Greater Wellington Regional Council
18-May-2020

Wellington Region Greenhouse Gas Inventory

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Client: Greater Wellington Regional Council

Co No.: N/A

Prepared by

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18-May-2020

Quality Information

Document Wellington Region Greenhouse Gas Inventory

Ref 60601402

Date 18-May-2020

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Reviewed by Ruth Williams

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
7	15-May-2020	Final Report	Anthony Hume Principal Sustainability & Resilience Consultant	

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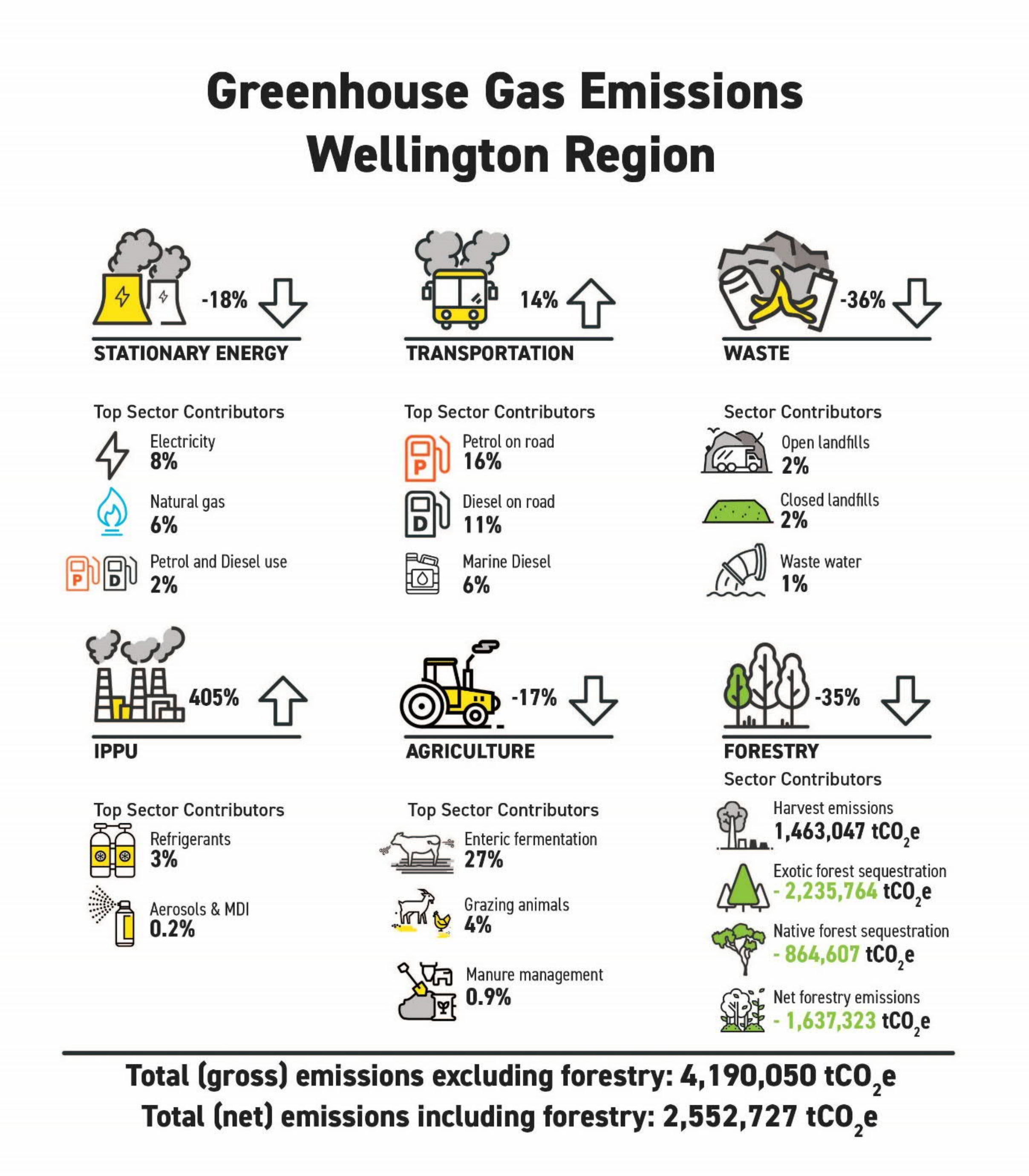
Executive Summary

Carbon emissions for the Wellington Region have been measured using the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC). The method includes emissions from stationary energy, transportation, waste, industry (IPPU), agriculture and forestry sectors. Figure 1 summarises the rate of change in emissions and top contributors to emissions for different sectors.

Figure 1 Summary of change in emissions from 2001 to 2019 including top contributors to total gross emissions from each sector in 2019



The document is split into two parts. In Part 1 this document focusses on the results for the 2018/19 financial reporting year. Referred to hereafter more commonly as 2019 for ease. Part 2 centres on emission trends in the last two decades (2000/01 to 2018/19) or more simply 2001 to 2019. Major findings of the project include:

PART 1 – 2019 Emissions Inventory

- In the 2018/19 reporting year, Wellington Region emitted **gross 4,190,050 tCO_2e**. The biggest emitting districts are Wairarapa and Wellington City, with each area emitting 41% and 25% of total gross emissions respectively.
- Transport (e.g. road, rail, and air travel) is the biggest source of emissions accounting for 40% of total gross emissions. Agriculture e.g. emissions from cattle, pigs and sheep is the second largest emitter, 34% of total gross emissions. Stationary Energy e.g. consumption of electricity or natural gas is the third highest emitting sector in the region, producing 18% of total gross emissions.
- After consideration of carbon sequestration (carbon captured and stored in plants or soil by forests), the Wellington Region emitted **net 2,552,727 tCO_2e** emissions. Carbon sequestration reduces gross emissions by 1,637,323 tCO_2e, a 39% reduction. Most sequestration, 84% occurs in the Wairarapa district.

PART 2 – Changes in Emissions Inventory, 2001 to 2019

- The Wellington Region's emissions fell by 5%, from **gross 4,427,849 tCO_2e** to **gross 4,190,050 tCO_2e (237,799 tCO_2e)** between 2001 and 2019.
- Waste, stationary energy and agricultural energy emissions reduced between 2001 and 2019, by 36%, 18% and 17% respectively. The reason for the changes differs between sectors. The use of landfill gas capture has driven down waste emissions more than any sector, while greater use of renewable energy to provide electricity has reduced the influence of stationary energy on total emissions. Agriculture emissions reduced due mainly to a reduction in the number livestock e.g. cattle, sheep, pigs, deer farmed within the region.
- Transport emissions and industry emissions both increased between 2001 and 2019, by 14% and 405% respectively. Within the transport sector road emissions from petrol and diesel use increased by 8% from 2001 to 2019. In the industrial sector many emissions are caused by industrial refrigerant use which has increased by 405% in this period.
- The reduction in agricultural emissions is the largest real change (rather than proportionate change) in emissions, decreasing by 286,575 tCO_2e between 2001 and 2019. The increase of -204,348 tCO_2e in emissions in the transport sector was the second biggest real change.
- Net emissions for Wellington Region rose by 34%, from **net 1,902,329 tCO_2e** to **net 2,552,727 tCO_2e** between 2001 and 2019. Net emissions were 650,398 tCO_2e higher in 2019 compared to 2001 due the rise in emissions from the harvest of forest.

1.0 Introduction

AECOM New Zealand Limited (AECOM) has been commissioned by Greater Wellington Regional Council (GWRC) via a consortium of Wellington Region Councils, to assist in the development of a greenhouse gas footprint for the District for the 2018 / 2019 financial year. The study boundary incorporates the jurisdictions of the Wellington Region.

The results of this study are split into two parts. The focus of Part 1 of this document is to explain the results for the 2018/19 financial reporting year. Referred to hereafter as 2019 for ease. Part 2 centres on emission trends in the last two decades (2000/01 to 2018/19), or more simply 2001 to 2019.

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) 2014. The GPC includes emissions from stationary energy, transport, waste, industry, agriculture and forestry activities within the District's boundary. The sector calculations for Agriculture, Forestry, Solid Waste and Wastewater are based on Intergovernmental Panel on Climate Change (IPCC) workbooks and guidance for emissions measurement. Sectors also use methods consistent with GHG Protocol standards published by WRI for emissions measurement when needed.

The same methodology was used for other community scale greenhouse gas (GHG) inventories around New Zealand, (e.g. Auckland, Christchurch, Dunedin, 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 are 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. rail and flights), and energy transportation and distribution losses fit into Scope 3.

