carbon dioxide.

Table 8: Biogenic Methane in Ōtautahi Christchurch (Included in gross emissions), FY23

Biogenic Methane (CH_4) (Included in gross emissions)		
Enteric Fermentation	10,888	tCH_4
Landfill Gas	2,987	tCH_4
Manure Management	514	tCH_4
Wastewater Treatment	345	tCH_4
Composting (Green Waste)	246	tCH_4
Biofuel	2	tCH_4
Total Biogenic CH4	**14,981**	**tCH_4**

Biogenic CO_2 emissions 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). Biogenic CO_2 emissions from humans, plants and animals (i.e. non-fossil origin) are excluded from gross and net emissions as they are part of the natural carbon cycle and have a relatively small impact on anthropogenic climate change. Additional biogenic CO_2 emissions such as from landfill are also present however measurement and reporting of these emissions is not prioritised within the GPC method.

Table 9: Biogenic CO_2 in Ōtautahi Christchurch (Excluded from gross emissions), FY23

Biogenic Carbon Dioxide (CO_2) (Excluded from gross emissions)		
Biofuel	56,681	tCO_2
Biogas Combustion	44,019	tCO_2
Total Biogenic CO_2	**100,699**	**tCO_2**

[9] The most up to date 100-year global warming potential values have been used, as recommended by the IPCC and GPC

4.0 Emissions Change from FY19 to FY23

Alongside calculating Christchurch's emissions inventory for FY23, Christchurch's inventory for FY21 has been calculated, and the previously published FY19 inventory has been recalculated. The FY19 inventory has been updated to account for updates in data and calculation best-practice, and to align with the other reporting years.

This section displays the results of the FY19, FY21 and FY23 emissions inventories with a focus on gross emissions and documents the change in emissions from FY19 to FY23. For the years between these assessed years, emissions have been calculated using the same methodology with emissions from some sources estimated where data was not collected.

Table 10 Change in Ōtautahi Christchurch total gross emissions from FY19 to FY23

	FY19 (tCO_2e)	FY20 (tCO_2e)	FY21 (tCO_2e)	FY22 (tCO_2e)	FY23 (tCO_2e)	% Change (FY19 to FY23)
Total Gross Emissions (excluding Forestry)	2,844,298	2,691,532	2,846,874	2,621,110	2,507,475	-12%

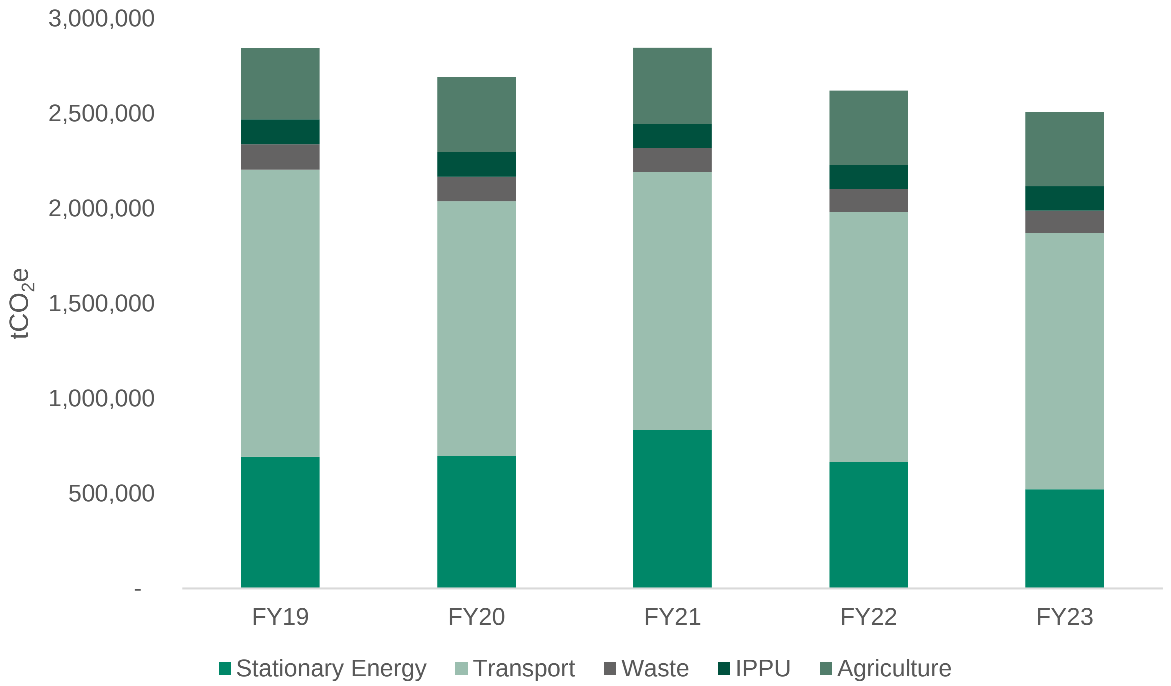

Figure 5 Change in Ōtautahi Christchurch total gross emissions from FY19 to FY23

Annual total gross emissions decreased by 12% from 2,844,298 tCO_2e in FY19 to 2,507,475 tCO_2e in FY23. The decrease in total gross emissions was driven by a reduction in electricity consumption emissions and air travel, with electricity consumption emissions impacted by increased national renewable energy generation in that year. The impact of COVID-19 pandemic restrictions contributed to a reduction in air travel emissions where air travel emissions reduced by 56% between FY19 and FY21. On-road transport was also impacted in FY20 and FY22 where travel restrictions were enforced during part of the year.

Despite the impact of COVID-19 restrictions on air travel, the highest total gross emissions in this period were in FY21. This was due to the high emissions intensity of electricity in that year caused by lower than usual hydro generation replaced with fossil fuel coal and gas generation.

Per capita emissions decreased from 7.4 to 6.3 tCO_2e per person per year as total gross emissions decreased by a proportionally larger amount than population growth. A discussion of gross emissions changes relative to population growth (and GDP) is found in Section 5.0.

The sections below outline the change in emissions between FY19 and FY23 for each sector and emissions source, highlighting the changes that have had the largest impact on total gross emissions. Due to rounding, there may be discrepancies between the sum of reported figures and reported totals.

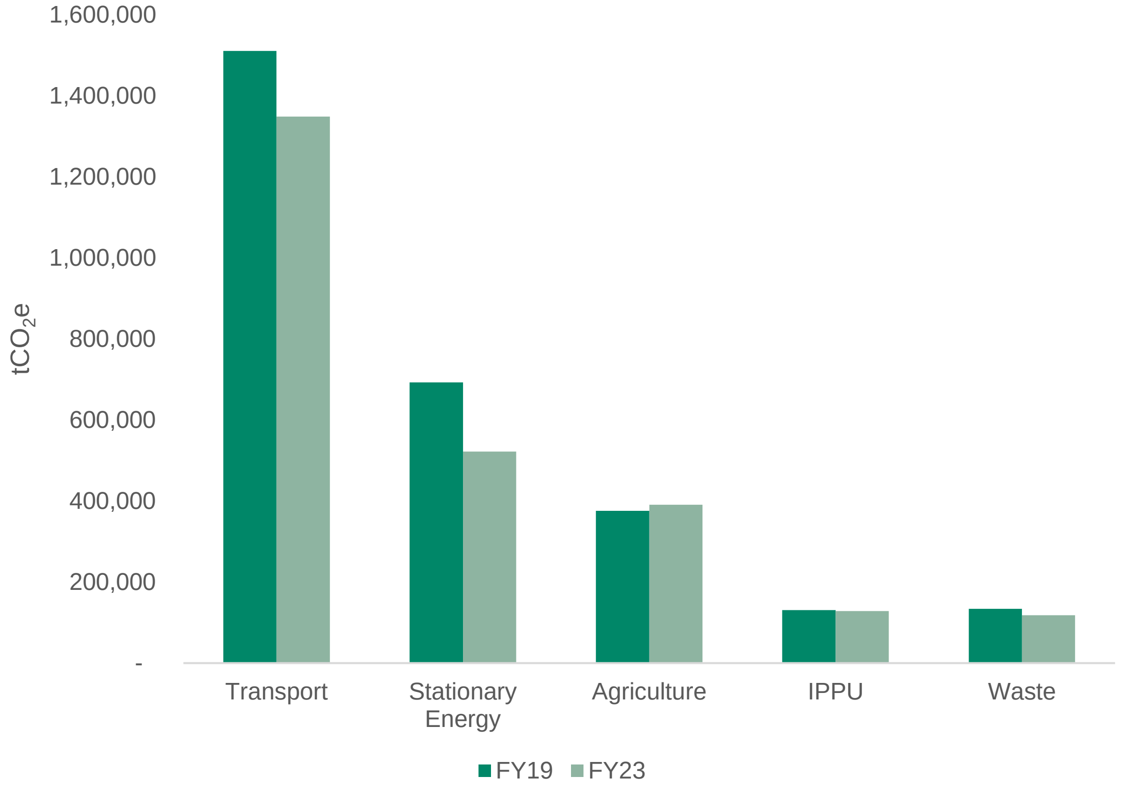

Figure 6 **Emissions for each sector of Ōtautahi Christchurch gross emissions inventory for FY19 to FY23**

