Auckland's Greenhouse Gas Inventory to 2023

Shanju Xie

August 2025

Technical Report 2025/14

aucklandcouncil.govt.nz

Auckland's greenhouse gas inventory to 2023

August 2025 Technical Report 2025/14

Shanju Xie

Environmental Evaluation and Monitoring Unit, EEMU

Auckland Council
Technical Report 2025/14

ISSN 2230-4525 (Print)
ISSN 2230-4535 (Online)

ISBN 978-1-991377-74-6 (PDF)

The Peer Review Panel reviewed this report.
Review completed on 4 August 2025 Reviewed by two reviewers
Approved for Auckland Council publication by: Name: Paul Klinac Position: General Manager, Engineering, Assets and Technical Advisory
Recommended for approval/publication by:
Name: Dr Jonathan Benge Position: Head of Environmental Evaluation and Monitoring
Name: Jacqueline Lawrence-Sansbury Position: Team Manager, Air, Land and Biodiversity. Environmental Evaluation and Monitoring Unit, EEMU
Date: 4 August 2025

Recommended citation

Xie, S (2025). Auckland's greenhouse gas inventory to 2023. Auckland Council technical report, TR2025/14

Cover image credit: Tāmaki Drive. Auckland. Photograph by Luke Harvey

Table of contents

List of figures

List of tables

Executive summary

Rising greenhouse gas (GHG) levels in the atmosphere caused by human activities are leading to climate change and rising global temperatures. *Te-Tāruke-ā-Tāwhiri: Auckland's Climate Plan* sets the target of net zero emissions by 2050 with an interim emissions reduction target of 50% by 2030 (against a 2016 baseline). An emissions inventory provided at a suitable frequency identifies and quantifies the most recent sources and sinks of greenhouse gas emissions and trends. This provides a robust evidence base and essential data to progress towards targets, evaluate impacts of current mitigation actions, frame further mitigation actions and inform future policy development.

This current inventory reports greenhouse gas emissions and carbon removals within the Auckland region for the period 2009-2023. In 2023, Auckland's gross emissions were 10,919 kilo-tonnes of carbon dioxide equivalent (kt CO_2e) and when land and harvested wood products (HWPs) were included, net emissions were 10,298 kt CO_2e. Transport and stationary energy are the dominant sectors, accounting for 46.8% and 23.5% of gross emissions, respectively. Carbon dioxide (CO_2) contributed 83.3%, methane (CH_4) 9.5%, nitrous oxide (N_2O) 2.6% and other GHGs 4.5%.

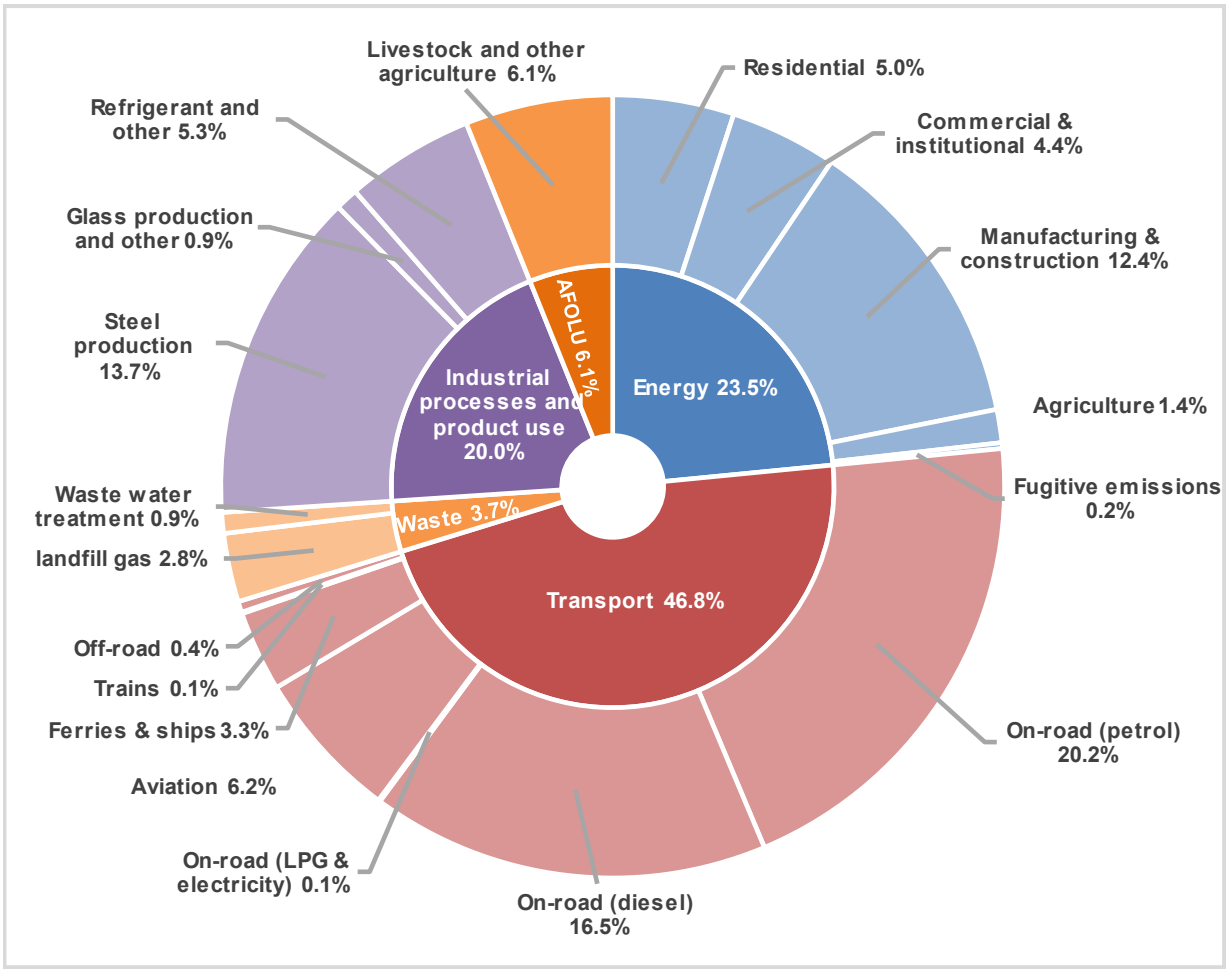

Figure E-1 Gross emissions percentages in 2023 by sector and source

Between 2016 and 2023, emissions decreased by 9.5% for gross and 8.3% for net emissions. On a finer level, gross and net emissions generally increased from 2009 to 2019, showed a marked drop from 2019 to 2020, then rebounded from 2020 to 2023. This trend was largely driven by the COVID-19 restrictions, which were introduced in 2020 and ended in 2023 and which saw a marked reduction in emissions from transport. Emissions in 2023 were still well below pre-pandemic levels of 2019, by 13.3% for gross emissions and 13.9% for net emissions, respectively.

In 2023, gross emissions were 6.3 t CO_2e per capita and 68 t CO_2e per million $NZ GDP (March 2024 prices) while net emissions were 5.9 t CO_2e per capita and 64 t CO_2e per million $NZ GDP. From 2009 to 2023, there was a downward trend in both per capita emissions and emissions per unit GDP. This shows that emissions have not increased as fast as population and economic growth.

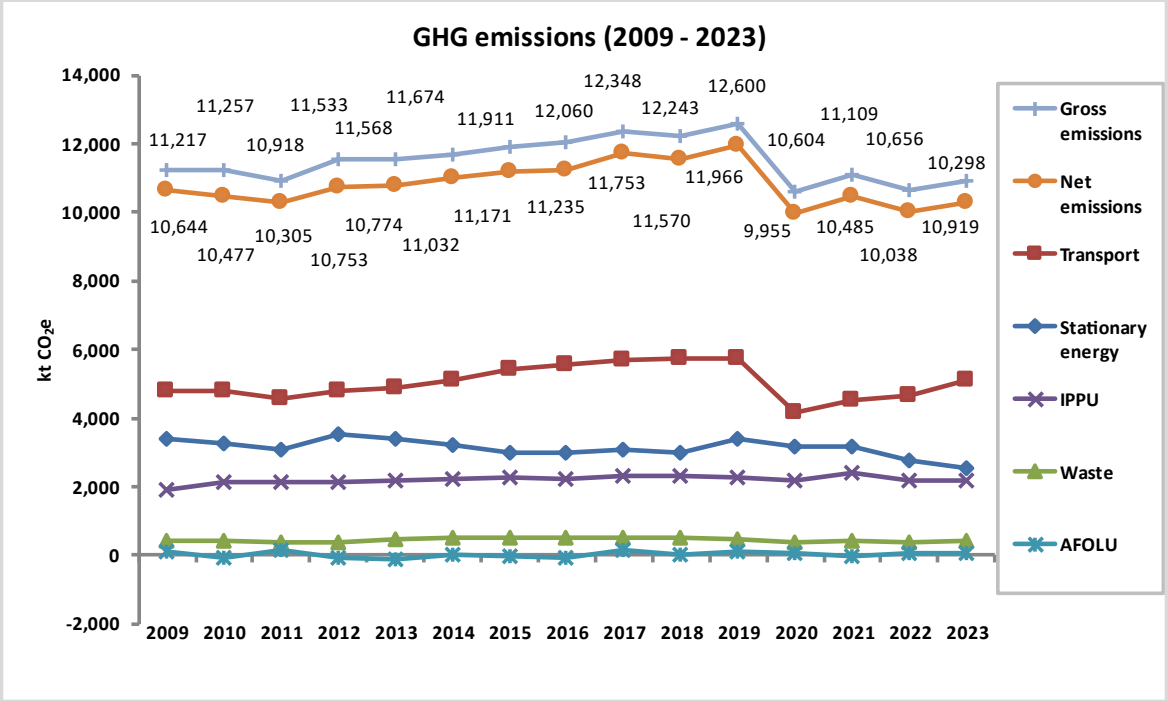

Figure E-2 Auckland's GHG emissions between 2009 and 2023

This inventory has been compiled with updated and more accurate activity data, emissions factors, and measurement methodologies and thereby has resulted in a change in historic emissions reported in previous inventories. Historic emissions from 2009 to 2021 have been updated to supersede all published previous inventories. Updated emissions in 2016 are higher than the previous baseline emissions used for the target setting. This will require additional reductions in emissions to meet the targets. To achieve the target of halving 2016 emissions by 2030, a reduction of 6,030 kt CO_2e and 5,618 kt CO_2e is required for gross and net emissions, respectively.

1 Introduction

The climate is changing as temperature rises because of increased greenhouse gas (GHG) concentration levels in the atmosphere caused by human activities. The world must reduce GHG emissions to limit temperature rise and the harmful impacts of associated risks such as accelerated sea level rise and more frequent extreme weather events. In early 2023, the Auckland Anniversary floods and Cyclone Gabrielle caused widespread destruction across Tāmaki Makaurau. Repair and rebuild efforts are still underway to recover from these devastating extreme weather events.

The *Auckland Plan 2050* sets the direction for how Auckland will grow and develop over the next 30 years (Auckland Council, 2018). It responds to the key challenges we face today – high population growth, sharing prosperity among all Aucklanders, and reducing environmental damage. To address these challenges, the plan identifies six outcomes that will deliver a better Auckland: Belonging and Participation, Māori Identity and Wellbeing, Homes and Places, Transport and Access, Environment and Cultural Heritage, and Opportunity and Prosperity. The *Auckland Plan 2050* is supported by other strategies and action plans that provide detail on how these outcomes can be delivered. The *Auckland Plan 2050* monitoring framework measures progress towards the strategic direction set out in the plan, including reductions of GHG emissions.

The council approved *Te-Tāruke-ā-Tāwhiri: Auckland's Climate Plan* in July 2020 (Auckland Council, 2020). This sets a direction, underpinned by cross-sector actions, for delivering on Auckland's emissions reduction targets and increasing the region's resilience to climate change impacts. The plan sets the target of net zero emissions by 2050 with an interim emissions reduction target of 50 per cent by 2030 (against a 2016 baseline). Both targets are consistent with New Zealand national ambition. They contribute to the global effort, under the Paris Agreement, to limit global average temperature increase to 1.5 degrees Celsius above pre-industrial levels.

An emissions inventory provided at a suitable frequency identifies and quantifies the most recent sources and sinks of GHGs and trends. This provides a robust evidence base and an essential tool to evaluate our progress, frame mitigation actions and inform future policy development. In addition, it provides input to the state of Auckland's environment reporting and *Te-Tāruke-ā-Tāwhiri: Auckland's Climate Plan's* annual progress report.

Supporting information

This report is one of a series of technical publications prepared in support of *Te oranga o te taiao o Tāmaki Makaurau – The health of Tāmaki Makaurau Auckland's Natural Environment in 2025: a synthesis of Auckland Council State of the Environment reporting*.

All related reports (past and present) are published on the Knowledge Auckland website.

All data supporting this report can be requested through our Environment Auckland Data Portal. Here you can also view live rainfall data and use several data explorer tools.

2 Methodology – the GPC

2.1 Guidance

Various methods have been used over the years to develop GHG inventories for cities across the world. The use of these different methods makes it difficult for comparisons between cities internationally (and in some cases nationally), raises questions around data quality, and limits the ability to aggregate GHG emissions data. To respond to this challenge and offer a robust and clear framework that builds on existing methodologies, the World Resources Institute (WRI), C40 Cities Climate Leadership Group (C40), and Local Governments for Sustainability (ICLEI) collaboratively developed the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (the GPC). The GPC offers a robust, transparent and globally accepted framework to consistently identify, calculate and maintain accurate, credible and comparable emissions accounting and reporting practices for cities' GHGs.

The GPC recommends an annual update of inventories, as it provides a robust evidence base to evaluate impacts of mitigation actions and progress to achieve net zero emissions by 2050. Auckland's GHG inventories have been published since the year 2009. All annual GHG inventories prepared for Auckland have been reviewed by C40 and were included in the C40 emissions database (C40, 2025).