All assumptions made during data collection and analyses 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].
- Total emissions are reported as gross emissions (excluding forestry) and net emissions (including forestry)
- Where district-level data was not accessible, information was calculated via a per capita break-down of national or regional level data, this is further detailed in Appendix B.
- Transport emissions:
    - Transport emissions associated with air, rail and port activity were calculated using the induced activity method. Fuel consumption data was determined from the number of journeys taken, distance travelled and consumption rates for the appropriate transport mode.
    - Shipping emissions due to the movement of logs and timber were allocated based on the relative contribution of each district to harvested forest activity within the region.

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)

- 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. The territorial authorities within the Greater Wellington region send waste to various landfill sites both within and outside their territorial boundaries. Examples inside the Region include the Southern Landfill, Spicer Landfill and Silverstream. Examples outside Region include the landfills at Bonny Glen and Levin.
    - As the GPC framework requires an assessment of emissions from waste back to 1950 the waste sent to closed landfill including the Northern Landfill and Wainuiomata Landfill are also included.
- Wastewater emissions:
    - There are a number of wastewater treatment plants in the region which use different methods to treat wastewater. Moa Point, Seaview, Western, and Porirua treatment plants are some of the main plants in the region. Some wastewater in the region is also treated using septic tanks, this is more common in rural areas. An estimate of the population using septic tanks has been used to calculate emissions from septic tanks.
- Industrial 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 emissions associated with industry is also restricted due to confidentiality issues and constraints in communication from relevant stakeholders.
- 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.
- Due to changes in data sources and methodology, emissions quoted for years prior to 2018/19 may be different to those previously reported.

3.0 2019 Emissions Inventory

This section (Part 1) deals with emission results for the reporting year 2018/19 (2019). The paragraphs, figures and tables below explain the overall emissions and emissions from each sector. The focus of the information presented are gross emissions that need to be addressed in local council policy and initiatives. Results in this section are supported by further information and data in Appendix A.

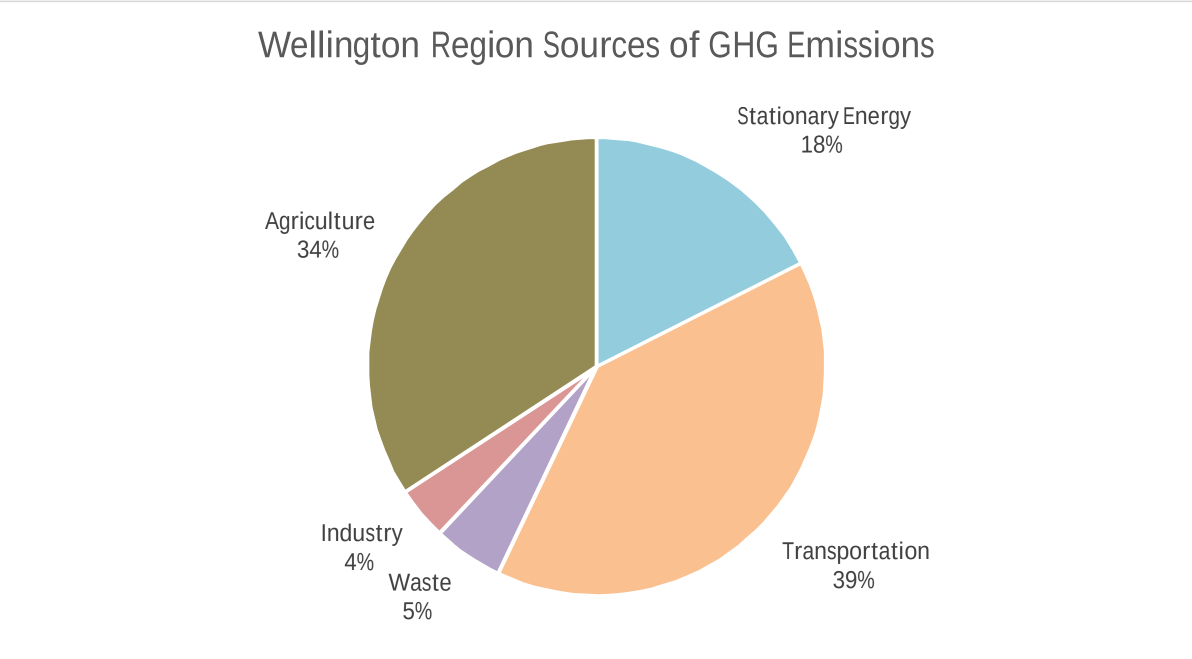
Discussion of per capita emissions is limited to when it is useful for comparing emission figures across the region or with other territorial authorities. Net emissions including results from forestry resources are reported separately.

3.1 Overall results

During the 2018/19 reporting period, Wellington Region emitted **gross 4,190,050 tCO_2e** and **net 2,552,727 tCO_2e** emissions.

The population of the Region in 2019 was approximately 527,790 people, resulting in per capita gross emissions of **7.9 tCO_2e/person.** Transportation emissions are the largest contributor to the inventory for the district, followed by Agriculture (refer to Figure 2 and Table 1).

Figure 2: Wellington Region's GHG gross emissions split by sector.



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

Stationary Energy: Producing 735,469 tCO_2e in 2019, stationary energy was the Region's third highest emitting sector (17.6% of total gross emissions). Electricity consumption was the cause of 341,937 tCO_2e, or 9% of the Region's total gross emissions.

- Industrial stationary energy consumption accounts for 50% of stationary energy emissions (365,742 tCO_2e) and 9% of total gross emissions.
- Residential stationary energy consumption accounts for 21% of stationary energy emissions (154,073 tCO_2e) and 4% of total gross emissions.
- Commercial stationary energy consumption accounts for 17% of stationary energy emissions (121,842 tCO_2e) and 3% of total gross emissions.

- The remaining 13% of stationary energy emissions (93,812 tCO_2e, 2% of gross emissions) were produced by diesel and petrol, which were not allocated to the above categories.

Transportation: The highest emitting sector, transport, produced 1,655,812 tCO_2e in the reporting year (39.5% of gross total emissions). Most of these emissions can be attributed to On and Off-Road transportation (Petrol and Diesel) within the Region, which produced a total of 1,158,614 tCO_2e (70% of the sector's emissions and 35% of Wellington Region's total gross emissions). The rest of the transport emissions are produced by Wellington Region's share of the emissions associated with air, rail, LPG and Bus Electricity and port activities totalling 479,198 tCO_2e (30% of the sector's total emissions and 12% of WC's total gross emissions).

Waste (solid & wastewater): Waste originating in Wellington Region (solid waste and wastewater) produced 206,848 tCO_2e in 2019 which comprises 4.9% of the Region's total gross emissions. Solid waste produced the bulk of this, 180,600 tCO_2e in 2019, making up 87% of total waste emissions.

Solid waste emissions include emissions from both open landfills and closed landfills that are still emitting GHGs. Both open and closed landfills emit landfill (methane) gas from the breakdown of organic materials disposed of in the landfill. Open landfills contributed 99,617 tCO_2e (2%) and closed landfills 80,982 tCO_2e (2%) to gross emissions respectively.

Wastewater produced 26,249 tCO_2e making up 13% of total waste emissions. Wastewater tends to be relatively small emission source compared to solid waste as advanced treatment of wastewater produce 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. The IPPU sector also includes emissions associated with industrial activity within the Region, which due to confidentiality of data, are reported as a single value. IPPU emissions do not include energy use from industrial manufacturing, which is included in the relevant stationary energy sub-category (e.g. coal, electricity and/or petrol and diesel).

IPPU in the Wellington Region produced 157,691 tCO_2e in 2019, contributing 4% to the region's total gross emissions.

Agriculture: The agricultural sector emitted 1,434,230 tCO_2e, in 2019. This sector is the second highest contributor to the Wellington Region's total gross emissions (34.2%). Enteric fermentation produced 80% of the Region's agricultural emissions (1,150,181 tCO_2e). Most of the remaining agricultural emissions 12%, were produced from manure from grazing animals on pasture (174,800 tCO_2e).

Forestry: The Wellington Region has a regenerative native forested area which includes Manuka, Kanuka and Broadleaved Hardwoods. Regenerating natives occupy 146,413 ha with exotics occupying a further 61,436 ha of land. In total, 3,100,370 tCO_2e were sequestered by forests in the Wellington Region in 2019.

Of the total sequestered CO_2, native forests sequestered 864,607 tCO_2e while exotic forests sequestered 2,235,764 tCO_2e in 2019. With emissions produced from harvesting of forestry producing 1,463,047 tCO_2e.

The detailed break-down of emissions into sub-categories for each sector is provided in Table 1, including the percentage contribution per sector and the total gross emissions (excl. forestry).

