EnviroStrat
Impact Investment Project Development

Waikato Regional Council

Waikato Region Greenhouse Gas Emissions Inventory

For the period July 2018 to June 2019

Prepared by EnviroStrat Ltd and AECOM
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Disclaimer

Acronyms and Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EECA	Energy Efficiency and Conservation Authority
GCoM	Global Covenant of Mayors for Climate and Energy
GHG	greenhouse gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories
GWP	global warming potential
HFCs	hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use
k	thousand
LEV	Low emissions vehicle
LPG	liquefied petroleum gas
N_2O	nitrous oxide
NF_3	nitrogen trifluoride
PFCs	perfluorocarbons
SF_6	sulphur hexafluoride
TAs	Territorial Authorities
WRC	Waikato Regional Council

Glossary

Emission factor(s)	A factor that converts activity data into GHG emissions data (e.g., kg CO_2e emitted per litter of fuel consumed, kg CO_2e emitted per kilometre travelled, etc.).
Scope 1 emissions	GHG emissions from sources located within the Waikato region boundary.
Scope 2 emissions	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the Waikato region boundary.
Scope 3 emissions	All other GHG emissions that occur outside the Waikato region boundary as a result of activities taking place within the Waikato boundary.
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.

Executive Summary

This is the second inventory report for Waikato Region's Community-scale Greenhouse Gas (GHG) Emissions Inventory. The inventory was compiled following the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC), which is considered best practice for community-based inventories.

Individual emissions inventories have also been prepared for each of the 10 districts of Waikato region: Hamilton City, Waikato, Hauraki, Thames Coromandel, Waitomo, Matamata Piako, Otorahonga, Waipa, South Waikato and Taupo. This is the first attempt to provide districts emissions breakdown and the expectation is that the insights will enable collaborations and actions for climate mitigation.

Activities within Waikato Region's boundaries generated approximately 12,646,982 metric tonnes of carbon dioxide equivalent (t CO_2e) between July 2018 and June 2019. When forestry is included, the total net emissions for the region are 7,116,073t CO_2e.

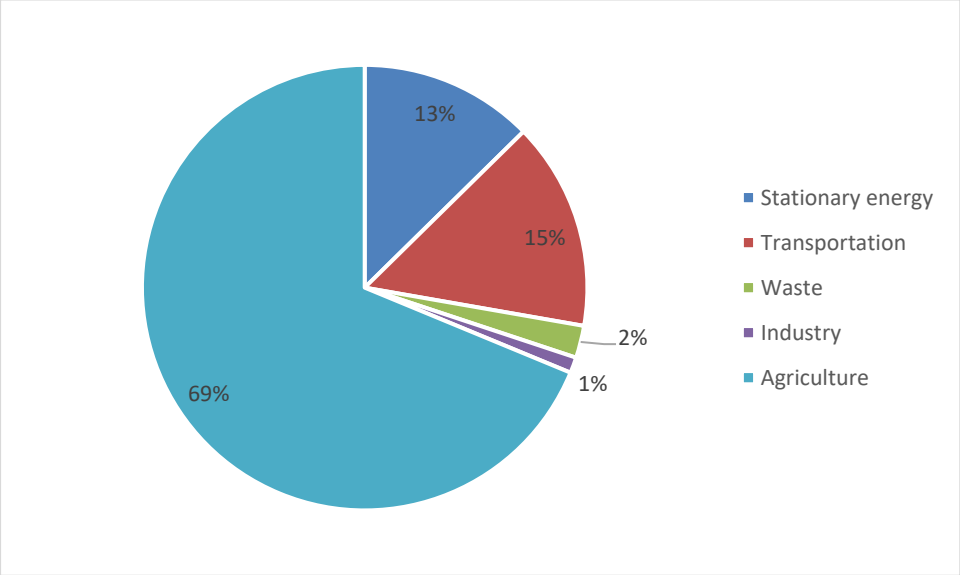

Figure 1. Total gross emissions by source (excl. forestry) for 2018/19.

Agriculture remains the largest contributor to the total gross emissions for Waikato (69%), followed by transportation (14.5%) and stationary energy (13%). Forestry removed a net volume of 5,530,909 t CO_2e or about 44% of the total gross emissions.

As expected, Scope 1 emissions (GHG emissions from sources located within the Waikato region boundary) make up the majority of emissions in Waikato Region, followed by Scope 2 (GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the Waikato region boundary). Scope 3 emissions (GHG emissions that are happening outside the Region but are driven by activities within the region) have been estimated for stationary energy and transportation related activities.

Table 1. Waikato emissions profile by sector and scope.

	Scope 1	Scope 2	Scope 3	Basic Total	% of Total
Stationary Energy	1,069,411	424,687	107,328	1,601,426	22.64%
Transportation	1,854,071		37,651	2,001,657	27.07%
Waste	291,708			291,708	4.20%
IPPU	143,213			143,213	2.05%
AFOLU	3,078,067			3,078,067	44.04%
Total	**6,455,967**	**424,687**	**144,979**	7,116,073	**100%**

Due to its emissions profile, Waikato Region would need to focus its reduction efforts on agriculture as well as consider options for maintaining or increasing its carbon removal potential (forestry). Within agriculture, a focus on methane emissions reduction is needed since it makes up about 70% of agricultural emissions.

At a district level, emissions profile varies with a clear difference between urban and rural.

The development of inventories for individual districts within the Region opens the opportunity for dialogue and collaboration in efforts to reduce emissions, starting with target setting. The insights can be leveraged to seek coordinated action in areas such as agriculture, transport or waste – including sharing of insights amongst districts and regional councils by those that are already exploring solutions.[1]

The preparation of the provisional 2021-2025 carbon budget for New Zealand is going to bring in sharp perspective the importance of understanding the emission gap and the trajectory change for emissions. For this reason, it is recommended that this emissions inventory is updated in two years' time (2021/22) so there is alignment with the first carbon budget period for 2022-2025[2].

Waikato Region's 2018/19 emissions inventory: key messages

Overall

- Waikato Region's per capita net emissions are approximately 30% higher than the national average (15.0 vs 11.6 t CO_2e/cap).
- Agricultural activities generate 69% of all emissions. On a per capita basis, Waikato's agricultural emissions are more than twice higher than the national average (18.2 vs 7.9 t CO_2e/cap).
- Forestry sector removes about 44% of the Waikato's total gross emissions, more than double the national per capita average (-11.7 vs -4.9 t CO_2e/cap). However, the majority of carbon sequestration comes from exotic forest.
- District councils have a wide range of emissions profiles, varying from urban to intensive pastoral land use; per capita net emissions vary widely between -34.4 (net positive) for Taupo District to 82.8 t CO_2e/cap for Otorohanga District.
- Two districts – Taupo and Thames-Coromandel are carbon positive due to high level of sequestrations from forestry.

Changes from 2015/16 baseline inventory

- Total net emissions increased by 349,291 t CO2e and total gross emissions increased 247,439 t CO2e from the 2015/16 baseline.
- Agriculture is the only sector for which gross emissions have decreased (4.20%), primarily due to a decrease in dairy herd size in Waikato.
- Stationary energy and transportation emissions have increased as well (8.41% and respectively 32.27%) – largely driven by an increase in population.
- Carbon removal rates by forestry have decreased due to rates of re-planting not keeping up with the pace of harvesting rates.

[1] See for example https://www.scoop.co.nz/stories/AK2002/S00461/new-climate-change-committee-springs-into-action.htm

[2] The 2021-2025 provisional budget is seen as a precursor to the formal budget for 2022-2025 that the Climate Change Commission will monitor.

1 Introduction and context

The New Zealand government ratified the Paris Agreement in April 2017, which is an international commitment to limit global warming to below two degrees. 196 countries are parties to this agreement which ultimately needs to lead to emissions reductions of 60-80 % if global warming is to stay below two degrees.

To achieve this goal and make a fair contribution to global emissions reductions, New Zealand adopted in 2019 the Carbon Change Response (Zero Carbon) Amendment Act to develop and implement clear climate change policies that contribute to the commitments under the 2015 Paris Agreement. The Act sets new mitigation targets committing New Zealand to:

- reduce annual net emissions of all greenhouse gases (except biogenic methane) to zero by 2050, and
- reduce annual emissions of biogenic methane to
    - 10 % below 2017 levels by 2030
    - 24 % to 47 % per cent below 2017 levels by 2050.

The Act also established a system of emissions budgets to act as stepping-stones towards the long-term target. The Ministry for the Environment is currently developing a provisional emissions budget for 2021–2025 period. Eventually, emissions budget will be set for the following periods: 2022–2025, 2026–2030 and 2031–2035.[3]

The target for biogenic methane is ambitious since it is accounting for about 42% of New Zealand's total emissions, representing primarily agriculture sector (MfE 2019).

1.1 Role of regional and district councils

Globally more than 10,000 cities and local governments have signed up to the Global Covenant of Mayors for Energy and Climate (GCoM)[4] and committed to report on their community greenhouse gas emission and emission reduction measures.

In 2017, the majority of Mayors and Chairs of New Zealand have re-confirmed the 2015 Climate Change Declaration and the key commitments and actions that Councils plan to undertake. Waikato Regional Council and many[5] of the region's territorial authorities are signatory to this declaration which covers all member agencies activities, roles and functions of the sector and specifically identifies how local government will act and what it requires of central government to support action on climate change.[6]

It is recognised that solutions to climate change and transition to a low carbon economy cannot be pursued by central government without the involvement and actions of local government – for adaptation as well as mitigation. Districts, cities and regions around New Zealand are exploring GHG reduction targets as part of their climate mitigation strategies. To develop their carbon reduction strategies, regional and local governments need to have a good understanding of their emissions profiles i.e. the sources of emissions by sectors and gases, and track emissions trends. The current central government focus on developing carbon budgets provide a context for engagement and transition perspective for territorial authorities.

