Rotorua Community Carbon Footprint prepared on behalf of Rotorua Lakes Council

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Prepared by

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Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
1	20-Oct-2020	Draft Report v1	Anthony Hume Team Leader - Sustainability	
2	30-Oct-2020	Draft Report v2	Sarah Lindberg – Principal Sustainability and Resilience Consultant	
3	11-Jan-2020	Final Report	Anthony Hume Team Leader - Sustainability	

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Executive Summary

Greenhouse Gas (GHG) emissions for the Rotorua District Territorial Area (that is covered by the Rotorua Lakes Council) have been measured using the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC) methodology. This approach includes emissions from Stationary Energy, Transport, Waste, Industrial Processes and Product Use (IPPU), Agriculture and Forestry sectors. This document reports greenhouse gas emissions produced in or resulting from activity or consumption within the geographic boundaries of the Rotorua District Territorial Area for the 2018/19 financial reporting year.

The Rotorua Territorial Area is referred to hereafter as Rotorua for ease. Greenhouse gas emissions are generally reported in this document in units of Carbon Dioxide Equivalents (CO_2e).

Major findings of the project include:

2018/19 Emissions Inventory

- In the 2018/19 reporting year, Rotorua emitted **gross 1,389,298 tCO_2e**.
- Agriculture (e.g. emissions from livestock and crops) is the largest source of emissions, accounting for 61% of Rotorua's total gross emissions, with enteric fermentation from livestock accounting for 77% of Agriculture emissions.
- Transport (e.g. emissions from road and air travel) is the second largest emitting sector in Rotorua, representing 21% of total gross emissions, with petrol and diesel consumption accounting for 97% of Transport emissions.
- Stationary Energy (e.g. consumption of electricity and natural gas) is the third highest emitting sector in the region, producing 10% of total gross emissions.
- After consideration of carbon sequestration, (carbon captured and stored in plants or soil by forests) and harvesting emissions from the Forestry sector, Rotorua emitted additional emissions to the gross amount noted above (344,697 tCO_2e). This is because carbon sequestration from forests was less (1,880,851 tCO_2e) than emissions from forest harvesting (2,225,548) tCO_2e. Calculations for the Forestry sector use an international convention for carbon accounting, which calculates emissions from harvesting at the time the trees are harvested, irrespective of the end-uses of the harvested wood.

Changes in Emissions, 2015/16 to 2018/19

- Between 2015/16 and 2018/19, total gross emissions in Rotorua increased from 1,377,549 tCO_2e to 1,389,298 tCO_2e, an increase of 1% (11,749 tCO_2e).
- Per capita gross emissions in Rotorua decreased by 4% between 2015/16 and 2018/19, from 19.2 to 18.5 tCO_2e per person per year. The population of Rotorua grew by 5% per annum over the three years, from 71,600 in 2015/16 to 75,300 in 2018/19.
- The increase in Forestry emissions is the largest real and proportionate change in emissions, increasing by 129,562 tCO_2e (60%) between 2015/16 and 2018/19. This increase was predominantly due to an increase in total harvest emissions. Forestry emissions are influenced by the cyclical nature of harvesting and planting regimes. In addition, with each subsequent planting of harvestable trees, there is a decreasing ebb and flow of sequestration.
- Emissions from Stationary Energy decreased by 5% between 2015/16 and 2018/19. Emissions from a range of sources within the Stationary Energy sector reduced during this time, with natural gas and coal emissions decreasing by 11% and 17% respectively.
- Waste emissions reduced by 4% between 2015/16 and 2018/19. The increased use and effectiveness of landfill gas capture systems has reduced Waste emissions in Rotorua. Solid waste volumes have also decreased in recent years.
- IPPU, Agriculture and Transport emissions increased between 2015/16 and 2018/19, by 17%, 2% and 1% respectively.

1.0 Introduction

AECOM New Zealand Limited (AECOM) was commissioned by Rotorua Lakes Council (RLC) to assist in the development of a greenhouse gas footprint for the district for the 2018/19 financial year. As part of this work, AECOM recalculated emissions for the previous inventory year (2015/16), using current best-practice methodology and additional emissions sources to enable direct comparison to the 2018/19 inventory. The study boundary incorporates the jurisdiction of the Rotorua Lakes Council.

2.0 Approach to Analysis

The methodological approach used to calculate emissions follows the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC) published by the World Resources Institute (WRI) 2015/16. The GPC includes emissions from Stationary Energy, Transport, Waste, IPPU, Agriculture and Forestry activities within the district's boundary. The sector calculations for Agriculture, Forestry and Waste are based on Intergovernmental Panel on Climate Change (IPCC) workbooks and guidance for emissions measurement. The sector calculators also use methods consistent with GHG Protocol standards published by the WRI for emissions measurement when needed.

The same methodology has been used for other community scale greenhouse gas (GHG) inventories around New Zealand, (e.g. Wellington, Auckland, Christchurch, Tauranga and Southland) and internationally. The GPC methodology[1] represents international best practice for city and regional level GHG emissions reporting.

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

All major assumptions made during data collection and analysis have been detailed within **Appendix B – Assumptions**. The following aspects are worth noting in reviewing the inventory:

- Emissions are expressed on a carbon dioxide-equivalent basis (CO_2e) including climate change feedback using the 100-year Global Warming Potential (GWP) values[2]. Climate change feedbacks are the climate change impacts from GHGs that are increased as the climate changes. For example, once the Earth begins to warm, it triggers other processes on the surface and in the atmosphere. Current climate change feedback guidance is important to estimate the long-term impacts of GHGs.
- GPC reporting is predominately production-based (as opposed to consumption-based) but includes indirect emissions from energy consumption. Production-based emissions reporting is generally preferred by policy-makers due to robust established methodologies such as the GPC, which enables comparisons between different studies. Production-based approaches exclude globally produced emissions relating to consumption (e.g. embodied emissions relating to products produced elsewhere but consumed within the geographic area).
- Total emissions are reported as both gross emissions (excluding Forestry) and net emissions (including Forestry).
- Emissions for individual main greenhouse gases are provided in the supplementary spreadsheet information supplied with this report.
- Where location specific data was not accessible, information was calculated via a per capita breakdown of national or regional level data.

[1] http://www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities
[2] https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf (Table 8.7)

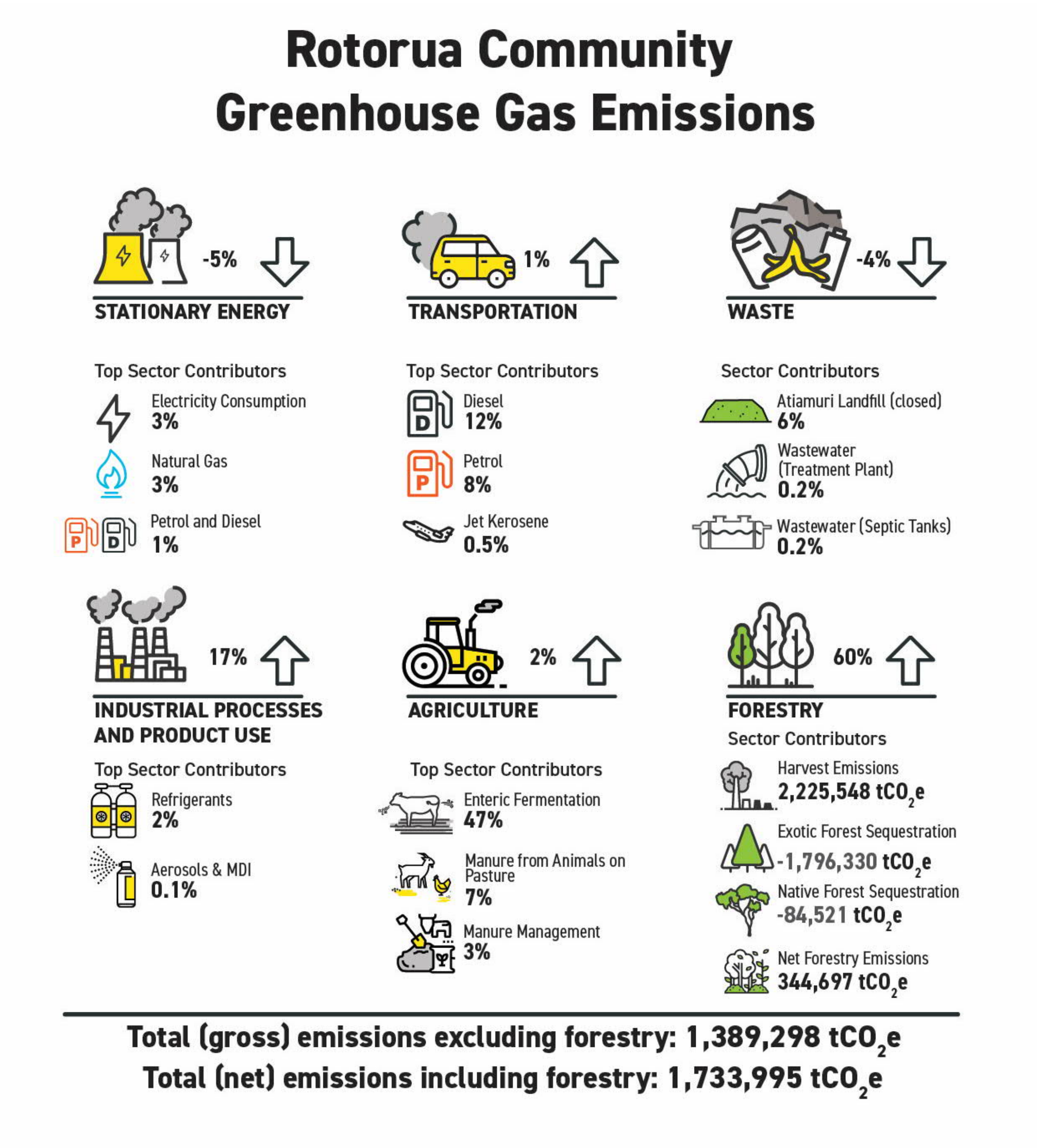
- Transport emissions:
  - Transport emissions associated with air travel were calculated using the induced activity method. Other Transport emissions from fuel consumption were determined by either the number of journeys taken; distance travelled and fuel consumption rates for the transport mode.
- Solid waste emissions:
  - Solid waste emissions from landfill are measured using the IPCC First Order Decay method that covers landfill activity between 1950 and the present day. Solid waste emissions were calculated for the currently operating landfill site at Tirohia and the closed Rotorua Landfill (Atiamuri).
- Wastewater emissions:
  - Emissions have been calculated based on the data provided following IPCC 2006 guidelines. Where data is missing, IPCC and MfE provided figures have been used. Wastewater emissions from both wastewater treatment plants, and individual septic tanks have been calculated.
  - Wastewater emissions include those released directly from wastewater treatment, flaring of captured gas and from discharge onto land/water.
- Industrial Processes and Product Use (IPPU) emissions:
  - Due to data confidentiality, the inventory reports all the known industrial product use emissions as one single value and does not break-down emissions by product type. The availability of IPPU emissions associated is also restricted due to confidentiality issues and constraints in communication from relevant stakeholders.
  - IPPU emissions are estimated based on data provided in the New Zealand Greenhouse Gas Emissions 1990-2017 report (MfE 2019). Emissions are estimated on a per capita basis applying a national average per person.
- Forestry emissions:
  - 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.
  - The inventory considers regenerating (growing) forest areas only. Capture of carbon from the atmosphere is negligible for mature forests that have reached a steady state.