Table 11 Ōtautahi Christchurch - Change in emissions by sector from FY19 to FY23

Sector / Emissions Source	Emissions (tCO_2e)					% Change FY19 - FY23
	FY19	FY20	FY21	FY22	FY23	
Transport	1,510,830	1,340,008	1,357,844	1,316,673	1,348,345	-11%
Stationary Energy	692,808	697,896	834,208	665,304	521,927	-25%
Agriculture	376,094	394,197	400,858	390,638	390,638	4%
IPPU	130,573	129,560	127,824	126,681	128,603	-2%
Waste	133,994	129,871	126,140	121,814	117,962	-12%
Total Gross Emissions	**2,844,298**	**2,691,532**	**2,846,874**	**2,621,110**	**2,507,475**	**-12%**

Table 12 Ōtautahi Christchurch - Change in emissions by source from FY19 to FY23

Sector / Emissions Source	Emissions (tCO_2e)					% Change FY19-FY23
	FY19	FY20	FY21	FY22	FY23	
On-Road Transport	961,967	905,059	986,809	932,264	961,459	<1%
Enteric Fermentation from Livestock	285,839	300,417	306,094	296,141	296,141	4%
Air Travel (Domestic and International)	293,743	211,167	129,147	140,815	211,779	-28%
Electricity Consumption	362,717	380,800	509,256	338,786	192,972	-47%
Coal	176,681	166,030	167,239	170,781	170,272	-4%
Refrigerant and Air Conditioning Gasses	121,087	120,561	119,532	118,763	120,684	<1%
Off-Road Transport	112,913	109,735	116,778	114,030	116,156	3%
LPG (Stationary)	85,926	85,460	88,163	87,840	89,513	4%
Solid Waste (Landfill)	98,297	93,444	88,991	84,961	81,377	-17%
Stationary Diesel and Petrol Use	62,057	60,202	64,177	62,559	63,750	3%
Marine Freight and Port Operational Vessels	127,411	99,790	110,343	114,797	44,185	-65%
Unmanaged Manure on Pasture	40,437	42,456	43,009	42,446	42,446	5%
Agricultural Leaching and Deposition (Manure, Urine, and Fertiliser)	27,815	29,049	29,238	29,646	29,646	7%
Wastewater	22,463	22,926	23,379	23,066	22,779	1%
Other Agriculture Emissions	22,002	22,273	22,517	22,405	22,405	2%
Rail	14,796	14,257	14,766	14,766	14,766	<1%
Composting (Green Waste)	13,233	13,501	13,769	13,788	13,807	4%
Other Industrial Gasses	9,486	8,999	8,292	7,919	7,919	-17%
Biofuel and Biogas	5,427	5,403	5,373	5,338	5,420	<1%
Total Gross Emissions	**2,844,298**	**2,691,532**	**2,846,874**	**2,621,110**	**2,507,475**	**-12%**

4.1 Transport

Transport emissions decreased 11% between FY19 and FY23, this is mainly due to a reduction in air travel due to the impact of COVID-19.

On-road fuel emissions returned to FY19 levels, following reductions in FY20 and FY22. A 3% decrease in petrol emissions was balanced by a 3% increase in diesel emissions.

Domestic and international air travel emissions decreased 28%, particularly due to a 40% decrease in international passengers and reduced number of flights compared to FY19.

4.1.1 Cruise Ships

As expanded on in section 3.2.1 cruise ship emissions have been calculated but not included in the total gross or net emissions for this inventory.

Table 13 Ōtautahi Christchurch - Change in cruise ship emissions from FY19 to FY23

Sector / Emissions Source	Emissions (tCO_2e)					% Change FY19-FY23
	FY19	FY20	FY21	FY22	FY23	
Cruise Ships	65,162	73,006	-	-	54,302	-17%

Cruise ship emissions were 17% lower in FY23 than in FY19. As with air travel, this is likely due to cruise ship visits not yet recovering from the impact of the COVID-19 pandemic. There were no cruise ship visits in FY20 and FY21.

If cruise ships were included in total gross emissions the change in total gross emissions from FY19 to FY23 would be a decrease of 12.0%, compared to a decrease of 11.8% without.

4.2 Stationary Energy

Emissions from stationary energy decreased by 25% between FY19 and FY23 (-170,881 tCO_2e). This was driven by a decrease in electricity consumption emissions due to changes in the emissions intensity of the national grid.

Electricity consumption in Christchurch (in kWh) increased by 9% between FY19 and FY23. However, emissions from this source decreased by 47% due to a decrease in the emissions intensity of the national electricity grid (tCO_2e/kWh). This decrease in emissions intensity stems from the occurrence of a year of particularly high average rainfall nationally in FY23, leading to increased hydroelectricity generation resulting in a reduction in coal and gas generation nationally. It is important to note that the emissions intensity of New Zealand's national grid fluctuates year on year, primarily driven by water levels in the hydropower system[10]. The 47% decrease in electricity emissions is therefore not necessarily indicative of a long-term trend, where future years may have higher electricity emissions. However, over the last 10 years there has been a general trend of decarbonisation occurring throughout the national grid.

Other notable changes include a 4% decrease in coal use which likely represents transitions away from coal use for energy to lower emission options.

4.3 Agriculture

Emissions from agriculture increased by 4% (14,545 tCO_2e). This is the only sector which increased during this period. Much of this increase was due to a 4% increase in enteric fermentation from livestock which was caused by an increase in livestock numbers, particularly an increase in non-dairy

[10] This can be seen in the electricity emissions for FY21 which were particularly high due to low hydroelectricity generation and high coal and gas generation nationally.

cattle and sheep[11]. An assessment of the reasons for changes in livestock numbers is beyond the scope of this inventory.

Of note:

- Sheep represented 75% of total livestock in FY23 and 33% of agricultural emissions. Emissions related to sheep increased by 12% (13,342 tCO_2e) due to an increase in the number of sheep.
- Non-dairy cattle represented 11% of total livestock in FY23 and 23% of agricultural emissions. Emissions related to non-dairy cattle increased by 14% (11,012 tCO_2e) due to an increase in the number of non-dairy cattle.
- Emissions related to dairy cattle decreased by 8% (-12,365 tCO_2e) due to a decrease in the number of dairy cattle.

4.4 Waste

Waste emissions decreased by 12% between FY19 and FY23 mainly due to a 21% reduction in annual emissions from closed landfill sites. As no additional waste enters these sites, annual emissions from this source will continue to fall over time.

At the currently open landfill site that processes Christchurch's landfill waste (Kate Valley Landfill), the total landfill gas (CH_4) produced annually increased by 5% between FY19 and FY23 due to increases in annual waste volumes sent to landfill over the last 18 years. However, due to the presence of landfill gas capture systems at this site, total emissions from this source are much lower than for closed landfill sites.

Waste diverted from landfill for composting in Christchurch includes horticultural, animal waste products, green waste, bark, and sawdust. Composting of this organic waste produces lower emissions than if sent to a landfill. Composting emissions increased by 4% between FY19 and FY23 as volumes of diverted waste increased (574 tCO_2e).

4.5 Industrial Processes and Product Use (IPPU)

IPPU emissions decreased by 2%, following the national trend for these emissions sources. The only notable change is a decrease in aerosol emissions which may be due to a decrease in the quantity used or an increase in the use of lower emissions-impacting aerosols. Note that national-level data is used for this sector and is portioned out using a population approach; actual emissions for Christchurch are unknown.

4.6 Forestry (Net Emissions)

Net Forestry sequestration (emissions released minus sequestration) increased between FY19 and FY23, from -230,939 tCO_2e to -247,610 tCO_2e. This was mostly driven by a 5% decrease in emissions released through harvesting. Sequestration by native forests remained unchanged during this time as the same data has been used for each year; however, it is unlikely that there have been significant changes.

Forestry emissions are influenced by the cyclical nature of harvesting and planting regimes, and the age of forests where some years will have higher sequestration and some years will have higher harvesting emission. This depends on the age of forests and the demand for lumber and timber. Improved and updated data sources may impact the estimation of emissions from this source in the future.

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[11] Livestock numbers have been taken from the StatsNZ Agricultural Production Statistics (https://www.stats.govt.nz/information-releases/agricultural-production-statistics-year-to-june-2022-final/). This dataset presents robust on-farm livestock numbers for the Christchurch District area.

4.7 Total Net Emissions

Annual total net emissions in Ōtautahi Christchurch decreased by 14% from 2,613,359 tCO_2e in FY19 to 2,259,865 tCO_2e. The decrease in total net emissions was driven by the 12% decrease in total gross emissions and the increase in net forestry sequestration.