[3] More information is available at: https://www.mfe.govt.nz/climate-change/zero-carbon-amendment-act.

[4] www.globalcovenantofmayors.org

[5] Four of the Waikato region TAs are not signatories.

[6] See the declaration here: https://www.lgnz.co.nz/assets/Uploads/0827d40e5d/Climate-Change-Declaration.pdf

1.2 Waikato Region's context

The first baseline emissions inventory for Waikato region was prepared in 2017 and covered the 2015/16 financial year[7].

The baseline inventory showed the specific context for the region: per capita net emissions are 50% higher than the national average and agricultural activities generate about 75% of all emissions. Methane emissions represent around 71% of total agricultural emissions and almost half of the region's total gross emissions (from 2015/16 inventory). The forestry sector is an important carbon sink as it removes / offsets about 40% of the total gross emissions (more than double the national average). High level of sequestration in exotic forest (which eventually is harvested) and the presence of peat soils pose challenges and uncertainties for the region as it pursues the regional climate mitigation target.

Currently, the region has set an aspirational goal as part of the Waikato Wellbeing Project[8] to reduce carbon emissions by a minimum of 25% by 2030 in relation to 2017 as an interim target on the path to net zero carbon by 2050.

1.3 Purpose of the emission inventory

A GHG emissions inventory is an estimate of GHGs emitted to, or removed from, the atmosphere over a given period. This inventory provides the Waikato Regional Council and the Districts of the Waikato region with an understanding of their emissions generation and profile for the 2018/19 financial year reporting period.

Specifically, the purpose of this report is to:

- Identify where Waikato's emissions are coming from and calculate the changes in emissions generation/removal compared to the 2015/16 baseline inventory.
- Determine the emissions profile of individual districts as basis for developing a climate action plan or setting reduction targets.
- Provide information and understanding to enable the regional and district councils to engage with key sectors and stakeholders towards reducing local emissions.

Overtime, the emissions inventory will assist with comparing emission trends and tracking progress in emissions reductions. It will be a valuable tool within the context of multi-year carbon budget allocations that New Zealand will apply.

This document summarises the findings and insights from the data collection and calculations, and it also outlines the underlying assumptions and limitations.

2 Methodology

2.1 The Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories

This inventory for Waikato region (and the individual territorial authorities) follows the methodology outlined in the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC)[9], published by the World Resources Institute in 2015. The GPC methodology represents international best practice for city and community level greenhouse gas (GHG) emissions reporting.

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[7] Waikato Region greenhouse gas inventory - July 2015 to June 2016 https://www.waikatoregion.govt.nz/assets/WRC/WRC-2019/TR201731.pdf

[8] More information about the initiative is available at https://www.waikatowellbeingproject.co.nz/

[9] The protocol is available at: http://www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities.

It includes emissions from stationary energy, transport, waste, industry, agriculture and forestry activities within the regional (administrative) boundary of Waikato Region. The inventory covers seven greenhouse gases: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

The same GPC methodology was used for the 2015/16 regional Waikato inventory and is applied by other community scale GHG inventories around New Zealand (e.g. Auckland Council) and internationally.

2.2 Inventory Boundary

The boundaries of the 2018/19 emissions inventory are the territorial boundaries of the 10 districts within the Region. Waikato Region covers 2,490,289 ha and has 473,480 residents. The region has a predominantly agricultural economy, it is a transportation corridor and distribution hub and has significant energy use including electricity generation. Hamilton and Taupo airports are located within the regional boundary.

2.3 Emissions calculations and reporting

This inventory assesses both direct (production-based) emission sources within the geographic area (Scope 1) and indirect (consumption-based) emission sources associated with goods and services imported into the geographic area. Examples of indirect emission sources include electricity from the national grid (Scope 2), transport into the area that originates or terminates outside the area e.g. aviation (Scope 3).

Emissions are reported for the period from 1 July 2018 to 30 June 2019. The inventory includes emissions from stationary energy, transport, waste, industry, agriculture and forestry as follows:

- Stationary energy includes emissions from electricity consumed by residential, commercial and industry users, electricity generated from non-renewable sources (i.e. landfill gas combustion), as well as consumption of coal, natural gas, biodiesel and wood;
- Transport includes emissions from on and off-road petrol and diesel (including biodiesel) sold within the region, rail diesel, jet kerosene and aviation gas used for aviation and LPG used for road transport;
- Waste includes emissions from the treatment of wastewater, the disposal of solid waste and composting of organic material;
- Industrial processes and product use (IPPU) cover GHG emissions from industrial chemical or physical processes, as well as emissions associated with the consumption (i.e. product use) of GHGs for refrigerants, foam blowing, fire extinguishers, aerosols, metered dose inhalers and Sulphur Hexafluoride (SF6) for electrical insulation and equipment production;
- Agriculture includes emissions from livestock, crops and fertiliser use;
- The forestry sector includes carbon sequestered from commercial exotic forests and other native forest cover, as well as emissions from harvested trees. Carbon stored in mature forests are not included in the inventory.[10]

Other aspects to note when reviewing the inventory:

- Emissions are expressed as a carbon dioxide-equivalent including climate change feedbacks using the 100-year GWP (Global Warming Potential) values and climate-carbon feedback from the Intergovernmental Panel on Climate Change Fifth Assessment Report: Climate Change 2013;
- Total emissions are reported for gross emissions (excluding forestry) and net emissions (including forestry);

[10] Maturing forests sequestered carbon in trees and wood products. When trees are harvested, the carbon is released back to the atmosphere through decay or combustion. Assuming that the total area used for forestry activities remains similar (i.e. all forests harvested are being replanted) the overall carbon balance is expected to neutral. Increasing the forest area will lead to net sequestration, while reducing the forest area will result in net emissions to the atmosphere.

- Emissions are calculated by multiplying activity data by an emission factor associated with the activity;
- In line with the GPC, activity data for the various emission sources includes data from bottom up sources (locally provided measures or estimates) and top down sources (based on national information), depending on data availability;
- GPC requires that total emissions are reported at the BASIC or BASIC+ levels. This inventory reports at the BASIC+ level (which includes scope 1 and scope 2 emissions from stationary energy and transport, scope 1 and scope 3 emissions from waste, and emissions from IPPU and AFOLU and transboundary transport);
- Following GPC guidance and requirements, notation keys (IE, NE, NO and C) have been used in the emissions report and data quality for each activity/sector assessed (see Appendix A for a description of data quality assessment).

2.4 Updates to 2015/16 emissions calculations

The first emissions inventory report developed for Waikato region in 2017 was a baseline inventory covering the 2015/16 financial year. It is common practice to re-calculate previous estimates to ensure consistency in emissions estimates and enable comparability between inventories.[11]

This review included an update of the assumptions made as the practice of emissions inventory is increasing and new insights emerge.

Some of the specific factors that have contributed to the updated values for 2015/2016 inventory include:

- The 2015/16 data was based on Waikato Region boundaries while the 2018/19 regional data represents the sum of the district data.
- Change in population figure used between original 2017 calculations and 2020 recalculation of 2015/16 – updated figure is based on the sum of districts included.
- The emissions factors were updated to align with the latest national inventory and data where applicable (MfE 2019).
- Methodologies were also updated or refined, for example for forestry which was revised to include an additional category for native forestry sequestration (broadleaf indigenous hardwoods) and application NZ Land Cover Database v5.0 (LCDB5)[12];
- Assumptions updates included, for example, change in grid exist points that led to change in electricity estimates.

As a result, the inventory was re-calculated and the new estimates are presented below.

Table 2. Revised emissions estimates for 2015/16 inventory

Emissions sources	Waikato Region 2015/16 2017 estimates (t CO2e)	Waikato Region 2015/16 2020 re-calculation (t CO2e)
Stationary Energy	1,333,908	1,477,156
Transportation	1,619,540	1,513,258
Waste	280,963	281,003
IPPU	141,334	141,492
Agriculture	10,421,352	8,986,635
Forestry	- 5,595,391	- 5,632,761
Total (net) incl. forestry	**8,201,706**	**6,766,782**
Total (gross) excl. forestry	**13,797,097**	**12,399,543**

[11] for more information, see Chapter 10 of the New Zealand's Greenhouse Gas Inventory 1990–2017 (MfE 2019).

[12] https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/

2.5 Assumptions, limitations and uncertainties

Emissions inventories of this nature involve a range of assumptions, limitations and uncertainties. Calculating the emissions footprint for individual territorial authorities within the Waikato Region has added more complexity to the data collection and calculations. Examples of data limitations include:

- Emissions from industrial product use by scaling national emissions from industrial product use on a population basis;
- This inventory estimates solid waste emissions from both open and closed landfills based on national inventory figures and allocated on a population basis;[13]
- This inventory estimates emissions from wastewater treatment by scaling national emissions from these sources on a population basis;
- Uncertainties also exist where data is missing or has been estimated based on limited information.

In addition to activity-related assumptions and uncertainties, the GPC methodology also includes assumptions in terms of calculations of sector emissions. Forestry is a relevant example given the importance of the sector for the Region: this inventory accounts for forest carbon stock changes from afforestation, reforestation, deforestation and forest management (i.e. it applies land-use accounting conventions under the UN 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.

A full listing of assumptions and limitations are included in the Appendix B. Data sources and identified data gaps are listed in Appendix C. Where helpful, specific information on assumptions, limitations and uncertainties are included along with the sector results.

3 Emissions results and analysis

This section provides the inventory results with emissions sectors and sub-sectors details to illustrate how emissions estimates are generated, and the changes in the three-year period since the 2015/16 baseline inventory for Waikato Region was developed.

3.1 Main sources of emissions

Activities within Waikato Region boundaries generated approximately 12,646,982 t CO_2e between July 2018 and June 2019. When forestry is included, the total net emissions for the region are 7,116,073t CO_2e.

Agriculture continues to be the largest contributor to the total gross emissions for Waikato (69 %), followed by transportation (15.83 %) and stationary energy (13 %). Forestry removed a net volume of 5,530,909 t CO_2e or about 44 % of the total gross emissions.