Overall sector data and results for the GHG inventory have been provided to Rotorua Lakes Council in calculation table spreadsheets. All assumptions made during data collection and analysis have been detailed within **Appendix B – Assumptions**.

It is important to consider the level of uncertainty associated with the results, particularly given the different datasets used. Depending on data availability, national, regional and local datasets are used across the different calculators. At the national level, New Zealand's Greenhouse Gas Inventory shows that for 2018 (the most recent national level inventory) an estimate of gross emissions uncertainty was +/- 9%, whereas a net emissions uncertainty estimate was +/- 12%. These levels of uncertainty should be considered when interpreting the results of this community carbon footprint (MfE, 2020).

3.0 Overall Results

Figure 1: Change in Rotorua's total sector emissions between 2015/16 and 2018/19 and the top contributors from each sector in 2018/19.



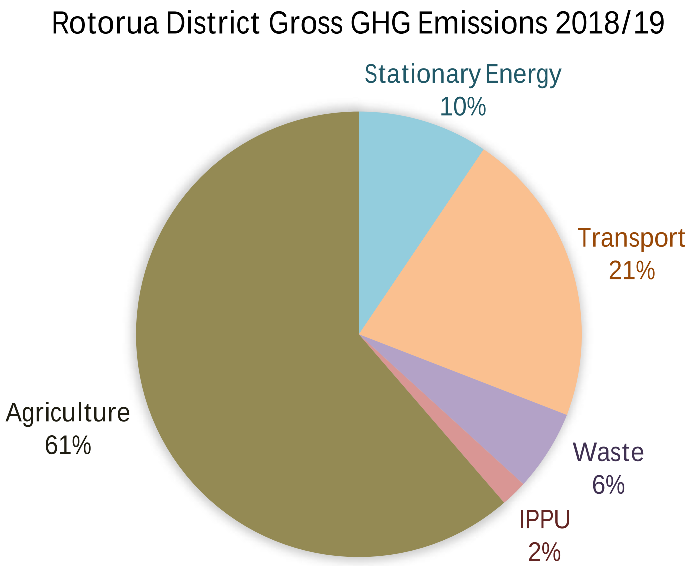
The paragraphs, figures and tables below explain Rotorua's total emissions, emissions from each sector and major emissions sources within each sector. The focus of emissions reporting is on gross emissions. Gross emissions reporting enables clear information, baselines and targets to be addressed by local council policy and initiatives.

Discussion of per capita emissions is limited to when it is useful for comparing emission figures against other territorial authorities. A breakdown of net emissions (i.e. including results from Forestry resources) is reported separately.

During the 2018/19 reporting period, Rotorua emitted gross 1,389,298 tCO_2e and net 1,733,995 tCO_2e emissions. Note that gross emissions do not account for Forestry, and net emissions account for sequestration and harvesting emissions. If sequestration is greater than emissions from harvesting, net emissions will be less than gross emissions. In 2018/19, emissions from harvesting were greater than carbon sequestered; hence net emissions were greater than gross emissions.

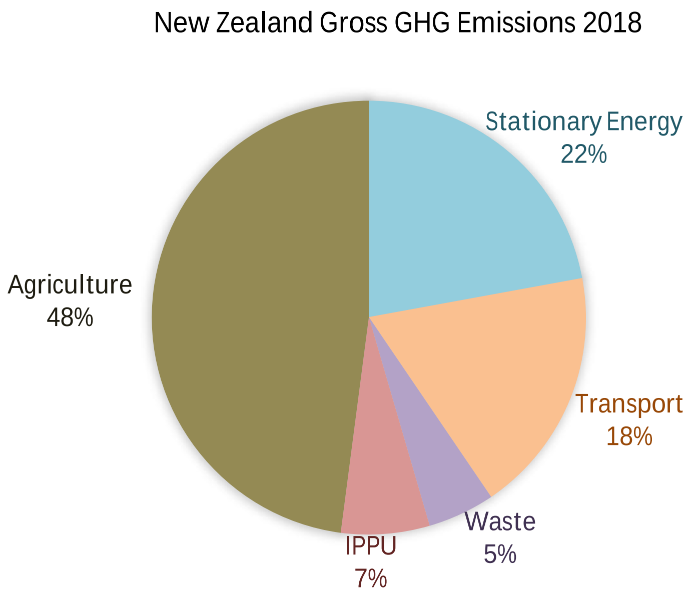
The population of Rotorua in 2018/19 was approximately 75,300 people, resulting in per capita gross emissions of 18.71 tCO_2e/person. Agriculture emissions are the largest contributor to the inventory for the district, followed by Transport (refer to Figure 2).

Figure 2: Rotorua District's total gross GHG emissions split by sector (tCO_2e).



Due to differences in emission factor used between the National inventory and the Rotorua inventory, caution should be taken when making comparison of reported emissions. A breakdown of New Zealand's total gross GHG emissions is shown in Figure 3 for reference only and not for direct comparison. The Rotorua inventory used updated emission factors for methane and nitrogen dioxide following guidance from the IPCC and in line with other district and regional level GHG inventories in New Zealand. This difference is especially relevant for the Agriculture sector. Further analysis of the differences between the Rotorua inventory and the national inventory is beyond the scope of this project.

Figure 3: New Zealand's total gross GHG emissions split by sector in 2018 (tCO_2e) (MfE 2020).

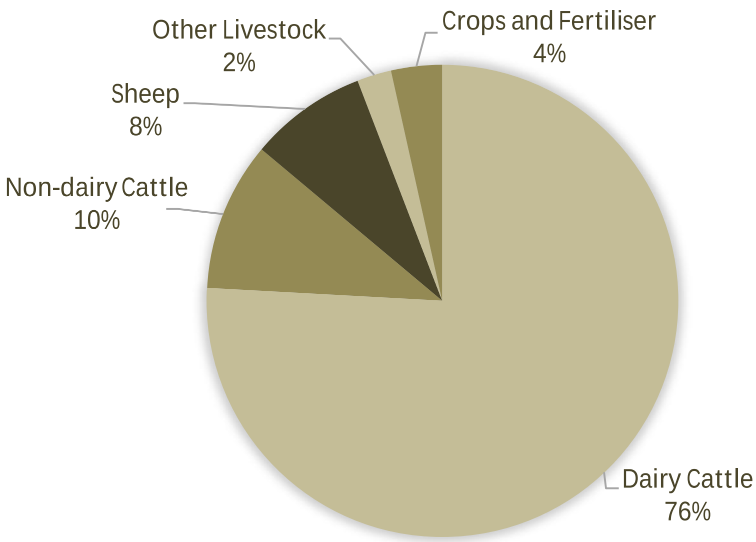


The district-level carbon footprint inventory comprises emissions for six different sectors, summarised below:

Agriculture

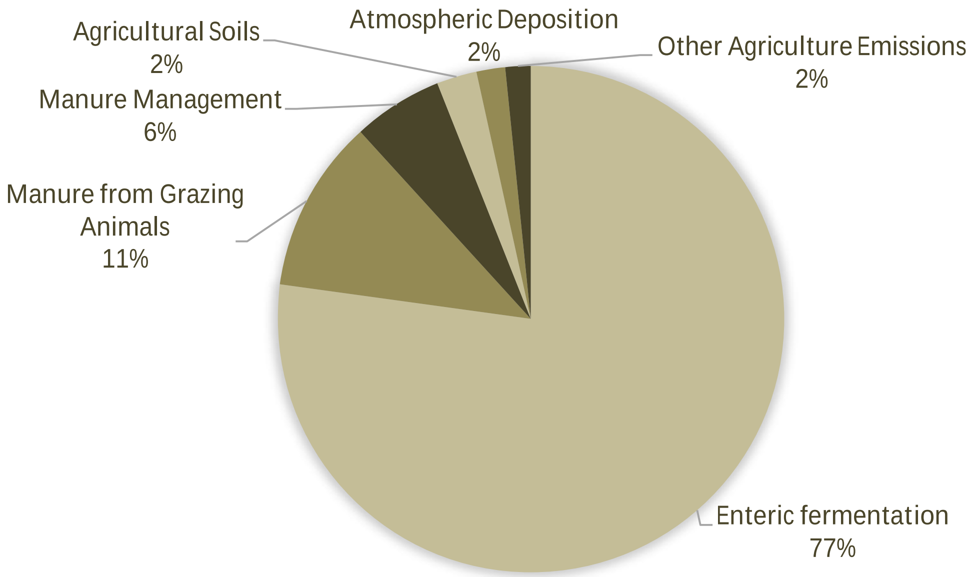
The highest emitting sector in Rotorua, Agriculture, emitted 852,016 tCO_2e, in 2018/19. Agricultural emissions are the result of both crop and livestock farming. Livestock produced the majority of the Agriculture sector's GHG emissions (93%). Dairy cattle account for 47% of farmed livestock (175,420 animals) and 76% of agricultural emissions in Rotorua. Non-dairy cattle make up 10% of farmed livestock (37,698 animals) and 10% of agricultural emissions. Figure 4 provides further detail on the proportion of livestock and crop emissions in Rotorua.

Figure 4: Rotorua District's Agriculture source GHG emissions, by % contribution of the sector's GHG emissions.



Enteric fermentation from livestock produced 77% of Rotorua's agricultural emissions (657,655 tCO_2e), with dairy cattle, non-dairy cattle and sheep emitting the majority of these emissions (76%, 10% and 8% respectively). The second highest source of agricultural emissions was produced from N_2O released by manure from grazing animals on pasture (94,190 tCO_2e or 11% of the agricultural sector's emissions). A breakdown of all sources of agricultural emissions in Rotorua is shown in Figure 5.

Figure 5: Emissions sources for the Agriculture sector for Rotorua District.