This inventory was prepared using the GPC version 1.1 (WRI et al., 2021) for the period from 2009 to 2023, with input from the most recently available *New Zealand's Greenhouse Gas Inventory 1990-2023* (MfE, 2025a). Emissions in 1990 were estimated in previous inventories but will not be included in this inventory or future inventories as only emissions trends in recent years are used to monitor and evaluate mitigation policy effectiveness, plus, input data in 1990 was less accurate.

As in the inventory to 2021 (Xie, 2024), this inventory was prepared with the most up-to-date information available at the time and in line with the recommendations of the GPC. Updates of activity data, emission factors and methodology have been made for this inventory. Previously reported emissions from 2009 to 2021 (Xie, 2024) have been recalculated and superseded.

The land under the jurisdiction of Auckland Council is the geographic boundary of this inventory. Each emission year covers the calendar year from January to December. However, if calendar year data is unavailable, other types of annual data are used, e.g., financial year from July to June.

This report considers all seven gases required by the GPC: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). NF_3 emissions are zero since they do not occur in New Zealand (MfE,

2025). Emissions are reported as metric tonnes of each GHG as well as CO_2 equivalents (CO_2e). CO_2e is a term used to compare the emissions from various GHGs based upon their global warming potential (GWP) over a time period. Individual GHGs are converted into CO_2e by multiplying the GWP values (over the 100-year time-horizon, i.e., GWP100) in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). GWP100 values for main GHGs are listed in MfE (2025b). This is consistent with the most recent release of *New Zealand's Greenhouse Gas Inventory* (MfE, 2025a) when this report was prepared.

Emissions are allocated into three scopes (Figure 2-1). Scope 1, or "territorial", emissions are those that physically occur within the city. Emissions that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries, are categorised as Scope 2 emissions. Scope 3 emissions refer to those that occur outside the city but are driven by activities taking place within the city's boundaries. The current version of GPC requires reporting of Scope 3 emissions from a limited number of sources (transmission and distribution losses associated with grid-supplied energy, and waste disposal and treatment outside the city boundary and transboundary transportation).

Emissions are classified into five main sectors: stationary energy; transport; waste; industrial processes and product use (IPPU); agriculture, forestry, and other land use (AFOLU). As discussed above, these emissions are further allocated into three scopes: Scope 1, Scope 2 and Scope 3. An additional sector (Other Scope 3) is for all other emissions occurring outside the geographic boundary as a result of city activities. Other Scope 3 includes emissions embodied in fuels, water, food and construction materials. Reporting on Other Scope 3 is optional by the current GPC version 1.1 (WRI et al., 2021) and is not reported in this inventory due to insufficient data. Five main sectors are sub-divided into sub-sectors (see Table A-1).

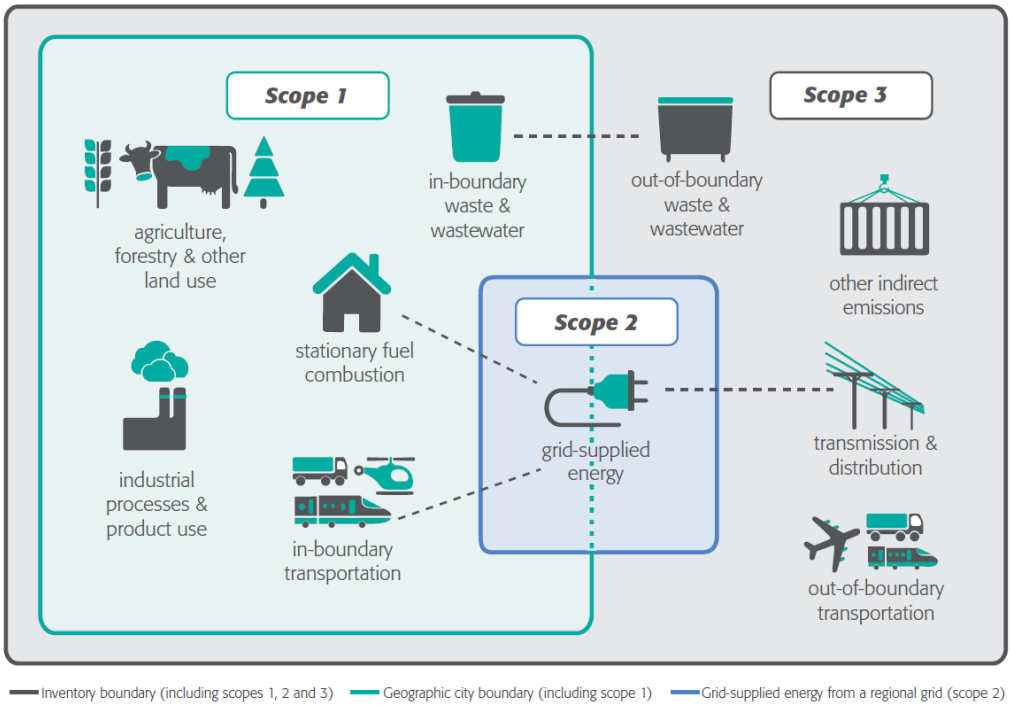

Figure 2-1 Sources and boundaries of city GHG emissions (WRI et al., 2021)

2.2 Information sources and data quality

Emissions are calculated by multiplying activity data (AD) by an emission factor (EF) associated with the activity. Activity data is a quantity of an activity that results in GHG emissions during a given period (e.g., the number of kilowatt-hours (kWh) of electricity used in a year). An emission factor is a number specific to each activity used to calculate the quantity of GHG emissions produced for each unit of that activity (e.g., CO_2 emissions in kg from the use of electricity in a kWh, kg CO_2/kWh).

Data used in the inventory is collected from a variety of sources and varies in quality, format, and completeness. For some sources, emissions data is directly provided by a third party. For others, depending on availability, activity data is either provided by data owners or estimated based on activity-related information. The detail is discussed in Chapter 4 and summarised in Table A-6. Latest available national emission factors are used in this inventory (MfE, 2024) when this report was prepared.

It is necessary to accommodate limitations in data availability and differences in emission sources between cities. The GPC requires the use of notation keys (IE, NE, NO and C, see below) and an accompanying explanation to justify exclusion or partial accounting of GHG emission source categories, for example, if the activity does not occur or when sufficient AD is unavailable.

IE (Included Elsewhere): GHG emissions for this activity are estimated and presented in another category of the inventory. That category shall be noted in the explanation.

NE (Not Estimated): Emissions occur but have not been estimated or reported; justification for exclusion shall be noted.

NO (Not Occurring): An activity or process does not occur or exist within the city.

C (Confidential): GHG emissions which could lead to the disclosure of confidential information and therefore cannot be reported.

The data quality for AD and EFs is assessed with a High-Medium-Low rating. High (H) rating is assigned to detailed activity data or where city/region-specific emission factors are used. Activity data that is estimated using robust assumptions or where more general emission factors are used (e.g., applied nationally) is rated as Medium (M). Low (L) is referred to highly modelled or uncertain activity data, or where default emission factors are used (e.g., those provided by IPCC guidance (IPCC, 2023)).

Under the GPC, total emissions can be reported at the BASIC or BASIC+ levels. The BASIC level covers scope 1 and scope 2 emissions from stationary energy and transport, as well as scope 1 and scope 3 emissions from waste. BASIC+ additionally includes emissions from IPPU and AFOLU and transboundary transportation. This inventory reports at the BASIC+ level since emissions were calculated for all the sectors required by BASIC+. The City Inventory Reporting and Information System (CIRIS) (v2.5) (C40, 2023) was used in the compilation of this inventory.

In line with New Zealand's greenhouse gas inventory, gross and net emissions are presented in this inventory. Gross emissions are reported as total emissions (i.e., net emissions) exclusive of those from land and harvested wood products (HWPs). This is discussed further in section 3.1.

2.3 Updates to historic emissions

This inventory has been updated and improved with updates to activity data, emission factors, and methodology, notably using GWP100 values from AR5, and updating emissions from land and HWPs. Previous inventories have been compiled using GWP100 values from AR4, and assuming no changes in emissions from land and HWPs from 2016 due to lack of data.

Historic emissions from 2009 to 2021 have been recalculated to supersede all published previous inventories. For comparison with this inventory which has been compiled using GWP100 values from AR5, emissions of previous inventories using AR4 have been recalculated in AR5 in this report.

Compared to the previous 2016 inventory, the improvements to data sources and methodology result in higher emissions from coal, aviation and land; and lower emissions from off-road transport and other agriculture. Overall, this inventory reports 5.2% and 9.4% higher gross and net emissions in 2016 (Tables A-2 and A-4).

Compared to the previous 2021 inventory, this inventory reports higher emissions from land and lower emissions from other agriculture. Overall, this results in 2.9% and 9.2% higher gross and net emissions in 2021 (Tables A-3 and A-5).

This inventory also reports the same trend for gross emissions, and higher net emissions from 2014 due to less removals of emissions from land and HWPs (Figure A-1).

3 Key findings

3.1 Emissions and sources (2023)

In 2023, Auckland's net GHG emissions were 10,298 kt CO_2e (BASIC+ emissions in Table 3-1). Blank cells in Table 3-1 indicate that emissions occur but have not been estimated or reported, or that an activity or process does not occur or exist within the city. Table 3-2 illustrates the GPC reporting requirements. As discussed earlier, reporting on Other Scope 3 is optional and not reported due to insufficient data.

Table 3-1 Emissions summary for 2023 (in the GPC format)*

GHG Emissions Source (By Sector)		Total GHGs (metric tonnes CO2e)					
		Scope 1	Scope 2	Scope 3	BASIC	BASIC+	BASIC+ S3
STATIONARY ENERGY	Energy use (all emissions except I.4.4)	1,771,144	733,849	55,811	2,504,993	2,560,804	2,560,804
	Energy generation supplied to the grid (I.4.4)	20					
TRANSPORTATION	(all II emissions)	4,078,977	9,923	1,020,504	4,088,900	5,109,405	5,109,405
WASTE	Waste generated in the city (III.X.1 and III.X.2)	310,533		93,045	403,578	403,578	403,578
	Waste generated outside city (III.X.3)						
IPPU	(all IV emissions)	2,180,000				2,180,000	2,180,000
AFOLU	(all V emissions)	43,974				43,974	43,974
OTHER SCOPE 3	(all VI emissions)						
TOTAL		8,384,648	743,772	1,169,360	6,997,471	10,297,760	10,297,760

** See Table 3-2 for the meaning of cell colours*

Table 3-2 Emission sources covered and reported by the GPC

Source	Report
	Sources required for BASIC reporting
+	Sources required for BASIC+ reporting
	Additional scope 1 sources required for territorial reporting
	Other scope 3 sources
	Non-applicable emission sources

New Zealand's greenhouse gas inventory reports gross emissions and net emissions (MfE, 2025a). Net emissions (i.e., total emissions) are sum of emissions from all sources while gross emissions exclude the contribution of the Land Use, Land Use Change and Forestry (LULUCF) sector. While it is not a requirement of the GPC to report gross emissions, they are presented in this inventory for consistency with national reporting. AFOLU comprises three sub-sectors: livestock, land, and aggregate sources and non-CO_2 emission sources on land (i.e., other agriculture and HWPs) (section 4.5). As LULUCF is the sum of land and HWPs, for gross and net emissions reporting, AFOLU is also disaggregated into two subsets: livestock and other agriculture, and land and HWPs. Therefore, gross emissions are reported as net emissions exclusive of land and HWPs.

In 2023, Auckland gross emissions were 10,919 kt CO_2e. Figure 3-1 shows gross emissions by sector, sub-sector and source. More detailed emissions data is also presented Table A-1. Transport is the dominant contributor of gross emissions (accounting for 46.8 per cent), followed by Stationary

Energy (23.5 percent), IPPU (20.0 percent), Waste (3.7 percent), and livestock and other agriculture (6.1 percent).

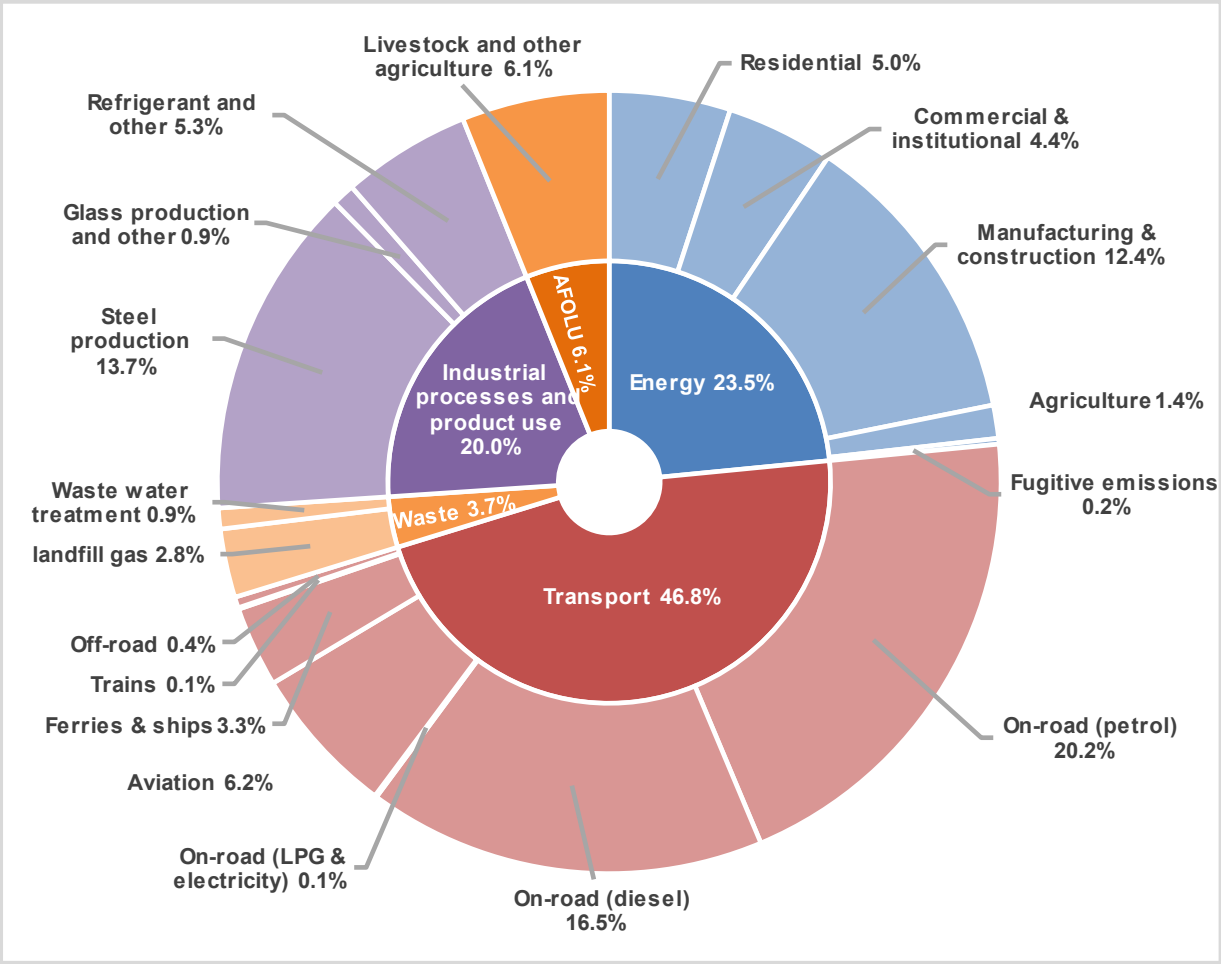

Figure 3-1 Gross emissions percentages in 2023 by sector and source

Table 3-3 shows the gross emissions by gases. Carbon dioxide is the dominant GHG, making up 83.3% of gross emissions, followed by methane at 9.5% and then smaller proportion of other GHGs.