Table 1: Summary of Wellington Region's gross emissions split by Sector and associated sub-categories.

Sector	tCO_2e	% Gross	% Sector
Stationary Energy			
Electricity Consumption	315,990	7.5%	43.0%
Electricity T&D Loss	25,947	0.6%	3.5%
Natural Gas	212,859	5.1%	28.9%
Natural Gas T&D Loss	33,875	0.8%	4.6%
LPG	36,145	0.9%	4.9%
Stationary Petrol & Diesel Use	93,812	2.2%	12.8%
Coal	8,309	0.2%	1.1%
Biofuel / Wood	8,533	0.2%	1.2%
Total:	735,469	17.6%	100%
Transportation			
Petrol	678,576	16.2%	41.0%
Diesel	480,039	11.5%	29.0%
Rail Emissions	7,262	0.2%	0.4%
Bus (Electric)	108	0.0%	0.0%
Jet Kerosene	271,515	6.5%	16.4%
Av Gas	579	0.0%	0.0%
Marine Diesel	180,472	4.3%	10.9%
Light Fuel Oil	34,588	0.8%	2.1%
LPG	2,673	0.1%	0.2%
Total:	1,655,812	39.5%	100%
Waste			
Solid Waste Disposal	180,600	4.3%	87.3%
Wastewater	26,249	0.6%	12.7%
Total	206,848	4.9%	100%
IPPU			
Industrial Emissions	157,691	3.8%	100%
Total	157,691	3.8%	100%
Agriculture			
Agriculture	1,434,230	34.2%	100.0%
Total	1,434,230	34.2%	100%
Forestry			
Exotic Forest Sequestration	-2,235,764	N/A	N/A
Native Forest Sequestration	-864,607	N/A	N/A
Harvest Emissions	1,463,047	N/A	N/A
Total	-1,637,323	N/A	100%

Total Emissions	**tCO_2e**
Total (net) incl. forestry	**2,552,727**
Total (gross) excl. forestry	**4,190,050**

3.2 Biogenic emissions

Biogenic CO_2 and methane emissions are stated in Table 2 and Table 3, respectively.

Biogenic CO_2 emissions from plants and animals are excluded from gross emissions as they are part of the natural carbon cycle. For example, wood biofuels originate from forestry and 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 warming relative Biogenic CO_2. For example, farmed cattle produce Biogenic CH_4 emissions via enteric fermentation that are 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 between 24 percent and 47 percent below 2017 levels by 2050, and 10 percent reduction 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 (Excluded from gross emissions)

Biogenic Carbon Dioxide (Excluded from gross emissions)		
Biofuel	89,847	t CO_2
Biodiesel	-	t CO_2
Landfill Gas	-	t CO_2
Total biogenic CO_2	**89,847**	**t CO_2**

Table 3 Biogenic Methane (Included in gross emissions)

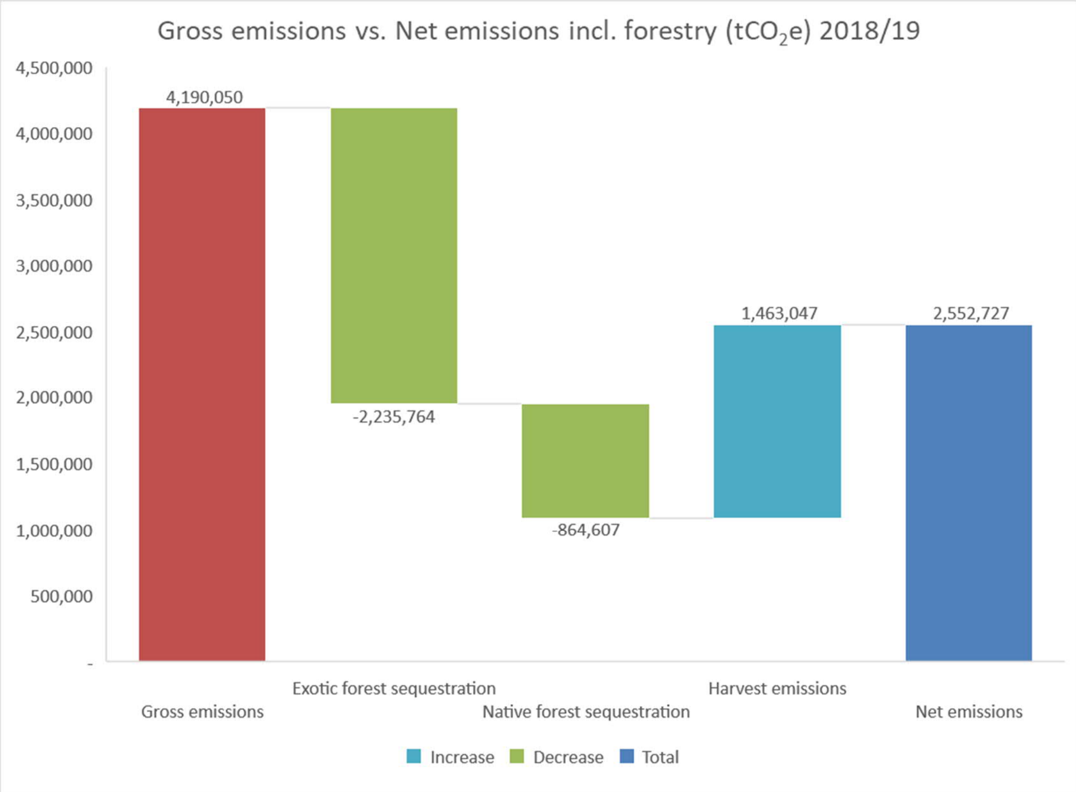
Biogenic Methane (Included in gross emissions)		
Biofuel	225	t CH_4
Biodiesel	-	t CH_4
Landfill Gas	5,312	t CH_4
Wastewater Treatment	437	t CH_4
Enteric fermentation	33,829	t CH_4
Manure Management	1,071	t CH_4
Total biogenic CH_4	**40,874**	**t CH_4**

3.3 Net emissions

Net emissions differ from gross emissions because they include emissions related to forestry activity within an area. Emissions from forestry include two main types of activity. Harvesting of forest increases emissions via the use of fuel by equipment and releasing carbon from plants and soils. Planting of native forest e.g. Manuka, Kanuka 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.

Overall, forestry is a net negative source of emissions of 1,637,323 tCO_2e due the sequestration of carbon mostly by exotic forest. Net negative emissions from forestry reduce gross emissions by 39% to a total of 2,552,727 tCO_2e net emissions. Figure 3 shows gross emissions versus net emissions in 2019 and the impact of sequestration by Forestry.

Figure 3 Gross versus Net emissions incl. forestry



Carbon sequestered by forestry can be viewed as a liability/risk needing careful consideration. For example, what happens if there is 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.

3.4 Breakdown of emissions between the cities and districts in the region

Wairarapa's contributes the most to the Wellington Region's total gross emissions. Wairarapa's high emissions are predominantly due to high agricultural emissions in that district, Wairarapa also has the largest impact of forestry sequestration which reduces its, and Wellington Region's total net emissions.

As expected with the largest population within the region, Wellington City contributes the highest overall emissions in comparison to the other Wellington Region districts (excluding Wairarapa). Hutt City has the second largest population and is the third highest contributor to emissions in the Wellington Region. Upper Hutt contributes the least to the Wellington Region's total gross emissions.

Table 4: Wellington Region overall emissions - a comparison of districts

	Wellington Region	Wellington City	Porirua City	Kāpiti Coast	Lower Hutt	Upper Hutt	Wairarapa
Total Gross Emissions (tCO_2e)	4,190,050	1,061,383	304,431	351,245	532,339	206,331	1,734,320
% of Region Gross Emissions	*100%*	25%	7%	8%	13%	5%	41%

Figure 4 Breakdown of gross emissions between the cities and districts in the Wellington Region