Table 14 Change in Ōtautahi Christchurch total net emissions from FY19 to FY23

	FY19 (tCO_2e)	FY20 (tCO_2e)	FY21 (tCO_2e)	FY22 (tCO_2e)	FY23 (tCO_2e)	% Change (FY19 to FY23)
Total Net Emissions (including Forestry)	2,613,359	2,456,633	2,614,654	2,373,501	2,259,865	-14%

5.0 GHG Emissions Relative to Changes in Population and GDP

The focus of this inventory is the total gross emissions produced in Ōtautahi Christchurch and Te Pātaka-o-Rākaihautū Banks Peninsula; however it can also be useful to look at total emissions per capita, and per unit of Gross Domestic Product (GDP)[12] to assist understanding of emissions relative to changes in the population and economic output of Christchurch.

Emissions changes between FY19 and FY23:

- Total gross emissions decreased by 12%
- Total gross emissions per capita decreased by 14% (with a 3% increase in population)
- Total gross emissions per unit of GDP decreased by 25% (with an 18% increase in GDP)

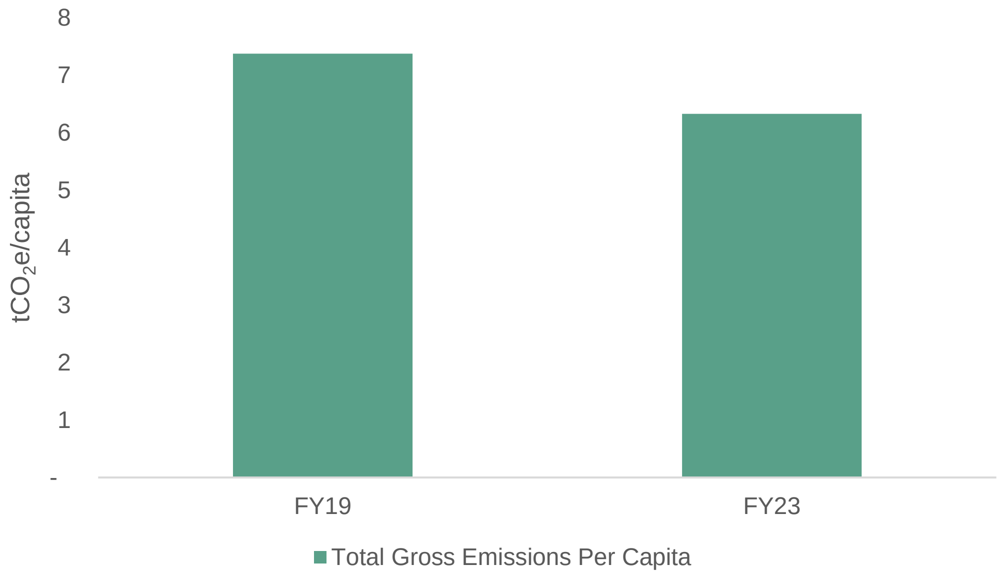

Figure 7: Total gross emissions per capita in Ōtautahi Christchurch for FY19 and FY23

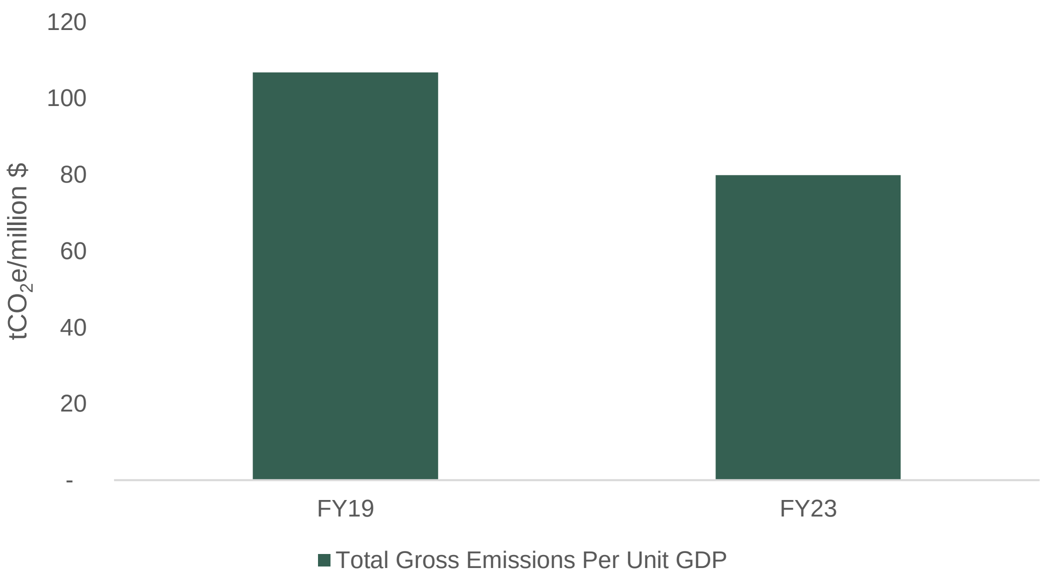

Figure 8: Total gross emissions per unit GDP in Ōtautahi Christchurch for FY19 and FY23

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[12] Used as an indicator of economic growth and provided by Christchurch City Council.

6.0 Updates to the FY19 and FY17 Emissions Inventories

Update to the Ōtautahi Christchurch Greenhouse Gas Inventory for FY19

Improvements to the methodology and available data, and updates to emission factors and Global Warming Potential (GWP) values since the FY19 Community Carbon Footprint (Emissions Inventory) was first published in 2020, have meant that the FY19 inventory results are required to be updated to allow direct comparison with the FY20-FY23 inventory years. The previous FY19 inventory results and updated FY19 inventory results are presented in Table 15.

Critical reasons for the change to results between these inventories are outlined below:

- GWP values have been updated from the previously used IPCC AR5 values (with climate feedbacks) to the AR6 values. This has reduced the calculated GHG impact of methane and nitrous oxide, particularly impacting agriculture and waste emissions. IPPU GWPs have also been updated.
- Emission Factors have been updated for a number of sources, especially impacting electricity, agriculture, and IPPU.
- Transport emissions have been adjusted due to data improvements and methodology changes, particularly in relation to air travel emissions where these emissions have been calculated and provided directly by Christchurch International Airport when previously they were calculated by AECOM.
- Stationary energy emissions have been adjusted due to data and methodology changes, notably for industrial coal use, where previously data was collected from identified large consumers and now it is derived from a top-down data source. It is unclear to what extent each method under or overestimates the relative scale of this emission source.
- Agriculture emissions have been adjusted due to, improvements in data to better reflect livestock numbers in that year.
- Waste emissions have been adjusted due to changes to waste composition data (landfill waste), and an update to wastewater treatment calculations to align with WaterNZ guidance (2021).
- Forestry emissions have been adjusted due to improvements in data to better reflect forest harvesting in that year.

Table 15 Reported GHG emissions in Ōtautahi Christchurch for FY19, showing the change in emissions between those previously reported (2020) and the updated results (2023)

	FY19 previous inventory (2020) – tCO_2e	FY19 updated inventory (2023) – tCO_2e	FY19 updated inventory (2023) – % of total gross emissions
Transport	1,470,159	1,510,830	53%
Stationary Energy	517,077	692,808	24%
Agriculture	417,545	376,094	13%
Waste	202,854	133,994	5%
Industrial Processes and Product Use (IPPU)	115,381	130,573	5%
Total Gross Emissions (excluding Forestry)	**2,723,016**	**2,844,298**	**100%**
Net Forestry	-197,733	-230,939	-
Total Net Emissions (including Forestry)	**2,525,283**	**2,613,359**	**-**

Future emissions inventories for Christchurch may also require adjustments to the emission results reported here due to improvements to the inventory process.

Update to the Ōtautahi Christchurch Greenhouse Gas Inventory for FY17

The Ōtautahi Christchurch FY17 greenhouse gas emissions inventory acts as a baseline year against which to track Christchurch's emission reduction targets against. The Ōtautahi Christchurch FY17 greenhouse gas emissions inventory has been updated as part of this work to better align with the updated emission factors and GWP values used in this inventory. The data previously used to calculate the FY17 inventory has not been updated (unlike the update to the FY19 inventory).

The previous and updated FY17 total gross emissions and total net emissions can be seen in Table 16. The most significant changes were seen in the waste and agriculture sectors, where the change in the GWP for methane and nitrous oxide has reduced the estimated global warming impact (in tCO_2e) from these sectors. Further detail on this update has been provided to Christchurch City Council.