Table 3-3 Auckland's gross emissions by gas for 2023

GHGs	Carbon dioxide (CO_2)	Methane (CH_4)	Nitrous oxide (N_2O)	Hydrofluoro-carbons (HFCs)	Perfluoro-carbons (PFCs)	Sulphur hexafluoride (SF_6)	Nitrogen trifluoride (NF_3)	Gross emissions
CO_2e (kt)	9,096	1,041	281	493	0	8	None	10,919
% of gross emissions	83.3%	9.5%	2.6%	4.5%	0.0%	0.1%	None	100.0%

3.2 Trends

This section discusses trends in emissions from various sectors between 2009 (first inventory year) and 2023 (current inventory), the impacts of COVID-19 restrictions on recent emissions, as well as changes between 2016 (baseline year) and 2023, and 2022 and 2023.

3.2.1 Between 2009 and 2023

Gross and net emissions generally increased from 2009 to 2019, showed a marked drop from 2019 to 2020, then rebounded from 2020 to 2023 (but still below the 2019 levels) (Figure 3-2). These trends were mainly driven by the transport sector (Figure 3-3).

The marked drop from 2019 to 2020 was largely due to reduced emissions from transport during COVID-19 restrictions (discussed later in this section).

The energy sector showed a gradual decrease in emissions driven by emissions from electricity generation. In 2012 and 2019, emissions from energy are slightly higher (Figure 3-2). This is due to lower-than-normal rainfall leading to lower hydro generation and an increase in gas and coal generation (MBIE, 2021). Emissions from IPPU gradually increased due to industrial product use, while emissions from waste, and AFOLU were mostly steady.

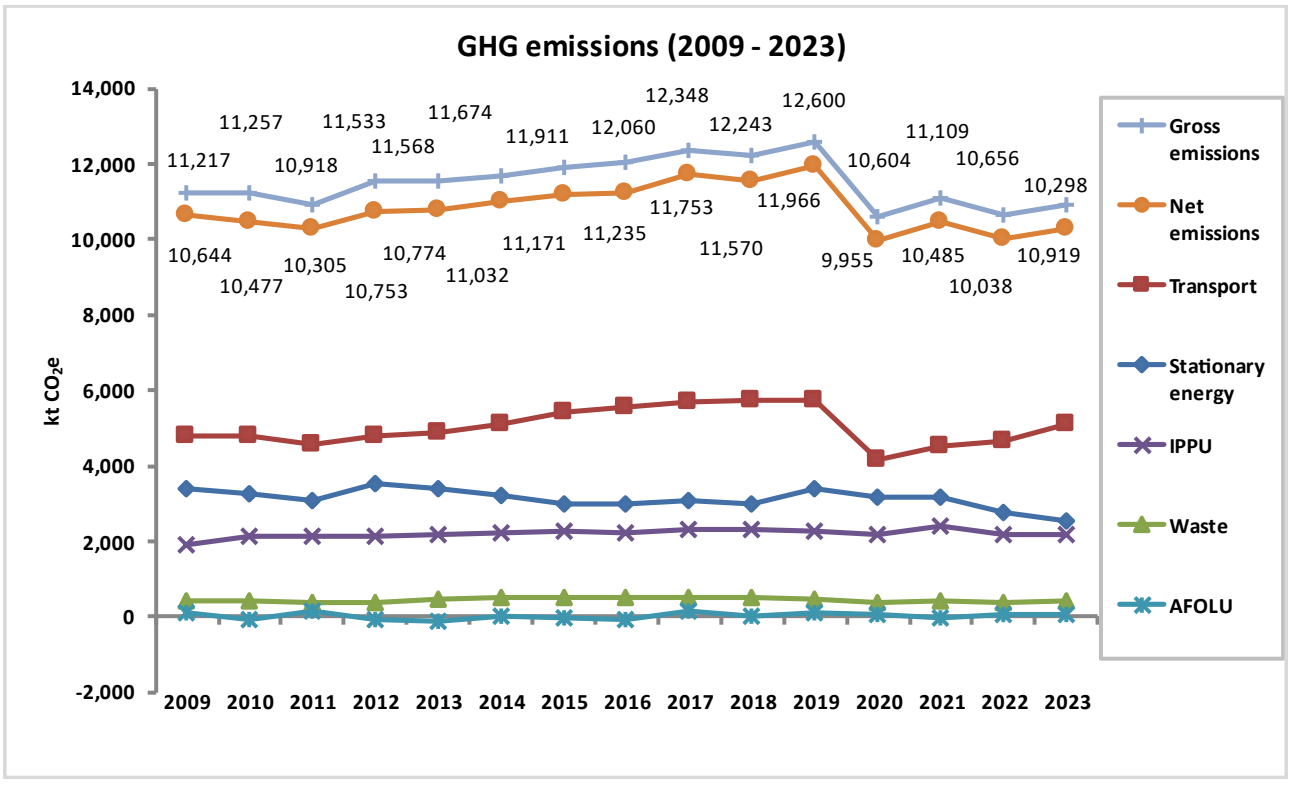

Figure 3-2 Auckland's GHG emissions from 2009 to 2023

3.2.1.1 Reduced emissions during COVID-19 restrictions

From pre-pandemic levels in 2019, emissions in 2020 decreased by 1,997 kt CO_2e (15.8 per cent) for gross emissions and 2,011 kt CO_2e (16.8 per cent) for net emissions. This was largely driven by reduced emissions from transport during COVID-19 restrictions (Figure 3-3). Emissions were lower from all sources (i.e., energy, transport, waste, IPPU, livestock and other agriculture, and land and HWPs).

Compared to 2020, emissions in 2023 increased by 315 kt CO_2e (2.9 per cent) for gross emissions and 343 kt CO_2e (3.3 per cent) for net emissions. This was largely driven by higher emissions from transport (Figure 3-3). Emissions in 2023 were still below the 2019 levels, by 1,681 kt CO_2e (13.3 per cent) for gross emissions and 1,668 kt CO_2e (13.9 per cent) for net emissions.

Overall, COVID-19 restrictions reduced emissions markedly in 2020 and continued to have an impact to 2023. Emissions in 2023 were still well below 2019 levels.

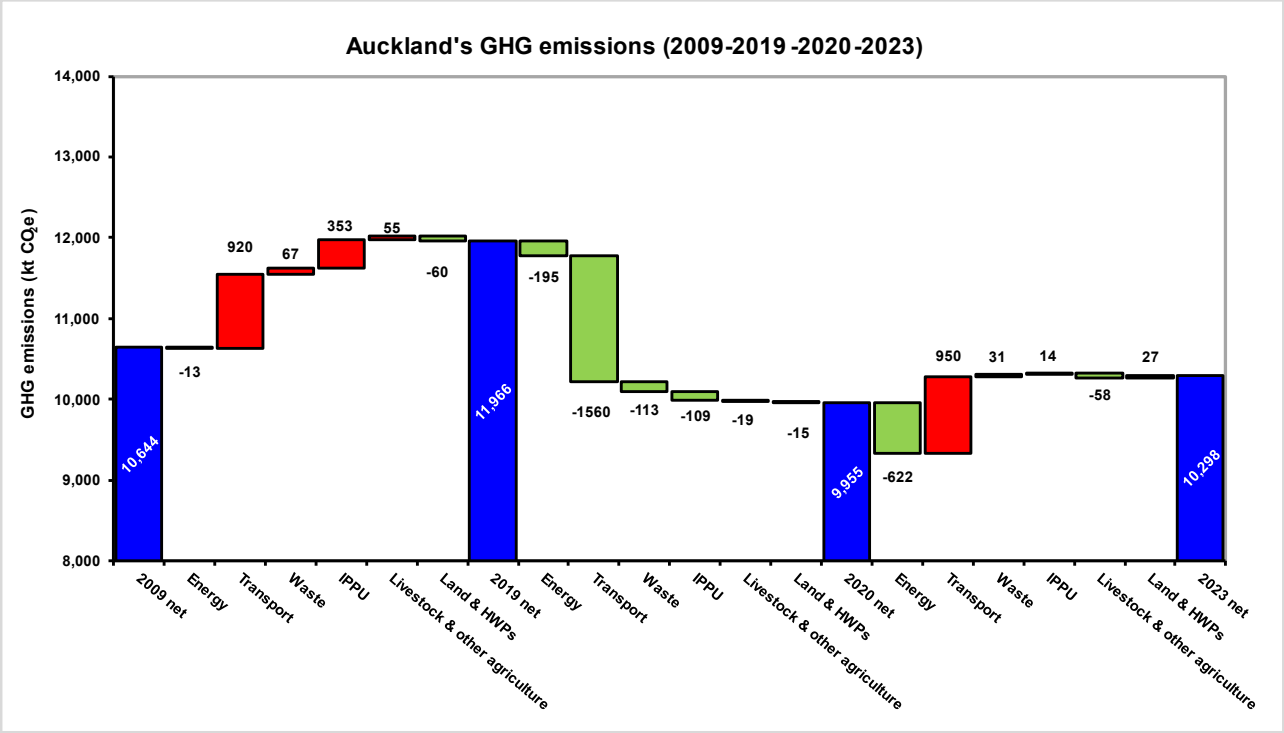

Figure 3-3 Auckland's GHG emissions between 2009, 2019, 2020 and 2023

3.2.2 Between 2016 and 2023

Between 2016 and 2023, emissions decreased by 1,141 kt CO_2e (9.5 per cent) for gross and 937 kt CO_2e (8.3 per cent) for net emissions (Table 3-4). As discussed earlier, the drop in emissions was due to

COVID-19 restrictions. Emissions were lower from energy, transport, waste, IPPU, and livestock and other agriculture; and higher from land and HWPs. Forest land area decreased from 2016 to 2023, resulting in less carbon sequestration. Therefore, there was a large increase in emissions from land and HWPs, and AFOLU. To achieve the target of halving 2016 emissions by 2030, a reduction of 6,030 kt CO_2e and 5,618 kt CO_2e of gross and net emissions is required.

Table 3-4 Auckland's emissions from 2016 to 2023

Sector	2016	2023	Change (2016-2023)				Per cent of gross			Change (2022-2023)		
	ktCO2e	ktCO2e	ktCO2e	%			2016	2023		ktCO2e	%	
Energy	3,003	2,561	-442	-14.7%	↓		24.9%	23.5%		-189	-6.9%	↓
Transport	5,580	5,109	-471	-8.4%	↓		46.3%	46.8%		445	9.5%	↑
Waste	513	404	-109	-21.3%	↓		4.3%	3.7%		20	5.3%	↑
IPPU	2,234	2,180	-54	-2.4%	↓		18.5%	20.0%		-16	-0.7%	↓
Livestock & other agriculture	730	665	-65	-8.9%	↓		6.1%	6.1%		3	0.4%	↓
Gross	12,060	10,919	-1,141	-9.5%	↓		100.0%	100.0%		263	2.5%	↑
Land & HWPs	-825	-621	204	24.7%	↑		-6.8%	-5.7%		-3	0.5%	↑
AFOLU	-95	44	139	146.4%	↑		-0.8%	0.4%		-1	-1.4%	↓
Net	11,235	10,298	-937	-8.3%	↓		N/A	N/A		259	2.6%	↑

3.2.3 Between 2022 and 2023

Between 2022 and 2023, emissions increased by 263 kt CO_2e (2.5 per cent) for gross and 259 kt CO_2e (2.6 per cent) for net emissions (Table 3-4). This is driven by increased emissions from transport. As discussed earlier, both emissions are still below the 2016 levels.

4 Sector analysis

4.1 Stationary Energy

Emissions from stationary energy come from energy consumption in buildings (e.g., natural gas for cooking at homes, electricity for heating at offices) and from non-mobile equipment and machinery, as well as fugitive emissions released in the process of generating, delivering, and consuming energy (such as electricity or gas). These emissions are split into the following sub-sectors: residential buildings; commercial and institutional buildings and facilities; manufacturing industries and construction; and agriculture, forestry, and fishing activities.

Scope 1 emissions are all direct emissions from burning fuel (oil, gas, liquefied petroleum gas (LPG), wood and coal) and fugitive emissions from delivering and distributing natural gas within city boundary. Scope 2 emissions are those associated with consumption of grid-supplied electricity which is generated within or outside Auckland. Scope 3 emissions are from distribution losses from grid-supplied electricity. GHGs in this sector are CO_2, CH_4 and N_2O.