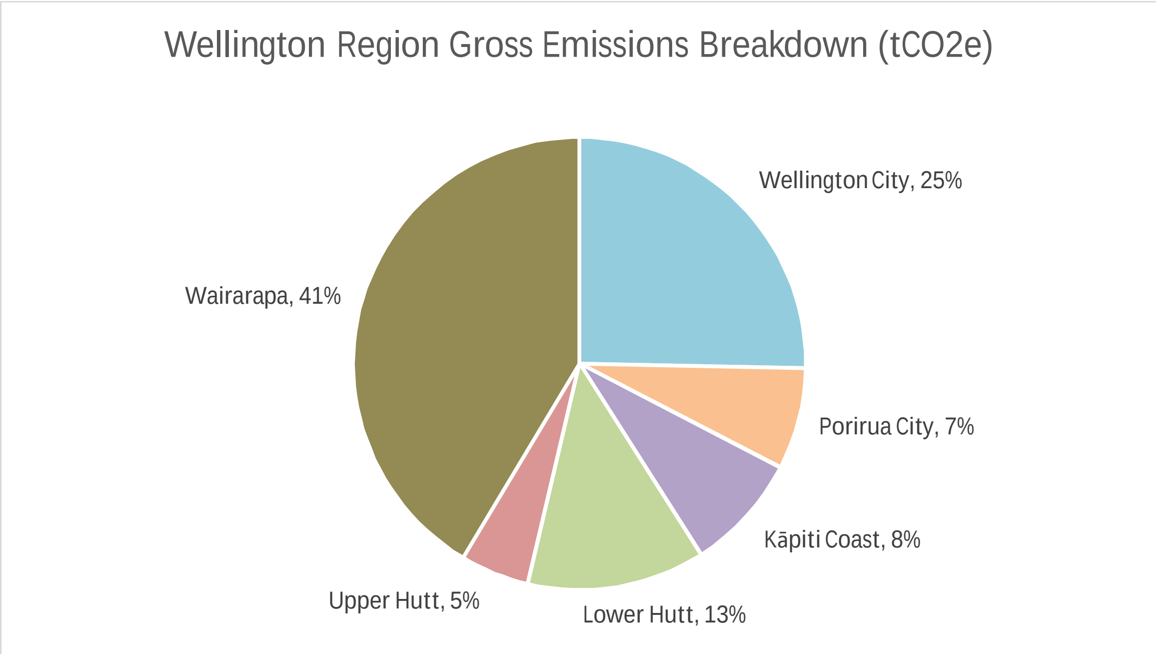


Figure 5 Total gross emissions in the Wellington Region, by sector

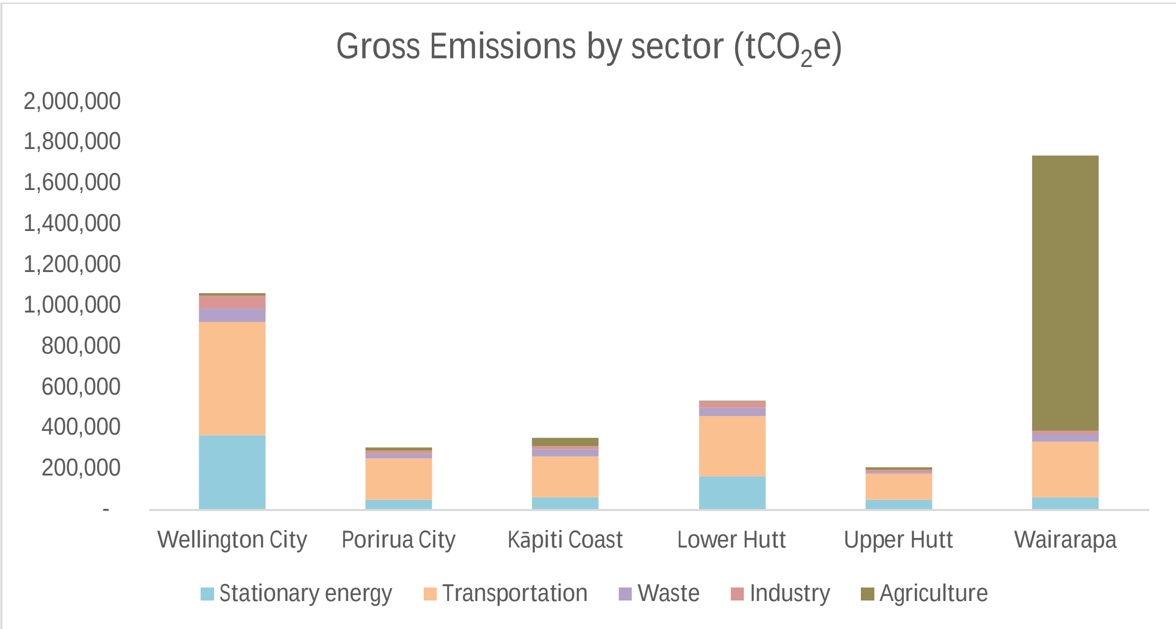


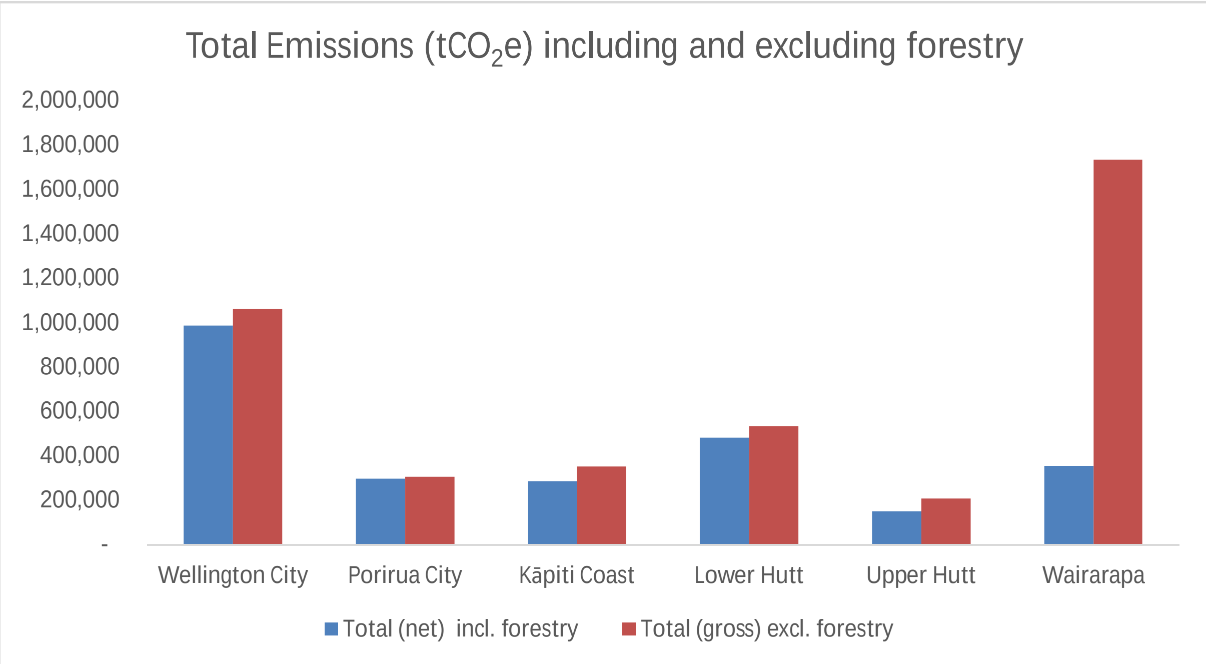
Table 5 shows figures for net emissions including sequestration from forestry. Net emissions produce a widely different pattern of results across the region than gross emissions. For example, net emissions for the Wairarapa, which has the highest gross emissions, are lower than both Lower Hutt and Wellington City.

Table 5 Net emissions (incl. forestry) in the Wellington Region

	Wellington Region	Wellington City	Porirua City	Kāpiti Coast	Lower Hutt	Upper Hutt	Wairarapa
Total Net Emissions (tCO_2e)	2,552,727	986,196	296,815	286,560	480,834	148,862	353,460
% of Region Net Emissions	100%	39%	12%	11%	19%	6%	14%

The influence of forest sequestration of carbon on gross emissions for across the Wellington Region, can be seen clearly in Figure 6.

Figure 6 Gross emissions and net emissions (incl. forestry) in the Wellington Region



4.0 Changes in Emissions Inventory, 2001 to 2019

PART 2 considers the trends in emissions from 2001 to 2019. The focus of these results remains on gross emissions. However, per capita emissions are included when useful. Net emissions are discussed in the context of managing carbon sequestration by forest. Results in this section are supported by further results and data visualisations in Appendix A.

4.1 Change in emissions

The Wellington Region's GHG inventory data covers 2001 to 2019. Figure 7 shows the change in gross emissions for each sector in the years between 2001 and 2019. The 2019 results can be directly compared with calculated data back to 2001 by using the same data and methodology as this study.

Total gross emissions fell by 5%, from 4,427,849 tCO_2e in 2001 to 4,190,050 tCO_2e in 2019, a difference of 237,799 tCO_2e. Reductions in emissions from Waste, Stationary Energy, and Agriculture are responsible for the fall in total gross emissions. As the Region's population has risen, per capita gross emissions have reduced by 21% from 10.1 tCO_2e in 2001 to 7.9 tCO_2e in 2019.