Table 16 Reported GHG emissions in Ōtautahi Christchurch for FY17, showing the change in emissions between those previously reported (2020) and the updated results (2023)

	FY17 previous inventory (2020) – tCO_2e	FY17 updated inventory (2023) – tCO_2e
Total Gross Emissions (excluding Forestry)	2,665,643	2,535,735
Total Net Emissions (including Forestry)	2,365,379	2,234,457

Changes in Annual Emissions, FY17 to FY23

- Emissions from some sources for FY17 are not directly comparable to the FY19 to FY23 results due to differences in the data used. This is particularly the case for coal, electricity, and rail emissions where different data sources have been used.
- It is however possible to use these results to identify general trends and assess progress towards emission reduction targets.
- Between FY17 and FY23, **Total Gross Emissions** in Christchurch decreased by 1% (-28,260 tCO_2e), largely due to a reduction in transport emissions (particularly air travel). Significantly, emissions from electricity consumption, closed landfill sites, and on-road transport also decreased while emissions from agriculture and coal increased.
- Between FY17 and FY23, **Total Net Emissions** in Christchurch increased by 1% (25,970 tCO_2e) due to an increase in forest harvesting emissions, despite the 1% decrease in total gross emissions.

Table 17 Change in Ōtautahi Christchurch total gross and net emissions from FY17 to FY23

	FY17 (tCO_2e)	FY19 (tCO_2e)	FY21 (tCO_2e)	FY23 (tCO_2e)	% Change (FY17 to FY23)
Total Gross Emissions (excluding Forestry)	2,535,735	2,844,298	2,846,874	2,507,475	-1%
Total Net Emissions (including Forestry)	2,234,457	2,613,359	2,614,654	2,259,865	1%

7.0 Closing Statement

Ōtautahi Christchurch's Greenhouse Gas Emissions Inventory, FY23 provides information for decision-making and action by Christchurch City Council, stakeholders, and the wider community.

The emissions footprint developed for Christchurch covers emissions produced in the stationary energy, transport, waste, IPPU, agriculture, and forestry sectors using the GPC reporting framework. Sector-level data allows Christchurch to work with the sectors that contribute the most emissions to the footprint.

Understanding of climate change's extensive and long-lasting effects is always improving. It is recommended that this emissions footprint be updated regularly to inform ongoing positive decision-making to address climate change issues.

The availability, quality, and applicability of data limit the accuracy of any emissions footprint. These results may need updating in the future with changes in data and methodology to enable comparable figures to assess trends over time.

8.0 Limitations

Where this Report indicates that information has been provided to AECOM by third parties, AECOM has made no independent verification of this information except as expressly stated in the Report. AECOM assumes no liability for any inaccuracies in or omissions to that information. This Report was prepared between **September** and **November 2023** and is based on the information reviewed at the time of preparation. AECOM disclaims responsibility for any changes that may have occurred after this time. This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice.

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Appendix A

Methods, Assumptions, and Data Sources

Appendix A Method, Assumptions and Data Sources

Sector / Category	Method, Assumptions and Data Sources
General	
Geographical Boundary	LGNZ local council mapping boundaries have been applied.
Population	Population figures are provided by StatsNZ. Financial year populations have been used, these are based on the average population from the two calendar years (e.g., the average of 2021 and 2022 calendar year populations for FY22).
Global Warming Potential Used	Emissions are expressed on a carbon dioxide-equivalent basis (CO_2e) using the 100-year Global Warming Potential (GWP) values including climate feedbacks, from the IPCC 6th Assessment Report (AR6).
Full Inventory	Emissions for all sources broken down by individual main greenhouse gases are provided in the supplementary spreadsheet information supplied with this report.
GPC Production Approach	GPC reporting is predominately production-based (as opposed to consumption-based) but includes indirect emissions from energy consumption. Production-based emissions reporting is generally preferred by policy-makers due to robust established methodologies such as the GPC, which enables comparisons between different studies. Production-based approaches exclude globally produced emissions relating to consumption (e.g., embodied emissions relating to products produced elsewhere but consumed within the geographic area such as imported food products, cars, phones, clothes etc.). Cross-boundary movements such as air travel and marine freight journeys departing or arriving in Christchurch have been included with emissions related to the journeys split equally between the origin and destination, despite the emissions being produced outside the Christchurch geographical boundary, as per the GPS requirements. Emissions related to the generation of electricity which is consumed in Christchurch are included as per the GPC method, even if generated outside of Christchurch. This emissions inventory aligns with BASIC+ GPC reporting.
Emission Factors	All emission factors have detailed source information in the calculation tables within which they are used. Where possible, the most up to date, NZ-specific emission factors have been applied.
Transport Emissions	
Petrol and Diesel:	Total petrol and diesel consumption in Christchurch was calculated from aggregated petrol and diesel sales data for the Christchurch and Selwyn districts which was allocated based on data provided for the Selwyn and Christchurch districts based on the Vehicle Kilometre Travelled (VKT) approach in each area. Fuel sold in an area does not always mean that the fuel is used in that area, however this approach is considered to be a robust and comparable estimate of fuel consumption in a geographic area. Allocating fuel consumption based on VKT does not account for the likely makeup of the vehicle fleet of a particular geographic area (e.g. where a more

	rural area may use more diesel, or a more urban area may have more hybrid or electric vehicles travelling). Total petrol and diesel fuel use was then divided by likely end use. The division into transport and stationary energy end use (and within transport, on-road and off-road) was calculated using fuel end use data provided by the Energy Efficiency and Conservation Authority (EECA) in April 2020. - On-road transport is defined as all standard transportation vehicles used on roads e.g. cars, bikes, buses. - Off-road transport is defined as machinery for agriculture, construction and other industry used off-roads (e.g. agricultural, forestry, and construction vehicles and equipment, and includes recreational marine use) - Stationary energy petrol and diesel use is defined as fuel not used for transport either on or off roads. Petrol and diesel used for stationary energy has been reported in the Stationary Energy sector. Improved understanding of off-road and stationary uses of petrol and diesel (nationally, regionally, or locally) would improve the accuracy of emissions estimates for these sources. At the time of writing the EECA is in the process of improving understanding of these sources.
Rail Diesel	Consumption was calculated by Kiwi Rail using the induced activity method for system boundaries. The following assumptions were made: - Net Weight is product weight only and excludes container tare (the weight of an empty container) - The Net Tonne-Kilometres (NTK) measurement has been used. NTK is the sum of the tonnes carried, multiplied by the distance travelled. - National fuel consumption rates have been used to derive litres of fuel for distance. - Type of locomotive engine used, and jurisdiction topography, have not been incorporated in the calculations. Using the induced activity method, the trans-boundary routes were determined, and the number of stops taken along the way derived. The total litres of diesel consumed per route was then split between the departure territorial authority, arrival territorial authority and any territorial authority the freight stopped at along the way. If the freight travelled through but did not stop within a territorial authority, no emissions were allocated.
Air Travel (Jet Kerosene and Aviation Gas)	Emissions related to fuel use by aircraft departing and arriving in Christchurch has been calculated and provided by Christchurch International Airport. AECOM has not reviewed the data or calculations behind these emissions. Emissions have been estimated based on ‘full flight’ fuel use with emissions split equally between the origin and destination. Air travel emissions have been split between the territorial authorities in the region based on the relative size of their populations to reflect that these flights do not just serve Christchurch. It is recognised that flights to and from Christchurch serve a wider area than just the region, however a regional approach has been taken to ensure that these emissions are captured in community-level emissions inventories and in alignment with the approach taken for other major transport hubs such as Lyttleton Port, Wellington Airport, and Tauranga Port.
Marine Diesel – Freight	An estimate of fuel use was calculated for vessels arriving and departing from ports within Christchurch:

	- The schedule of vessels arriving and departing from ports in Christchurch containing details on size of the vessel was used to calculate fuel consumption. - Shipping distances and vessel fuel burn rates were used for these calculations. - Emissions have been estimated based on full journey fuel use to/from the next/last destination with emissions split equally between the origin and destination. Marine freight emissions have been split between the territorial authorities in the region based on the relative size of their populations to reflect that freight imports and exports do not just serve Christchurch. It is recognised that freight imports and exports to and from Christchurch serve a wider area than just the region, however a regional approach has been taken to ensure that these emissions are captured in community-level emissions inventories and in alignment with the approach taken for other major transport hubs such as Christchurch International Airport, Wellington Airport, and Tauranga Port.
Marine Diesel (Local)	Port operational vessels: - Fuel use has been provided directly from ports within Christchurch - All emissions from this source have been allocated to Christchurch Local ferries: - Diesel fuel use has been provided directly by ferry operators. - All emissions from this source have been allocated to Christchurch Private use, other commercial operators, and commercial fishing: - Most small private boats use fuel purchased at vehicle gas stations so this consumption will be included in off-road transport petrol and diesel emissions. - No data was available to determine emissions from other commercial operators, and commercial fishing.
Cruise Ships	Cruise ship emissions have previously not been included in Ōtautahi Christchurch's GHG emission's inventory. This is due to the limited data and information available to estimate emissions from this source. Using a new method, emissions from this source have been estimated for the first time but not included in the reported total gross emissions or total net emissions as sources of reliable data are limited. The reported cruise ship emissions are based on estimates of fuel used during the journeys to and from Christchurch (with emissions split equally between the origin and destination) and fuel use while stationary in Christchurch. Unlike marine freight, where emissions are allocated across the Canterbury region, cruise ship emissions are 100% allocated to Christchurch, where the benefits are experienced. This method enables a simplified way to estimate emissions from this source. As data and understanding of cruise ship fuel usage improves, and standard methodologies to estimate GHG emissions are developed, it is recommended that emissions from this source are included in future city-wide emissions inventories.
LPG	Total North Island consumption data was used and then split on a per capita basis to determine the territorial authority's consumption. National LPG end use data has been used to breakdown consumption into stationary energy and transport usage, these are then reported separately in their respective categories.