4.1.1 Emissions from stationary energy

Emissions from stationary energy are summarised in Figure 4-1. In 2023, total emissions were 2,561 kt CO_2e, with majority (64.0 %) of emissions from consumption of electricity and natural gas, followed by coal (21.7 per cent), LPG (12.5 per cent), diesel (0.9 per cent), and wood (0.9 per cent) (Figure 4-1). Emissions from electricity, mainly from burning coal and natural gas to generate electricity, are all occurred outside Auckland.

Looking at sub-sector distribution, over half (52.9 per cent) of all emissions came from manufacturing industries and construction, 21.3 per cent from residential buildings; 18.9 per cent from commercial and institutional buildings and facilities; 5.8 per cent from agriculture, forestry, and fishing activities; and 1.0 per cent from natural gas transport and distribution (T&D) losses (i.e., fugitive emissions).

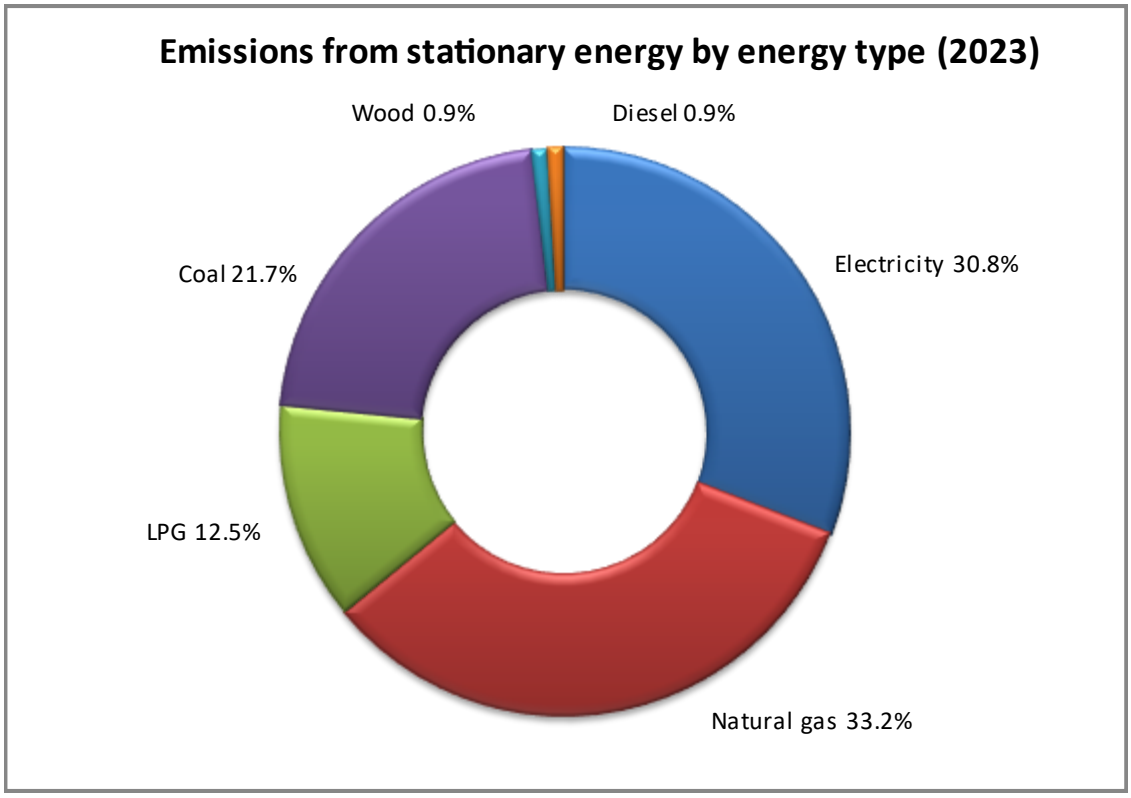

Figure 4-1 Emissions from stationary energy by energy type for 2023

4.1.1.1 Scope 1: emissions from fuel combustion

Scope 1 emissions are calculated based on consumption data for each of the fuel types used in Auckland (natural gas, LPG, coal, wood, petrol, diesel and fuel oil).

The total amount of natural gas consumption in Auckland was estimated from various sources (Vector Ltd, 2024; MfE, 2025a). Its allocation to sub-sectors was calculated based on two datasets: Stats NZ's emissions data for Auckland (Stats NZ, 2024a) and industrial emissions data (Atkins, 2018). Emissions from gas use at Otahuhu and Southdown power stations were not included in total emissions since generated electricity was supplied to national electric grids. The two stations ceased operation from 2016.

The two datasets were also used to estimate emissions (total and sub-sectors) from LPG, coal, diesel, petrol and fuel oil for stationary and off-road transport sources.

Emissions from wood were estimated from the Auckland air emissions inventory (Metcalfe, et. al., 2018) and industrial emissions data (Atkins, 2018). CO_2 emissions from wood burning were reported as biogenic, which were not included in total emissions. CH_4 and N_2O emissions from wood burning were included in total emissions.

CO_2 (biogenic), CH_4 and N_2O emissions from landfill gas combustion for electricity or heat in 2016 were sourced from the air emissions inventory (Crimmins, 2018). The amount of waste to landfills relative to 2016 was used to estimate emissions for other years. Emissions from landfill gas flaring were reported in the Waste sector (section 4.3).

4.1.1.2 Scope 2: emissions from consumption of grid-supplied electricity

The GPC covers emissions from consumption of grid-supplied electricity, steam, heating and cooling in the city under Scope 2. There is no grid supply of heating or cooling from outside Auckland and therefore only emissions associated with grid-supplied electricity are reported.

Electricity consumption was sourced from various organisations (Vector Ltd, 2024; Counties Power Ltd, 2024; NZEA, 2024). Allocation of electricity consumption into sub-sectors was based on Vector Ltd data (Vector Ltd, 2024). Electric passenger trains went into service from 2014 and gradually replaced all diesel trains in 2023. Emissions from electricity consumption by trains and vehicles were reported in the Transport sector (section 4.2).

4.1.1.3 Scope 3: distribution losses from grid-supplied energy

Scope 3 emissions include transmission and distribution losses from the use of grid-supplied electricity.

4.2 Transport

Emissions from transport come from directly combusting fuel or indirectly consuming grid-delivered electricity to transport vehicles and mobile equipment or machinery. For transport occurring within the Auckland region, emissions from combustion of fuels are reported in Scope 1 and emissions from grid-supplied electricity used for transporting vehicles (e.g. electric vehicles, electric trains) are included in Scope 2. Scope 3 reports the emissions from a portion of transboundary journeys occurring outside the Auckland region, and transmission and distribution losses from grid-supplied electricity. The emissions are calculated for on-road vehicles, railways, water transport, aviation and off-road transport, respectively. The gases reported in this sector are CO_2, CH_4 and N_2O.

4.2.1 Emissions from transport

Emissions from transport are summarised in Figure 4-2. In 2023, on-road transport accounted for 78.5 per cent of total 5,109 kt CO_2e emissions from transport (Figure 4-2). Contributions from other sources were 13.3 per cent from aviation, 7.1 per cent from ferries and ships, 1.0 per cent from off-road transport, and 0.1 per cent from trains.

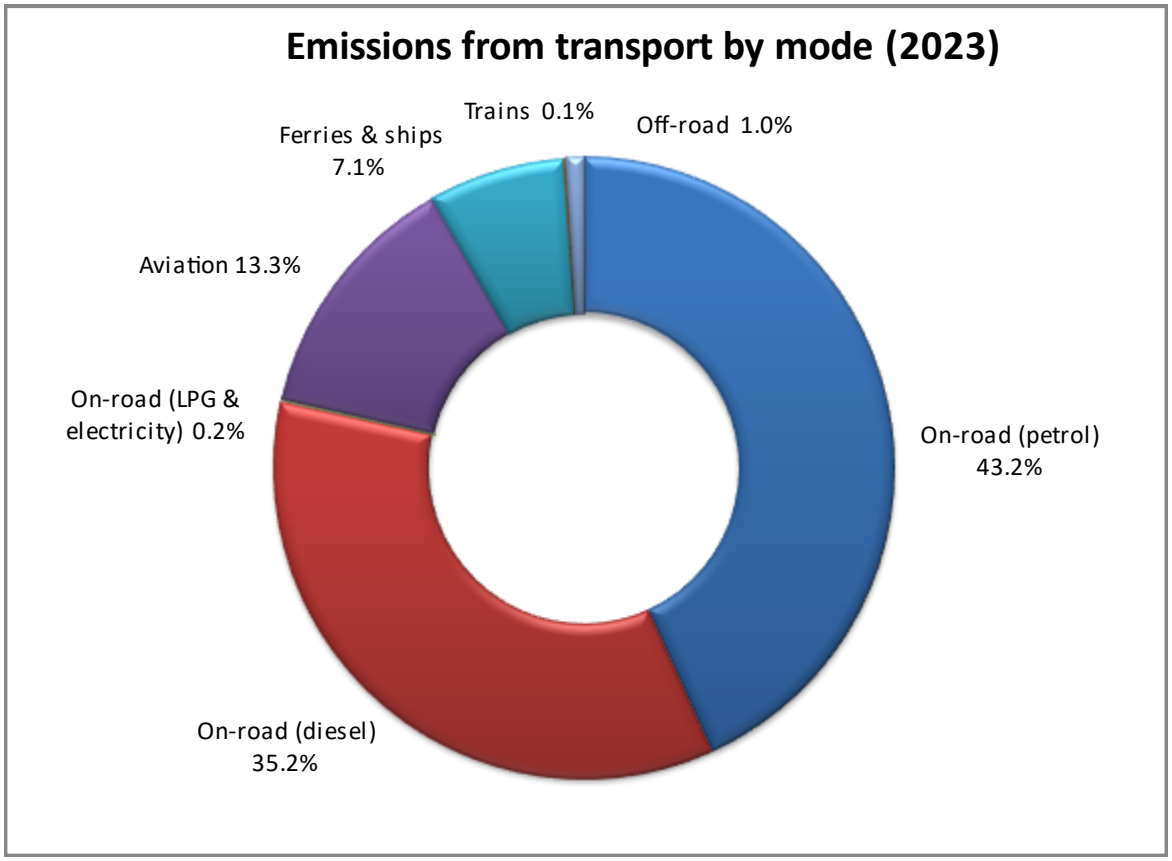

Figure 4-2 Emissions from transport by mode for 2023

4.2.1.1 On-road transport

Petrol and diesel sales within Auckland region are provided by Auckland Transport and based on the local authority fuel tax reports (Auckland Transport, 2025). The data was used to calculate emissions from on-road transport. The results were included in Scope 1 emissions.
LPG and electricity use for New Zealand was sourced from Ministry of Transport (MoT, 2024a). The vehicle fleet for Auckland and New Zealand was also sourced from Ministry of Transport (MoT, 2024b). The ratio of vehicle fleet in Auckland to New Zealand was used to portion New Zealand's consumptions for Auckland.

4.2.1.2 Railways

Rail is for the mass transit of commuters within the region (managed by Auckland Transport) or for moving freight within or to and from Auckland (managed by KiwiRail). Diesel and electricity consumption for passenger trains was provided by Auckland Transport (2025). Diesel use by freight trains was calculated by freight carried (in tonnes-km) multiplied by fuel burn rate (in litres per t-km) (MfE, 2025b). Rail freight was estimated based on rail tonnage data from the Freight Information

Gathering System (FIGS) (MoT, 2024b) for 2012 - 2023. The data for 2009 to 2011 was estimated by scaling the national total.

4.2.1.3 Water transport

Emissions from diesel consumption on ferries were provided by Auckland Transport (2025) and reported in Scope 1.

Auckland Transport provided the total amount of fuel oil used to refuel ships at seaports from 2012 to 2023. Average ratio of fuel oil consumption in Auckland to the national total over the period of 2012 to 2017 was used to estimate consumption for 2009-2011.

Emissions from shipping were reported in Scope 3. Export data at NZ shipping ports in tonnage was extracted from the Freight Information Gathering System (FIGS) (MoT, 2024b). This data was used to portion goods of total export at ports of Auckland, to estimate shipping emissions attributable to Auckland.

4.2.1.4 Aviation

Aviation activities in Auckland are dominated by domestic and international flights at Auckland Airport. Other activities include local helicopter, light aircraft, sightseeing and training flights at three other airports in Auckland (Ardmore Airport, North Shore Aerodrome and the military airbase at Whenuapai). Emissions from the jet fuel use at the three airports were small and not reported. Emissions from grid-supplied energy consumed by aircraft charging at airports were included in Scope 2 of Stationary Energy (section 4.1.1.2). Emissions from departing flights at Auckland Airport were reported in Scope 3. The proportion of Scope 3 emissions attributable to Auckland was calculated based on the proportion of departure passengers who were Auckland residents. International and domestic departures were estimated from data from Stats NZ (2024b) and Auckland Airport (2024). The Joint User Hydrant Installation (JUHI) Depot provided aviation fuel consumption at Auckland Airport.

4.2.1.5 Off-road transport

Emissions from fuels for off-road transport were estimated based on Stats NZ's emissions data for Auckland (Stats NZ, 2024a) and industrial emissions data (Atkins, 2018), as discussed in Section 4.1.1.1.

4.3 Waste

Emissions are generated from the processing and disposal of solid waste and wastewater treatment, predominantly CH_4 with smaller contributions from N_2O and CO_2. Emissions from waste treated inside Auckland are reported in Scope 1 and emissions from waste generated in Auckland but treated

outside Auckland are included in Scope 3. Emissions from grid-supplied electricity used in waste treatment facilities are reported in Scope 2 in Stationary Energy.

4.3.1 Emissions from waste

Emissions from waste, generated from the processing and disposal of solid waste and wastewater treatment, are summarised in Table A-1. The waste sector emitted 404 kt CO_2e, with 76.7 per cent from solid waste sources and 23.3 per cent from wastewater treatment.