The rest of this section briefly summarises major changes in the sectors that make up community-scale emissions.

- **Stationary Energy:** Emissions from stationary energy reduced in number, and as a proportion of total gross emissions, in this time from 900,449 tCO_2e (20% of total gross emissions) to 735,469 tCO_2e (18% of total gross emissions), a fall of 2%.

  Emissions from residential stationary energy consumption shrank by 29% between 2001 and 2019, from 218,318 tCO_2e to 154,073 tCO_2e. Emissions from commercial stationary energy consumption decreased by 26%, from 163,958 tCO_2e to 121,842 tCO_2e). Industrial stationary energy emissions dropped by 19%, from 453,745 tCO_2e to 365,742 tCO_2e. Overall, the sector's emissions fell by 23% across industrial, residential and commercial activities between 2001 and 2019.

  The main changes in stationary energy emissions are explained most noticeably by the changes in electricity, natural gas, petrol and diesel use between 2001 and 2019. The change in electricity consumption in 2001 and 2019 was 5% while associated emissions reduced by 31% (496,892 tCO_2e to 341,937 tCO_2e). The fall in stationary energy electricity emissions are largely due to changes in the mix of fuels used for electricity generation in New Zealand e.g. the greater use of renewable energy including wind rather than fossil fuels e.g. oil, gas and coal. The use of fossil fuel to generate electricity in New Zealand has decreased since 2010 and has been replaced by renewable sources. For example, oil for electricity production was phased out and the use of wind power increased.

  Natural gas use for stationary energy has a direct relationship to the change observed in emissions. Emissions from natural gas lowered by 9% from 223,840 tCO_2e in 2001 to 199,720 tCO_2e in 2019.

  The emissions from petrol and diesel used for stationary energy have different trends between 2001 and 2019. Petrol emissions fell by 7% from 5,432 tCO_2e to 5,031 tCO_2e. In the same year's diesel emissions increased from 58,996 tCO_2e to 88,781 tCO_2e, a rise of 50%.

- **Transport:** Emissions from transport increased in number, and as a proportion of total gross emissions between 2001 and 2019, from 1,451,464 tCO_2e (33% of total gross emissions) to 1,655,812 tCO_2e (40% of total gross emissions), an increase of 7%.

  Road transport is the highest emitting activity within the transport sector. Road emissions increased by 8% between 2001 and 2019. Petrol emissions reduced by 7%, from 732,651 tCO_2e in 2001 to 678,576 tCO_2e in 2019 and diesel emissions rose by 50% (161,047 tCO_2e), from 318,992 tCO_2e to 480,039 tCO_2e.

  Air travel also emissions grew in importance for the transport sector. Emissions jumped by 36% (70,574 tCO_2e) from 197,829 tCO_2e to 268,403 tCO_2e in 2001 and 2019, respectively. Marine transport emissions also trended upwards by 22%, up from 176,003 tCO_2e in 2001 to 215,060 tCO_2e in 2019.

- **Waste (solid & wastewater):** Waste emissions are an important measure of progress for reducing environmental impact for many stakeholders. Overall waste emissions dropped by 36% from 323,927 tCO_2e in 2001 to 206,848 tCO_2e in 2019. The change in emissions reflects the impact of greater use of landfill gas capture. Gas capture reduces the warming effect of emissions from landfill by either using the methane captured for electricity production or breaking it down by flaring.

  Waste continues to emit methane for many years after entering a landfill site. We have calculated annual emissions from currently open, and currently closed, landfill sites (as of 2019). Solid waste emissions from closed landfill sites reduced by 46% (80,634 tCO_2e) from 175,783 tCO2e in 2001 to 95,149 tCO_2e in 2019. In 2001 solid waste emissions from currently closed landfill sites made up 54% of total waste emissions for the Wellington Region. None of the sites included in this category have landfill gas capture capability. By 2019 the same emission source still accounted for 46% of total waste emissions.

  Solid waste emissions from currently open landfill sites decreased by 32% from 126,090 tCO_2e in 2001 to 85,451 tCO_2e in 2019. Since reaching a peak in 2012, emissions from open landfill sites have decreased by 47%. This is due to the increased use, and efficiency of, landfill gas capture systems.

  Wastewater emissions are the smallest cause of emissions in the waste sector. As the population of the Region has grown (by 32% between 2001 and 2019), associated emissions from the treatment of wastewater have trended upward. Wastewater emissions increased from 22,053 tCO_2e in 2001 to 26,249 tCO_2e in 2019, 19% higher.

- **Industry (IPPU):** Industrial Processes and Product Use (IPPU) emissions between 2001 and 2019 were a relatively small part of total gross emissions (representing 1% and 4% of total emissions in 2001 and 2019 respectively). Emissions from industrial sources jumped to 157,691 tCO_2e from 31,206 tCO_2e in this time, an increase of 405%. The increase in the industrial emissions follows developments at the national level in NZ where emissions have risen.

- **Agriculture:** Agriculture contributed second highest number of emissions (34%) to the Region's footprint, despite falling by 17%, from 1,720,804 tCO_2e to 1,434,230 tCO_2e, between 2001 and 2019. The number of farm animals within the Region area e.g. cattle (both diary and non-dairy), sheep and pigs fell from 2,154,677 to 1,721,907 in this period. Agricultural emissions remain an important source of Biogenic Methane targeted as a reduction opportunity in the Climate Change Response (Zero Carbon) Amendment Act.

- **Forestry:** In the last two decades sequestration levels from regenerating forest remained steady. Sequestration by exotic forest was main source of capturing carbon in this time. Carbon sequestered per year by exotic forestry (e.g. pine) fell by less than 1%, sequestering 2,256,015 tCO_2e in 2001 compared to 2,237,507 tCO_2e in 2019. Native forests (e.g. Manuka and Kanuka) stored 865,360 tCO_2e and 864,607 tCO_2e, in 2001 and 2019 respectively; a change of just 0.1%.

  Data availability and quality for harvest emissions has rapidly improved in recent years. Harvesting emissions increased 147% from 595,855 tCO_2e in 2001 to 1,470,875 tCO_2e in 2019. The growth in harvesting emissions potentially means exotic trees are being removed in greater numbers.