Electric Buses	Electric bus emissions relate to the electricity use by electric buses (as per electricity consumption). Electricity consumption information has been provided by one operator and estimated for the other operator based on the size of the fleet.
Electric Vehicles	Electric vehicle emissions relate to the electricity use by electric vehicles (as per electricity consumption). This is a high-level estimate based on a Waka Kotahi estimate for 2019, adjusted for the years of this study based on the size of the electric vehicle fleet in Christchurch. The electric vehicles category does not include electric buses (reported separately), or other modes of electric transport (e.g. scooters, e-bikes, or other electric micro-mobility).
Stationary Energy Emissions	
Consumer Energy End Use	Stationary energy demand (e.g. electricity use, natural gas, etc.) is broken down by the sector in which they are consumed. We report stationary energy demand in the following categories: industrial (which includes agriculture, forestry, and fishing); commercial; and residential. These sectors follow the Australia New Zealand Standard Industrial Classification 2006 definitions. In addition to agriculture, forestry and fishing, the industrial sector includes mining, food processing, textiles, chemicals, metals, mechanical/electrical equipment and building and construction activities. Emissions from petrol and diesel used for stationary energy are not broken down into these sectors. Energy demand used for transport is reported in the transport sector.
Electricity Consumption	Electricity consumption has been calculated using grid demand trends from the EMI website (www.emi.ea.govt.nz) to obtain raw grid exit point data for Christchurch. Reconciled demand has been used as per EMI's confirmation. Electricity consumption emissions relate to the generation of the electricity, even if generated outside of Christchurch, as per the GPC methodology. An emissions per unit of electricity value (tCO_2e/GWh) for each year is derived from Ministry for Business, Innovation and Employment (MBIE) data covering the financial year. This value is based on the sources of generation nationally as the national grid supplies electricity to the entire country. The breakdown into sectors is based on NZ average consumption per sector (residential, commercial, and industrial).
Coal Consumption	National coal consumption data has been provided by MBIE for 2022. National coal consumption has been divided between territorial authorities on a per capita basis.
Biofuel and Wood Consumption	National biofuel consumption data has been provided by the Ministry for Business, Innovation and Employment (MBIE 2021). Biofuel consumption has been divided between territorial authorities on a per capita basis. Biofuel emissions are considered to be biogenic. Biofuel biogenic CO_2 emissions are not included in total gross emissions but are reported separately in this report.

LPG Consumption	South Island LPG sales data (tonnes) has been provided by the LPG Association for 2020 and 2021. Data was interpolated between known data points or copied from the most recent data point where data is not available. ‘Auto’ and ‘Forklift’ sales represent transport uses of LPG. All other sales represent stationary energy uses of LPG. Sales have been divided between territorial authorities on a per capita basis. The breakdown into sectors (Residential, Commercial, and Industrial) is based on NZ average consumption per sector as per MfE data.
Petrol and Diesel (stationary energy end use)	Total petrol and diesel consumption in Christchurch was calculated as described under ‘Transport Emissions’. Total petrol and diesel fuel use was then divided by likely end use. The division into transport and stationary energy end use (and within transport, on-road and off-road) was calculated using fuel end use data provided by the Energy Efficiency and Conservation Authority (EECA) in April 2020. - Stationary energy petrol and diesel use is defined as fuel not used for transport either on or off roads. Petrol and diesel used for stationary energy has been reported in the stationary energy sector. Improved understanding of off-road and stationary uses of petrol and diesel (nationally, regionally, or locally) would improve the accuracy of emissions estimates for these sources. At the time of writing the EECA is in the process of improving understanding of these sources.
Natural Gas Consumption	There is no natural gas supply in the South Island.
Biogenic Emissions	Some Carbon Dioxide (CO_2) emissions are considered to be biogenic. These are CO_2 emissions where the carbon has been recently derived from CO_2 present in the atmosphere (for example, some agricultural and waste emissions). These emissions are not included in calculating total gross emissions in CO_2e.
Agricultural Emissions	
Agriculture	Territorial authority livestock numbers and fertiliser data were taken from the Agricultural production statistics for 2017 and 2022 (StatsNZ). Regional agricultural data from StatsNZ (2022) has been used to estimate the change in livestock numbers for the remaining years. No information existed to derive FY23 data so the FY22 data has been used for FY23. Livestock grazing in Christchurch but belonging to a farm with their address outside the district are included in this inventory. For consistency, ‘Grazing elsewhere’ livestock (i.e. grazing outside Christchurch but with the farm address in Christchurch) are not included in the total livestock numbers used in this inventory. This category of livestock represents less than 1% of total livestock in Christchurch. The data used for agricultural emissions was checked with Stats NZ during the assessment for consistency and applicability to Christchurch. See https://www.stats.govt.nz/information-releases/agricultural-production-statistics-year-to-june-2022-final/ for additional detail on this data source.
Solid Waste Emissions	
Landfill Emissions	Landfill waste volume and landfill gas capture system information has been provided by the respective council departments. Solid waste emissions from landfill are measured using the IPCC First Order Decay method that covers landfill activity between 1950 and the present day, as

<table>
<tr><td></td><td>per the GPC reporting requirements. This method accounts for the gradual release of emissions from waste over a long period of time, and so calculates the emissions produced per year from waste in landfill (including emissions from closed landfill sites).

This approach differs from organisational footprints which generally include council-owned landfill sites. Organisational footprints methodology generally calculates the likely future emissions from the waste entering landfill that year, and attributes those emissions to that year (and doesn’t include emissions from waste already in the landfill, or emissions from closed landfill sites).

Waste volume:
- Where information is not available, waste volumes have been estimated based on historical national data on a per capita basis.
Landfill gas capture system efficiency:
- Burwood Landfill – Efficiency of the system used in the emissions calculations has been taken from data provided by CCC.
- Kate Valley Landfill – Efficiency of the system used in the emissions calculations has been taken from data provided by CCC.

Landfill gas combustion for energy generation:
- Emissions relating to burning of landfill gas for energy generation have been included in the stationary energy sector.

Emissions are allocated to territorial authorities based on where the waste was produced, even if the waste is disposed in landfill outside the territorial authority.</td></tr>
<tr><td colspan="2">Wastewater Emissions</td></tr>
<tr><td>Wastewater Treatment</td><td>Wastewater Treatment Plant emissions totals were provided by Christchurch City Council, developed according to WaterNZ (2021) guidance. All wastewater emissions have been calculated following the WaterNZ (2021) guidance.

Wastewater Treatment Plants:
- Calculation of emissions includes emissions released directly from wastewater treatment, flaring of captured gas and from discharge onto land/water.
- Where data was not available assumed values have been used based on the WaterNZ (2021) guidance
- Emissions relating to discharge of biosolids sent to landfill has been included in the Solid Waste emissions source.
- Emissions are allocated to territorial authorities based on where the wastewater was produced, even if the wastewater is treated outside the territorial authority.
- AECOM has not reviewed wastewater treatment emissions calculated by Christchurch City Council
Individual Septic Tanks:
- Populations not connected to known wastewater treatment plants are assumed to be using septic tanks.
- The population not connected to centralised wastewater treatment has been estimated based on the number of rateable properties not connected to sewerage in FY23.
- Septic tank emissions have been estimated for all prior years based on the FY23 data, adjusted to account for population change.</td></tr>
<tr><td colspan="2">Industrial Processes and Product Use Emissions</td></tr>
</table>

Industrial processes	It is assumed that there are no significant non-energy related emissions of greenhouse gasses from industrial processes in the district (e.g. aluminium manufacture).
Industrial Product Use	National data covering industrial product use (e.g. fire extinguishers, refrigerants) have been estimated based on data provided in the New Zealand Greenhouse Gas Emissions 1990-2021 report (MfE 2023). Emissions are estimated on a per capita basis applying a national average per person. No information existed to derive FY22 or FY23 data so the FY21 data has been used for these years.
Forestry Emissions	
Exotic Forestry Harvested and Exotic Forest coverage	Harvested forestry, and forest cover information has been derived from Ministry for Primary Industries (MPI) data. Exotic forest cover includes data from forest owners with more than 40 hectares of exotic forest. This emissions footprint accounts for forest carbon stock changes from afforestation, reforestation, deforestation, and forest management (i.e., it applies land-use accounting conventions under the United Nations Framework Convention on Climate Change rather than the Kyoto Protocol). It treats emissions from harvesting and deforestation as instantaneous rather than accounting for the longer-term emission flows associated with harvested wood products. The emissions footprint considers regenerating (growing) forest areas only. Capture of carbon from the atmosphere is negligible for mature forests that have reached a steady state. No information existed to derive FY23 data so the FY22 data has been used for FY23.
Native Forest	Native forest land area for each territorial authority has been provided by Landcare Research for FY18, this figure has been used for each year due to a lack of accurate data however it is likely that native forests in Christchurch have not changed significantly during this time.