4.3.1.1 Solid waste

The council's waste team provided the total amount of solid waste and the emissions for all five landfills receiving Auckland's waste (Claris, Puwera, Redvale, Whitford, and Hampton). A small amount of CO_2 (biogenic), CH_4 and N_2O are emitted from landfill gas flaring. Emissions for 2016 were sourced from the air emissions inventory (Crimmins, 2018). Emissions for other years were estimated based on the amount of waste to landfills relative to 2016. Emissions from farm fills and rural waste were provided by Stats NZ (2024a).

4.3.1.2 Wastewater treatment and discharge

Watercare Services Ltd is the water and wastewater service provider for Auckland. Auckland's wastewater is transported through a public wastewater network to wastewater treatment plants. The majority of Auckland's wastewater is treated at the Mangere or Rosedale treatment plants. Emissions from wastewater treatment and discharge in Auckland were sourced from Watercare's carbon footprint reporting (Watercare Services Ltd, 2024).

4.4 Industrial Processes and Product Use (IPPU)

Emissions from non-energy related industrial processes and product use are assessed and reported in the IPPU sector. Emissions (CO_2, N_2O, HFCs, PFCs and SF_6) are reported in Scope 1.

4.4.1 Emissions from IPPU

Emissions from IPPU are summarised in Table A-1. Most emissions came from Industrial Processes (1,599 kt CO_2e, 73.3 percent) and followed by Industrial Product Use (581 kt CO_2e, 26.7 per cent).

4.4.1.1 Industrial processes

In New Zealand, all the iron and steel production (from New Zealand Steel Ltd and Pacific Steel Ltd until its close in 2015) is in Auckland. *New Zealand's Greenhouse Gas Inventory* reports its emissions in the categories of "Iron and Steel Production" (MfE, 2025a). Production of steel and iron results in

CO_2 emissions. Other industrial processes include the glass production from Visy Glass Operations (NZ) Limited. Total emissions from industrial processes were provided by Stats NZ (2024a).

4.4.1.2 Industrial product use

GHGs are emitted from lubricants and paraffin waxes used in non-energy products, fluorinated gases used in electronics production, and fluorinated gases used as substitutes for ozone depleting substances. Total CO_2e emissions from industrial product use were provided by Stats NZ (2024a). The reported proportion of CO_2, N_2O, HFCs, PFCs and SF_6 was the same as in *New Zealand's Greenhouse Gas Inventory* (MfE, 2025a).

4.5 Agriculture, Forestry and Other Land Use (AFOLU)

AFOLU activities are divided into three categories: livestock, land, and aggregate sources and non-CO_2 emission sources on land. GHGs consist of CH_4, N_2O and CO_2, and are reported as Scope 1 emissions. As discussed in section 3.1, to assist the reporting of gross and net emissions, AFOLU is also disaggregated into two subsets: livestock and other agriculture, and land and HWPs.

4.5.1 Emissions from AFOLU

Emissions from the AFOLU sector are summarised in Table A-1. Emissions from livestock and other agriculture were 665 kt CO_2e. Emissions from land and HWPs was –624 kt CO_2e, resulting in AFOLU emissions of 44 kt CO_2e. The removal is expressed as a negative value to clarify that the value is a removal and not an emission.

4.5.1.1 Livestock

CH_4 is produced in digestive processes of livestock (enteric fermentation) and through management of their manure. N_2O is also emitted from the manure management system (i.e., direct N_2O emissions from manure management). The number of livestock (dairy cattle, non-dairy cattle, sheep, deer, pig, goat and horse) in Auckland was sourced from Stats NZ (2024b).

4.5.1.2 Land

Land use is divided into six broad categories: forest land, cropland, grassland, wetlands, settlements and other. Emissions and removals are calculated from the changes in ecosystem carbon stocks for both land remaining in a land use category and land converted to another land use category. The calculation was undertaken by Ministry for the Environment based on *New Zealand's Greenhouse Gas Inventory* methodologies (MfE, 2025a). There were some assumptions, including partitioning the Land Use and Carbon Analysis System (LUCAS) New Zealand Land Use Map (LUM) into region, with some Auckland specific input, e.g., the area of tall natural forest.

4.5.1.3 Aggregate sources and non-CO_2 emission sources on land

Aggregate sources and non-CO_2 emission sources on land include other agriculture (liming, urea application; direct and indirect N_2O from managed soils) and HWPs.

4.5.1.4 Other agriculture

Emissions from liming and urea application were estimated based on national emissions (MfE, 2025a) allocated to Auckland based on the proportion of all fertilisers used to the national total (Stats NZ, 2024b). Direct and indirect N_2O from managed soils were calculated based on the number of livestock.

4.5.1.5 Harvested wood products (HWPs)

HWPs include all wood material that leaves harvest sites and constitutes a carbon reservoir (the time carbon is held in products will vary depending on the product and its uses). As for the land sub-sector, changes of carbon stocks in the harvested wood products pool were provided by Ministry for the Environment. The calculation was based on *New Zealand's Greenhouse Gas Inventory* methodologies (MfE, 2025a) using the regional harvested area proportion as a proxy to apportion national roundwood production, wood product outputs, and exported logs to the Auckland region.

Overall, emissions from the AFOLU sector are shown from 2009 to 2023 in Figure 4-3.

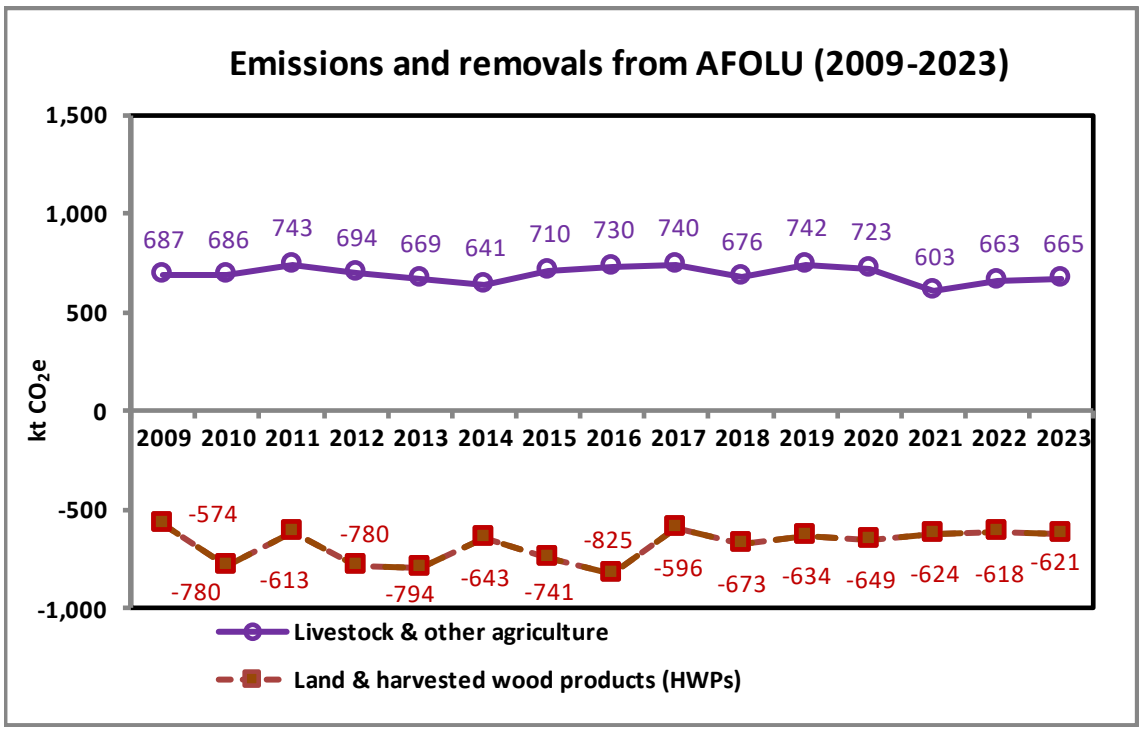

Figure 4-3 Emissions and removals from livestock and other agriculture, and land and HWPs from 2009 to 2023

5 Discussion

5.1 Emissions per capita and per unit GDP

Increased population and economic activities could result in increased emissions. Trends of emissions per capita or per unit GDP are useful indicators for tracking progress on climate actions. GDP (i.e., real GDP) is measured in 2024 prices and based on March years (Infometrics, 2025) and is therefore aligned to the closest December year (e.g., March 2024 is reported as 2023). From 2009 to 2023, Auckland's population increased from 1.4 million to 1.7 million (Stats NZ, 2024b) and GDP increased from $NZ 99.4 billion to $NZ 159.7 billon (March 2024 prices) (Infometrics, 2025). Population, GDP and emissions are compared in Figure 5-1. In 2023, gross emissions were 6.3 t CO_2e per capita and 68 t CO_2e per million $NZ GDP while net emissions were 5.9 t CO_2e per capita and 64 t CO_2e per million $NZ GDP.

Figure 5-2 shows trends of emission intensity by population and GDP. The emission intensity generally decreased since 2009, suggesting Auckland's emissions have not increased as fast as population and economic growth. The marked drop in the emission intensity between 2019 and 2020 is due to COVID-19 restrictions.

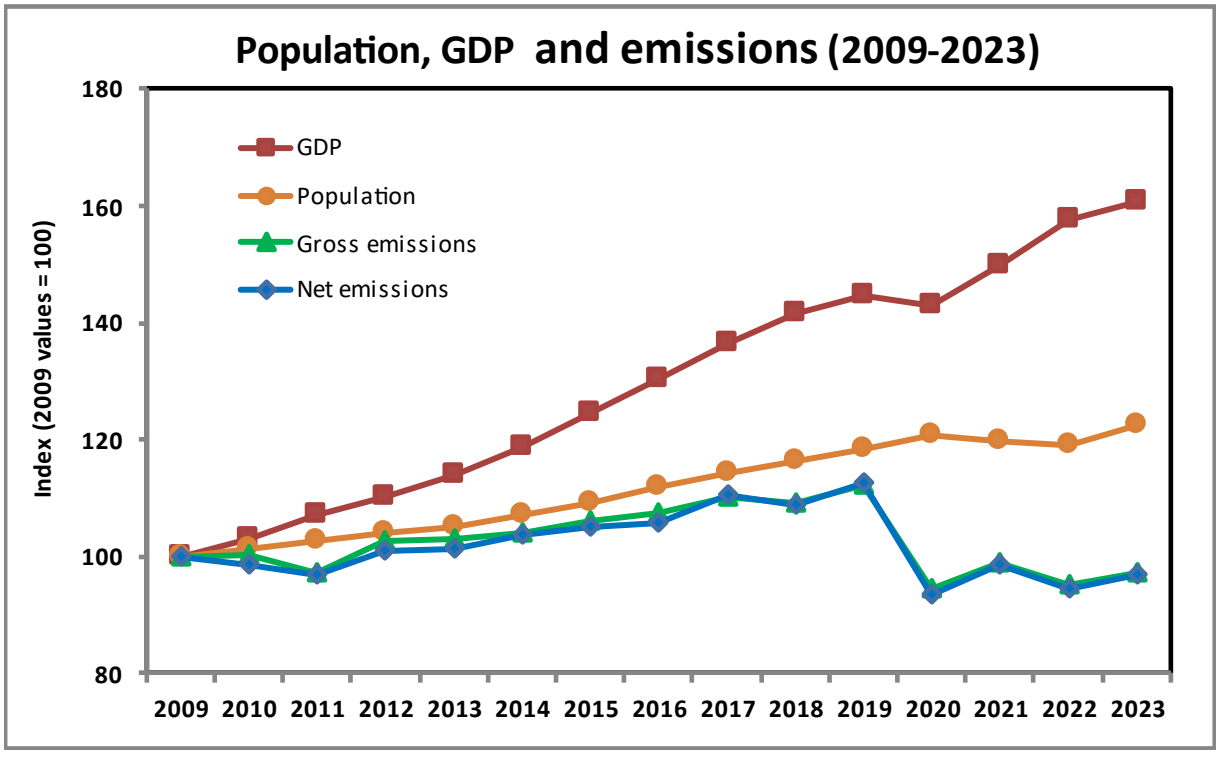

Figure 5-1 Auckland's population, GDP and GHG emissions from 2009 to 2023

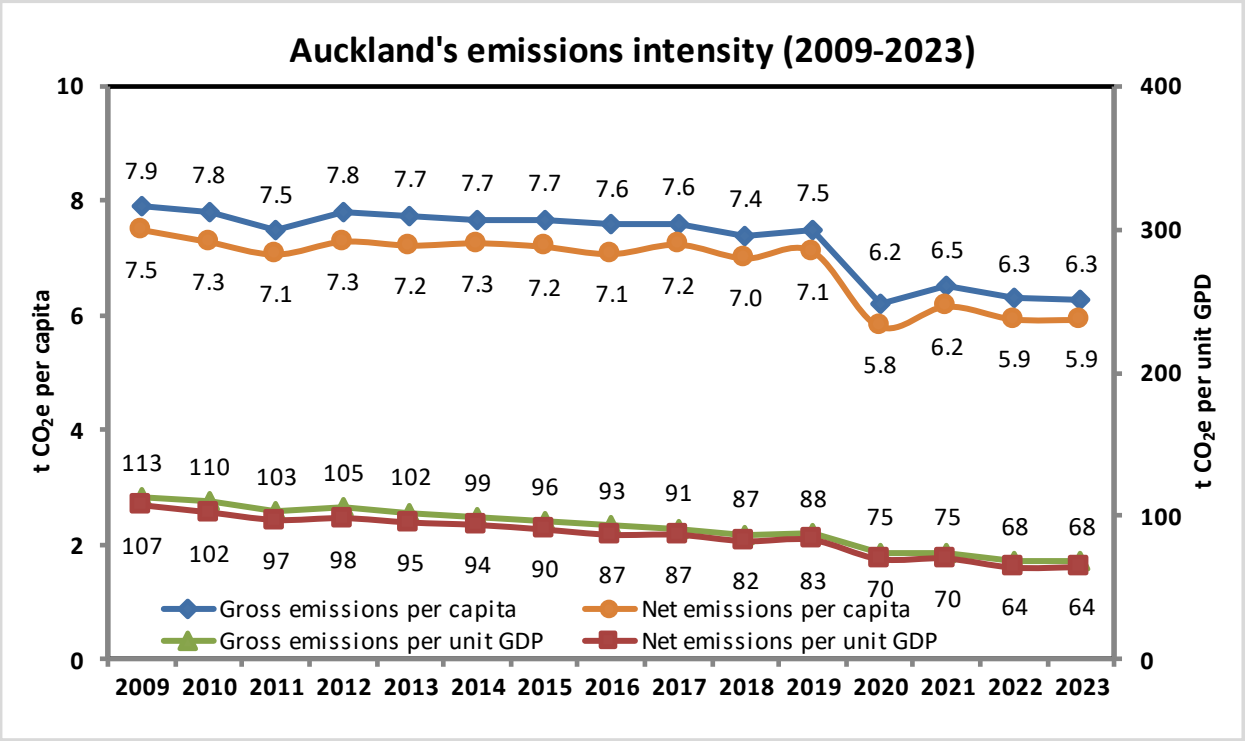

Figure 5-2 Auckland's emissions intensity from 2009 to 2023

5.2 Impact of 2016 baseline update on achieving the emission target

The target of net zero emissions by 2050 with an interim emissions reduction target of 50 per cent by 2030 was set against a 2016 baseline which was reported in *Auckland's greenhouse gas inventory to 2016* (Xie, 2019). Gross and net emissions in 2016 in this inventory are higher than those reported in the previous 2016 inventory (Table A-4) by 597 ktCO_2e (5.2 per cent) and 969 ktCO_2e (9.4 per cent), respectively. Additional 299 kt CO_2e and 485 kt CO_2e emissions need to be reduced for halving gross and net emissions, respectively. This demonstrates the importance of maintaining an annual inventory update which reflect the latest information available. This informs the timely development and update of effective mitigation strategies, policy and actions which are necessary for Auckland to meet its targets.