Figure 7 Gross emissions per year (excluding forestry) from 2001 to 2019

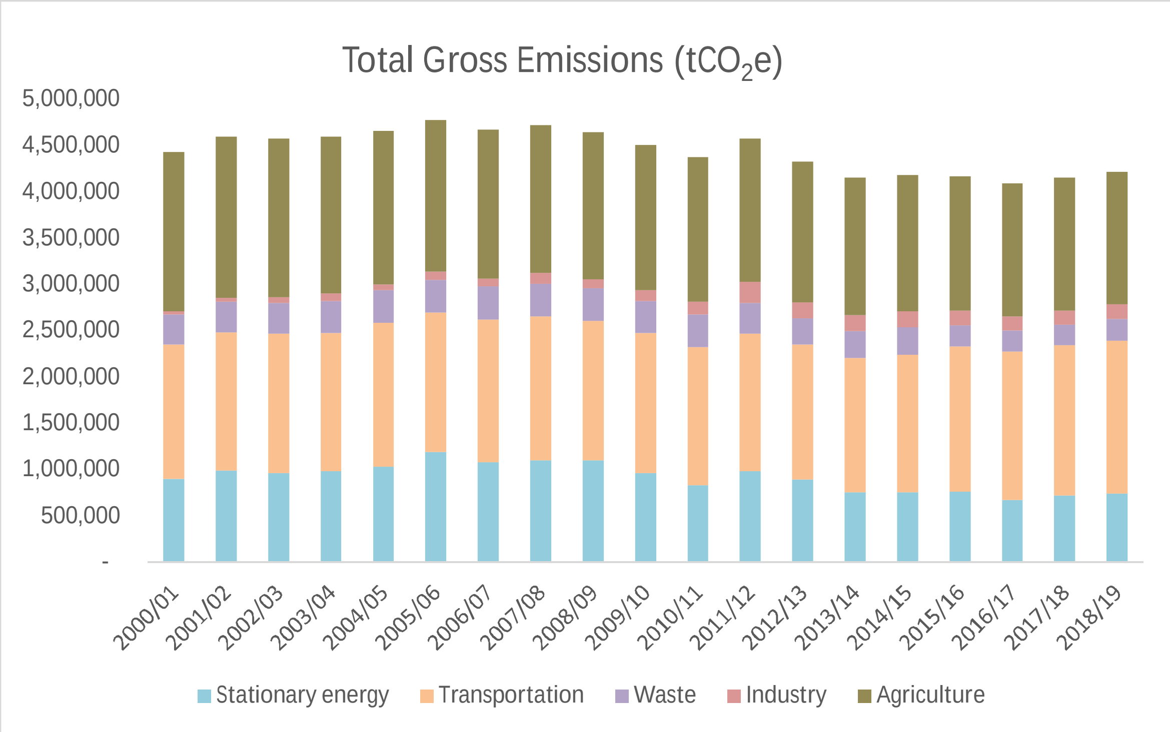
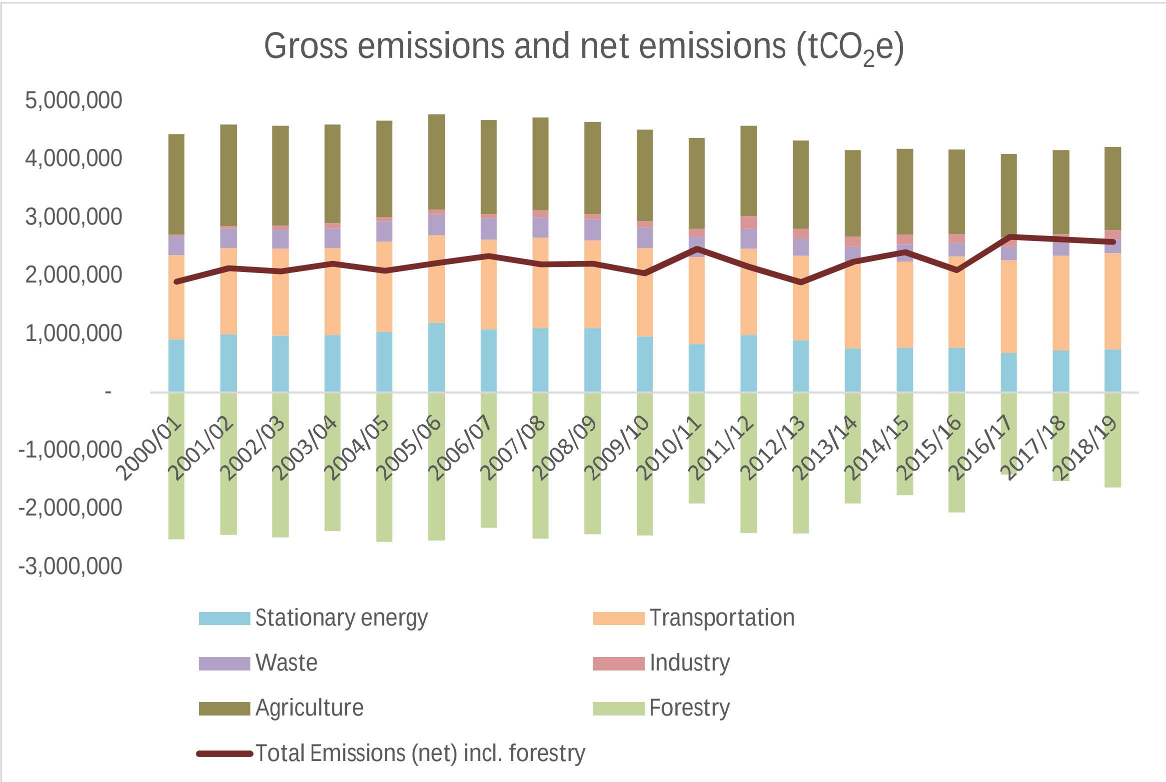


Figure 8 shows the impact of sequestration in the forestry sector on reducing net emissions. Net forestry sequestration remained steady in Wellington Region and the change in net emissions follows the same pattern as gross emissions.

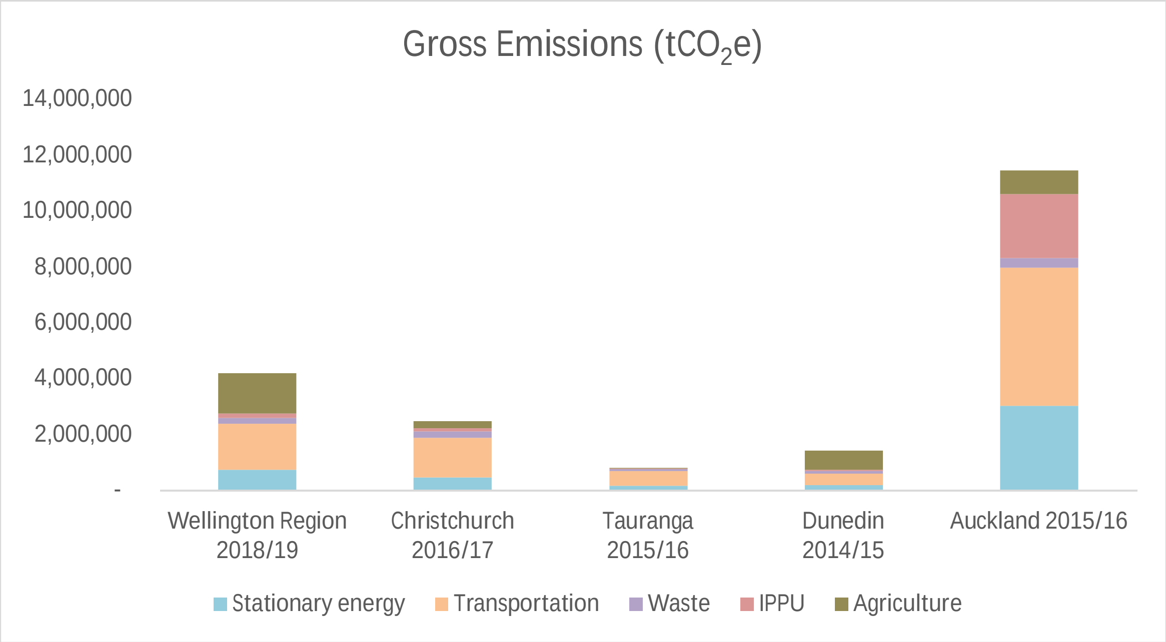
Figure 8 Emissions per year showing gross and net emissions (including forestry) from 2001 to 2019



5.0 Comparison with other New Zealand cities and regions

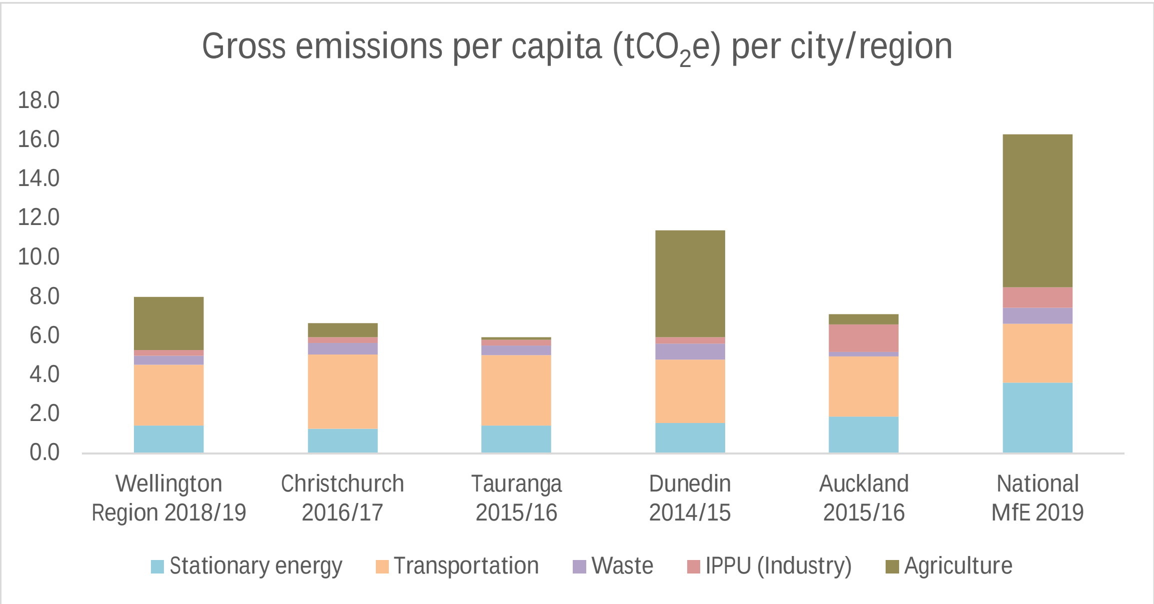
When compared with other GHG Inventory studies, Wellington Region has higher gross emissions compared to Christchurch, Tauranga and Dunedin and lower gross emissions than the Auckland Region. Note that the compared studies were conducted at differing geographic levels and in differing timeframes.