[13] This approach is practical but does not provide accurate estimates – since it apportions emissions based on national data instead of actual waste practices and performance outcomes.

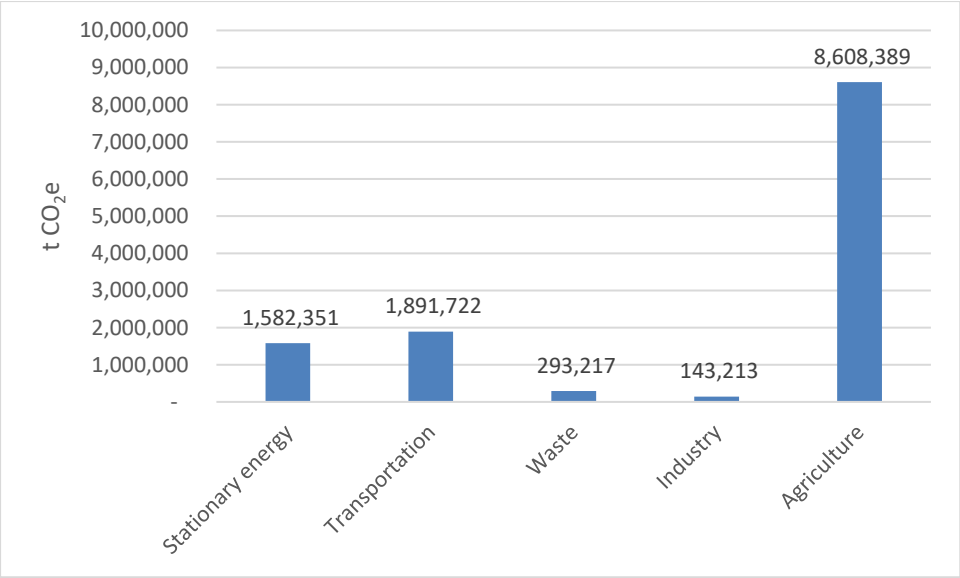

Figure 2. Total gross emissions by source (excl. forestry) for Waikato Region, 2018/19

Table 3. GPC BASIC Community Greenhouse Gas Emissions Inventory by Sector and Sub-Sector, Waikato Region (2018/19)

	Scope 1	Scope 2	Scope 3	Basic Total	% of Total (net)
Stationary Energy	**1,050,335**	**424,688**	**107,327**	**1,601,427**	**22.64**
Residential Buildings	65,605	134,525	17,074	217,204	3.11
Commercial & Institutional buildings and facilities	81,017	102,460	16,169	199,645	2.89
Manufacturing Industries and Construction	371,776	187,703	74,084	633,564	9.07
Other sources (fugitive emissions from mining)	531,938			531,938	7.61
Transportation	**1,854,071**		**37,651**	**2,001,658**	**27.07**
On road transportation	1,669,316			1,669,316	23.89
Aviation			37,651	37,651	0.54
Off-road transportation	184,755			184,755	2.64
Waste	291,708			291,708	**4.20**
Solid waste disposal	247,877			247,877	3.57
Wastewater treatment and discharge	43,831			43,831	0.63
IPPU	**143,213**			**143,213**	**2.05**
AFOLU	**3,078,067**			**3,078,067**	**43.04**
Total	**6,455,967**	**424,687**	**144,979**	**7,116,073**	**100 %**

A greater detail on the distribution of emissions within each sector is provided below for sectors, sub-sectors, and fuel-type. Appendix D contains further details following GPC templates for calculations breakdown.

3.1.1 Stationary energy

Stationary energy use in the Region is responsible for 1,601,427 t CO_2e in 2018/19, representing 12.64 % of the gross emissions (excluding forestry).

The main source of emissions from stationary energy is natural gas consumption, contributing 3.4 % of the total regional emissions, with natural gas transmission and distribution losses contributing (T&D Losses) an additional 0.58 %. Electricity consumption (Scope 2) and electricity T&D losses from electricity contribute approximately 3.39 % and 0.28 % respectively. Fugitive emissions (Scope 1) from coal mining contribute 2.75% of gross regional emissions.

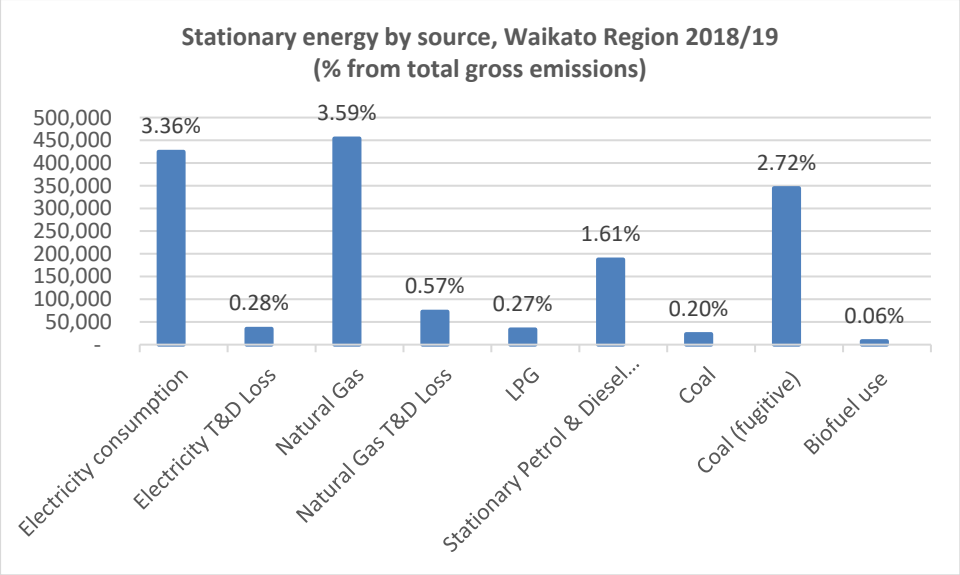

Figure 3. Total stationary emissions by source for Waikato Region, 2018/19

Emissions from electricity consumption are based on the national average emissions factor for electricity generation. In line with the approach for the 2015/16 inventory, the emissions from electricity generation have not been included in the Waikato carbon footprint, as these are part of the national emissions inventory for electricity generation.[14]

A detailed breakdown of the stationary energy emission sources is provided in the table below.

Table 4. Summary of Stationary Energy Emissions by Source, 2018/19

Sector/Category Source		**Emissions (tCO_2e)**		**Sector Percentage Contribution**
Stationary Energy	Electricity	424,687	Σ 1,601,427	26.52 %
	Electricity T&D Loss	34,872		2.18 %
	Natural Gas	453,944		28.35 %
	Natural Gas T&D Loss	72,456		4,52 %
	LPG	33,523		2.09 %
	Petrol and Diesel use	204,105		12.75 %
	Coal	25,526		1.59 %
	Biofuel use	7,717		0.48 %
	Fugitive Emissions (coal mining)	344,596		21.52 %

[14] Waikato Region is a net generator of electricity; with less than 20% of production being consumed in the region.

3.1.2 Transportation

Transportation sources emitted 2,001,658 t CO_2e for the period 2018/19, representing 15.83% of the Waikato Region's total gross emissions, respectively 28.13% from net emissions.[15] Transportation was the second highest contributor to regional net and gross emissions after agriculture although it represents less than a quarter of agricultural emissions. Figure 4 provides a breakdown of the emissions generated by individual fuel types.

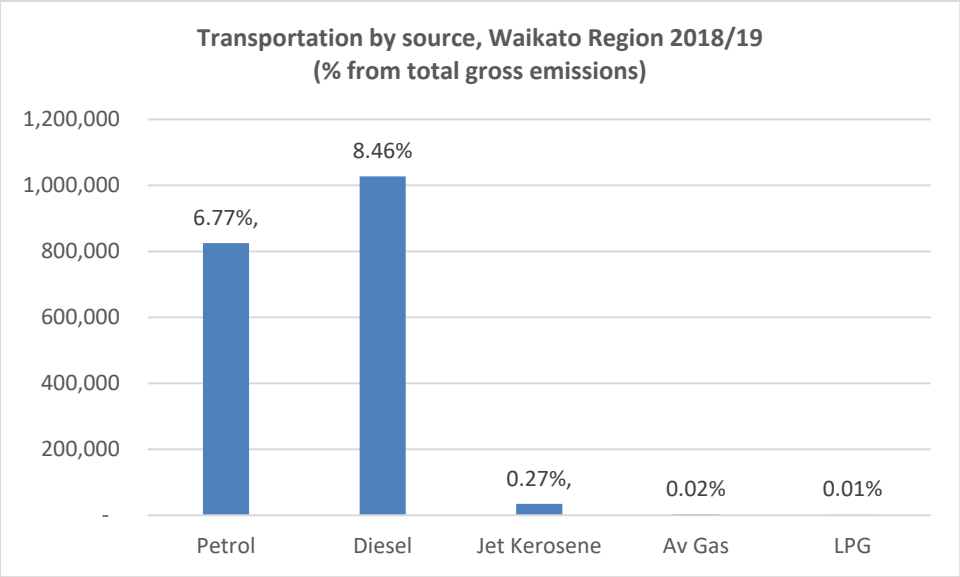

Figure 4. Total transportation emissions by source for Waikato Region, 2018/19

On-road transport (predominantly Scope 1 emissions from diesel and petrol), contributing approximately 96% of the transportation emissions during the reporting period. A breakdown of the transportation emission sources is provided in the table below.