5.3 Comparison with national inventory

Identifying differences in emissions profiles between Auckland and New Zealand helps develop mitigation actions to address major sources in Auckland. Figure 5-3 shows the emission distribution within various sectors for New Zealand and for Auckland. In 2023, New Zealand's gross emissions were dominated by agriculture (53.1%), energy (19.2%), and transport (18.5%) sectors (MfE, 2025a). Comparatively, in Auckland, transport (46.8%) was the dominant sector, followed by energy (23.5%) and IPPU (20.0%) sectors.

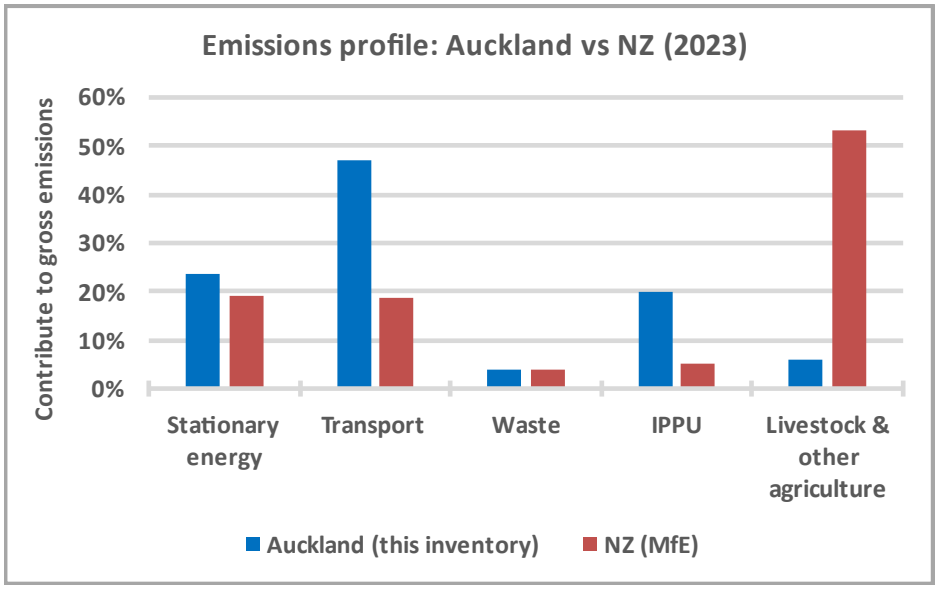

Figure 5-3 A comparison of emissions profiles between Auckland (this inventory) and NZ (MfE, 2025a)

Although the inventories have different sectoral profiles, Auckland's gross emissions largely tracked a similar trend to national emissions (MfE, 2025a) (Figure 5-4, emissions were indexed back to 2009). In Auckland, the increase in gross emissions between 2009 and 2019 was relatively faster and mainly driven by the transport sector. A bigger drop between 2019 and 2020 and a bigger rebound between 2020 and 2023 are due to the dominance of the transport sector for Auckland emissions profile. Work is ongoing to further understand Auckland's emissions trends and driving factors for evaluating progress of *Te-Tāruke-ā-Tāwhiri: Auckland's Climate Plan*.

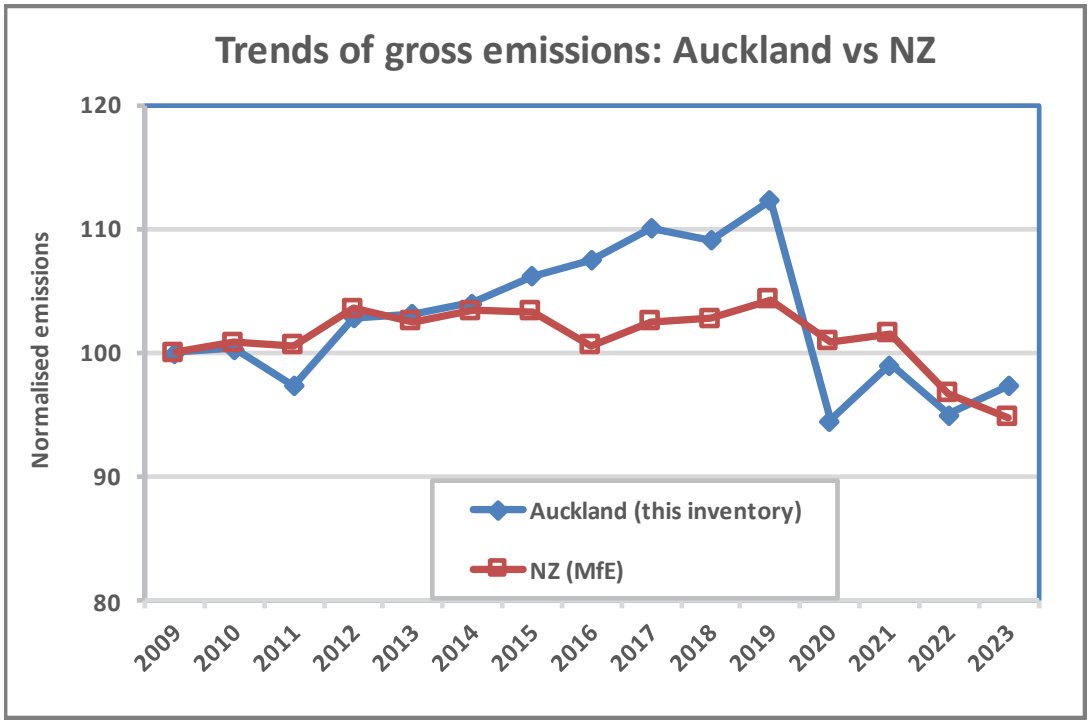

Figure 5-4 Trends of gross emissions: Auckland (this inventory) vs NZ (MfE, 2025a) (2009-2023)

5.4 Comparison with Stats NZ regional emissions

Stats NZ (2024a) reported Auckland's GHG emissions for 2007-2023 using the United Nations System of Environmental-Economic Accounting (SEEA) framework which is designed primarily to show interactions between the environment and economy in a way consistent with the System of National Accounts. The data is suited to compare emissions between regions, with other regional datasets, such as GDP, labour market statistics or population. It can show how a region contributes to national emissions. It provides complimentary insights into Auckland's emissions, e.g. by households and industries. However, the difference in scope of the GPC and the SEEA framework leads to differences in emissions estimates. For example, the GPC reports grid-supplied electricity use in Auckland's emissions while the SEEA does not. Nevertheless, it is still useful to compare the two datasets to ensure that the differences can be justified by the difference in methodology.

Figure 5-5 presents a comparison of gross emissions in 2022 with Stats NZ data (2024a). 2022 is the most recent year with emissions disaggregated in these sectors by Stats NZ. Both datasets show a similar emissions profile. This inventory reports higher emissions from energy due to including consumption of grid-electricity is included and lower emissions from waste due to a higher recovery rate of landfill gas than national average (used in Stats NZ estimates). This gives confidence that this inventory provides an accurate account of emissions in Auckland. Based on the SEEA framework, Auckland contributed 13.1 per cent to national gross emissions in 2023 (Stats NZ, 2024a).

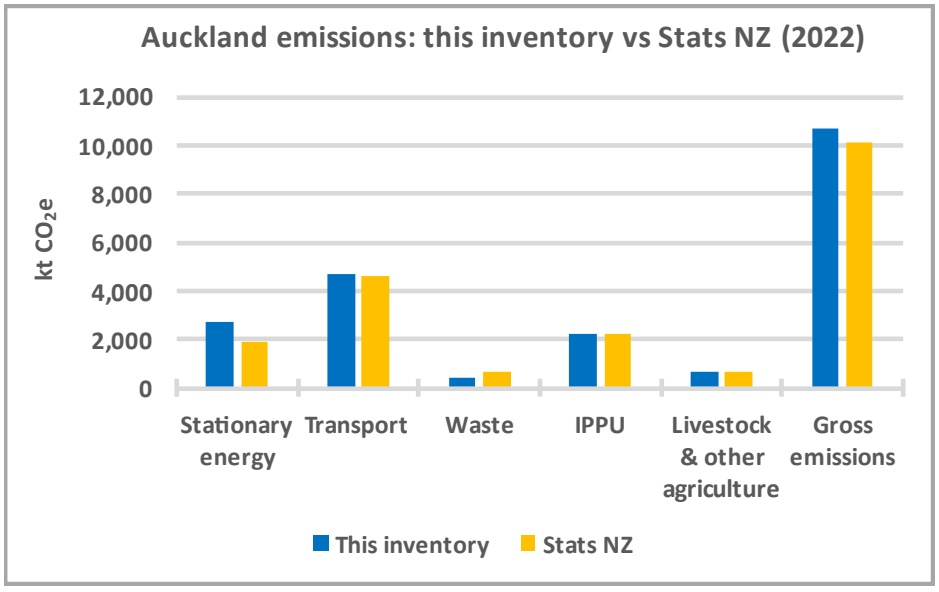

Figure 5-5 Auckland's gross emissions in 2022 by sector vs Stats NZ data (2024a)

6 Limitations

The input data of this inventory came from various organisations. Emissions data and activity data were collected where and when available. Activity data of some emissions sources were calculated based on activity-related information. Work is in progress to fill in existing gaps where possible. These include:

- There is a need to gather more updated information as well as improve data quality of some estimated activity data, for example, coal consumption, energy use by off-road transport, allocation of energy consumption into sub-sector (residential, commercial, industrial and agriculture).
- The apportionment of on-road emissions by vehicle class (heavy vs light).
- Electricity use for electric vehicles.

7 Conclusions

Concluding findings of the inventory are as follows:

- In 2023, Auckland's gross and net emissions were 10,919 kt CO_2e and 10,298 kt CO_2e, respectively. Carbon dioxide (CO_2) contributed 83.3 per cent of gross emissions. Transport and stationary energy dominated emissions, accounting for 46.8 per cent and 23.5 per cent of gross emissions, respectively.

- Between 2009 and 2023, gross and net emissions generally increased from 2009 to 2019, markedly dropped from 2019 to 2020, then rebounded from 2020 to 2023. This change was largely driven by the COVID-19 restrictions which resulted in a marked reduction in emissions from transport. Emissions in 2023 were still below the 2019 levels, by 1,681 kt CO_2e (13.3 per cent) for gross emissions and 1,668 kt CO_2e (13.9 per cent) for net emissions, respectively.

- Between 2016 (baseline year) and 2023, emissions decreased by 1,141 kt CO_2e (9.5 per cent) for gross and 937 kt CO_2e (8.3 per cent) for net emissions. To achieve the target of halving 2016 emissions by 2030, a reduction of 6,030 kt CO2e and 5,618 kt CO_2e of gross and net emissions is required.

- Between 2022 and 2023, emissions increased by 263 kt CO2e (2.5 per cent) for gross and 259 kt CO2e (2.6 per cent) for net emissions. This is driven by increased emissions from transport.

- In 2023, gross emissions were 6.3 t CO_2e per capita and 68 t CO_2e per million $NZ GDP (March 2024 prices) while net emissions were 5.9 t CO_2e per capita and 64 t CO_2e per million $NZ GDP. Emissions per capita or per unit GDP broadly decreased from 2009. This shows that emissions have not increased as fast as population and economic growth.

- Due to higher 2016 emissions in this inventory than previous baseline emissions, additional 299 kt CO_2e and 485 kt CO_2e emissions need to be reduced for halving gross and net emissions, respectively.

8 Acknowledgements

This report has been significantly improved from feedback by the peer-reviewers: Mike Harvey of Auckland Council and Ben Morrow of Ministry for Primary Industries. The data for the inventory came from various sources. The author acknowledges the following for providing data and advice:

Auckland Airport Joint User Hydrant Installation (JUHI): Mark Davies, Rob Almond, Caleb Noonan

Auckland Council: Caroline Rose

Auckland Transport: Christiaan Moss, Jason Son, Lewis Gibson, Manoj Pokhrel

C40 Cities Climate Leadership Group: Michael Doust and his team for review and constructive feedback on previous Auckland GHG inventories

Counties Power Limited: John Ewens

Ministry for Primary Industries: Joel Gibbs for advice on agricultural emissions

Ministry for the Environment: Prem Sivakanthan and Anne Wekesa for providing emissions data for the LULUCF sector and documentations

Stats NZ: Adam Tipper for providing customised Stats NZ's data which are licensed by Stats NZ for re-use under the Creative Commons Attribution 4.0 International licence

Vector Limited: Ross Malcolm

Watercare Services Limited: Atisha Daya, Kuljit Kaur

9 References

Atkins, M. (2018). Process heat emissions & energy use in the Auckland Region. Report prepared by Energy Research Group, University of Waikato for Auckland Council.