Figure 9 Comparison of gross emissions by city/region



When comparing different regional carbon footprints, a per capita figure can be useful because it provides a common reference point to understand the difference in emissions. The Wellington region has higher per capita gross emissions than Christchurch, Tauranga and Auckland partly due to large agricultural emissions within the region. However, per capita emissions in Wellington Region are lower than Dunedin and the National Inventory.

Figure 10 Comparison of per capita gross emissions by city/region



6.0 Emissions and other metrics

Figure 11 shows the change in gross emissions when compared to changes in other metrics of interest between 2001 and 2019. Total gross emissions have reduced by 5%, against the backdrop of a 20% growth in population within the Wellington Region. Per capita emissions have fallen roughly in line with the rise in population observed.

When emissions grow less rapidly than Gross Domestic Product (GDP) as a measure of income then this 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. However, the changes in emissions and GDP illustrated in Figure 11 suggest at a high-level decoupling has occurred in the last two decades. GDP was 48% higher in 2019 than in 2001 while emissions per unit of GDP declined by 36%.

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

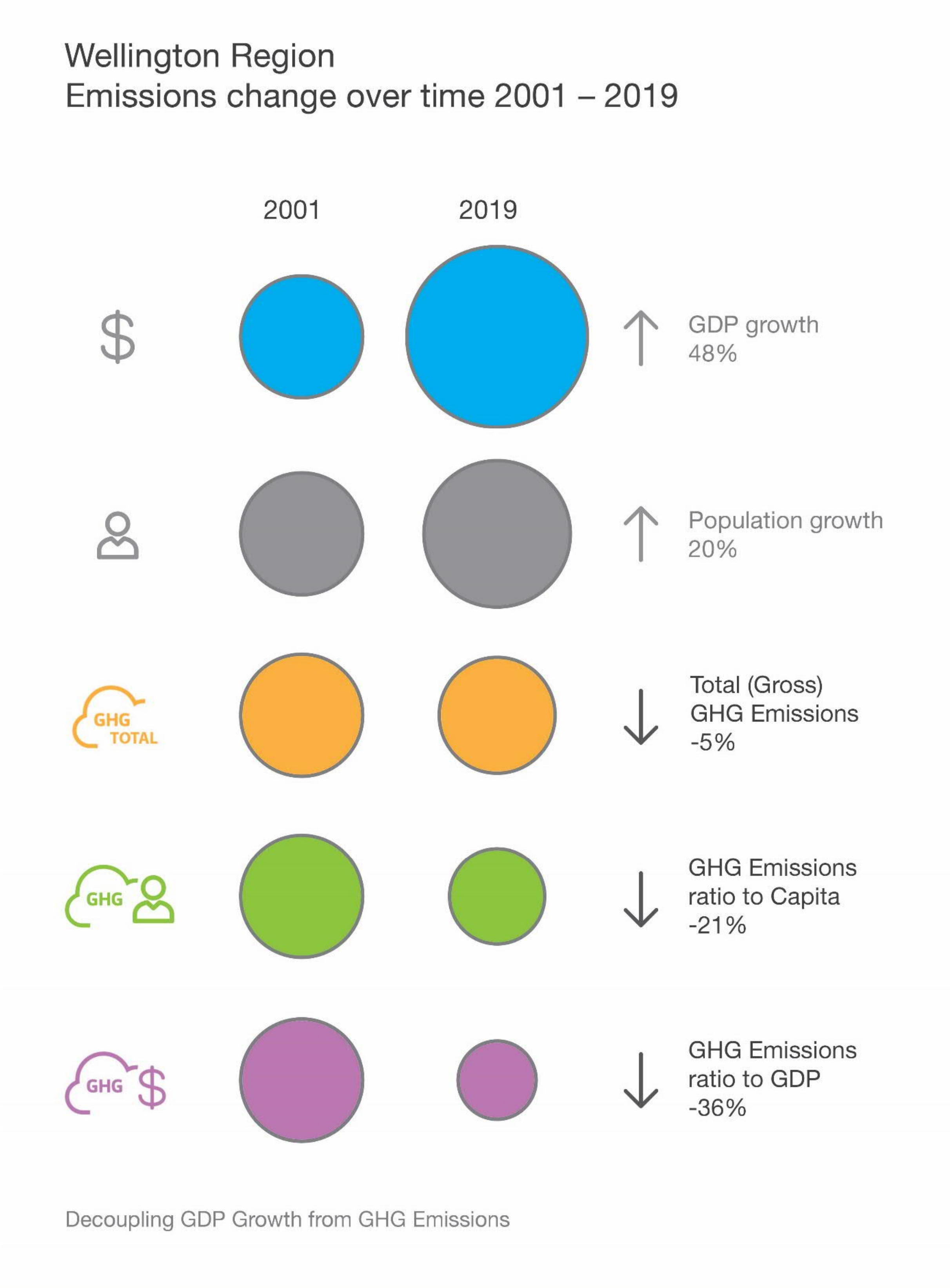
7.0 Closing statement

Wellington Region's updated GHG inventory provides information for the Council to demonstrate progress in emissions reductions as well as providing a continuing platform for action by the Regional Council, their stakeholders and the wider community**.** Sector-level data allows the City Council to target and work with those sectors, e.g. transport, which contribute the most emissions to the footprint.

Understanding of the extensive and long-lasting effects of climate change are improving all the time. The database the Council has developed over the last two decades provides an excellent foundation to implement informed decisions and policies to reduce emissions and to address climate change adaptation across the region.

We encourage councils to use the results of this study to update current climate actions plans. For example, results clearly highlight the need for rapid action to tackle the growth in emissions from air travel, marine shipping, and diesel consumption. Stationary Energy accounts for around a third of emissions; facilitating improvements in energy efficiency within this sector may be an effective method of reducing overall emissions.

Figure 11 Change in total gross emissions compared to other metrics of interest



8.0 Limitations

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Appendix A

Emission Breakdowns

Appendix A Emission Breakdowns

The pie charts below show a breakdown of the proportion of gross emissions from each sector and source. The second pie chart is focussed on the sources of emissions from stationary energy and transport emission sources.

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

Figure 12 Total gross emissions breakdown, by source

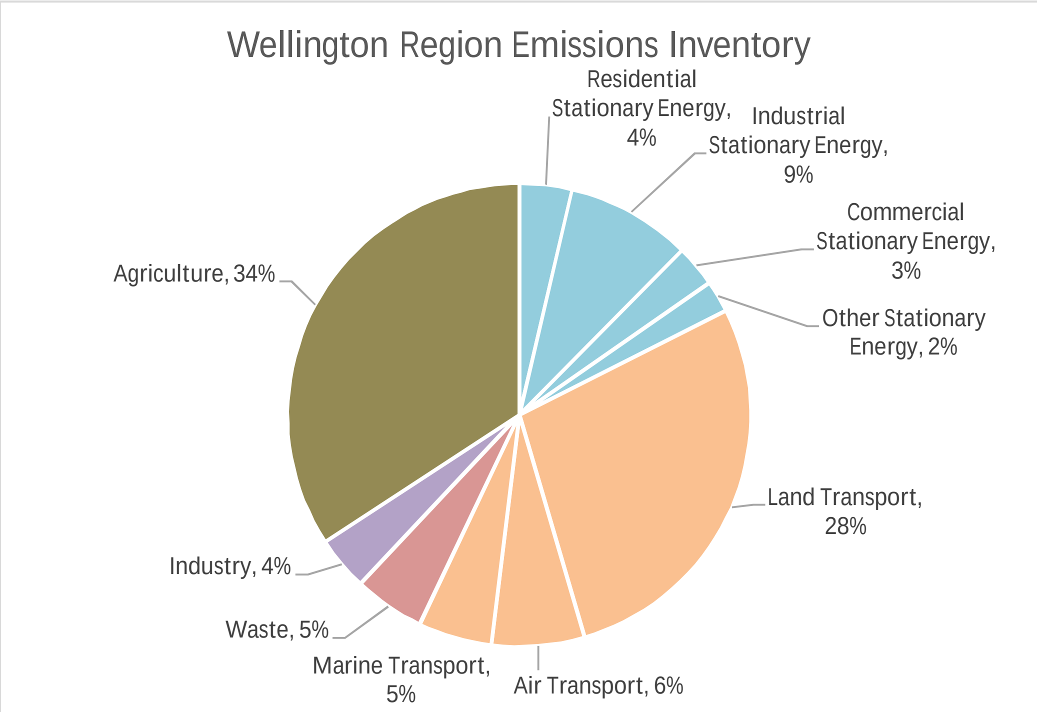


Figure 13 Total gross emissions breakdown, by detailed source (emissions representing less than 1% of total emissions are not shown)