Table 5. Summary of Waikato Region transportation emissions by source, 2018/19

Sector/Category		Emissions (t CO_2e)		Sector Percentage Contribution
Transportation	On-road petrol and diesel	1,567,100	Σ 2,001,658	97.9 %
	Rail emissions	37,383		1.87 %
	LPG	1,763		0.09 %
	Av gas	2,001		0.10 %
	Jet kerosene	34,415		1.72 %

3.1.3 Waste

The waste sector generated 291,708 t CO_2e emissions in 2018/19, accounting for 2.31 % of the Region's emissions. The majority of waste sector emissions result from landfilling solid waste collected (85 %). Process emissions from wastewater treatment contributed 15 % of the sector total (Table *6*).

Combustion of landfill gas (LFG) and sludge incineration was estimated to generate approximately 10,380 t CO_2e (biogenic[16]).

[15] Because updated data from Kiwirail was not yet available, railway emissions included in this inventory are the same from 2015/16.

[16] The GPC Standard recommends reporting biogenic emissions outside of the total greenhouse gas emissions.

Table 6. Summary of Waikato Region waste emissions by source 2018/19

Sector/Category Source		Emissions (t CO_2e)		Sector Contribution
Waste	Solid Waste Disposal	247,877	Σ 291,708	84.97 %
	Wastewater	43,831		15.03 %

Solid waste emissions were estimated using a 1st-order decay model that requires waste volume estimates for the last 50 years. Historical waste volumes sent to landfill were estimated using the average waste generated per person per year, as reported by Ministry for the Environment (MfE), and historical national population figures as reported by Stats New Zealand. Solid waste (247,877 t CO2e) accounts for 1.96 % of total gross emissions for the Waikato.

A significant proportion of municipal solid waste generated within Waikato was disposed of at the Hampton Downs and Tirohia Landfills (Scope 1), the remaining solid waste is deposited at a number of smaller landfills (35 %).

The majority of solid waste emissions (65%) were released from landfills without landfill gas collection. These are predominantly from closed landfills that have been used in the past but are still emitting landfill gas. The calculations assume all waste sent to landfills other than Hampton Downs and Tirohia was sent to landfill without LFG collection systems, including historic waste sent to landfill prior to the opening of these two landfills.

Emissions from landfills with landfill gas collection systems (i.e. Hampton Downs and Tirohia Landfills) are responsible for 35% of the regional emissions from solid waste. Details of Landfill Gas (LFG) collection and efficiency were unable to be confirmed with the operating landfills. Therefore, the NZ average was used, as reported by the MfE 2019.

Wastewater treatment generated 43,831 t CO_2e or approximately 0.35% of the total gross emissions for the Region. Because of incomplete data across the region, national wastewater emissions data were used to calculate the per capita wastewater treatment and disposal emissions, and the total wastewater emissions from the Waikato Region. The top down approach adopted for the Waikato Region is regarded as sufficient to provide an estimate of the likely order of magnitude and the expected emissions – at approximately 0.35 %, these emissions are not material for the overall regional carbon footprint.

3.1.4 Industrial processes and product use (IPPU)

This section covers product use only as stationary energy emissions from industrial processes using coal, natural gas and electricity for production and operation processes have been estimated within the respective emission categories (Stationary Energy – 3.1.1).

In 2018/19 industrial GHG emissions contributed 143,213 t CO_2e (1.13 %) towards regional gross emissions. The emissions for industrial product use include emissions from hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (Scope 1). Emissions from industrial product use (refer Table 7) were estimated based on data provided in the New Zealand Greenhouse Gas Emissions 1990-2017 report (MfE 2019).

Table 7 Summary of industrial product use emissions for Waikato Region

Sector/Category		Emissions (t CO_2e)		Sector Percentage Contribution
IPPU	Refrigerants	132,366	Σ 143,213	92.43 %
	Foam Blowing	528		0.037 %
	Fire extinguishers	214		0.15 %
	Aerosols & MDI*	8,618		6.02 %
	SF_6	1,486		1.04 %

3.1.5 Agriculture

Agriculture generated an estimated 8,608,389 t CO_2e in Scope 1 emissions in 2018/19. This represents approximately 68% of the total gross emissions for the Region. A breakdown of agricultural emissions by source is provided below.

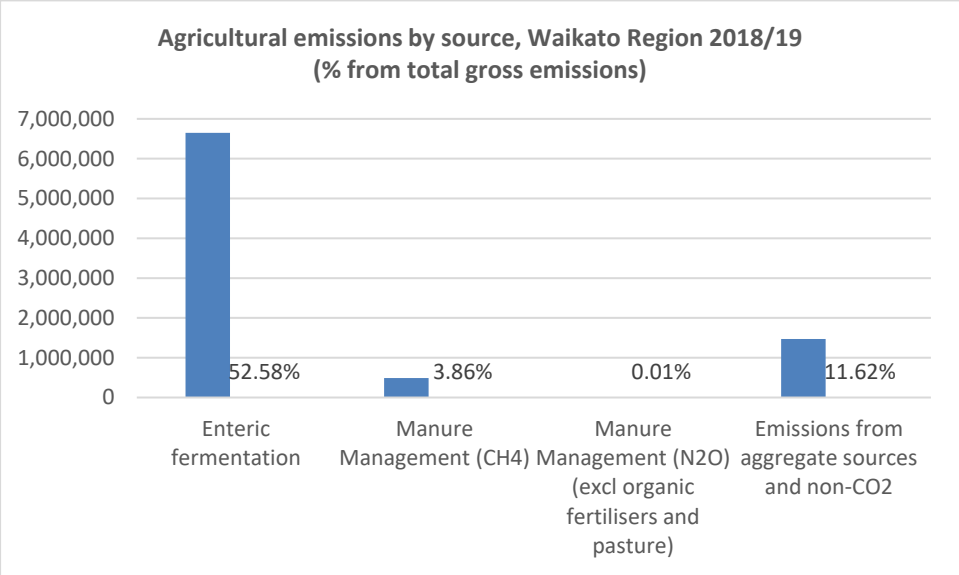

Figure 5. Agricultural emissions by source, Waikato Region 2018/19

The majority of emissions (83 % or 7,137,496 t CO_2e) were generated by methane (CH_4) emitted from enteric fermentation and manure management of farmed animals (Table *8*). Overall, approximately 56 % of Waikato Region's gross emissions are related to methane and this represents a significant challenge for the region.

Table 8. Summary of Waikato Region agricultural emissions by source and gases 2018/19

	Emission source	Emissions (t CO_2e)		Sector Contribution
Agriculture	Enteric fermentation (CH4)	6,649,325	Σ 8,608,389	77.24 %
	Manure Management (CH4)	488,171		5.67 %
	Manure Management (N2O)	1,366,363		0.02 %
	Emissions aggregate sources17	1,470,113		17.08 %

The Zero Carbon Act commits New Zealand to reduce emissions of biogenic methane to 10 % below 2017 levels by 2030 – the pathway for achieving this will need to be considered carefully and early i.e. presently, in order to allow for farmer / land-owner transition.

3.1.6 Forestry carbon sequestration and emissions

Forestry activities in Waikato Region in 2018/19 led to a net sequestration of -5,530,909 t CO_2e (43.26 % of gross emissions). The forestry sector emissions include carbon sequestered through growing trees, and carbon lost through harvesting. The GPC methodology assumes that all carbon stored in trees is released in the year the trees are harvested. For Waikato Region, exotic forest contributed 89 % of sequestration and 11 % was from native forest.

[17] They include agricultural soils, leaching, atmosphere depositions.

Table 9 Summary of forest emissions/removals by source 2015/16

Sector/Category Source		Emissions (t CO_2e)		Sector Contribution
Forestry	Exotic forest sequestration	- 10,750,994	Σ- 5,530,391	89 %
	Native forest sequestration	- 1,307,025		11 %
	Total harvest emissions*	6,527,111		

*it includes wood remaining on site, below ground, dead wood and litter

Re-planting and new planting rates are lower than harvesting rates and this led to increase in net emissions for the region through loss of sinks.[18]

[18] Facts & figures 2018/19. New Zealand plantation forest industry report. available at https://www.nzfoa.org.nz/images/Facts_and_Figures_2018-2019_Web.pdf.

3.2 Emissions estimates for Waikato Region and breakdown by territorial authorities

Calculations of emissions for individual territorial authorities was based on activity data at local / district level or by applying national averages. Activity data was available as follows:

- agriculture: TA level data
- stationary energy, transport and forestry: primarily TA level data with limited national level data used for estimates at TA level; emissions distributed based on population and land area
- waste: primarily national level data with specific TA data linked to landfill gas; emissions distributed by population
- IPPU: national level data, emissions distributed based on population

The breakdown below is not intended as a benchmark between territorial authorities but simply as an indicative framework of reference to understand the range of differences between emissions profiles and the potential areas of interest to work together (Table *10*10).

Table 10. Overall emission estimates for Waikato Region and breakdown by territorial authorities (2018/19)

t CO_2e	Waikato Region (2018/19	Hamilton City 2018/19	Hauraki 2018/19	Matamata-Piako 2018/19	Otorohanga 2018/19	South Waikato 2018/19	Taupo 2018/19	Thames-Coromandel 2018/19	Waikato District 2018/19	Waitomo 2018/19	Waipa 2018/19
Stationary energy	**1,601,427**	277,392	35,802	133,351	18,448	422,036	71,704	53,937	450,305	35,616	102,836
Transportation	**2,001,658**	635,615	110,175	131,961	47,349	96,952	161,673	235,486	297,225	76,871	208,351
Waste	**291,708**	30,999	3,843	6,596	21,567	35,097	80,874	12,247	47,438	19,661	33,386
Industry	**143,213**	50,732	6,285	10,775	3,143	7,512	11,763	9,428	23,914	2,840	16,821
Agriculture	**8,608,976**	6,257	619,799	1,475,468	838,017	784,720	928,268	183,042	1,721,291	903,761	1,148,353
Forestry	**-5,530,909**	-752	-42,449	14,318	-62,152	-1,244,246	-2,589,419	-612,004	-350,870	-618,081	-25,254
Total net (incl. forestry)	**7,116,073**	1,000,243	733,455	1,772,469	866,371	102,072	-1,335,139	-117,864	2,189,304	420,668	1,484,493
Total gross (excl. forestry)	**12,646,982**	1,000,995	775,904	1,758,151	928,523	1,346,318	1,254,281	494,140	2,540,173	1,038,750	1,509,747
Population	**473,480**	167,700	20,800	35,750	10,450	24,950	38,800	31,150	78,850	9,530	55,500
Per capita net emission (incl Forestry)	**15.0**	6.0	35.3	49.6	82.9	4.1	- 34.4	-3.8	27.8	44.1	26.7
Per capita gross emission (excl Forestry)	**26.7**	6.0	37.3	49.2	88.9	54.0	32.3	15.9	32.2	109.0	27.2

For further perspective, the emissions intensity was also calculated per unit of GDP (Table 11).