The measurement of GHG emissions in the Agriculture sector considers both direct and indirect GHG emissions from N_2O. Direct sources include those where N_2O is emitted directly to the atmosphere from cultivated soils and fertiliser applied and/or grazed grassland systems (e.g. enteric fermentation). Indirect GHG emissions sources result from either the movement of nitrogen from agricultural systems into ground water or surface water through drainage and surface runoff (leaching), or ammonia or nitrogen oxides released to the atmosphere (atmospheric deposition)[3].

Enteric Fermentation GHG emissions are produced by CH_4 released from the digestive process of ruminant animals (e.g. cattle and sheep). GHG emissions from Manure from Grazing Animals on Pasture refers to N_2O released from unmanaged manure. Manure Management refers to the GHG emissions (N_2O and CH_4) released in a managed environment (e.g. within cattle sheds) through the capture, storage, treatment, and utilization of animal manure. Decomposition of organic matter occurs when manure or urine is deposited leading to aerobic and anaerobic processes that release N_2O. Agricultural Soils refers specifically to N_2O emitted from nitrogen leaching/runoff from cultivated soils (such as through turning of the earth using ploughs).

Atmospheric Deposition is the process whereby N_2O GHG emissions are produced through volatilisation (the loss of nitrogen into the atmosphere) from nitrogen applied by grazing animals as manure and urine on pasture. Atmospheric Deposition GHG emissions are also produced by volatilisation from synthetic nitrogen fertilisers or organic fertilisers. The application of synthetic or organic fertilisers will greatly increase the amount of direct N_2O emissions through volatilisation because of the greater amounts of nitrogen available.

Indirect GHG emissions from N_2O include leaching of N_2O in the form of water-soluble plant nutrients from the soil, due to rain and irrigation. The application of synthetic or organic fertilisers will also increase the amount of leaching of N_2O by increasing the nitrogen available. For example, the use of

[3] https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_5_N2O_Agricultural_Soils.pdf

organic fertiliser can cause ammonia volatilisation leading to N_2O production. The volatilisation of ammonia is considered an indirect GHG emission source to distinguish this process from direct volatilisation of nitrogen.

GHG emissions from Liming and Dolomite refers to CO_2 emissions from lime applications (calcic lime and dolomite). Liming is used to reduce soil acidity and improve plant growth on agricultural land. Adding lime or dolomite leads to CO_2 emissions as the carbonate in the minerals dissolve and release bicarbonate, which evolves into CO_2 and water[4]. Both Leaching and Liming and Dolomite are included within the Other Agricultural Emissions segment in Figure 5.

Transport

Transport produced 297,832 tCO_2e in the reporting year (21.4% of Rotorua's gross total emissions). Most of these emissions can be attributed to petrol and diesel, which produced a total of 289,238 tCO_2e (97.1% of the sector's emissions and 20.8% of total gross emissions). Petrol contributed to 39.9% of Transport emissions (118,755 tCO_2e) while diesel contributed to 57.2% of Transport emissions (170,483 tCO_2e).

Petrol and diesel transport related emissions can also be broken down by use into on-road and off-road use. On-road transport consists of all standard transportation vehicles used on roads (e.g. cars, bikes and buses). Off-road transport consists of all fuel used for the movement of machinery and vehicles off roads (e.g. within agriculture, construction and industry). On-road transport produced 255,616 tCO_2e (85.8% of Transport emissions and 18.3% of total gross emissions). Off-road transport from petrol and diesel consumption produced 33,717 tCO_2e (11.3% of Transport emissions and 2.4% of total gross emissions). The remaining Transport emissions were attributed to air travel.

Stationary Energy

Producing 131,405 tCO_2e in 2018/19, Stationary Energy was Rotorua's third highest emitting sector (9.5% of total gross emissions). Electricity consumption was the cause of 35.5% of Stationary Energy emissions (50,513 tCO_2e), and 3.4% of Rotorua's total gross emissions (including transmission and distribution losses). Natural gas consumption accounted for 31.6% of the sector's emissions, (48,131 tCO_2e, including transmission and distribution losses). Coal consumption contributed 4.4% to Stationary Energy's sectoral emissions (5,800 tCO_2e) while LPG consumption contributed 4.2% (5,491 tCO_2e) and petrol and diesel consumption contributed 14.4% (18.981 tCO_2e). The remaining 1.9% of Stationary Energy emissions are produced by the burning of biofuels (e.g. firewood), contributing 2,489 tCO_2e to total emissions.

Stationary Energy demand is broken down by fuel type, and by the sector in which it is consumed. Stationary Energy demand is reported for the following sectors: commercial; residential and industrial. Emissions from petrol and diesel used for Stationary Energy are broken down by fuel type rather than by sector.

- Residential Stationary Energy consumption accounts for 21.2% of Stationary Energy emissions (27,837 tCO_2e) and 2.0% of total gross emissions. Residential Stationary Energy is energy used in homes (e.g. for heating, lighting and cooking).

- Commercial Stationary Energy consumption accounts for 14.7% of Stationary Energy emissions (19,298 tCO_2e) and 1.4% of total gross emissions. Commercial Stationary Energy is energy used in all non-residential and non-industrial settings (e.g. in retail, hospitality, education and healthcare).

- Industrial Stationary Energy consumption accounts for 49.7% of Stationary Energy emissions (65,290 tCO_2e) and 4.7% of total gross emissions. Industrial Stationary Energy is energy used within all industrial settings (including agriculture, forestry and fishing, mining, food processing,

[4] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf

textiles, chemicals, metals, mechanical/electrical equipment and building and construction activities).

- The remaining 14.4% of Stationary Energy emissions (18,981 tCO_2e, 1.4% of gross emissions) were produced by diesel and petrol, which were not allocated to the above categories. Stationary Energy uses of diesel and petrol include use in stationary generators and motors and for heating.

Waste (Solid & Wastewater)

Waste originating in Rotorua (solid waste and wastewater) produced 81,447 tCO_2e in 2018/19, which comprises 5.9% of Rotorua's total gross emissions. Solid waste produced the bulk of this (76,280 tCO_2e in 2018/19), making up 93.7% of total Waste emissions.

Solid waste emissions include emissions from open landfills and closed landfills. Both open and closed landfills emit landfill (methane) gas from the breakdown of organic materials disposed of in the landfill. The only open landfill site, Tirohia, contributed 62 tCO_2e (less than 1% of total gross emissions). This emissions source is particularly small as this landfill was only being used by Rotorua from late 2018 and there is a lag between waste entering landfill and the peak in emissions created by that waste. Emissions from the closed landfill site (Atiamuri) produced 76,218 tCO_2e (5.5% of total gross emissions).

Wastewater (both treatment plants and individual septic tanks) produced 5,166 tCO_2e making up 6% of total Waste emissions. Most households in Rotorua are connected to wastewater treatment plants, which produced total emissions of 2,756 tCO_2e. Households not connected to treatment plants produced 2,411 tCO_2e in wastewater emissions. Wastewater treatment tends to be a relatively small emission source compared to solid waste as advanced treatment of wastewater produces low emissions. In contrast, solid waste generates methane gas over many years as organic material enters landfill and emissions depend on the efficiency and scale of landfill gas capture.

Industrial Processes and Product Use (IPPU)

This sector includes emissions associated with the consumption of GHGs for refrigerants, foam blowing, fire extinguishers, aerosols, metered dose inhalers and Sulphur Hexafluoride for electrical insulation and equipment production. IPPU emissions do not include energy use for industrial manufacturing, which is included in the relevant Stationary Energy sub-category (e.g. coal, electricity and/or petrol and diesel).

IPPU in Rotorua produced 26,598 tCO_2e in 2018/19, contributing 1.9% to Rotorua's total gross emissions. Use of refrigerants produced 94% of IPPU emissions (24,900 tCO_2e).

These emissions are based on nationally reported IPPU emissions due to the difficulty of allocating emissions to particular geographic locations. Addressing IPPU emissions is typically a national policy issue.

Forestry

Rotorua has a regenerative native forested area, which includes mānuka, kānuka and broadleaved hardwoods. Regenerating natives occupy 14,228 ha with exotics occupying a further 51,070 ha of land. Forested area represents 25% of the total Rotorua area (65,298 ha). In total, 1,880,851 tCO_2e was sequestered by forests in Rotorua in 2018/19. Of the total sequestered CO_2, native forests sequestered 84,521 tCO_2e while exotic forests sequestered 1,796,330 tCO_2e in 2018/19. Emissions from the harvesting of forestry produced 2,225,548 tCO_2e. As emissions from harvesting were greater than carbon sequestered, Forestry was a net-positive emissions source of 344,697 tCO_2e in 2018/19.

3.1 Total Gross Emissions by Greenhouse Gas

Each greenhouse gas has a different level of impact on climate change, this is accounted for when converting quantities of each gas into CO_2e.

By far the largest source of emissions in tonnes is carbon dioxide (CO_2). In 2018/19, 426,522 tonnes of CO_2 were produced in Rotorua. The amount of other gases are as follows; 23,156 tonnes of biogenic methane; 354 tonnes of non-biogenic methane; 505 tonnes of nitrous oxide; and 12,935 tonnes of carbon dioxide equivalent units made up of unknown quantities of various greenhouse gasses.

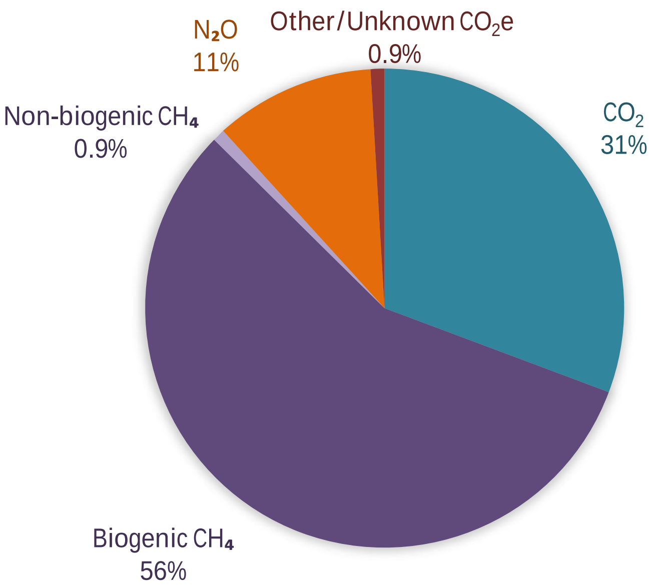
Table 1: Rotorua' total gross emissions, by greenhouse gas

Total Gross Emissions by Greenhouse Gas				
Greenhouse Gas	Tonnes	Tonnes (%)	Tonnes CO_2e	Tonnes CO_2e (%)
CO_2	426,522	92%	426,522	31%
Biogenic CH_4	23,156	5%	787,301	57%
Non-biogenic CH_4	354	0.1%	12,027	1%
N_2O	505	0.1%	150,513	11%
Other / Unknown (CO_2e)	12,935	3%	12,935	1%
Total	**463,643**	**-**	**1,389,298**	**-**

Due to the greater impact of methane than carbon dioxide, methane represents 5% of the total tonnage of greenhouse gas emissions from Rotorua but represents 58% of CO_2e from Rotorua. Nitrous oxide represents 0.1% of the total tonnage of greenhouse gas emissions from Rotorua but represents 11% of CO_2e from Rotorua.