Auckland Airport (2024). Monthly traffic updates and Annual Reports, retrieved on 5 October 2024 from https://www.aucklandairport.co.nz

Auckland Council (2018). Auckland Plan 2050, retrieved on 25 August 2023 from https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/auckland-plan/Pages/default.aspx

Auckland Council (2020). Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan, retrieved on 25 August 2023 from https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/topic-based-plans-strategies/environmental-plans-strategies/aucklands-climate-plan/Documents/auckland-climate-plan.pdf

Auckland Transport (2025). Annual reports and other information, retrieved on 15 January 2025 from https://at.govt.nz and personal communications

C40 (C40 Cities Climate Leadership Group) (2023). City Inventory Reporting and Information System (CIRIS) (v2.5), retrieved on 7 May 2023 from https://resourcecentre.c40.org

C40 (C40 Cities Climate Leadership Group) (2025). Auckland's GHG emissions, retrieved on 19 April 2025 from https://www.c40knowledgehub.org/s/article/C40-cities-greenhouse-gas-emissions-interactive-dashboard?language=en_US

Counties Power Ltd (2024). Annual reports and Disclosure Information, retrieved on 30 September 2024 from http://www.countiespower.com

Crimmins, P (2018). Auckland Air Emissions Inventory 2016 – Industry. Auckland Council technical report, TR2018/019

Infometrics (2025). Auckland GDP data, retrieved on 25 February 2025 https://www.infometrics.co.nz/

IPCC (2023). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, retrieved on 22 August 2023 from https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

MfE (2025a). New Zealand's Greenhouse Gas Inventory 1990-2023, retrieved on 30 April 2025 from https://environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2023

MfE (2025b). Measuring Emissions Guide 2025, retrieved on 20 June 2025 from https://environment.govt.nz/assets/publications/Measuring-Emissions-Guide-2025/EmissionFactors_Workbook_2025_2.xlsx

Metcalfe, J., Wickham, L. and Sridhar, S. (2018). Auckland air emissions inventory 2016 – home heating. Prepared by Emission Impossible Ltd for Auckland Council. Auckland Council technical report, TR2018/018

MoT (2024a). Vehicle Fleet Model, retrieved on 20 December 2024 from https://www.transport.govt.nz/statistics-and-insights/vehicle-fleet-model

MoT (2024b). Fleet Statistics, retrieved on 20 December 2024 from https://www.transport.govt.nz/statistics-and-insights/fleet-statistics

NZEA (New Zealand Electricity Authority) (2024). Electricity market information (EMI), retrieved on 15 June 2024 from http://www.emi.ea.govt.nz

Stats NZ (2024a). Regional greenhouse gas emissions by industry and households: year ended 2023, retrieved on 21 November 2024 from https://protect-au.mimecast.com/s/3uIZCRONEjivGD7AFNELf8?domain=stats.govt.nz/ and customised report and licensed by Stats NZ for re-use under the Creative Commons Attribution 4.0 International licence

Stats NZ (2024b). Infoshare database, retrieved on 30 November 2024 from http://www.stats.govt.nz/infoshare

Vector Ltd (2024). Annual reports, regulatory disclosure documents, retrieved on 15 October 2024 from http://vector.co.nz

Watercare Services Ltd (2024). Annual Reports 2024 and of previous years, retrieved on 6 October 2024 from https://www.watercare.co.nz/About-us/Reports-and-publications, and personal communications

WRI (World Resources Institute) et al., (2021). Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (version 1.1), retrieved on 25 August 2023 from https://ghgprotocol.org/ghg-protocol-cities

Xie, S (2019). Auckland's greenhouse gas inventory to 2016. Auckland Council technical report, TR2019/002

Xie, S (2024). Auckland's greenhouse gas inventory to 2021. Auckland Council technical report, TR2024/7

10 Abbreviations

This chapter is based on WRI et al., (2021)

AFOLU	Agriculture, forestry and other land use
AR4	IPCC Fourth Assessment Report
AR5	IPCC Fifth Assessment Report
C40	C40 Cities Climate Leadership Group
CDP	Formerly the Carbon Disclosure Project, a global disclosure system
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EF	Emission factor
GDP	Gross domestic product
GHG	Greenhouse gas
GPC	Global Protocol for Community-scale Greenhouse Gas Emission Inventories
GWP	Global warming potential
HFCs	Hydrofluorocarbons
HWPs	Harvested wood products
ICLEI	ICLEI – Local Governments for Sustainability
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
LULUCF	Land use, land use change and forestry
MSW	Municipal solid waste
N_2O	Nitrous oxide
NF_3	Nitrogen trifluoride
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
WRI	World Resources Institute
WWTP	Wastewater treatment plant

11 Glossary

This chapter is based on WRI et al., (2021).

Activity data: A quantitative measure of a level of activity that results in GHG emissions. Activity data is multiplied by an emission factor to derive the GHG emissions associated with a process or an operation. Examples of activity data include kilowatt-hours of electricity used, quantity of fuel used, output of a process, hours equipment is operated, distance travelled, and floor area of a building.

Allocation: The process of partitioning GHG emissions among various outputs.

Base year: A historical datum (e.g., year) against which a city's emissions are tracked over time.

BASIC: An inventory reporting level that includes all scope 1 sources except from energy generation, imported waste, *IPPU*, and *AFOLU*, as well as all scope 2 sources.

BASIC+: An inventory reporting level that covers all BASIC sources, plus scope 1 *AFOLU* and *IPPU*, and scope 3 in the *Stationary Energy* and *Transportation* sectors.

Biogenic emissions (CO_2(b)): Emissions produced by living organisms or biological processes but not fossilised or from fossil sources.

City: Used throughout the GPC to refer to geographically discernible subnational entities, such as communities, townships, cities, and neighbourhoods.

City boundary: See geographic boundary.

CO_2 equivalent: The universal unit of measurement to indicate the global warming potential (GWP) of each GHG, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate the climate impact of releasing (or avoiding releasing) different greenhouse gases on a common basis.

Emission: The release of GHGs into the atmosphere.

Emission factor(s): A factor that converts activity data into GHG emissions data (e.g., kg CO_2e emitted per litre of fuel consumed, kg CO_2e emitted per kilometre travelled, etc.).

Geographic boundary: A geographic boundary that identifies the spatial dimensions of the inventory's assessment boundary. This geographic boundary defines the physical perimeter separating in-boundary emissions from out-of-boundary and transboundary emissions.

Global warming potential: A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one unit of CO_2.

Greenhouse gas inventory: A quantified list of a city's GHG emissions and sources.

Greenhouse gases (GHG): For the purposes of the GPC, GHGs are the seven gases covered by the UNFCCC: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF_6); and nitrogen trifluoride (NF_3).

In-boundary: Occurring within the established geographic boundary.

Inventory boundary: The inventory boundary of a GHG inventory identifies the gases, emission sources, geographic area, and time span covered by the GHG inventory.

Out-of-boundary: Occurring outside of the established geographic boundary.

Reporting: Presenting data to internal and external users such as regulators, the general public or specific stakeholder groups.

Reporting year: The year for which emissions are reported.

Scope 1 emissions: GHG emissions from sources located within the city boundary.

Scope 2 emissions: GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.

Scope 3 emissions: All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

Transboundary emissions: Emissions from sources that cross the geographic boundary.

12 Appendix: Emissions tables, update of historic emissions, data sources

Table A-1 GHG emissions by sector and sub-sector for 2023 (in the GPC format)*

GPC ref No.	GHG Emissions Source (By Sector and Sub-sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
I	STATIONARY ENERGY				
I.1	Residential buildings	200,314	321,461	24,448	546,223
I.2	Commercial and institutional buildings and facilities	406,571	71,786	5,459	483,816
I.3	Manufacturing industries and construction	1,063,962	270,497	20,572	1,355,031
I.4.1/2/3	Energy industries	NO	NO	NO	
I.4.4	Energy generation supplied to the grid	20			
I.5	Agriculture, forestry and fishing activities	74,028	70,105	5,332	149,465
I.6	Non-specified sources	NO	NO	NO	
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			
I.8	Fugitive emissions from oil and natural gas systems	26,269			26,269
SUB-TOTAL	(city induced framework only)	**1,771,144**	**733,849**	**55,811**	**2,560,804**
II	TRANSPORTATION				
II.1	On-road transportation	4,004,831	7,520	572	4,012,923
II.2	Railways	3,803	2,403	183	6,389
II.3	Waterborne navigation	21,286	IE	341,593	362,879
II.4	Aviation	NO	IE	678,157	678,157
II.5	Off-road transportation	49,057	NO	NO	49,057
SUB-TOTAL	(city induced framework only)	**4,078,977**	**9,923**	**1,020,504**	**5,109,405**
III	WASTE				
III.1.1/2	Solid waste generated in the city	216,605		93,045	309,650
III.2.1/2	Biological waste generated in the city	NO		NO	
III.3.1/2	Incinerated and burned waste generated in the city	NO		NO	
III.4.1/2	Wastewater generated in the city	93,928		NO	93,928
III.1.3	Solid waste generated outside the city	NO			
III.2.3	Biological waste generated outside the city	NO			
III.3.3	Incinerated and burned waste generated outside city	NO			
III.4.3	Wastewater generated outside the city	NO			
SUB-TOTAL	(city induced framework only)	**310,533**		**93,045**	**403,578**
IV	INDUSTRIAL PROCESSES and PRODUCT USES				
IV.1	Emissions from industrial processes occurring in the city boundary	1,599,000			1,599,000
IV.2	Emissions from product use occurring within the city boundary	581,000			581,000
SUB-TOTAL	(city induced framework only)	**2,180,000**			**2,180,000**
V	AGRICULTURE, FORESTRY and OTHER LAND USE				
V.1	Emissions from livestock	579,144			579,144
V.2	Emissions from land	-400,413			-400,413
V.3	Emissions from aggregate sources and non-CO2 emission sources on land	-134,757			-134,757
SUB-TOTAL	(city induced framework only)	**43,974**			**43,974**
VI	OTHER SCOPE 3				
VI.1	Other Scope 3			NE	
TOTAL	(city induced framework only)	**8,384,628**	**743,772**	**1,169,360**	**10,297,760**

* See Table 3-2 for the meaning of cell colours

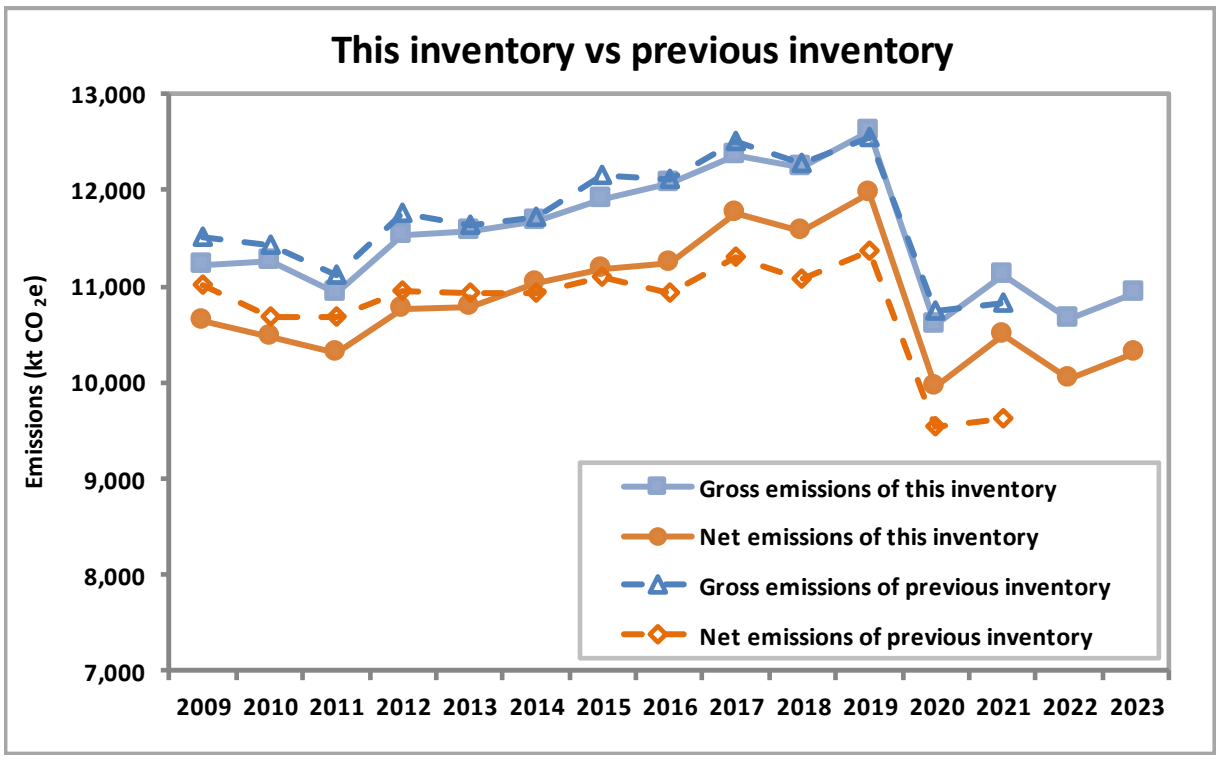

Figure A-1 Comparison of GHG emissions: this inventory vs previous 2021 inventory

Table A-2 2016 gross emissions profile in this inventory vs previous 2016 inventory*

Sources	2016 inventory**		This inventory		Change	
	$ktCO_2e$	**% of gross emissions**	**$ktCO_2e$**	**% of gross emissions**	**$ktCO_2e$**	**% of gross emissions**
Energy - Residential	595	5.2%	547	4.5%	-48	-0.4%
Energy - Commercial	604	5.3%	462	3.8%	-142	-1.2%
Energy - Industrial	1,513	13.2%	1,691	14.0%	179	1.6%
Energy - Agricultural	322	2.8%	189	1.6%	-133	-1.2%
Fugitive from natural gas**			114	0.9%		
Transport - Road	4,256	37.1%	4,340	36.0%	84	0.7%
Transport - Rail	12	0.1%	9	0.1%	-3	0.0%
Transport - Sea	412	3.6%	389	3.2%	-23	-0.2%
Transport - Air	257	2.2%	800	6.6%	543	4.7%
Transport - Off-road**			43	0.4%		
Waste	396	3.5%	513	4.3%	116	1.0%
Industrial processes & product use	2,317	20.2%	2,234	18.5%	-83	-0.7%
Agriculture	778	6.8%	730	6.1%	-48	-0.4%
Gross emissions	**11,463**	**100.0%**	**12,060**	**100.0%**	**597**	**5.2%**

* "Change" is calculated using emissions values in tCO_2e.