Table 111. Emission estimates for Waikato Region and individual territorial authorities (2018/19)

	Total net emissions (incl. Forestry)	Total gross emissions (excl. Forestry)	GDP 2019 ($m)	Net emissions intensity (t CO_2e/$ million GDP)	Gross emissions intensity (t CO_2e/$ million GDP)
Hamilton	1,000,243	1,000,995	9,899	101.04	101.12
Hauraki	733,455	775,904	1,055	695.22	735.45
Matamata-Piako	1,772,469	1,758,151	2,075	854.20	847.30
Otorohanga	866,371	928,523	582	1488.61	1595.40
South Waikato	102,072	1,346,318	1,284	79.50	1048.53
Taupo	-1,335,139	1,254,281	2,305	-579.24	544.16
Thames-Coromandel	-117,864	494,140	1,307	-90.18	378.07
Waikato	2,189,304	2,540,173	2,954	741.13	859.91
Waipa	1,484,493	1,509,747	2,662	557.66	567.15
Waitomo	420,668	1,038,750	852	493.74	1219.19
Waikato Region	7,116,072	12,646,982	24,975	284.93	506.39

3.3 Comparison to New Zealand average

To provide a perspective into the Waikato Region's emissions profile, a summary overview is presented below in comparison to New Zealand's most recent inventory (2017), both in terms of total emissions and on a per capita basis (Table 11).

On a per capita basis, Waikato's gross emissions are significantly higher than national per capita average (26.7 vs 16.5 t CO_2e / cap). Agriculture emissions are high (18.2 vs 7.9 t CO_2e) while forestry sector removes more than double the national average (-11.7 vs -4.9 t CO_2e / cap). Stationary energy, waste and IPPU emissions are below the national averages.

Table 122. Overview of Waikato Region's emissions against New Zealand Average (t CO2e)

	Waikato GHG inventory 2018/19		New Zealand GHG inventory 2017	
Population no		473,480		4,917,000
	t CO_2e	t CO_2e/cap	t CO_2e	t CO_2e/cap
Stationary energy	1,601,427	3.4	16,940,880	3.4
Transportation	2,001,658	4.2	15,935,700	3.2
Waste	291,708	0.6	4,124,700	0.8
IPPU	143,213	0.3	4,968,560	1.0
Agriculture	8,608,389	18.2	38,880,720	7.9
Forestry	-5,530,909	(11.7)	–23,958,400	(4.9)
Total net (incl. forestry)	**7,116,073**	**15.0**	**56,895,000**	**11.6**
Total gross (excl. forestry)	**12,646,982**	**26.7**	**80,853,500**	**16.4**

3.4 Changes from 2015/16 baseline

In gross terms, the total emissions for entire region have increased by about 247,000 t CO_2e between 2015/16 and 2018/19 (12,399,543 vs.12,646,982 t CO_2e) (Table 12). The changes are largely a result of changes in population and animal number but also better activity data for calculating emissions.

- Transportation emissions have increased the most (32.27 %), partly due to better activity data but also change in emissions factors and population increase.
- Stationary energy increased mainly as a result of overall population increase by 6.68 % between 2015/16 and 2018/19.
- Agriculture is the only sector for which the gross emissions have decreased (4.20 %) – primarily due to a decrease in dairy herd size in Waikato.
- Forestry sequestration has decreased, primarily due to afforestation rates being lower than harvesting rate.

Because the baseline (2015-16) inventory was not calculated by territorial boundaries, the trends at TA level cannot be determined at this point. However, due to the different emissions profiles, it is not expected that future inventories will show comparable trends but rather a diverse range of trajectories reflective of the specific TA context. Waikato Region would need to focus its reduction efforts on agriculture as well as consider options for maintaining its carbon removal potential from forestry.

Table 133. Emissions overview & changes from 2015/16 baseline

Emissions sources	Waikato Region 2015/16 (t CO2e)	Waikato Region 2018/19 (t CO2e)	% difference
Stationary Energy	1,477,156	1,601,427	8.41%
Transportation	1,513,258	2,001,658	32.27%
Waste	281,003	291,708	3.81%
IPPU	141,492	143,213	1.22%
Agriculture	8,986,635	8,608,976	- 4.20%
Forestry	- 5,632,761	- 5,530,909	- 1.81%
Total (net) incl. forestry	**6,766,782**	**7,116,073**	**5.16%**
Total (gross) excl. forestry	**12,399,543**	**12,646,982**	**2.00%**

Agricultural emissions trends

Gross agricultural emissions have decreased approximately 4% (377,660 t CO_2e) since the baseline inventory primarily due to a decrease in dairy stock numbers. This is in line with trends reported at national level where emissions from dairy and sheep decreased marginally and only emissions from non-dairy cattle increased (MfE 2019).

While the downward trend for Waikato region is positive, the challenge for the Region continues to be the high proportion of methane (83%). It should be noted that current emissions footprint from agriculture does not include soil carbon, in line with the national Greenhouse Gas Inventory that is prepared on the assumption that soil carbon does not change when land use is constant, and changes in carbon are only taken into account when there is a change in land-use. Efforts to reduce emissions (and potential reduction targets) need to consider the risks that peat soil pose through the potential release of emissions if they are not managed appropriately.[19]

Forestry emissions trends

[19] Some of the research to date suggests rates of carbon loss from peat soils ranging from 2.9 to 7 t CO2 / ha.

Forestry is a significant sink for Waikato region as it removes about 44% of the Waikato's total gross emissions, more than double the national average (-11.7 vs -4.9 t CO_2e/cap). However, forest sequestration has decreased in the Region due to more trees being harvested than replanted and / or newly planted (Figure 6).

Current policy developments, including carbon neutrality goals, are expected to increase the interest in afforestation / re-forestation. Indicative data for the year to December 2019 shows that 22,000 hectares of new planting occurred across New Zealand, which is a significant increase to the 7,000 ha in 2018.[20]

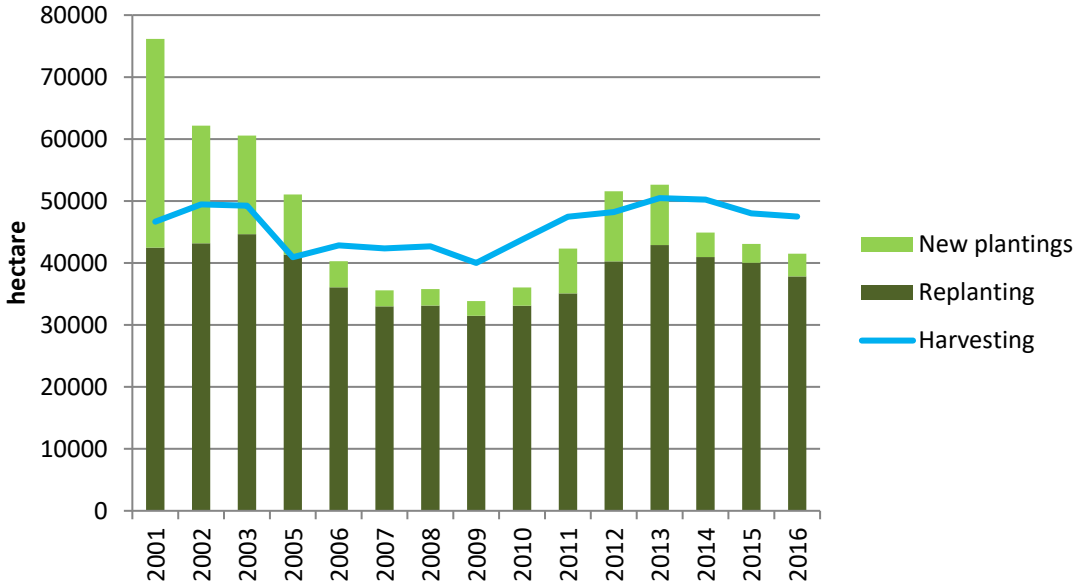

Figure 6: Forest planting and harvesting rates in the Waikato Region

Transportation emissions trends

The transportation sector has seen the largest increase in emissions from 2015/16 inventory (over 30 %). Better activity data and increase in population number are main reasons for the increase. The largest increase was for Jet Kerosene (214 %) followed by road transport, specifically diesel (43 % increase).

This is in line with the road transport increase at national level (MfE 2019), however, the increase in Waikato region is more significant (32 % vs 6.3 % national level).

[20] Information available at www.teururakau.govt.nz/dmsdocument/34425/direct, pg 14-15.

4 Conclusions and recommendations

The interest in GHG emissions inventory and experience with analysing trends and setting reduction targets is increasing throughout New Zealand. New Zealand's climate commitments and central government's focus on emissions budget provide a framework for exploring perspectives and mitigation options informed by detailed regional emissions inventory.

4.1 Inventory preparation and data collection

This is the second emissions inventory prepared for Waikato Region and is based on best available data. Development of territorial authority inventory breakdowns within the Region has raised new data access challenges and the need to access bottom-up data as much as possible.

For preparation of future inventories, WRC and the territorial authorities may consider the following recommendations to improve the quality of the inventory, enhance the process for inventory development and enable action on the insights the inventory provides.