Figure 6 illustrates Rotorua's total gross emissions by greenhouse gas in units of carbon dioxide equivalents (CO_2e).

Figure 6: Rotorua District's total gross emissions, by greenhouse gas (in tCO_2e)



Rotorua District's gross emissions split by Sector and associated sub-categories (2018/19)			
Sector	**tCO_2e**	**% Gross**	**% Sector**
Stationary Energy			
Electricity Consumption	46,680	3.4%	35.5%
Electricity Transmission and Distribution Losses	3,833	0.3%	2.9%
Natural Gas	41,507	3.0%	31.6%
Natural Gas Transmission and Distribution Losses	6,624	0.5%	5.0%
LPG	5,491	0.4%	4.2%
Stationary Petrol & Diesel Use	18,981	1.4%	14.4%
Coal	5,800	0.4%	4.4%
Biofuel / Wood	2,489	0.2%	1.9%
Bioethanol	0.0	<0.1%	<0.1%
Total:	131,405	9.4%	100%
Transport			
Petrol	118,755	8.5%	39.9%
Diesel	170,483	12.3%	57.2%
Jet Kerosene (Commercial Flights)	7,340	0.5%	2.5%
Aviation Gas	1,159	0.1%	0.4%
LPG	95	<0.1%	<0.1%
Total:	297,832	21.3%	100%
Waste			
Open landfill (Tirohia)	62	0.0%	0.1%
Closed landfill (Rotorua/ Atiamuri)	76,218	5.5%	93.6%
Wastewater Treatment Plants	2,756	0.2%	3.4%
Individual Septic Tanks	2,411	0.2%	3.0%
Total	83,477	6.0%	100%
IPPU			
Industrial Product and Process Use	26,598	1.9%	100%
Total	26,598	1.9%	100%
Agriculture			
Enteric fermentation	657,655	47.3%	77.2%
Manure from Grazing Animals	94,189	6.8%	11.1%
Manure Management	48,992	3.5%	5.8%
Agricultural Soils	21,604	1.6%	2.5%
Atmospheric Deposition	15,819	1.1%	1.9%
Other Agriculture Emissions	13,754	1.0%	1.6%
Total	852,016	61.1%	100%
Forestry			
Exotic Forest Sequestration	-1,796,330	N/A	N/A
Native Forest Sequestration	-84,521	N/A	N/A
Harvest Emissions	2,225,548	N/A	N/A
Total	344,697	N/A	N/A
Total Net Emissions (incl. Forestry)	1,733,995		
Total Gross Emissions (excl. Forestry)	1,389,298		

3.2 Biogenic emissions

Biogenic carbon dioxide (CO_2) and methane (CH_4) emissions are stated in Table 2 and Table 3, respectively.

Biogenic CO_2 emissions from plants and animals are excluded from gross and net emissions as they are part of the natural carbon cycle. For example, as wood biofuels originate from forestry, the biogenic CO_2 from biofuels is excluded from gross emissions.

Biogenic CH_4 emissions are included in gross emissions due to their relatively large impact on global warming relative to biogenic CO_2. For example, biogenic CH_4 produced by farmed cattle via enteric fermentation is included in gross emissions.

The importance of biogenic CH_4 is highlighted in NZ's Climate Change Response (Zero Carbon) Amendment Act. The Act includes targets to reduce biogenic CH_4 by between 24% and 47% below 2017 levels by 2050, and by 10% below 2017 levels by 2030. More information on the Act is available here: https://www.mfe.govt.nz/climate-change/zero-carbon-amendment-act.

Table 2: Biogenic CO_2 in Rotorua (Excluded from gross emissions)

Biogenic Carbon Dioxide (CO_2) (Excluded from gross emissions)		
Biofuel	56,792	t CO_2
Biodiesel	320	t CO_2
Landfill Gas	120	t CO_2
Total Biogenic CO_2	**57,232**	**t CO_2**

Table 3: Biogenic Methane in Rotorua (Included in gross emissions)

Biogenic Methane (CH_4) (Included in gross emissions)		
Biofuel	56	t CH_4
Bioethanol	0	t CH_4
Landfill Gas	2,244	t CH_4
Wastewater Treatment	73	t CH_4
Enteric Fermentation	19,343	t CH_4
Manure Management	1,441	t CH_4
Total Biogenic CH_4	**23,156**	**t CH_4**

Biogenic methane represents 5% of the gross total tonnage of GHG emissions in Rotorua but represents 57% of total gross GHG emissions when expressed in CO_2e. This is caused by the higher global warming impact of methane per tonne, compared to carbon dioxide. The total tonnage of each GHG and the contribution of each GHG to total gross emissions when expressed in CO_2e is shown in Table 1.

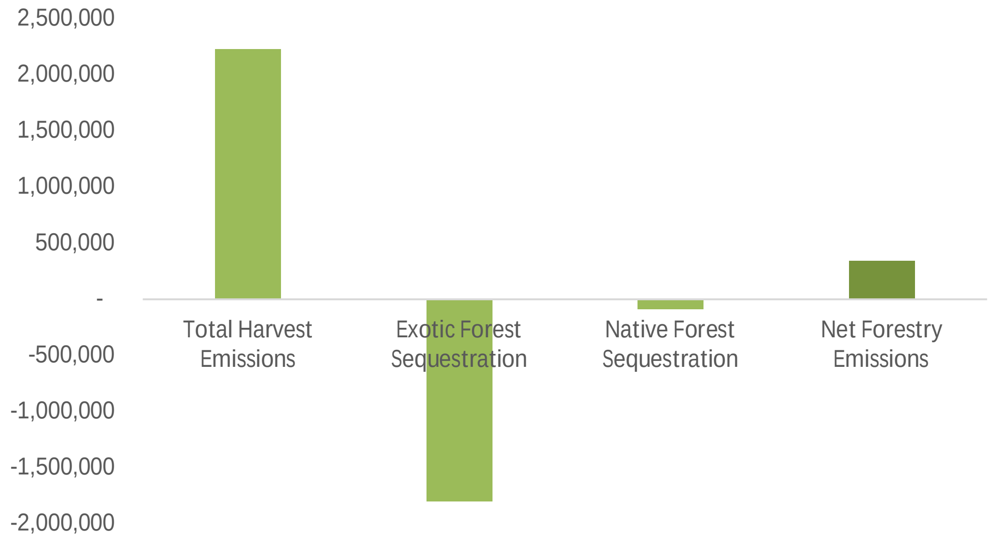
3.3 Net emissions

Net emissions differ from gross emissions because they include emissions related to forestry activity (harvesting and planting) within an area. Forestry emissions are influenced by the cyclical nature of harvesting and planting regimes. In addition, with each subsequent planting of harvestable trees, there is a decreasing ebb and flow of sequestration.

Harvesting of forest increases emissions via the release of carbon from plants and soils. Planting of native forest (e.g. mānuka and kānuka) and exotic forest (e.g. pine), sequesters (captures) carbon from the atmosphere while the trees are growing to maturity. When sequestration by forests exceeds emissions from harvesting, the extra quantity of carbon sequestered by forest reduces total gross emissions. Conversely when emissions from harvesting exceed the amount of carbon sequestered by native and exotic forests, then total gross emissions will increase.

Forestry in Rotorua was a positive source of emissions in 2018/19 (rather than a negative source of emissions due to greater sequestration than emissions), emitting 344,697 tCO_2e. Sequestration in 2018/19 was 188,851 tCO_2e (which was mostly from exotic forestry) while harvesting emissions were 2,225,548 tCO_2e, leading to emissions from Forestry being positive at 344,697 tCO_2e (see Figure 7).

Figure 7: Rotorua District's forestry harvest emissions, forestry sequestration and net forestry emissions (tCO_2e)

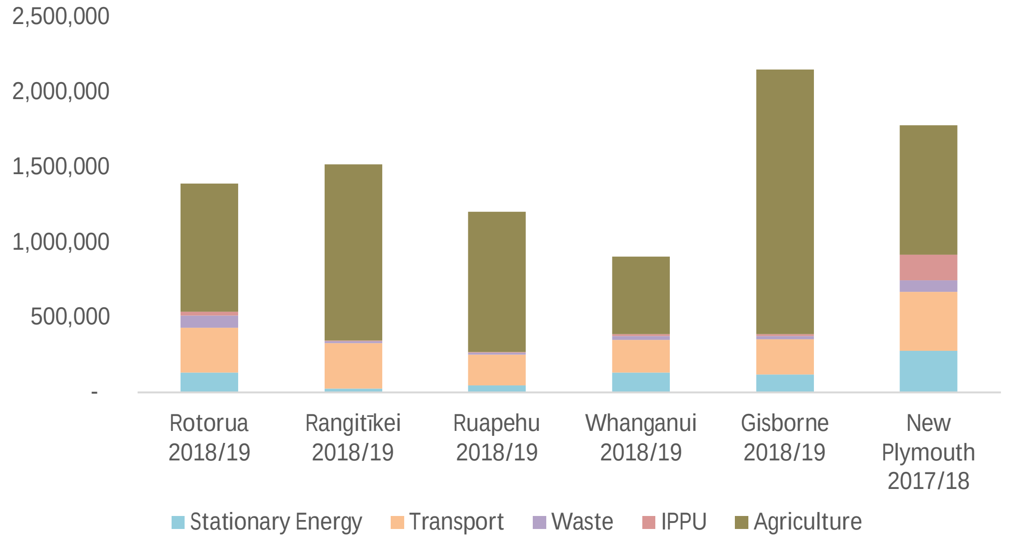


Carbon sequestered by forestry can be viewed as a liability/risk that needs careful consideration. For example, what happens if there is a large downturn in exports of exotic pine? If plantations are not replanted or other land use change occurs to exotic forested areas, then emissions will quickly rise. Equally, if native forest is not protected from removal, and removal does happen, then emissions will rise. In summary, when a large of amount of carbon is captured by forests, long-term planning is needed on how best to manage this carbon sink.