Appendix B

Christchurch Emissions Inventory FY19-23 – Full Inventory Tables

Appendix B Christchurch Emissions Inventory FY19-23 - Full Inventory Tables

Transport Emissions

Table 18 Christchurch FY19-23 Transport emissions by emission source

Emissions Source	FY19 Emissions (tCO_2e)	FY20 Emissions (tCO_2e)	FY21 Emissions (tCO_2e)	FY22 Emissions (tCO_2e)	FY23 Emissions (tCO_2e)
Diesel (on-road and off-road)	547,635	533,323	566,947	554,833	564,597
Petrol (on-road and off-road)	523,705	477,816	532,788	487,274	508,297
Air Travel (Jet Kerosene and Aviation Gas)	293,743	211,167	129,147	140,815	211,779
Marine Freight	125,028	97,469	108,473	112,924	42,012
Rail[13]	14,796	14,257	14,766	14,766	14,766
LPG (for Transportation)	3,316	3,298	3,402	3,390	3,454
Marine Diesel (Local)	2,383	2,321	1,870	1,873	2,174
Private EV's	224	299	370	559	948
Buses (Electric only)	-	58	80	239	318
Total	**1,510,830**	**1,340,008**	**1,357,844**	**1,316,673**	**1,348,345**

Stationary Energy Emissions

Table 19 Christchurch FY19-23 Stationary Energy emissions by emission source

Emissions Source	FY19 Emissions (tCO_2e)	FY20 Emissions (tCO_2e)	FY21 Emissions (tCO_2e)	FY22 Emissions (tCO_2e)	FY23 Emissions (tCO_2e)
Electricity Consumption	333,580	350,176	465,938	306,299	176,045
Coal	176,681	166,030	167,239	170,781	170,272
LPG (Stationary)	85,926	85,460	88,163	87,840	89,513
Stationary Petrol & Diesel Use	62,057	60,202	64,177	62,559	63,750
Electricity Transmission and Distribution Losses	29,137	30,624	43,318	32,487	16,927
Biofuel / Wood	5,367	5,320	5,293	5,260	5,341
Biogas Combustion for Energy Generation	60	83	80	79	78
Total	**692,808**	**697,896**	**834,208**	**665,304**	**521,927**

[13] For rail freight, the most recent data available (FY21) has been used for all subsequent years.

Waste Emissions

Table 20 Christchurch FY19-23 Waste emissions by emission source

Emissions Source	FY19 Emissions (tCO_2e)	FY20 Emissions (tCO_2e)	FY21 Emissions (tCO_2e)	FY22 Emissions (tCO_2e)	FY23 Emissions (tCO_2e)
Closed Landfill	82,526	77,569	73,005	68,783	64,871
Wastewater Treatment Plants	21,111	21,559	22,008	21,698	21,388
Open Landfill	15,772	15,875	15,987	16,178	16,506
Composting (Green Waste)	13,233	13,501	13,769	13,788	13,807
Individual Septic Tanks[14]	1,353	1,367	1,371	1,367	1,390
Total	**133,994**	**129,871**	**126,140**	**121,814**	**117,962**

Industrial Processes and Product Use (IPPU) Emissions

Table 21 Christchurch FY19-23 IPPU emissions by emission source

Emissions Source	FY19 Emissions (tCO_2e)	FY20 Emissions (tCO_2e)	FY21 Emissions (tCO_2e)	FY22 Emissions (tCO_2e)	FY23 Emissions (tCO_2e)
Refrigerants and Air Conditioning	121,087	120,561	119,532	118,763	120,684
Aerosols	7,513	6,942	6,281	5,952	5,952
SF_6 - Electrical Equipment	1,049	1,121	1,100	1,056	1,056
Foam Blowing	505	522	501	502	502
SF_6 - Other	228	226	223	222	222
Fire Extinguishers	192	189	186	186	186
Total[15]	**130,573**	**129,560**	**127,824**	**126,681**	**128,603**

[14] For septic tank emissions, the most recent data available (FY23) has been used for all prior years, adjusted for population change.
[15] For all IPPU emissions, the most recent data available (FY21) has been used for all subsequent years, adjusted for population change.

Agriculture Emissions

Table 22 Christchurch FY19-23 Agriculture emissions by emission source

Emissions Source	FY19 Emissions (tCO_2e)	FY20 Emissions (tCO_2e)	FY21 Emissions (tCO_2e)	FY22 Emissions (tCO_2e)	FY23 Emissions (tCO_2e)
Livestock Enteric Fermentation	285,839	300,417	306,094	296,141	296,141
Unmanaged Manure on Pasture	40,437	42,456	43,009	42,446	42,446
Agricultural Leaching and Deposition (Manure, Urine, and Fertiliser)	27,815	29,049	29,238	29,646	29,646
Managed Manure	14,667	14,969	15,727	14,385	14,385
Fertilisers on Land	7,335	7,305	6,790	8,020	8,020
Total[16]	**376,094**	**394,197**	**400,858**	**390,638**	**390,638**

Forestry Emissions

Table 23 Christchurch FY19-23 Forestry emissions

Emissions Source	FY19 Emissions (tCO_2e)	FY20 Emissions (tCO_2e)	FY21 Emissions (tCO_2e)	FY22 Emissions (tCO_2e)	FY23 Emissions (tCO_2e)
Harvest Emissions	251,318	252,876	253,259	238,916	238,916
Native Forest Sequestration	-108,965	-108,965	-108,965	-108,965	-108,965
Exotic Forest Sequestration	-373,292	-378,811	-376,513	-377,561	-377,561
Total[17]	**-230,939**	**-234,899**	**-232,219**	**-247,610**	**-247,610**

[16] For agriculture emissions, the most recent data available (FY22) has been used for FY23.
[17] For exotic forest harvesting and sequestration, the most recent data available (FY22) has been used for FY23. For native forest sequestration, the most recent data available (FY18) has been used for all subsequent years.

Appendix C

Ōtautahi Christchurch On-Road Transport, FY19 to FY23

Appendix C Ōtautahi Christchurch On-Road Transport, FY19 to FY23

Executive Summary

This section details the additional analysis undertaken to further break down Ōtautahi Christchurch's on-road transport Greenhouse Gas (GHG) emissions as reported in the Ōtautahi Christchurch Emissions Inventory, FY23. On-road transport represented 38% of Christchurch's total gross emissions in the FY23 government financial year (1st July 2022 to 30th June 2023). The study boundary incorporates the jurisdiction of Christchurch City Council.

This document addresses emissions produced from on-road transport in FY23 and examines trends in on-road transport emissions from FY19 to FY23. Within on-road transport emissions, this assessment looks at the relative contribution of each vehicle type (cars, commercial vehicles, buses, etc.) to Christchurch's transport emissions.

Greenhouse gas emissions are generally reported in this document in Carbon Dioxide Equivalent (CO_2e) units and are referred to as 'emissions'. Vehicle Kilometres Travelled (VKT) refers to the total distance travelled by vehicles expressed in kilometres.

Key findings of this analysis include:

FY23 Transport Emissions by Vehicle Type

- Cars represented 58% of Christchurch's on-road transport emissions, and 22% of Christchurch's total gross emissions (556,222 tCO_2e). Cars represented 73% of on-road VKT in Christchurch.
    - Electric cars represented 0.1% of on-road transport emissions (939 tCO_2e), and 1.1% of on-road VKT in FY23.
- Commercial vehicles represented 40% of on-road transport emissions and 15% of total gross emissions (387,608 tCO_2e).
    - Light commercial vehicles (e.g. 'utes' and vans) represented 26% of on-road transport emissions while heavy commercial vehicles represented 14% of on-road transport emissions.
    - 25-50+ tonne heavy commercial vehicles represented 11% of on-road emissions and 4% of VKT.
- Buses represented 2% of on-road transport emissions (this includes public transport, electric buses, school buses, and coaches).
    - Electric buses represented 2% of bus emissions in Christchurch, with diesel buses accounting for 98% of bus emissions.