Recommendation 1: Reporting intervals

It is recommended that WRC and territorial authorities consider updating the inventory in a two-year interval cycle. A three-year interval was applied previously and is normally considered adequate for updating a regional emission inventory. However, because central government is going to put in place the provisory carbon budget for the period of 2021-2025, an update in 2021/22 is recommended to align with the national carbon budget timeline. Yearly emissions inventories may still be valuable for those that are party to platforms such as C40 Cities.

Recommendation 2: Data availability and process for data access

Overall, data quality is adequate and the significant emission sources (e.g. agriculture) have been estimated using bottom-up data. However, there are a number of data sets that have been estimated using a top down approach and applying national average emissions (e.g. aviation transportation, waste-water and solid waste).

It is recommended that WRC and territorial authorities engage with targeted data holders to get better data and easier access to them. Early notification about the inventory process and its cyclical nature would help too since some of the data holders may be willing to put in place internal processes for data collection for this purpose.

2.1. Emissions from wastewater and solid waste.

The context for wastewater and solid waste management is complex, with different providers involved across the Region.

Solid Waste

The Bay of Plenty and Waikato Region's Waste Stocktake that is regularly carried out provides a reasonable level of insights for a wide range of waste data. However, the waste stocktake is not carried out with the purpose of collecting reliable data in support of emissions inventory development. A coordinated effort between regional council and territorial authorities to improve and get access to data collected by waste management companies (for example EnviroWaste or Waste Management) would be beneficial for future emissions inventories. This engagement could be used to encourage those companies to develop their own emissions inventory as well.

The potential to include data provision requirements in service contracts with waste management companies should be considered as well; this is a highly effective solution and service providers accommodate such contract requirements.

Wastewater

Similar to the recommendation for solid waste, there is scope to improve data sets by incorporating service contracts requirements for data provision at the outset of the contracts for service providers; this is a relatively easy measure to put in place when the services provider / asset is owned by the territorial authority (for example wastewater services in Hamilton City which are provided by the Council). A standardised data form can be developed and shared in advance with contractors.

2.2. Emissions from aviation

Current data used to calculate emissions are based on flight movements. Given that five of the territorial authorities in the Waikato Region are shareholders of Hamilton airport, it is recommended that the airport company is approached in advance about the supply of emissions data for the next inventory. This includes fuel use data at the airport (for flights & ground operations) as well as actual flight movement data.

Furthermore, because aviation emissions are increasing, the engagement for data may be used to encourage Taupo and Hamilton airports to develop their own corporate emissions inventory – which would help provide the most accurate data.

Recommendation 3: Data automation and real-time GHG emissions analytics: development of active GHG inventories to support (regional) decision-making

At the regional level, emissions inventory is a key approach available to territorial authorities across Waikato and beyond to measure and report emissions, including for setting reduction targets. GHG inventories aggregate data overtime across activities, sectors and fuel type, and have significant potential to be used as a spatial management and collaboration tool by local government. Experience to date with developing regional inventories highlight the need and opportunity for Waikato region to explore smart tools for data gathering, reporting, and analytics with respect to emissions and climate change effects.

It is recommended to consider the development of a pilot project as proof of concept that would leverage the experience with emissions inventory to develop an effective, real time GHG emissions analytics tool using real time data to track emissions generation and provide the evidence to inform early action for emissions reduction. This could initially target a single sector – for example transportation or agriculture – to test feasibility and plan for scale-up.

4.2 Setting and pursuing reduction goals

The GPC suggests four different approaches to setting emissions reduction targets as follows:

- Base year emissions goals
- Fixed level goals
- Base year intensity goals
- Baseline scenario goal

Recommendation 4: Reduction goals considerations

Reduction goals need to be informed by dialogue with iwi and stakeholders, and the level of ambition and preferred approach within councils on emissions reduction targets. Communities also use long term aspiration to set carbon neutral goals and other science-based approaches looking at the gap to meet the 1.5°C and 2°C temperature targets of the Paris Agreement.

Waikato region has an aspirational goal to reduce carbon emissions by a minimum of 25% by 2030 in relation to 2017 - as an interim target on the path to net zero carbon by 2050. From a regional perspective, several broad aspects need to be carefully considered:

- Waikato region's territorial authorities have diverse profiles and will likely focus on different opportunities for emissions reductions, the most important being agriculture, forestry, transportation and energy sectors. There is a need to support collaborations between councils when choosing reduction pathways in order to share knowledge and achieve scale.
- Agriculture and forestry are significant sources of emissions, respectively sequestration, governed by a dynamic policy environment and uncertainty. Examples of this include the NZ ETS review and the National Climate Risk Assessment currently underway.
- Carbon sequestration and removal in Waikato region has decreased since previous inventory i.e. replanting rates are not high enough.
- Soil carbon and soil management regimes will have a material impact on the carbon balance, presenting either opportunities for sequestration or liabilities for the Region.

The region will need to consider all these aspects, including the gaps in knowledge (technological developments, investments etc) that need to be addressed to effectively pursue emissions reductions. Ability to influence decisions needs to be considered as well in the pursuit of achieving reduction targets.

Recommendation 5: Areas to consider for emissions reductions

5.1. Transport

The transport sector is a strong candidate for low carbon transition (high footprint, technological solutions available, high public interface). A focus on petrol and diesel use reduction and substitution is encouraged, especially when considering that petrol and diesel emissions from land transport and stationary energy combined account for approximately 2,000,000 t CO_2e across Waikato. Further considerations for a focus on transport include:

- opportunity for collaboration across territorial authorities with significant transport footprint (for example Hamilton City, Waikato District or Thames – Coromandel) and beyond (EECA, NZT, Auckland City).
- use procurement rules and economies of scale in order to support the growth of bio-diesel[21] as a transition fuel and to increase LEV uptake.

5.2 Agriculture, land use and land use change

Consider the development of a long-term strategy for offsetting emissions in order to incentivise land-owners to shift to, and accelerate de-intensification and land-use change. Potential interventions include:

- support measurements and verification programmes for adaptative management on farms to reduce carbon emissions and / or generate offsets (possibly linked to water quality).
- commitment by WRC and TAs to offset their own operational emissions with locally sourced carbon offsets.
- investigate and promote projects and activities that could generate carbon offsets with multi-benefits for the region i.e. riparian planting, wetlands restoration, ecosystem corridors, water storage, blue carbon, thus simultaneously supporting implementation of freshwater limits and biodiversity policies.
- develop guidelines and methodologies for measurement and verification of offset projects that meet voluntary or compliance (NZ ETS) requirements.
- explore partnerships with private sector players interested in offsets to create demand / buyer interest and drive investment in low carbon solutions.

Recommendation 5: Strategic outlook for emissions reduction – the challenge of biogenic emissions

Biogenic emissions are very large for Waikato Region and to date there is no agreement how they will be regulated at the national level. Biogenic emissions are not covered by the NZ ETS (at least no decision has been made) and it is unclear if landowners will be able to mitigate their methane emissions through offsets.

WRC and the TAs with significant agricultural emissions need to be engaged in policy discussions and seek viable pathways to emissions reduction – including by seeking co-benefits to carbon sequestration (climate resilience, water quality, biodiversity).

This inventory is only a step in the process of understanding and building capability to respond to climate change.

[21] Bio-diesel is price-prohibitive and the government could assist with market growth (of bio-fuels more broadly) by using GHG reduction targets mandates or procurement rules to demand contractors and suppliers to use low-carbon alternatives where available.

Acknowledgements

The preparation of this inventory required access to significant data sets that came from a wide range of sources. The team is grateful for the support of Waikato region territorial authorities through the provision of data and engagement in this process. We would also like to extend our thanks for their support with data and data insights private sector and industry bodies, including Z Energy, Watercare, First Gas, LPG Association and Genesis Energy.

Throughout the project, the project team worked closely with, and received valuable support from Karen Bennet and Blair Dickie at WRC.

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Appendices

A. Data Quality Assessment

Data management	Data collection		
	Measured	**Derived**	**Estimated**
Robust	M1	D1	E1
Satisfactory	M2	D2	E2
Questionable	M3	D3	E3
Measured = Data directly provided by a service provider, contractor or directly obtained from a monitoring device. For example electricity invoices, contractor receipts, emissions monitoring equipment, incident reports, consultant reports etc.			
Derived = Data obtained from calculations, mass balances, use of physical/chemical properties, use of coefficients and emission factors etc. For example converting cubic meters of waste into tonnes			
Estimated = Usually where there is no other available method for obtaining the data. Such data could be prorated on previous results, use of precedents or historical data, or even a calculated guess			
Robust = Evidence of sound, mature and right reporting system, where room for error is negligible. Examples would include use of spread sheets, databases and on-line reporting			
Satisfactory = Examples would include manual, but structured keeping of records, files and results. Some potential for error or loss of data.			
Questionable = No logical or structured approach to data or record keeping. High potential for error &/or loss of data. Data may appear to differ from those initially reported.			