4.0 Comparison with other areas in New Zealand

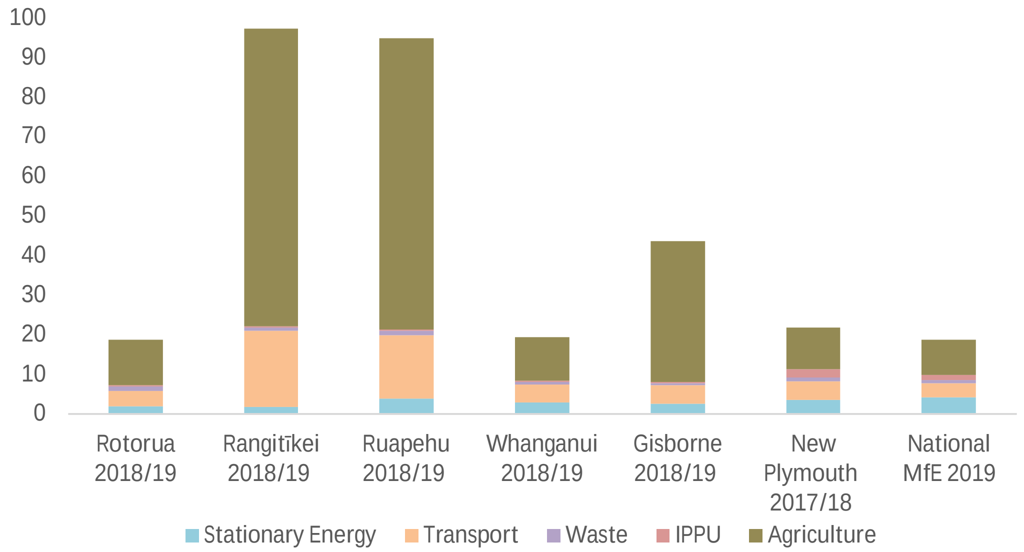
Figure 8 shows a comparison of gross emissions (excluding Forestry) for Rotorua with other territorial authorities in New Zealand, split by sector. When compared with other GHG inventory studies, Rotorua had higher gross emissions than Whanganui and Ruapehu, but lower gross emissions compared to Rangitikei, Gisborne and New Plymouth. Note that the compared studies were conducted at differing geographic levels and in differing timeframes.

Figure 8: A comparison of Rotorua District's GHG emissions with other regions of New Zealand by gross emissions (tCO_2e).



When comparing the carbon footprints of different districts, a per capita figure can be useful because it provides a common reference point to understand the difference in emissions. Rotorua had lower per capita gross emissions than all other districts considered, illustrated in **Figure 9**, with the exception of the National per capita gross emissions, which was exactly the same as Rotorua's per capita gross emissions, at 18.7 tCO_2e per person per year.

Figure 9: A comparison of Rotorua District's GHG emissions with other districts of New Zealand on a per capita basis (tCO_2e).



5.0 Changes in Emissions Inventory between (updated) 2015/16 and 2018/19

Total gross emissions per year increased by 1% from 1,377,683 tCO_2e in 2015/16 to 1,389,298 tCO_2e in 2018/19. Total net emissions in Rotorua increased by 9% from 1,592,683 in 2015/16 to 1,733,995 tCO_2e (141,311 tCO_2e). Emissions from all sectors besides Waste and Stationary Energy increased since 2015/16.

Emissions from the Stationary Energy sector reduced by the largest amount between 2015/16 and 2018/19, by 5% (6,907 tCO_2e). Waste sector emissions also reduced between 2015/16 and 2018/19 by 4% (3,374 tCO_2e).

For the Stationary Energy sector, emissions from a range of sources decreased, notably natural gas use decreased by 11% and coal use decreased by 17%. For the Waste sector, the increased use and effectiveness of landfill gas capture systems reduced Waste emissions in Rotorua. The old Rotorua Landfill (Atiamuri) is now closed and from late 2018 onwards waste was sent outside the district to Tirohia Landfill, which had a very high (90%) landfill gas capture rate. Solid waste volumes have also decreased in recent years with kerbside recycling resulting in increased diversion.

The increase in emissions in the Forestry sector was the biggest proportionate and real change in sector emissions, (60% or 129,562 tCO_2e), predominantly due to an increase in total harvest emissions.

Industrial Process and Product Use (IPPU) emissions were the second largest proportionate change, increasing by 17% (or 3,945 tCO_2e) between 2015/16 and 2018/19. Note that national level data is used for this sector and is portioned out using a population approach; exact emissions for the district are unknown.

Although Agriculture was the most significant contributor to Rotorua's community carbon footprint, the sector's emissions increased only slightly between 2015/16 and 2018/19 (by 2% or 14,706 tCO_2e). Changes in Agriculture emissions were caused by changes in livestock numbers. In terms of stock numbers, the numbers of dairy cattle and non-dairy cattle increased the most significantly (by 1,496 and 893 respectively), whereas the numbers of sheep decreased the most significantly, by 9,283. Figure 10 shows the number of livestock in 2015/16 and 2018/19. Table 4 shows the raw stock number changes in Rotorua between 2015/16 and 2018/19.

Figure 10: Rotorua District's livestock number changes (by animal) between 2015/16 and 2018/19

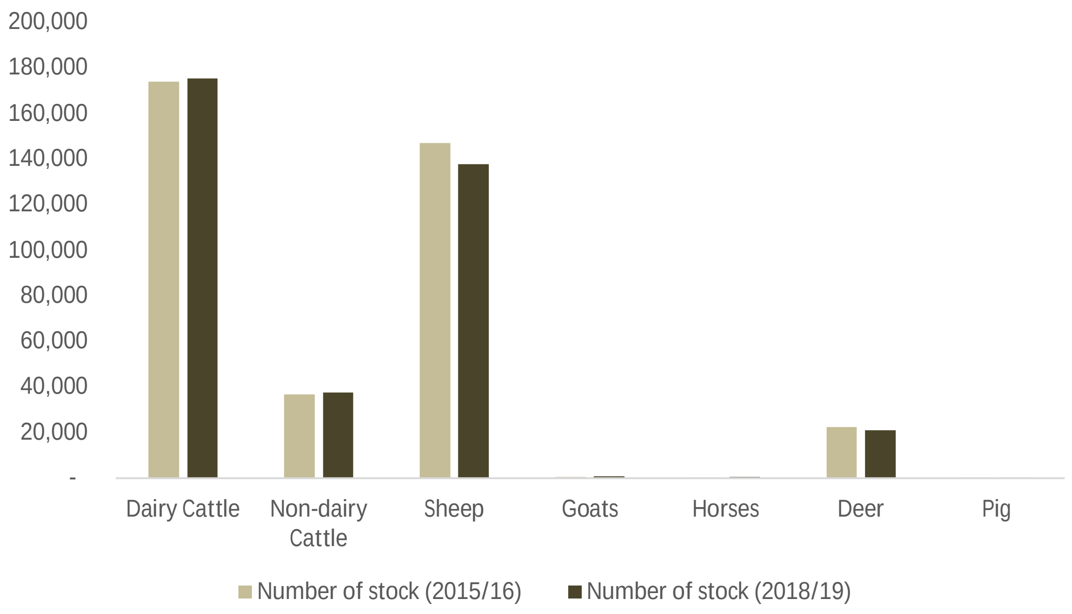


Table 4: Raw and percentage increase and decrease in stock numbers between 15/16 and 18/19.

Animal	Increase in Stock Numbers Between 15/16 and 18/19	% Increase
Dairy Cattle	1496	1%
Non-dairy Cattle	893	2%
Goats	58	9%
Pig	31	43%
Horses	9	2%
Deer	-1303	-6%
Sheep	-9283	-6%

Figure 11 and Figure 12 provide a more detailed visual breakdown of the comparison between Rotorua's emissions in both 2015/16 and 2018/19.

Figure 11: A comparison of Rotorua District's total gross emissions in 2015/16 and 2018/19, by sector (tCO_2e).

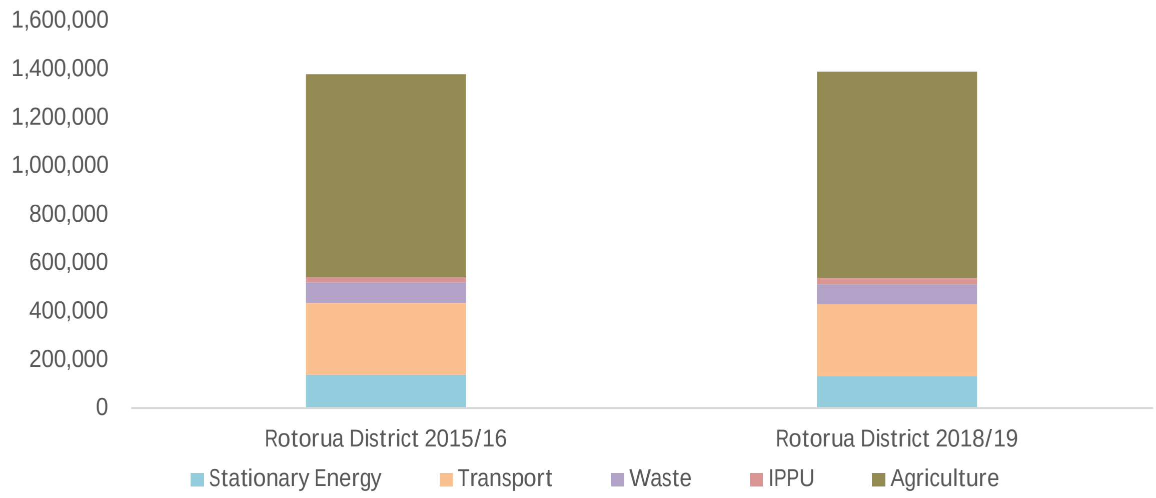
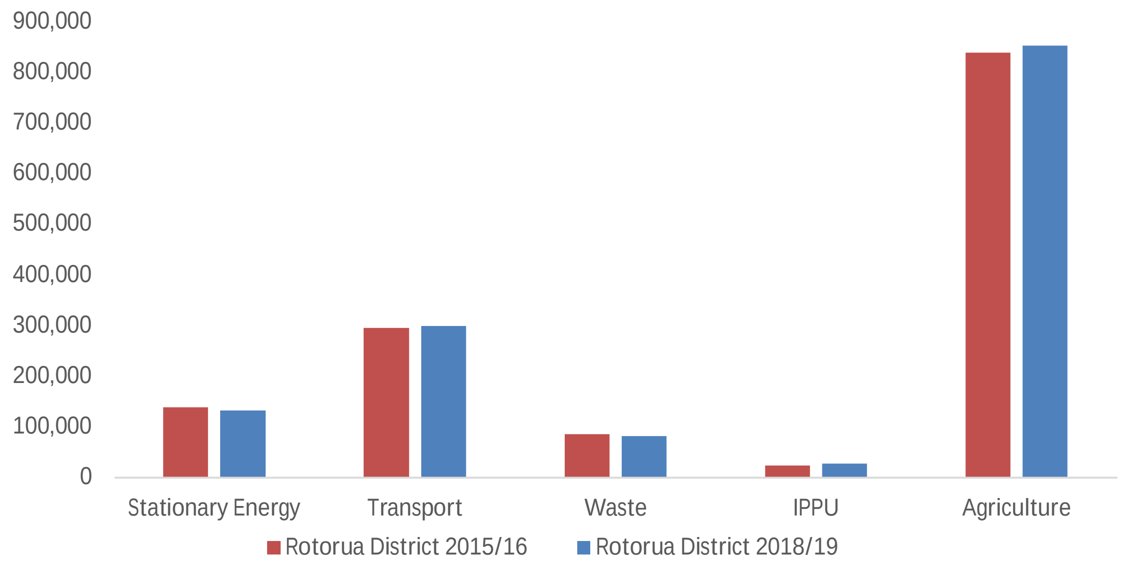


Figure 12: A comparison of Rotorua District's emissions by sector, in 2015/16 and 2018/19 (tCO_2e).