** *Auckland's greenhouse gas inventory to 2016* (Xie, 2019), updated emissions CO_2e in AR5. Emissions from "Fugitive from natural gas" and "Transport - Off-road" were reported in "Energy" sources.

Table A-3 2021 gross emissions profile in this inventory vs previous 2021 inventory*

Sources	2021 inventory**		This inventory		Change	
	$ktCO_2e$	**% of gross emissions**	**$ktCO_2e$**	**% of gross emissions**	**$ktCO_2e$**	**% of gross emissions**
Energy - residential buildings	683	6.3%	727	6.5%	44	0.4%
Energy - commercial & institutional buildings	588	5.4%	567	5.1%	-22	-0.2%
Energy - manufacturing & construction	1,560	14.4%	1,623	14.6%	64	0.6%
Energy - agriculture	283	2.6%	207	1.9%	-76	-0.7%
Energy - gas T&D losses	57	0.5%	30	0.3%	-27	-0.2%
On-road transport	4,013	37.2%	4,040	36.4%	27	0.2%
Trains	10	0.1%	10	0.1%	1	0.0%
Ferries & ships	144	1.3%	145	1.3%	1	0.0%
Aviation	249	2.3%	248	2.2%	-1	0.0%
Off-road transport**			65	0.6%		
landfill gas	293	2.7%	308	2.8%	16	0.1%
Waste water treatment	62	0.6%	132	1.2%	70	0.7%
Steel production	1,718	15.9%	1,718	15.5%	0	0%
Glass making & others	50	0.5%	60	0.5%	10	0.1%
Industrial product use	453	4.2%	624	5.6%	171	1.6%
Agriculture	636	5.9%	603	5.4%	-32	-0.3%
Gross emissions	**10,800**	**100.0%**	**11,109**	**100.0%**	**309**	**2.5%**

* "Change" is calculated using emissions values in tCO_2e.

** *Auckland's greenhouse gas inventory to 2021* (Xie, 2024), updated emissions CO_2e in AR5. Emissions from "Off-road transport" were reported in "Energy" sources.

Table A-4 Analysis of changes in 2016 emissions from previous 2016 inventory*

Source	Emissions in 2016 ($ktCO_2e$)		Change		% Change to 2016 inventory		Reasons of change
	2016 inventory**	This inventory	$ktCO_2e$	%	Gross emissions	Net emissions	
STATIONARY ENERGY							
Electricity	925	930	5	1.8%	0.0%	0.1%	Update of emissions factors
Natural gas	978	977	0	0.0%	0.0%	0.0%	Update of emissions factors
LPG	131	261	130	98.7%	1.1%	1.3%	Update of LPG use
Wood	149	23	-116	-84.4%	-1.0%	-1.1%	Update of wood use
Coal	34	790	755	2,211.3%	6.8%	7.4%	Update of coal use
TRANSPORT							
Petrol (vehicles)	2,583	2,682	99	3.8%	0.9%	1.0%	Update of emissions factors
Diesel (vehicles)	1,668	1,657	-11	-0.7%	-0.1%	-0.1%	Update of emissions factors
LPG (vehicles)	5	2	-4	-70.6%	0.0%	0.0%	Update of LPG use
Electricity (trains and vehicles)	3	3	0	3.9%	0.0%	0.0%	Update of emissions factors
Train (diesel)	8	6	-3	-33.9%	0.0%	0.0%	Update of diesel use
Ferry	33	27	-6	-18.0%	-0.1%	-0.1%	Update of diesel use
Aviation	257	800	543	211.5%	4.8%	5.3%	Update of emissions allocated to Auckland
Shipping	379	362	-17	-4.4%	-0.1%	-0.2%	Update of emissions factors
Diesel for off-road transport	828	43	-785	-94.8%	-6.8%	-7.6%	Update of diesel use
WASTE							
Solid waste disposal	390	454	65	16.6%	0.6%	0.6%	Update of emissions factors
Waste water treatment	7	58	51	748.4%	0.4%	0.5%	Update of Watercare GHG inventory
INDUSTRIAL PROCESSES and PRODUCT USES (IPPU)							
Industrial processes	1,770	1,774	4	0.2%	0.0%	0.0%	Update of Stats NZ customised emissions data

Product use	547	460	-87	-15.9%	-0.8%	-0.8%	Update of Stats NZ customised emissions data
AGRICULTURE, FORESTRY and OTHER LAND USE (AFOLU)							
Livestock	637	604	-33	-5.1%	0.3%	0.3%	Update of emissions factors
Land	-1,313	-805	508	-38.7%	4.4%	4.9%	Update of emissions
Aggregate sources and non-CO2 emission sources on land	257	106	-151	-58.6%	-1.3%	-1.5%	Update of emissions
Gross emissions	**11,463**	**12,060**	**597**	**5.2%**			
Net emissions	**10,266**	**11,235**	**969**	**9.4%**			

* "Change" is calculated using emissions values in tCO_2e.

** *Auckland's greenhouse gas inventory to 2021* (Xie, 2024), updated emissions CO_2e in AR5.

Table A-5 Analysis of changes in 2021 emissions from previous 2021 inventory*

Source	Emissions in 2021 ($ktCO_2e$)		Change		% Change to 2021 inventory		Reasons of change
	2021 inventory**	This inventory	$ktCO_2e$	%	Gross emissions	Net emissions	
STATIONARY ENERGY							
Electricity	1,207	1,254	47	3.9%	0.4%	0.5%	Update of emissions factors
Natural gas	910	849	-61	-6.7%	-0.6%	-0.6%	Update of emissions factors
LPG	371	357	-15	-4.0%	-0.1%	-0.2%	Update of LPG use
Wood	23	23	0	0.0%	0.0%	0.0%	No changes
Coal	578	650	71	12.3%	0.7%	0.7%	Update of coal use
TRANSPORT							
Petrol (vehicles)	2,194	2,202	8	0.4%	0.1%	0.1%	Update of emissions factors
Diesel (vehicles)	1,816	1,833	17	0.9%	0.2%	0.2%	Update of emissions factors
LPG (vehicles)	1	1	0	-33.3%	0.0%	0.0%	Update of LPG use
Electricity (trains and vehicles)	6	8	2	28.8%	0.0%	0.0%	Update of emissions factors
Train (diesel)	6	6	0	1.2%	0.0%	0.0%	No changes
Ferry	18	19	0	0.9%	0.0%	0.0%	Update of emissions factors
Aviation	250	248	-2	-0.7%	0.0%	0.0%	Update of emissions factors
Shipping	126	127	1	0.8%	0.0%	0.0%	Update of emissions factors
Diesel for off-road transport	81	65	-16	-19.6%	-0.1%	-0.2%	Update of diesel use
WASTE							
Solid waste disposal	293	309	16	5.3%	0.1%	0.2%	Update of emissions factors
Waste water treatment	62	132	70	11.3%	0.7%	0.7%	Update of Watercare GHG inventory
INDUSTRIAL PROCESSES and PRODUCT USES (IPPU)							
Industrial processes	1,768	1,778	10	0.5%	0.1%	0.1%	Update of Stats NZ customised emissions data

Product use	453	624	171	37.7%	1.6%	1.8%	Update of Stats NZ customised emissions data
AGRICULTURE, FORESTRY and OTHER LAND USE (AFOLU)							
Livestock	514	518	5	1.0%	0.0%	0.1%	Update of emissions factors
Land	-1,313	-339	975	-74.2%	9.0%	10.2%	Update of emissions
Aggregate sources and non-CO2 emission sources on land	238	-201	-439	-184.7%	-4.1%	-4.6%	Update of emissions
Gross emissions	**10,800**	**11,109**	**309**	**2.9%**			
Net emissions	**9,602**	**10,485**	**883**	**9.2%**			

* "Change" is calculated using emissions values in tCO_2e.

** *Auckland's greenhouse gas inventory to 2021* (Xie, 2024), updated emissions CO_2e in AR5.

Table A-6 Information sources and data quality

	Activity data or emissions data	Data quality*
STATIONARY ENERGY		
Electricity	Total consumption was sourced from various organisations (Vector Ltd, 2024; Counties Power Ltd, 2024; NZEA, 2024). Allocation of total consumption into sub-sectors was based on Vector Ltd and NZEA data.	H for total consumption as data was robust. M for sub-sector consumption due to uncertainty in breakdown of total consumption into sub-sectors.
Natural gas	Total consumption was collected from various sources (Vector Ltd, 2024; MfE, 2025a). Its allocation to sub-sectors was calculated based on two datasets: Stats NZ's data for Auckland (Stats NZ, 2024a) and industrial emissions data (Atkins, 2018).	H for total consumption as data was robust. M for sub-sector consumption due to uncertainty in breakdown of total consumption into sub-sectors.
LPG	The two datasets (see the cell above) were also used to estimate emissions (total and sub-sectors) from LPG, coal and diesel for stationary and off-road transport sources.	M for total and sub-sector consumption due to uncertainty in calculations.
Wood	Emissions from wood were estimated from the Auckland air emissions inventory (Metcalfe, et. al., 2018) and industrial emissions data (Atkins, 2018).	The same as LPG.
Coal	The same as LPG.	The same as LPG.
Diesel for off-road transport	The same as LPG.	L due to high uncertainty in calculations.
TRANSPORT		
Petrol (vehicles)	Petrol sales were provided by Auckland Transport and based on the local authority fuel tax reports.	H as data was robust.
Diesel (vehicles)	Diesel sales were provided by Auckland Transport and based on the local authority fuel tax reports.	H as data was robust.
LPG (vehicles)	LPG use was estimated by portioning New Zealand's consumptions (MoT, 2024a) by the ratio of vehicle fleet in Auckland to New Zealand (MoT, 2024b).	M as data was estimated.
Electricity (trains and vehicles)	Electricity use for trains was provided by Auckland Transport. The data for vehicles was estimated by portioning New Zealand's consumptions (MoT, 2024a) by the ratio of vehicle fleet in Auckland to New Zealand (MoT, 2024b).	M as data for vehicles was estimated.
Train (diesel)	Diesel consumption for passenger trains was provided by Auckland Transport. Diesel use by freight trains was calculated based on rail tonnage data from the Freight Information Gathering System (FIGS) (MoT, 2024b).	M as data for freight trains was calculated based on activity-related information.
Ferry	Diesel use was provided by Auckland Transport.	H as data was robust.
Aviation	The Joint User Hydrant Installation (JUHI) Depot provided aviation fuel consumption at Auckland Airport. The proportion attributable to Auckland was calculated based on passenger information (Stats NZ, 2024b; Auckland Airport, 2024).	M due to uncertainty in estimating the portion attributable to Auckland.

	Activity data or emissions data	Data quality*
Shipping	Total amount of fuel oil used to re-fuel ships at seaports was provided by Auckland Transport. The proportion attributable to Auckland was calculated based on export data at NZ shipping ports in tonnage from the Freight Information Gathering System (FIGS) (MoT, 2024b).	M due to uncertainty in estimating the portion attributable to Auckland.
WASTE		
Solid waste disposal	Emissions from landfills were provided by the waste team at Auckland Council, which was based on total amount of solid waste and its composition. Emissions from farm fills and rural waste were provided by Stats NZ (2024a).	M due to uncertainty in estimating total amount of solid waste and its composition.
Waste water treatment	Emissions data was provided by Watercare Services Ltd (2024).	M due to uncertainty in calculations.
INDUSTRIAL PROCESSES and PRODUCT USES (IPPU)		
Industrial processes	Emissions data was sourced from Stats NZ (2024a) and New Zealand's Greenhouse Gas Inventory (MfE, 2025a)	H as data was robust.
Product use	Total CO2e emissions from industrial product use were provided by Stats NZ (2024a). The proportion of CO_2, N_2O, HFCs, PFCs and SF_6 was reported the same as in New Zealand's Greenhouse Gas Inventory (MfE, 2025a)	M due to uncertainty in the proportion of CO_2, N_2O, HFCs, PFCs and SF_6.
AGRICULTURE, FORESTRY and OTHER LAND USE (AFOLU)		
Livestock	The number of livestock (dairy cattle, non-dairy cattle, sheep, deer, pig, goat and horse) was sourced from Stats NZ (2024b).	M due to uncertainty in calculations.
Land	Emissions and removals data was provided by Ministry for the Environment.	M due to uncertainty in calculations.
Aggregate sources and non-CO2 emission sources on land	Emissions from liming and urea application were estimated based on national emissions (MfE, 2025a) allocated to Auckland based on the proportion of all fertilisers used to the national total (Stats NZ, 2024b). Direct and indirect N_2O from managed soils were calculated using the number of livestock. HWPs emissions were provided by Ministry for the Environment.	M due to uncertainty in calculations.

* The quality of activity data was assessed with a High (H)-Medium (M)-Low (L) rating where possible, see section 2.2 for details.

Find out more:

environmentaldata@aucklandcouncil.govt.nz

or visit knowledgeauckland.org.nz and aucklandcouncil.govt.nz