B. Assumptions and limitations

Sector/Category	**Assumptions and Exclusions**
Stationary Energy Emissions	
Residential, commercial and industrial stationary energy emissions	• Coal and biomass related emissions have been estimated using a top down approach, applying the national average consumption for commercial and residential coal use, estimated based on population figures. • Consumption of natural gas and electricity data are based on total energy distributed to grid exit points within the Region. The energy provided to these grid exit points have then been allocated to the entire Region. This may in some instances mean that energy used outside the Region may be counted as part of

	the Region's Footprint, depending on the distribution network for gas and electricity, which may not fully match the Region's boundaries in all cases. • Emission per user group (i.e. residential, commercial and industrial) was estimated based on national average energy use split between these groups as reported by MBIE (2017a). • Coal and natural gas consumption for the Huntly Power Station have been excluded from the regional emissions estimates, as this is already reflected in the national emissions factor for electricity generation.
Electricity Generation	• National emission factor for electricity generation was estimated based on data published by MBIE in their quarterly electricity and liquid fuel emissions table (MBIE 2020). • It is understood from the Electricity Authority's 'Generating Station List' (September 2012) that more electricity is generated in the Region than is consumed. • The emissions from stationary energy generation (e.g. from the Huntly Power Station) occurring within the region have not been included in the Waikato Region carbon footprint, as these are part of the national emissions calculations for electricity generation. Waikato's share of the emissions from stationary energy generation is already accounted for as part of the emissions estimated for the region's electricity consumption.
Electricity Consumption	• Consumption of electricity data is based on total energy distributed to grid exit points within the Transpower Network. • The methodology was changed slightly and includes additional grid exit points than in 2015/16. Emissions estimates were recalculated for 2015/16 to ensure consistent reporting • The electricity consumption figure used for the Waikato Region is likely to be conservative, as the total energy distributed to the exit-grid points does not follow regional boundaries. However, it is likely that the affected population/area is relatively small and therefore the impact to the energy consumption to the Waikato Region is not likely to be significant.
LPG	• LPG consumption in the Waikato Region is based on the total amount of LPG supplied to the North Island and calculated on a per capita basis using 2018/19 population estimates. • LPG stationary energy estimates are based on the national share of 9kg and 45kg gas bottles, and bulk sales provided by the LPG Association of New Zealand.
Natural Gas	• Natural gas consumption is based on total gas distributed to exit grid points within the Waikato Region as supplied by First Gas (excludes sites that have direct connections to the transmission network) as well as the direct gas volumes for Fonterra Te Rapa and Lichfield Dairy Factory. • Natural gas used by Huntly Power station and the Te Rapa cogeneration plant has not been included as these are already reflected in the national emissions factor for electricity generation. • The natural gas distribution network does not follow regional boundaries and may include some of the surrounding rural areas. However, it is assumed that the population in these areas is relatively small and therefore the impact to the regional natural gas consumption is not likely to be significant.

	• Emissions of 6.34 kgCO2e/GJ during distribution was applied, based on the national average reported for distribution loss of reticulated natural gas (MfE 2019).[22]
Industrial Stationary Energy Emissions	• No specific data was available for industrial stationary energy consumption with the exception of natural gas use for co-generation plants at the Fonterra Te Rapa & Lichfield Dairy plants and fugitive emissions from mining. • Emissions from industrial consumption of coal and LPG have been estimated based on a top-down approach allocating national emissions on a per capita basis. • Industrial stationary petrol and diesel use have been estimated based on total fuel sold within the region and the EECA Energy Enduse Database.
Fugitive Emissions	• Not included in the Inventory as there is no production of oil or gas within the Waikato Region. • Fugitive emissions from coal have been included in industrial stationary energy emissions.
Coal	• Emissions relating to the use of coal from residential, commercial, as well as from agriculture, forestry and fishery activities have been included for the Waikato Region. • Coal consumption for heavy industry was not included (e.g. dairy processing) as these are not relevant for the region (no heavy industry) or use natural gas as fuel source. • Fugitive emissions from coal mining have been included under Stationary Energy (industrial emissions), based on the national average emissions factor for fugitive emissions from sub-bituminous coal mining reported by MfE.
Transportation Emissions	
Road	• Total volume of fuel sold within the Waikato Region and the breakdown by region in FY2018/2019 was provided by nine of the ten territorial authorities. A regional average was allocated to Taupo District Council based on population numbers. • Fuel consumption figures (petrol and diesel) also include fuel used for off-road transport and recreational water transport, as these are sold through the same network. Due to lack of data these could not be reported separately.
Rail	• Emissions from rail transport are estimated based on length of rail network and average fuel consumption per tonne km and freight volume as provided by Kiwi Rail for the 2018/19 financial year. • The rail network in the Waikato is electric and diesel. • Rail diesel use is estimated based on the average fuel consumption per tkm travelled within the Region. Due to lack of more detailed data it is not possible to estimate what portion of the rail related diesel use was purchased in- or outside the Region. • It was assumed that Diesel sold for rail transport is not included in the Waikato fuel sales data for road transport.

[22] For more details, see https://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/2019-emission-factors-summary.pdf

	• Electricity emissions are estimated based on the total kWh consumed by KiwiRail and the national emissions factor for electricity generation, and transmission and distribution losses.
Aviation	• Aviation fuel data sold/pumped at Hamilton and Taupo Airport could not be obtained during the data collection. • Aviation emissions, from Jet Kerosene, have been estimated using the average number of plane movements understood to take place via the FlightAware.com website. The number of flights estimated is likely to be conservative as movements of large jet planes and some smaller planes. Planes departing and arriving at the same airport (e.g. tourist flights) have not been included. • The estimated aviation emissions represent 50% of aviation related emissions associated with Air NZ movements at Hamilton and Taupo Airport, in line with the GPC framework. • Aviation gas fuel consumption for smaller aircraft (e.g. tourist flights) and helicopters were estimated based on conversation with aviation fuel experts.
LPG	• LPG consumption in the Waikato Region is based on the total amount of LPG supplied to the North Island and calculated on a per capita basis using 2018/19 population estimates. • LPG transportation energy estimates are based on the national share of automotive and forklift sales as provided by the LPG Association of New Zealand. • LPG consumption estimate does not take into account automotive and forklift sales in the Region that may then be taken out of the Region or individual district boundaries.
Off-Road	• Estimated based on EECA – End-Use Energy Database applying a national average split to the total amount of petrol and diesel sold within the region.
Waste Emissions	
Solid Waste Disposal	• Solid waste emissions were estimated using a 1st-order decay model (which requires waste volume estimates for the last 50 years). • Reliable historic population figures, provided by StatsNZ, only go back to 1986 therefore 30 years of data has been estimated for the Waikato Region Solid Municipal Waste emissions. • Due to limited specific current and/or historic data for the Region, waste volumes sent to landfill for the Waikato Region have been estimated by applying the New Zealand national average waste generation per capita (reported by MfE, 2017 Inventory) and using historic population figures reported by StatsNZ. • Landfill gas emissions were estimated for landfills with and without landfill gas capturing systems. • Data on specific waste composition was not available therefore this data has been modelled based on the national average waste composition reported by MfE 2019. • Waikato and Waipa Districts send all their waste to landfill at Hampton Downs. Hauraki District, Hamilton City, and Matamata-Piako District send all their waste to landfill at Tirohia. Thames-Coromandel District send waste to Hampton Downs and Tirohia. South Waikato District sends waste to Tirohia, Waitomo and Tokoroa landfill sites. Otorohanga and Waitomo districts send all their waste to

	Waitomo landfill site. Taupo District sends all their waste to Broadlands Road landfill site. • Hampton Downs has been collecting landfill gas since 2006 and Tirohai has been collecting landfill gas since 2001. All other landfill sites in the Waikato Region do not collect landfill gas.
Incineration	• Emissions from waste incineration have not been included, as only small quantities of clinical and hazardous waste is incinerated in New Zealand. Emissions from these sources are assumed to be insignificant[1].
Wastewater Treatment	• No data for the specific type of wastewater treatment methods or number of individuals in the Region using different wastewater treatment methods was available for the Waikato Region at the time of deriving the wastewater emissions. • National Wastewater emissions from 2017 Inventory (MfE 2019) and population data from 2018/19 were used to calculate the per capita waste water treatment and disposal emissions, and the total waste water emissions from the Waikato Region. 2017 data was the most up to date information available from the New Zealand Greenhouse Gas Inventory 1990-2017.
Industrial Emissions	
Industrial Processes	• No emissions from industrial processes have been included due to the lack of specific activity data. It is understood there are very few large industrial operations resulting in emissions from chemical or physical processes taking place within the Waikato Region.
Product Use including: HFC, PCFs and SF_6	• Emissions for refrigerants, fire extinguishers, foam blowing, aerosols and metered dose inhalers, as well as SF_6 in electrical equipment are estimated based on New Zealand average per capita emissions (MfE 2019).
Agricultural Emissions	
Agriculture	• Agricultural emissions are based on agricultural production data provided by Statistics New Zealand. • Emissions from field burning of agricultural residues have not been included in the calculations above, due to lack of data and methodological guidance by the IPCC 2006 Guidelines. These emissions are assumed to be insignificant.
Forestry Emissions	
Forestry	• Exotic forest volumes are based on data provided in the National Exotic Forest Description published by MPI (MPI 2016 and MPI 2015). The data is provided on a Territorial Authority (TA) level. • Carbon sequestration for exotic forests include above ground, below ground, dead wood and litter. • Carbon sequestration rates for exotic forest are based on yield tables provided by MfE, assuming a 50/50 split between pre 1990 and post 1989 forests within the Waikato Region. • Harvest data has been calculated using the Waikato's available regional data.

[1] Nationally, emissions from incineration of waste represent about 0.1% of the total waste emissions.

	• Due to insufficient data for land use changes, no emissions from land use change of cropland, wetlands, settlements and other land have been estimated. • Maturing native forests (i.e. Manuka and Kanuka), as well as grassland with woody biomass have been included as native forests. • Data for native forests is based on LCDB vol. 5 data. • Sequestration rates for native forest were based on advice from MfE (2017). • Emissions from forest harvesting activities are included in the Inventory as part of the LULUCF emissions. • For the purpose of this report, it was assumed that all carbon stored in tree biomass (above and below ground as well as in dead wood and litter) become an emission in the year of the tree harvest.
Emission Factors	
Emission Factors – Mobile and Stationary Energy	• Emissions factors are based on published New Zealand specific emission factors where possible. Sources include the New Zealand National Greenhouse Gas Inventory (MfE 2019) and Guidance for Voluntary Greenhouse Gas Reporting for Organisations (MfE 2019), National Energy File data (MBIE 2019) and the 5th IPCC Assessment Report (IPCC 2013). A detailed list of emission factors is provided in the individual emissions calculations table in the Excel tables prepared as part of this project. • Advice received by MfE (for a previous report) supported the use of the most recently published emissions factors for all reporting years and emissions calculations. • The Global Warming Potential used to convert CH_4 and N_2O to CO_2e are based on the IPCC Fifths Assessment Report for 100-year GWP including climate-carbon feedbacks.