Summary of Rotorua District's gross emissions split by Sector and associated sub-categories (2015/2016)			
Sector	tCO_2e	% Gross	% Sector
Stationary Energy			
Electricity Consumption	47,198	3.4%	34.1%
Electricity Transmission and Distribution Losses	2,919	0.2%	2.1%
Natural Gas	46,895	3.4%	33.9%
Natural Gas Transmission and Distribution Losses	7,482	0.5%	5.4%
LPG	4,966	0.4%	3.6%
Stationary Petrol & Diesel Use	19,534	1.4%	14.1%
Coal	6,983	0.5%	5.0%
Biofuel / Wood	2,335	0.2%	0.0%
Total:	138,312	10.0%	100%
Transport			
Petrol	128,340	9.3%	43.6%
Diesel	158,355	11.5%	53.8%
Jet Kerosene (Commercial Flights)	5,861	0.4%	2.0%
Aviation Gas	1,159	0.1%	0.4%
LPG	739	0.1%	0.3%
Total:	294,454	21.4%	100%
Waste			
Open Landfill (Tirohia) (not used as at 15/16)	-	-	-
Closed Landfill (Rotorua/Atiamuri) (all waste sent here at 15/16, closed in late 2018)	79,724	5.8%	94.0%
Wastewater Treatment Plants	2,781	0.2%	3.1%
Individual Septic Tanks	2,316	0.2%	2.6%
Total	84,821	6.2%	100%
IPPU			
Industrial Processes and Product Use	22,653	1.6%	100%
Total	22,653	1.6%	100%
Agriculture			
Enteric fermentation Agriculture	639,649	46.3%	76.4%
Manure from Grazing Animals	97,588	7.1%	11.7%
Manure Management	48,608	3.5%	5.8%
Agricultural Soils	21,047	1.5%	2.5%
Atmospheric Deposition	15,566	1.1%	1.9%
Other Agriculture Emissions	14,851	1.1%	1.8%
Total	837,309	61.8%	100%
Forestry			
Exotic Forest Sequestration	- 1,778,228	N/A	N/A
Native Forest Sequestration	- 84,794	N/A	N/A
Harvest Emissions	2,078,156	N/A	N/A
Total	215,135	N/A	100%
Total Net Emissions (incl. Forestry)	1,592,683		
Total Gross Emissions (excl. Forestry)	1,377,549		

6.0 Emissions and other metrics

Figure 13 Rotorua District's emissions change, and changes to other relevant metrics for Rotorua District, 2015 to 2019

The above graphic shows the change in gross emissions when compared to the changes in other metrics of interest between 2015/16 and 2018/19. Total gross emissions have increased by 0.5%, against a backdrop of a 5% growth in population in Rotorua. Per capita gross emissions have reduced by 4% between 2015/16 and 2018/19.

When emissions grow less rapidly than Gross Domestic Product (GDP) as a measure of income, the process is known as decoupling. The term decoupling is an expression of the desire to mitigate emissions without harming economic wellbeing. A full discussion of decoupling of emissions is beyond the scope of this project. Although GDP has grown faster than the growth in emissions, the changes in emissions, GDP and other metrics illustrated in the above graphic suggest that it is unclear whether sustained high-level decoupling has occurred between 2015/16 and 2018/19.

The exact drivers for the decoupling of emissions from GDP are difficult to pinpoint. New policies for the way to meet energy demand, food, transport and housing needs will all contribute. In this case, both direct local actions including reducing the emissions from landfill and indirect national trends (e.g. reduction of emissions from electricity generation) will have contributed to the trends noted.

7.0 Closing statement

Rotorua's GHG inventory provides information for decision-making and action by the council, Rotorua stakeholders and the wider community. We encourage the council to use the results of this study to update current climate actions plans and set emission reduction targets.

The inventory of greenhouse gas emissions developed for Rotorua covers emissions produced in the Stationary Energy, Transport, Waste, IPPU, Agriculture and Forestry sectors using the GPC reporting framework. Sector-level data allows Rotorua to target and work with the sectors that contribute the most emissions to the footprint.

Agriculture is the highest emitting sector in Rotorua at 61%. Enteric fermentation from farmed livestock is the largest emissions source within the Agriculture sector, at 47% of gross emissions.

Emissions produced in the Forestry sector increased the most between 2015/16 and 2018/19, by 129,562 tCO_2e. Emissions produced in the Agriculture sector had the second largest increase in terms of tCO_2e by 14,706 tCO_2e, although this only accounted for a 2% sectoral increase. Both Stationary Energy and Waste emissions decreased, by 5% and 3% respectively.

Comparing reported emissions between years presents an opportunity to understand emissions trends. Between 2015/16 and 2018/19 total gross emissions rose by 1% while per capita gross emissions decreased by 4%, with population growth of 5% occurring in the same timeframe.

Data quality and availability varies widely between the sectors. Higher quality data for aviation, solid waste and industrial coal use would be beneficial in improving accuracy of the results of future inventories.

Understanding the extensive and long-lasting effects of climate change is improving all the time. It is recommended that this emissions inventory be updated regularly to inform ongoing positive decision making to address climate change issues.

8.0 Limitations

Where this Report indicates that information has been provided to AECOM by third parties, AECOM has made no independent verification of this information except as expressly stated in the Report. AECOM assumes no liability for any inaccuracies in or omissions to that information. This Report was prepared between **August 2020 and October 2020** and is based on the information reviewed at the time of preparation. AECOM disclaims responsibility for any changes that may have occurred after this time. This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice.

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Appendix A

Emissions Breakdown

Appendix A Emissions Breakdown

The pie charts below show a breakdown of the proportion of gross emissions from each sector and source.

Note: Emission sources lower than 1% of total emissions are not shown but can displayed, if needed.

Figure 14 Rotorua District total gross emissions, by sector (tCO_2e)

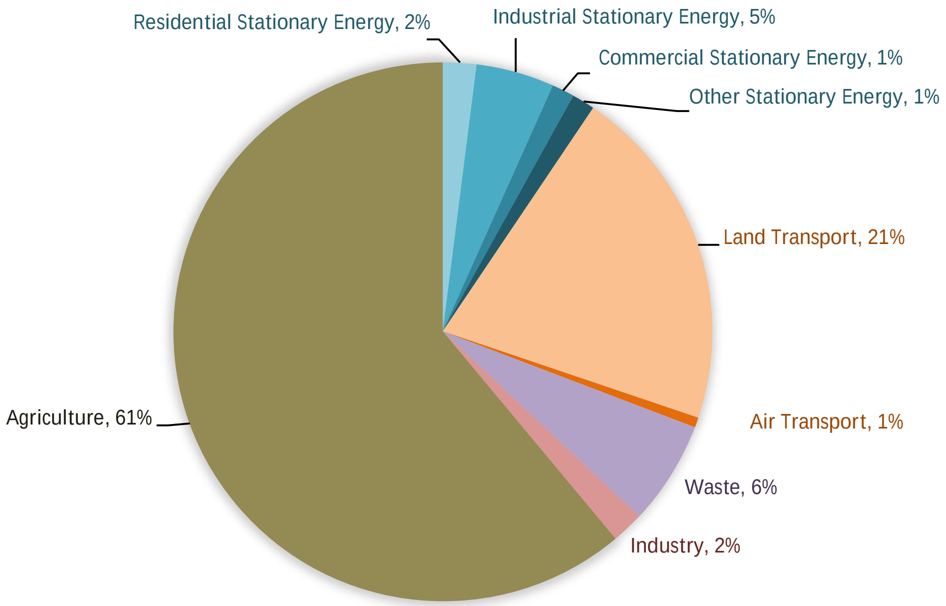


Figure 15 Rotorua District total gross emissions, by source (tCO_2e)

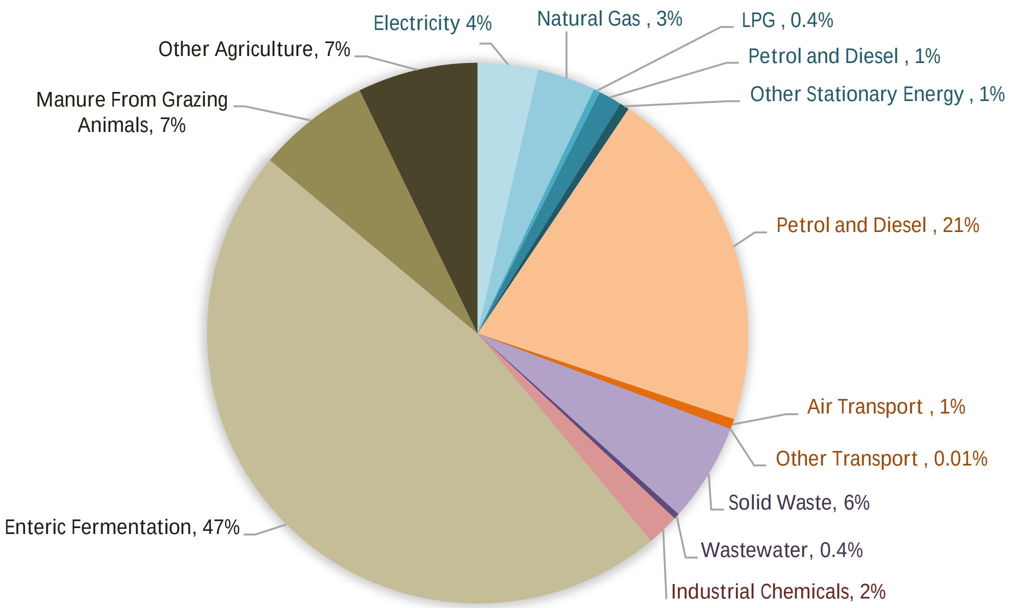


Figure 16 Rotorua District total gross emissions, by fuel source, highlighting Stationary Energy emissions (tCO_2e)