Changes in Transport Emissions (FY19 to FY23)

- On-road transport emissions changed by less than 0.1%.
- COVID-19 restrictions contributed to decreased annual on-road transport emissions in FY20 and FY22 by 6% compared to the year before for both years. Emissions from on-road transport rebounded by 9% and 3% in FY21 and FY23 following these COVID-19 affected years.
- Car emissions decreased by 2%, driven by a 5% decrease in petrol car emissions.
    - During the measured period, use of hybrid and electric cars increased, potentially contributing to the reduction in total car emissions.
- Commercial vehicle emissions increased 4%, driven by an 8% increase in light commercial vehicle emissions.
    - Heavy commercial vehicle emissions decreased by 2% during the same period.

- Bus emissions decreased by 19%. This is likely due to a transition to electric buses since FY20.

Methodology

The basis for this assessment is the results presented in the Ōtautahi Christchurch Greenhouse Gas Emissions Inventory for FY23 (1 July 2022 to 30 June 2023). The emissions for on-road transport have been calculated based on the sale of petrol and diesel within the geographic area for each year, broken down by sector and vehicle type using data provided by Waka Kotahi and the Energy Efficiency and Conservation Authority (EECA).

Data provided by Waka Kotahi covering an estimate of emissions (by gas) for Christchurch by vehicle class in FY19 (1 July 2018 to 30 June 2019) has been used to assess the relative contribution of vehicle class types to on-road transport emissions in Christchurch in FY19. Waka Kotahi Vehicles Kilometres Travelled[18] (VKT) and other national and vehicle fleet data from Ministry of Transport[19] covering the years from FY19 to FY23 has been used to estimate changes in on-road emissions during this period, aligning with the results of the Ōtautahi Christchurch Greenhouse Gas Emissions Inventory, FY23.

Emissions related to energy use from Electric Vehicles (EV's) have been calculated using an average electricity consumption per km travelled and are based on the carbon intensity of the national electricity grid in FY22.

All calculated emissions have been converted to tonnes of CO_2 equivalent (tCO_2e) to allow direct comparison with the results of the Ōtautahi Christchurch Greenhouse Gas Emissions Inventory, FY23. For this analysis, the word 'emissions' represents Greenhouse Gas (GHG) emissions only.

Definition of on-road vehicle categories[20]:

- Light vehicles:
  - Cars: passenger cars and sports utility vehicles (SUVs). This includes passenger cars and SUVs used for commercial purposes (e.g., taxis).
  - Light commercial vehicles: Utes and vans with gross vehicle mass up to 3.5 tonnes
- Heavy duty vehicles:
  - Heavy commercial vehicles: commercial vehicles with gross vehicle mass higher than 3.5 tonnes
  - Buses with gross vehicle mass higher than 3.5 tonnes

Key Limitations

- The results presented are Waka Kotahi data adjusted to align with the Ōtautahi Christchurch Greenhouse Gas Emissions Inventory, FY23.
- The electricity contribution to plug-in hybrid vehicle emissions has not been calculated for this assessment, however it is assumed to have a minimal impact on results.
- Data used for this assessment is based on modelling results provided by Waka Kotahi, there are inherent assumptions within all modelling.

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[18] https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/transport-data/data-and-tools/
[19] https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/
[20] https://www.nzta.govt.nz/assets/Highways-Information-Portal/Technical-disciplines/Air-quality/Planning-and-assessment/Vehicle-emissions-prediction-model/VEPM-6.3-technical-report-2022.pdf

On-Road Transport Emissions in FY23

On-road transport emissions relate to cars, commercial vehicles (including utes, trucks, and large commercial vehicles), and on-road buses. On-road transport is the largest contributor to transport emissions in Christchurch, representing 71% of Transport emissions and 38% of Christchurch's total gross emissions. This is followed by air, off-road transport, marine, and rail. Table 24 and Figure 9 detail on-road transport emissions per vehicle category and fuel type. Cars in Christchurch tend to be fuelled by petrol while commercial vehicles and buses tend to use diesel (excluding some electric buses in Christchurch). Fully electric cars represent 0.1% of total on-road emissions but represented approximately 1% of kilometres travelled by vehicles in Christchurch.

Of note:

- Cars represented 58% of on-road emissions, and 22% of Christchurch's total gross emissions.
- Commercial vehicles (light and heavy) represent 40% of on-road emissions, and 15% of total gross emissions.
- Buses represent 2% of on-road emissions. The bus category includes public transport, school buses, and private commercial buses (including tourist coaches).

Table 24 On-road transport emissions by vehicle type and fuel type in FY23 (tCO_2e)

Vehicle Type	Petrol	Diesel	Electric	Total	% of Total
Cars	474,509	80,773	939	**556,222**	58%
Commercial Vehicles	29,122	358,476	9	**387,608**	40%
Buses	-	17,311	318	**17,629**	2%
Total	**503,632**	**456,561**	**1,266**	**961,459**	**100%**

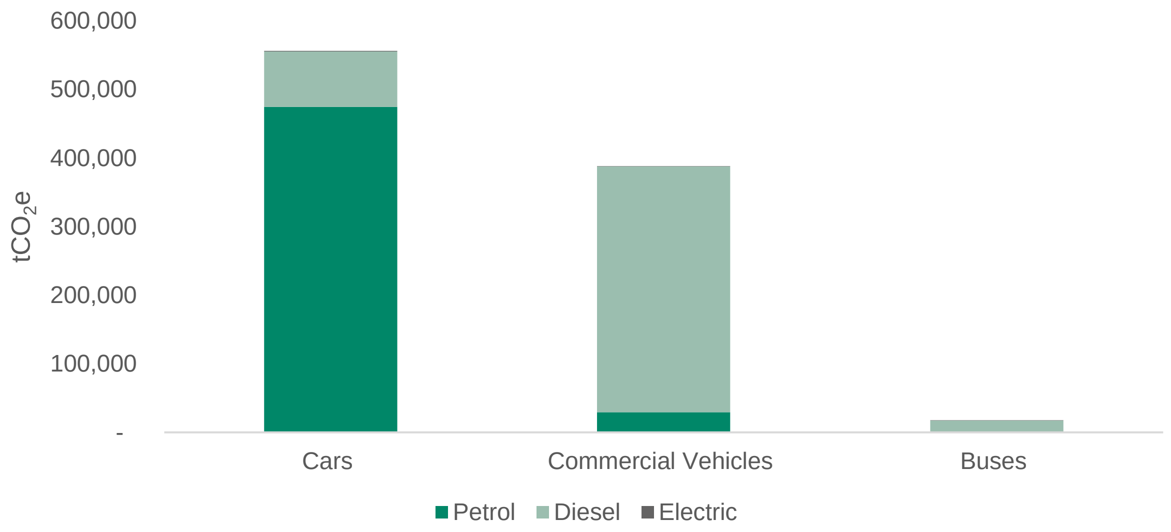

Figure 9 On-road transport emissions by vehicle type and fuel type in FY23

Emissions from these vehicle types can be broken down further by vehicle class. Table 25 details on-road transport emissions per vehicle class.

Of note:

- Commercial vehicles lighter than 3.5 tonnes represented 26% of on-road emissions. Many of these will be commercial 'utes' and small vans.
- Commercial vehicles heavier than 25 tonnes represented 11% of on-road emissions. This generally represents vehicles used for freight movement.

These results highlight the impact of both private cars and commercial vehicles on Christchurch's on-road transport emissions. Efforts to reduce emissions from on-road transport will require a range of actions to address the variety of uses and vehicle types used for on-road transport in Christchurch.

Table 25 On-road transport emissions by vehicle class in FY23 (tCO_2e)

Vehicle Class	GHG Emissions (tCO_2e)	% of Total
Cars	556,222	58%
Light Commercial Vehicles <3.5 Tonne	246,690	26%
Heavy Commercial Vehicles 3.5-25 Tonne	31,342	3%
Heavy Commercial Vehicles >25 Tonne	109,576	11%
Bus Urban	16,090	2%
Bus Coach	1,539	<1%
Total	**961,459**	**100%**