C. Data Sources and Data Gaps

Data for the community carbon footprint was collected from a number of data sources. Key data sources are detailed below:

Table 144. Waikato Region GHG Inventory Data Sources – 2018/19

Emissions Category	Data Source
Stationary Energy	First Gas Limited Transpower Electricity Authority KiwiRail Genesis Energy (Huntley Power Station coal and gas use) LPG Association NZ Z Energy MBIE (2015) Energy in NZ, Section K MBIE (2015) Data Tables for Coal MfE (2015) National Greenhouse Gas Inventory Report
Transportation	Air travel movements (FlightAware.com) KiwiRail

		LPG Association NZ Hamilton City Council (fuel sales data for Hauraki, Matamata-Piako, South Waikato, Thames-Coromandel, Waipa and Waikato Districts) Otorohanga District Council (fuel sales data for Otorohanga, Ruapehu and Waitomo Districts) Ministry of Business, Innovation & Employment (fuel properties)
Waste	Solid Waste	Waste Management Envirowaste Individual City and District Councils Internal Waste data
	Wastewater	MfE (2017) 1990-2015 National Greenhouse Gas Inventory Report
Industrial		MfE (2019) 1990-2017 National Greenhouse Gas Inventory Report
Agriculture		MfE (2019) 1990-2017 National Greenhouse Gas Inventory Report Statistics New Zealand (Agricultural production data)
Forestry		MPI (2018) National Exotic Forest Description Statistics New Zealand

A data gap analysis was undertaken during the data collection stage of the project. The following data gaps and alternative data sources were identified:

Table 155. Waikato Region GHG Inventory Data Gaps – 2018/19

Emissions Category		**Data Gap**	**Alternative Data Source**
Stationary Energy		- District specific biofuel (wood) consumption data - District specific coal consumption data	- No alternative data source (assumed to be included in total forest harvest emissions) - National average (on per capita basis)
Transportation		- Public Buses - Airport fuel sales - Maritime fuel use (for small private vessels)	- Assumed to be included in total fuel sales data - Estimated based on flight movements - Assumed to be included in the total diesel sales data for the Region
Waste	Solid Waste	- Landfill gas collection efficiency for Tirohia, Hampton Down - Historic waste volumes	- National average collection efficiency - Assume no landfill collection at any landfills other than Hampton Downs and Tirohia, this includes historic (now closed) landfills - Assume national average waste generation per person (as outlined in the national GHG inventory by MfE)
	Waste Water	- Incomplete data available for local wastewater treatment systems or number of people connected to these	- Assume national average wastewater treatment emissions on a per capita basis
Industrial		- Significant industrial (physical & chemical) process activity resulting in GHG emissions - Industrial product use (e.g. asthma inhaler, aerosols, etc.)	- No sources identified – assumed not to be relevant or significant - Emissions were estimated based on national emissions data on a per capita basis

Agriculture	- No estimates of cultivated organic soils within Region	- Not estimated
Forestry	- No data for Harvest Wood Products (i.e. what harvested wood is used for) - Insufficient data to estimate annual changes in land use (grassland, cropland, wetland, settlements and other land)	- Assumed that all carbon stored in trees is released in the year of harvest - Not estimated

D. GPC emissions source by sector and sub-sector – Waikato Region (2018/19)

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	t CO_2e
I	**Stationary Energy**		**1,601,427**
I.1	Residential Buildings		**213,544**
I.1.1	1	Emissions from fuel combustion within the city boundary	61,945
	Residential	Natural Gas	37,836
		LPG	14,418
		Coal	1,979
		Biofuel	7,710
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	134,525
		Electricity Consumption	134,525
I.1.3	3	Transmission and distribution losses from grid-supplied energy	17,074
		Grid Electricity T&D losses	11,046
		Natural Gas T&D Losses	6,028
I.2	Commercial & Institutional buildings and facilities		**186,826**
I.2.1	1	Emissions from fuel combustion within the city boundary	68,197
	Commercial	Natural Gas	48,681
		LPG	14,754
		Coal	4,756
		Biofuel	6.50
I.2.2	2	Emissions from grid-supplied energy consumed in the city for on-road transportation	102,460

		Electricity Consumption	102,460
I.2.3	3	Transmission and distribution losses from grid-supplied energy	16,169
		Grid Electricity T&D losses	8,413
		Natural Gas T&D Losses	7,755
I.3	Manufacturing Industries and Construction		**652,355**
I.3.1	1	Emissions from fuel combustion within the city boundary	390,568
		Natural Gas	367,427
		LPG	4,350
		Coal	18,791
I.3.2	2	Emissions from grid-supplied energy consumed in the city for on-road transportation	187,703
		Electricity Consumption	187,703
I.3.3	3	Transmission and distribution losses from grid-supplied energy	74,084
		Grid Electricity T&D losses	15,413
		Natural Gas T&D Losses	58,672
I.4	Energy Industries		-
I.4.1	1	Emissions from fuel combustion within the city boundary	-
I.4.2	2	Emissions from grid-supplied energy consumed in the city for on-road transportation	-
			-
I.4.3	3	Transmission and distribution losses from grid-supplied energy	-
I.4.4	1	Emissions from energy generation supplied to the grid	-
I.5	Agriculture, forestry and fishing activities		-
I.51	1	Emissions from fuel combustion within the city boundary	-
I.5.2	2	Emissions from grid-supplied energy consumed in the city for on-road transportation	-
I.5.3	3	Transmission and distribution losses from grid-supplied energy	-
I.6	Other sources		**204,105**
I.6.1	1	Emissions from fuel combustion within the city boundary	204,105
		Diesel	197,913
		Petrol	6,192

I.6.2	2	Emissions from grid-supplied energy consumed in the city for on-road transportation	-
I.6.3	3	Transmission and distribution losses from grid-supplied energy	-
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal		**344,596**
I.7.1	1	Emissions from fugitive emissions within the city boundary	344,596
		Sub-bituminous coal	344,596
I.8	Fugitive emissions from oil and natural gas systems		-
I.8.1	1	Emissions from fugitive emissions within the city boundary	-
II	**Transportation**		2,001,658
II.1	On road transportation		**1,735,573**
II.1.1	1	Emissions from fuel combustion on-road transportation occurring within the city boundary	1,735,573
		On Road Petrol (L)	844,354
		On Road Diesel (L)	889,456
		Biodiesel	0.05
		LPG	1,763
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for onroad transportation	-
		Electric Bus	-
II.1.3	3	Emissions from proportion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid supplied energy consumption.	-
	Electric Bus T&D	Electricity T&D losses from bus electricity consumption	-
II.2	Railways		**37,383**
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	37,383
		Rail Diesel	37,383
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	-
		Rail electric (nat. ave EF)	-
II.2.3	3	Emissions from proportion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid supplied energy consumption.	-
		Electricity T&D losses from rail electricity consumption	-
II.3	Waterborne navigation		-
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	-

		Marine Diesel		-
		Light Fuel Oil		-
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne transportation		-
		Electricity		-
II.3.3	3	Emissions from proportion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid supplied energy consumption.		-
		Electricity T&D losses		-
II.4	Aviation			**36,415**
II.4.1	1	Emissions from fuel combustion for aviation ocuring within the city boundary		36,415
		Jet Kerosene		34,415
		Aviation Gas		2,001
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation		-
		Electricity		-
II.4.3	3	Emissions from proportion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid supplied energy consumption.		-
		Electricity T&D losses		-
II.5	Off-road transportation			**192,286**
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary		192,286
		Off Road Petrol (L)		12,425
		Off Road Diesel (L)		179,861
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for offroad transportation		-
		Electricity		-
II.5.3	3	Emissions from proportion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid supplied energy consumption.		-
		Electricity T&D losses		-
III	**Waste**			291,708
III.1		**Solid waste disposal**		**247,877**
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary		247,877
		Tirohia Landfill		22,894
		Hampton Downs Landfill		76,281
		Other Landfill Sites		148,701

		Composting	-
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	-
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	-
III.2		**Biological treatment of waste**	-
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	-
			-
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	-
			-
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	-
			-
III.3		**Incineration and open burning**	-
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	-
			-
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	-
			-
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	-
III.4		**Wastewater treatment and discharge**	**43,831**
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	43,831
		Total WWTP emissions (t C02e)	43,831
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	-
III.4.3	1	Emissions from wastewater generated outside the city boundary but treated within the city boundary	-
IV	**Industry**		-
IV.1	1	Emissions from industrial processes occurring within the city boundary	-
	Processes		-
IV.2	1	Emissions from product use occurring within the city boundary	**143,213**
	Product uses	Refrigerants	132,366
		Foam Blowing	528
		Fire extinguishers	214
		Aerosols & MDI*	8,618

		SF6	1,486
			-
V	**Agriculture, Forestry and Other landuse**		3,078,067
V.1	1	Emissions from livestock within the city boundary	**7,138,863**
		Enteric fermentation	6,649,325
		Manure Management (CH4)	488,171
		Manure Management (N2O) (excluding organic fertilisers and pasture)	1,366
V.2	1		**- 5,530,909**
	Forestry	Exotic forest sequestration	- 10,750,994
		Native forest sequestration	- 1,307,025
		Total harvest emissions	6,527,111
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	**1,470,113**
		Liming & Dolomite	75,901
		Agricultural Soils (synthetic and organic fertilisers + crop residue)	174,601
		Manure from grazing animals on pasture	990,496
		Agricultural leaching (Indirect Emissions)	78,822
		Agricultural atmospheric deposition (Indirect Emissions)	150,293
VI	**Other Scope 3**		
V1.1	3	**Other Scope 3**	