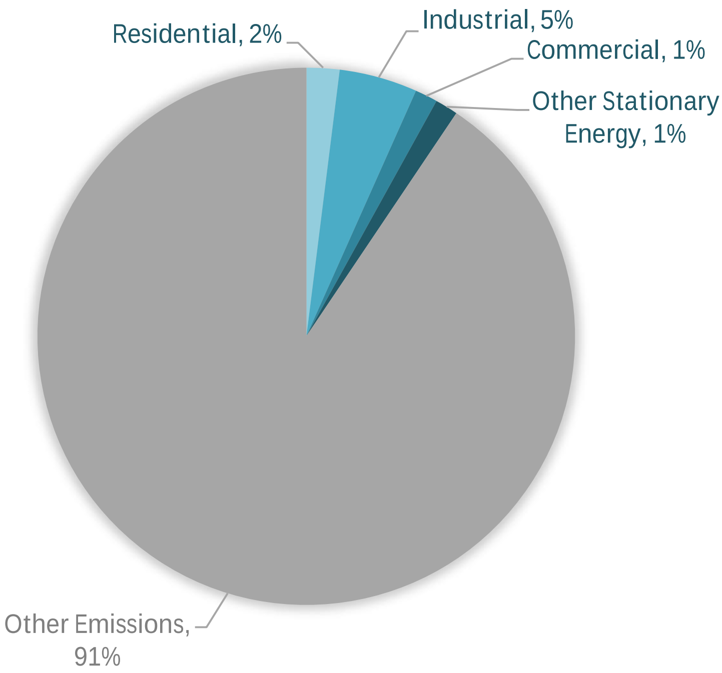


Figure 17 Rotorua District total gross emissions, highlighting Stationary Energy emissions, showing source of Stationary Energy emissions (tCO_2e)

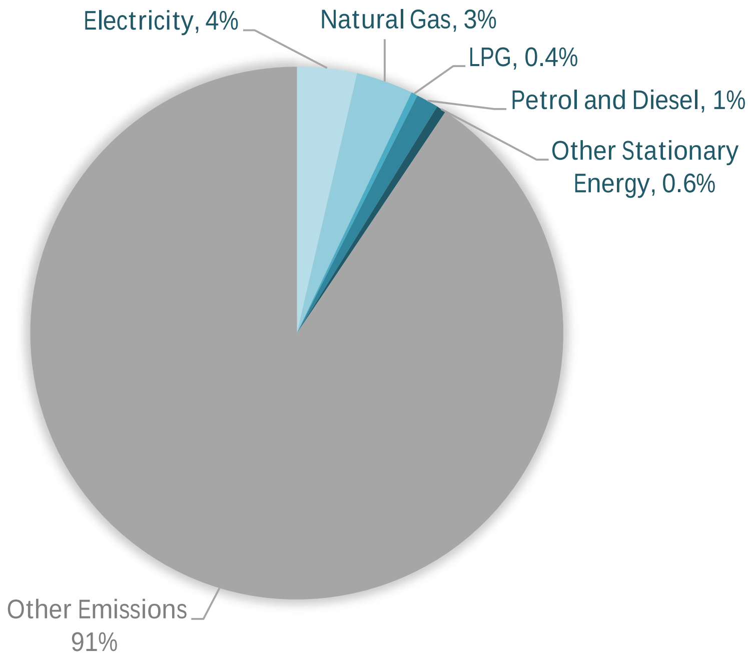


Figure 18 Rotorua District total gross emissions, by source, highlighting Transport emissions (tCO_2e)

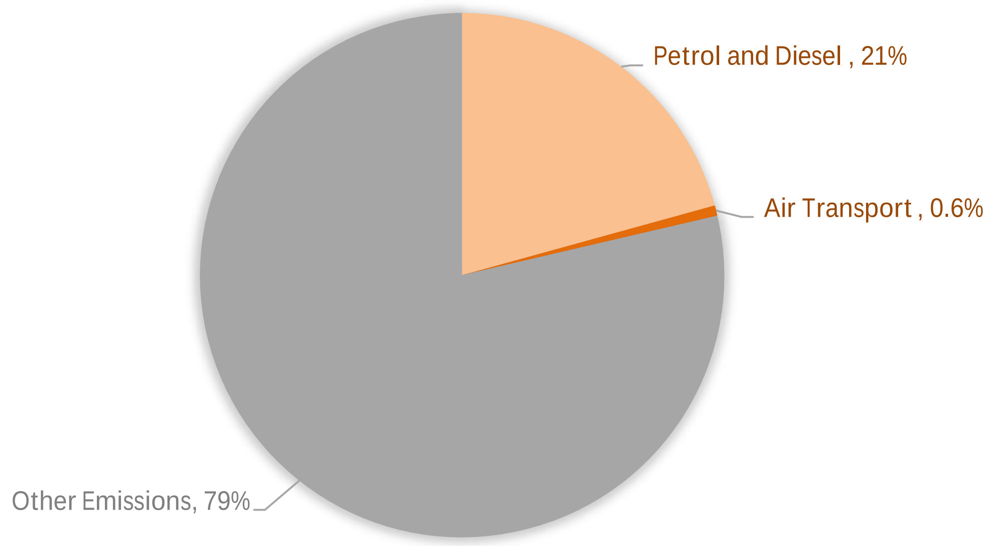


Figure 19 Rotorua District total gross emissions by source, highlighting Agriculture emissions (tCO_2e)

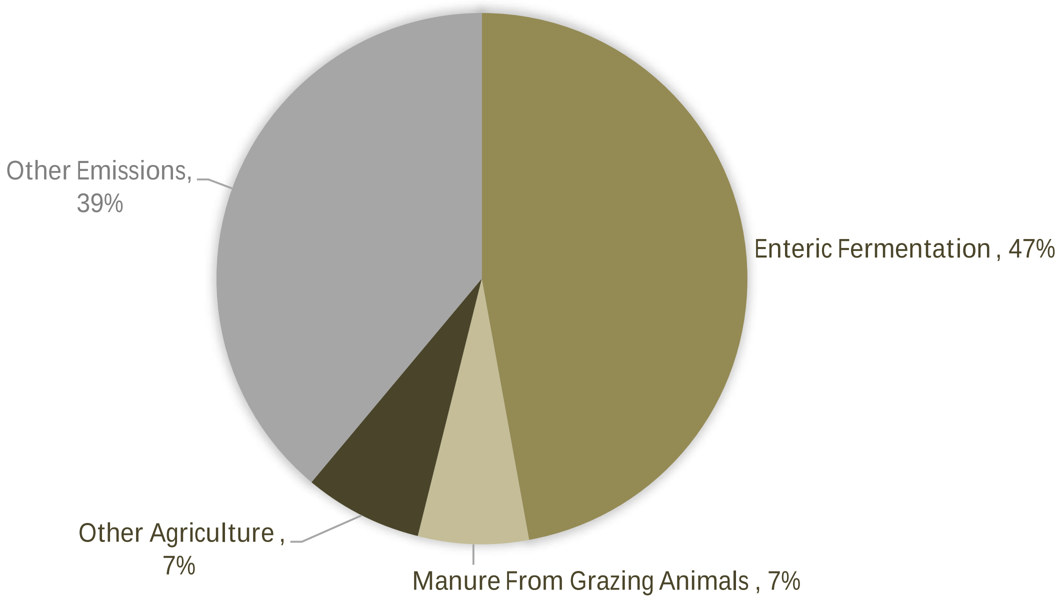
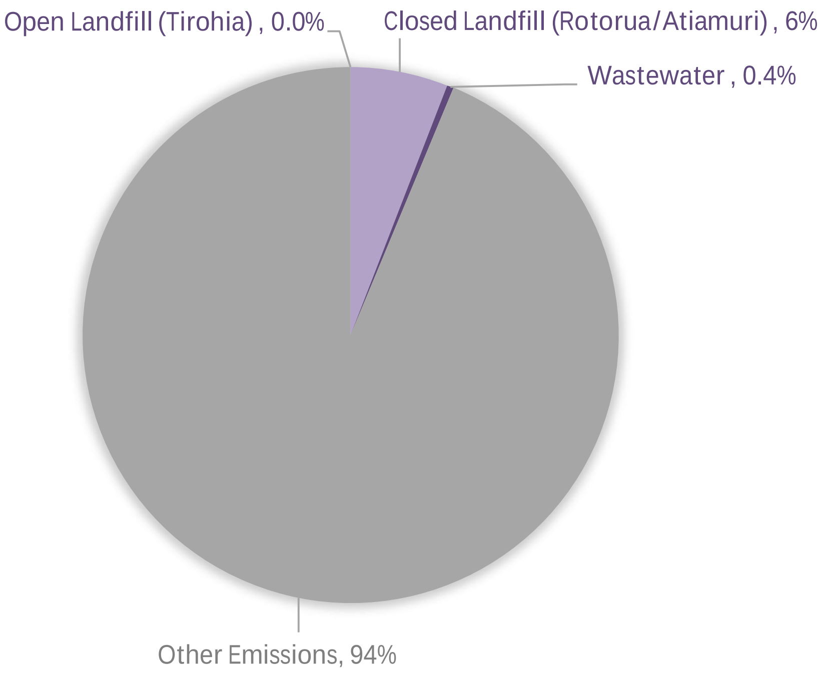


Figure 20 Rotorua District total gross emissions by source, highlighting Waste emissions (tCO_2e)



Basic and Basic+ emissions reporting (Global Covenant of Mayors)

BASIC and BASIC+ emissions reporting are standardised reporting methods used by the Global Covenant of Mayors for Climate and Energy. They enable comparison of emissions with other cities around the world and help demonstrate the importance of city-level climate action at a local and global scale. BASIC and BASIC+ emissions are reported as outlined in the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC).