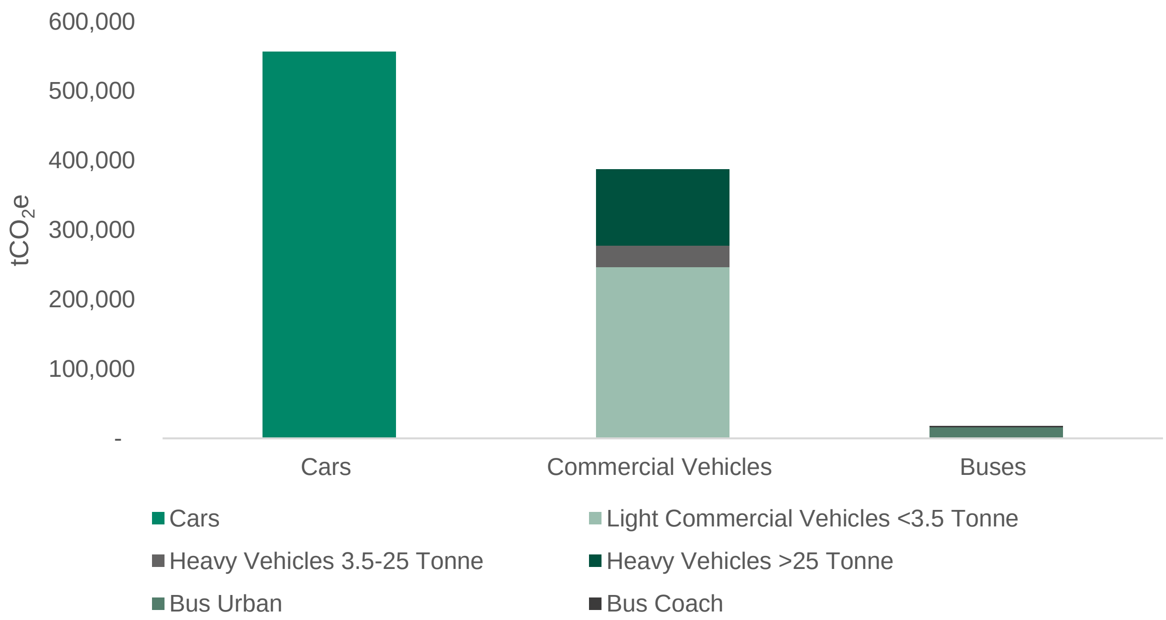

Figure 10 On-road transport emissions by vehicle class in FY23

Alongside total emissions, emissions have also been compared to distance travelled by different vehicle types. Vehicle Kilometres Travelled (VKT) refers to the total distance travelled by vehicles expressed in kilometres. Table 26 shows the emissions per vehicle class as above but also includes the VKT by each vehicle class in Christchurch and shows the average emissions per VKT for each vehicle class.

Of note:

- Cars represented 73% of all VKT in Christchurch but represent 58% of all on-road emissions. This is due to the relatively low average tCO_2e per VKT of cars compared to heavier vehicles (which is also partly due to the use of petrol rather than diesel for cars).
- >25 tonne commercial vehicles represented 4% of all VKT but represent 11% of all on-road emissions. This is due to the higher average tCO_2e per VKT of heavy commercial vehicles compared to lighter vehicles.
- Light commercial vehicles represented 20% of all VKT and 26% of on-road transport emissions.

These figures do not consider the weight of freight, or the number of people moved per vehicle. Potentially larger vehicles are more efficient per tonne of freight moved compared to smaller vehicles, and/or buses are more efficient per person compared to cars.

Table 26 On-road transport vehicle class VKT, emissions, and calculated average emissions per VKT FY23

Vehicle Type	Vehicle Kilometres Travelled (VKT)	GHG Emissions (tCO_2e)	Average tCO_2e per VKT*
Cars	2,309,670,800	556,222	0.0002
Light Commercial Vehicles <3.5 Tonne	635,512,987	246,690	0.0004
Heavy Commercial Vehicles 3.5-25 Tonne	65,596,792	31,342	0.0005
Heavy Commercial Vehicles >25 Tonne	122,181,051	109,576	0.0009
Bus Urban	13,675,843	16,090	0.0012
Bus Coach	2,075,690	1,539	0.0007
Total	**3,148,713,162**	**961,459**	**0.0039**

On-Road Transport Emissions Change FY19 to FY23

This section reports on the change in on-road transport emissions from FY19 to FY23, during which, emissions changed by less than 0.1%. On-road transport emissions per capita have decreased by 3% during this period.

In Figure 11 we can see the impact of COVID-19 travel restrictions in FY20 and FY22, particularly affecting car emissions. During these years there were periods of restricted on-road travel. Commercial vehicle emissions appear to have been slightly less affected by the COVID-19 restrictions. There were no restrictions on on-road travel in FY21 or FY23 although reduced travel related to tourism may have impacted emissions in those years. On-road transport emissions in FY21 were higher than any other year from FY19 to FY23 (3% higher than FY19), the reason for this is unknown.

Table 27 Change in on-road transport emissions by vehicle type (tCO_2e)

Vehicle Type	FY19	FY20	FY21	FY22	FY23	% Change (FY19 to FY22)
Cars	567,527	522,090	580,198	537,416	556,222	-2%
Commercial Vehicles	372,588	361,941	385,695	375,710	387,608	4%
Buses	21,852	21,028	20,916	19,138	17,629	-19%
Total	**961,967**	**905,059**	**986,809**	**932,264**	**961,459**	**<0.1%**

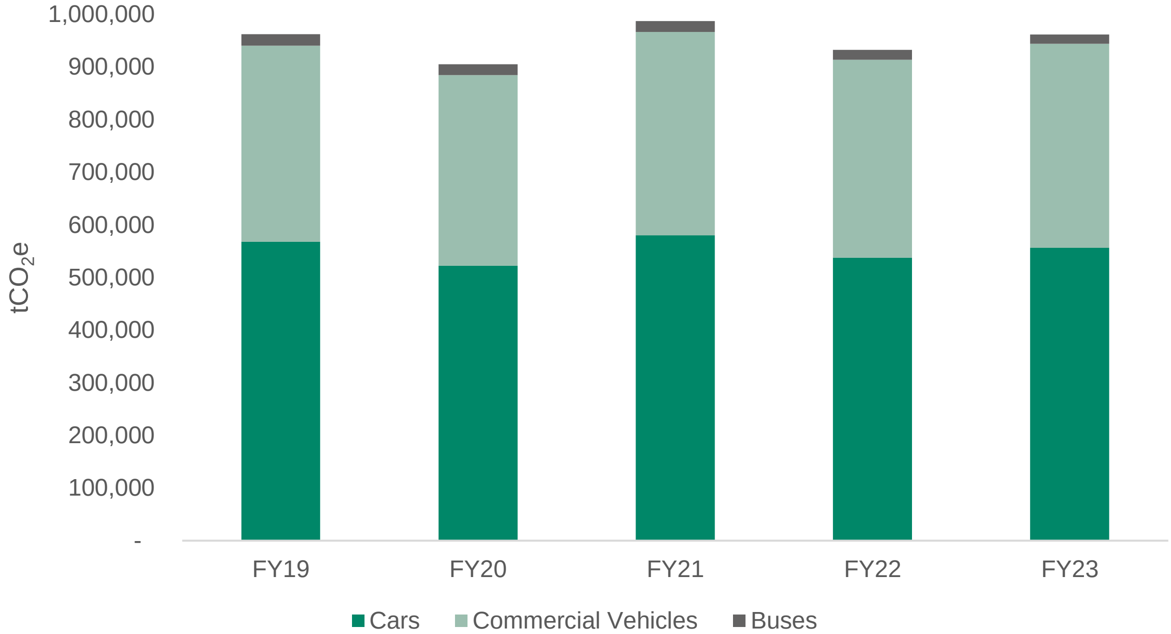

Figure 11 On-road transport emissions by vehicle type FY19-FY23

Notable changes when examining on-road emissions changes in more detail (Table 28):

- The highest emissions decrease was a 5% (-25,396 tCO_2e) reduction in petrol car emissions. A transition to hybrid and electric vehicles (see below) may have contributed to the reduced petrol car emissions, alongside other changes such as improvements in fuel efficiency, and transport mode shift (e.g., increased walking or cycling).

- Bus emissions decreased by 19% (-4,223 tCO_2e). A transition from diesel buses to electric buses in Christchurch has corresponded with a reduction in bus emissions with electric buses in FY23 representing approximately 20% of the fleet.
- The highest emissions increase was an 8% rise in light commercial vehicle emissions (17,539 tCO_2e).
- There was a relatively large increase in hybrid and electric vehicle emissions, of 328% and 322% respectively. There has been a large growth in these vehicles in Christchurch and emissions have grown in line with this increase. However, these vehicles still represent a very small proportion of on-road emissions and are generally lower emitting than the equivalent internal combustion engine vehicles.

Table 28 Change in on-road transport emissions by vehicle class (tCO_2e)

Vehicle Type	FY19	FY20	FY21	FY22	FY23	% Change (FY19 to FY22)
Car Petrol	483,562	439,281	488,700	442,899	458,166	-5%
Car Diesel	79,925	77,071	82,432	81,714	80,773	1%
Car Hybrid	3,818	5,442	8,699	12,253	16,343	328%
Car Electric	223	296	367	551	939	322%
Light Commercial Vehicles <3.5	229,151	221,249	239,865	237,599	246,690	8%
Heavy Commercial Vehicles >3.5	143,437	140,692	145,830	138,111	140,918	-2%
Buses	21,852	21,028	20,916	19,138	17,629	-19%
Total	**961,967**	**905,059**	**986,809**	**932,264**	**961,459**	**<1%**

Limitations

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