BASIC emissions reporting excludes emissions from Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use and GHG emissions occurring outside the district boundary as a result of activities taking place within the boundary. BASIC+ emissions reporting includes those emissions excluded from BASIC emissions reporting (which is equal to the total gross emissions reported in this study).

Table 5 Rotorua District BASIC and BASIC+ emissions

Reporting Method	Emissions (tCO_2e)
BASIC	500,227
BASIC per capita	6.7
BASIC+	1,389,298
BASIC+ per capita	18.6

Appendix B

Assumptions

Sector / Category	Assumption and Exclusions
General	
Geographical Boundary	LGNZ local council mapping boundaries have been applied
Transport Emissions	
Petrol and Diesel:	Total petrol and diesel fuel use was divided by likely end use. The division into Transport and Stationary Energy end use (and within Transport, on-road and off-road) was calculated using fuel end use data found in the 2017-2019 Energy end use database as published by the Energy Efficiency and Conservation Authority (EECA) in September 2020. On-road transport is defined as all standard transportation vehicles used on roads e.g. cars, bikes, buses. Off-road transport is defined as machinery for agriculture, construction and other industry used off-roads. Stationary Energy petrol and diesel use is defined as fuel not used for transport either on or off roads. Petrol and diesel used for Stationary Energy has been reported in the Stationary Energy sector.
Biofuel	The bioethanol component of petrol mixed with bioethanol has been calculated and subtracted from the total petrol sales in Rotorua. Note: some biodiesel is sold in Rotorua (by Gull) but is blended at 1% biofuel and represents an insignificant amount of fuel sold in Rotorua so has not been included (confirmed by Gull Sept. 2020).
Jet Kerosene	Calculated using the Induced Activity method. An estimate of fuel use was calculated for flights arriving and departing from Rotorua Airport using the following methodology: - The schedule of flights arriving and departing from Rotorua Airport containing details on the aircraft used for each flight was used to calculate fuel consumption. - Flight distances and aircraft fuel burn rates were then sourced from websites and used to calculate the distance travelled for each flight and the amount of estimated jet kerosene consumed during each flight. - As per the induced activity method, only 50% of emissions calculated per one-way arrival and departure were allocated to Rotorua Airport. The remaining 50% of each leg was allocated to the originating or destination airport. All aircraft fuel emissions have been classified as Scope 3. Scope 2 electricity use by the airport is incorporated within the general electricity consumption data for the territorial authority.
Aviation Gas	Aviation gas is mostly used by small aircrafts for relatively short flights. The aviation gas consumption estimate of 500,000 litres for Rotorua airport has been used for both 15/16 and 18/19. This estimate was calculated by AECOM using advice from industry aviation experts. Although general aviation flight data was provided by Julie Rowe, only those local flights 'arriving' at Rotorua Airport are recorded; there is no destination data. Based on the methodology we used, it is therefore impossible to calculate the distance these local

	flights travel. Discussions with Julie Rowe indicate that some flights merely just touch down on their journey elsewhere, whereas others simply refuel – in both instances no destination data for these aircrafts is recorded. Therefore, we have used an estimate that we use in many CCFs to calculate emissions from local flights (which are smaller aircrafts that use aviation gas rather than jet kerosene). This same figure was used in the 15/16 RLC CCF. All aircraft fuel emissions have been classified as Scope 3. Scope 2 electricity use by airport / planes is incorporated within the general electricity consumption data for the territorial authority.
Marine Diesel	No marine diesel emissions calculated as there are no ports within the Rotorua District area. Most small private users (on lakes and rivers) use regular diesel which will be included in the Petrol and Diesel emissions. Any additional use of marine fuels is assumed insignificant.
LPG	Total North Island consumption data was used and then split on a per capita basis to determine the district's consumption. National LPG end use data has been used to break down consumption into Stationary Energy and Transport usage; these are then reported separately in their respective categories.
Bitumen	Not calculated
Lubricants	Not calculated
Stationary Energy Emissions	
Consumer Energy End Use	Stationary Energy demand (e.g. electricity use, natural gas, etc.) is broken down by the sector in which the energy is consumed. We report Stationary Energy demand in the following categories: industrial (which includes agriculture, forestry and fishing); commercial; and residential. These sectors follow the Australia New Zealand Standard Industrial Classification 2006 definitions. Additional to agriculture, forestry and fishing, the industrial sector includes mining, food processing, textiles, chemicals, metals, mechanical/electrical equipment and building and construction activities. Emissions from petrol and diesel used for Stationary Energy are not broken down into these sectors. Energy demand used for transport is reported in the Transport sector.
Electricity Consumption	Electricity consumption data for the Rotorua District was provided directly by the network that supplies electricity to the Rotorua District. The breakdown into sectors is based on NZ average consumption per sector (residential, commercial and industrial).
Electricity Generation	There is electricity generation in the Rotorua District however, emissions produced in electricity generation are not required to be reported for the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) standard. Emissions relating to electricity generation are captured in the Electricity Consumption sector. Electricity Generation is reported separately.
Public Transport Electricity	Any electricity used in the public transport system is included in the Stationary Energy, electricity consumption figures.
Coal production / Fugitive Emissions	Not Calculated: There are no active coal mines within the region. (NZP&M 2019)

Coal Consumption	Different datasets are used to calculate residential and commercial coal consumption and industrial coal consumption. Residential and commercial coal consumption is calculated using a national per capita approach. For industrial coal consumption, regional-specific consumption data is available, so this data is used to calculate a more accurate industrial coal consumption figure (MBIE, 2019).
Biofuel and Wood Consumption	Different datasets have been used to calculate residential and commercial biofuel consumption and industrial biofuel consumption. Residential and commercial biofuel consumption is calculated using a national per capita approach. We reached out to a number of industries that we thought may use biofuel in their industrial processes. Only Red Stag provided biofuel consumption data for both FY18/19 and FY15/16. This data source has been used for the industrial biofuel consumption component.
LPG Consumption	Total North Island consumption data was used and then split on a per capita basis to determine the district's consumption. National LPG end use data has been used to break down consumption into Stationary Energy and Transport usage; these are then reported separately in their respective categories.
Petrol and Diesel (Stationary Energy end-use)	Total petrol and diesel fuel use was divided by likely end use. The division into Transport and Stationary Energy end use (and within Transport, on-road and off-road) was calculated using fuel end use data provided by the Energy Efficiency and Conservation Authority (EECA) in April 2020. Stationary Energy petrol and diesel use is defined as fuel not used for transport either on or off roads. Petrol and diesel used for transport has been reported in the Transport sector (see above).
Natural Gas Consumption	Natural gas consumption data has been sourced from the gas provider servicing the Rotorua District (FirstGas).
Oil and Gas Fugitive Emissions	Not Calculated: There are no gas or oil processing plants within the region.
Biogenic Emissions	Some carbon dioxide (CO_2) emissions are considered to be biogenic. These are CO_2 emissions where the carbon has been derived from natural sources such as plants and animals. These emissions are not included in calculating total CO_2e.
Geothermal Energy	We have not considered emissions from geothermal energy for the purposes of this assessment.
Agricultural Emissions	
General	Agricultural data was sourced from territorial authority (district-specific) data provided by Statistics NZ and the Ministry for the Environment National Inventory. Alpacas and llamas have been added to the goats emission source as alpacas and llamas have a similar emissions factor to goats and llamas and there is no separate emission factor provided for goats and llamas.
Solid Waste Emissions	
Landfills	Solid waste emissions from landfill are measured using the IPCC First Order Decay method that covers landfill activity between 1950 and the present day. Solid waste emissions

	were calculated for waste generated within the Rotorua District territorial area boundary that was sent to Tirohia and the closed Rotorua Landfill (Atiamuri). For Tirohia, we understand that landfill gas capture has been occurring since early 2019, when the flare was operating continuously. This data has been provided by Waste Management. We understand that the Rotorua Landfill has a landfill gas system. However, there is a lack of data on landfill gas capture for this site and therefore we have assumed no landfill gas recovery occurs at Rotorua Landfill. Note that we haven't included landfill gas capture data from Atiamuri because we do not have a readily available data source. We understand that there will be improvements to capture this data in the future, and updates can then be made to the solid waste calculations. Where waste volume data was not available, we have used the national per capita waste volume to estimate waste volume. We have used the national average of SWAP data between 1950-2003 and 2010-2019. We had Rotorua-specific SWAP data for 2003-2009.
Wastewater Emissions	
Wastewater Treatment	We understand from the data provided that there is an active sludge treatment plant as well as septic tanks within the district. Emissions have been calculated based on the data provided, following IPCC 2006 guidelines. Where data is missing, IPCC and MfE provided figures have been used, for example, for biochemical oxygen demand (BOD). Calculation of emissions includes emissions released directly from wastewater treatment and from discharge onto land/water. Calculations for wastewater emissions from individual septic tanks are also included. Populations not connected to known wastewater treatment plants are assumed to be using septic tanks. We have not calculated emissions from combustion within sludge digestion. We have also not accounted for overflows, fugitive emissions or sludge removal.
Biochemical Oxygen Demand (BOD)	The biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in water. It is used as a surrogate to measure the degree of organic pollution in water.
Industrial Emissions	
Industry & Solvent Emissions	Calculated from Ministry for Environment National Inventory data, as this the latest, most recently available data on the required solvents. Emissions are estimated on a per capita basis.
Industrial Activity	There was not enough data available to undertake a district-specific level approach. Therefore, national level data has been used and split on a per capita basis to determine the territorial authority's consumption.
Forestry Emissions	
Exotic Wood Harvested	Exotic wood harvest emissions provided at the regional level. Territorial authority harvest emissions were calculated using the percentage share of the region's forest area of harvest age (>26 years old) to estimate the share of the region's harvest emissions.
Roundwood Removal	It has been assumed that only 70% of the tree is removed as roundwood and that the above ground tree makes up approximately 74% of the total carbon stored.

	Note that Taupo has been excluded from exotic forestry emissions calculations for both 2015/16 and 2018/19 when calculating regional exotic wood emissions, as only a small portion of the Taupo district falls within the Bay of Plenty Regional Council area (see - https://datafinder.stats.govt.nz/layer/87753-regional-council-2015-v1-00-clipped/).
Emission Factors	
General	All emission factors have detailed source information in the calculation tables within which they are used. Where possible, the most up to date, NZ specific emission factors have been applied. We have used the same emission factors for both 15/16 and 18/19. We have used yearly emission factors for electricity for both the 15/16 and 18/19 financial year time periods (as those are available for specified years). We have assumed the properties of gases for electricity production is based on the published proportions of methane, carbon dioxide and nitrous oxide published in Ministry for Environment, Voluntary Guidance for Emissions Guide Table 9.