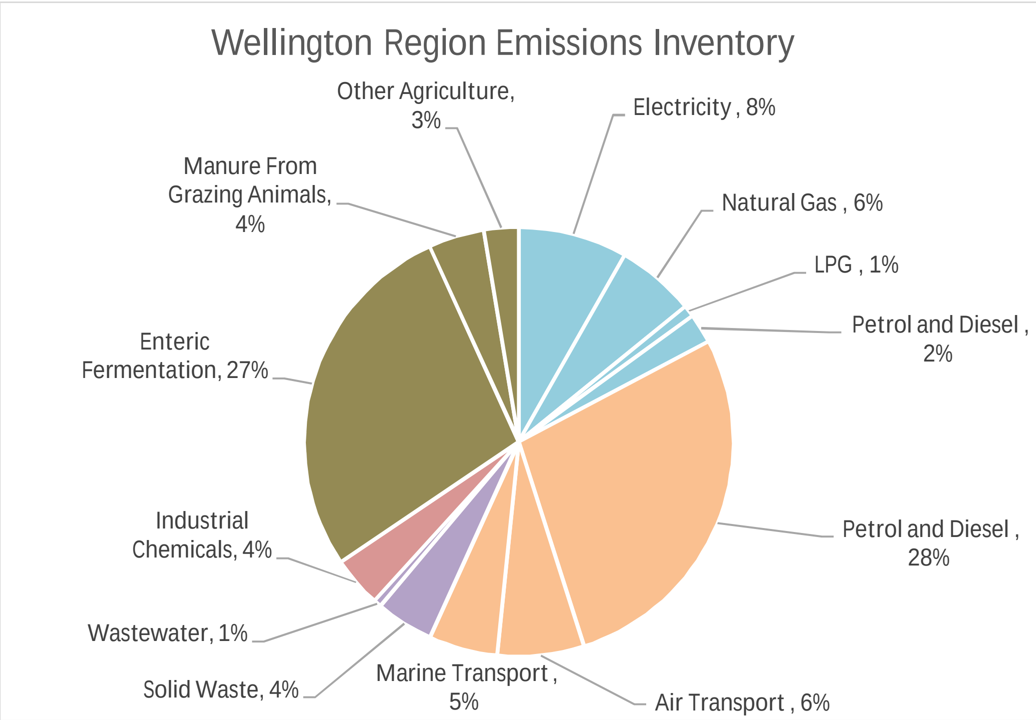


Figure 14 Total gross emissions breakdown, by source, highlighting stationary energy emissions

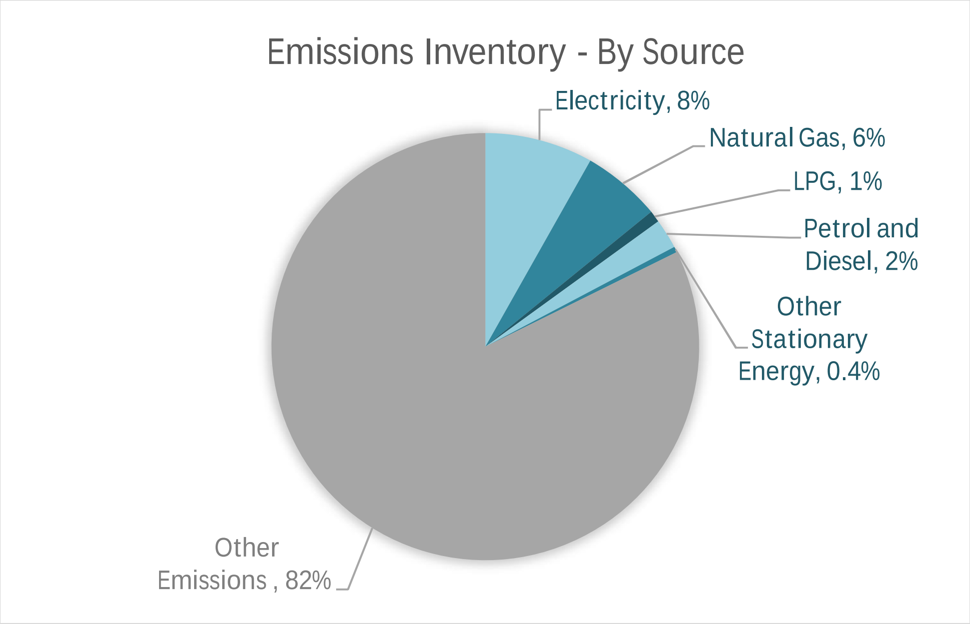


Figure 15 Total gross emissions breakdown, by sector, highlighting stationary energy emissions

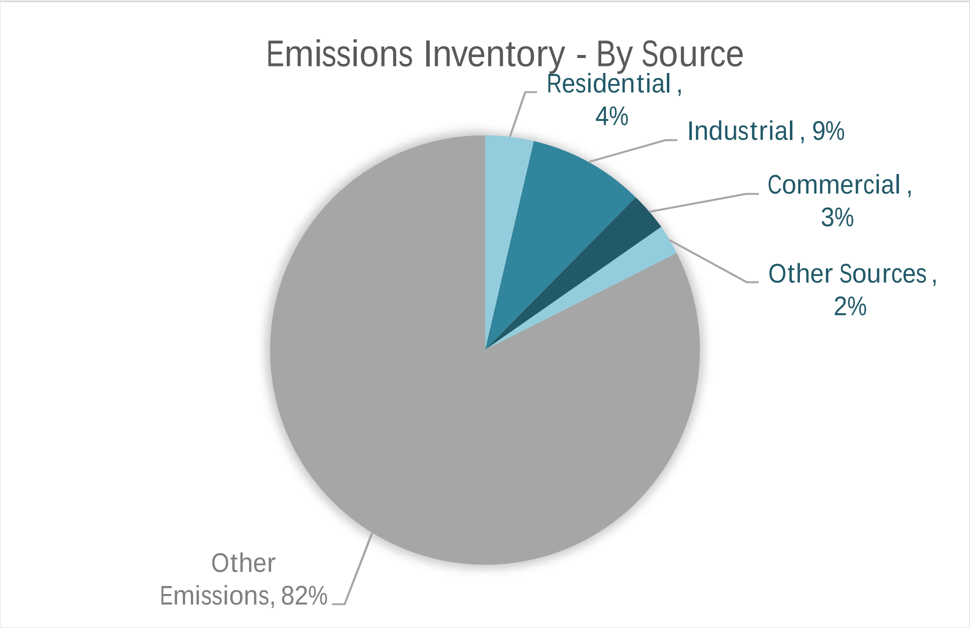


Figure 16 Total gross emissions breakdown, by source, highlighting agriculture emissions

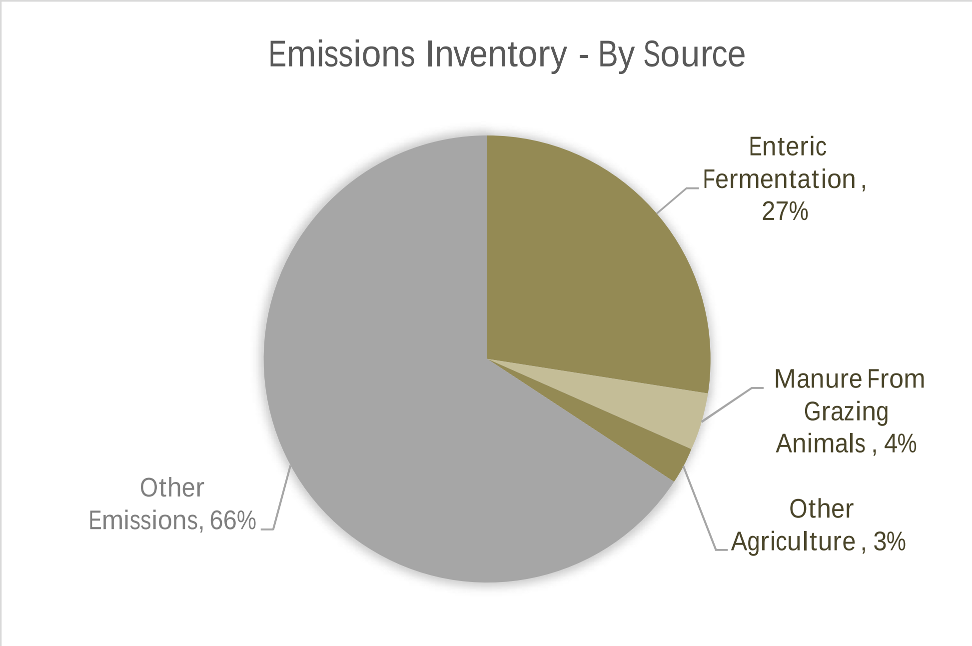
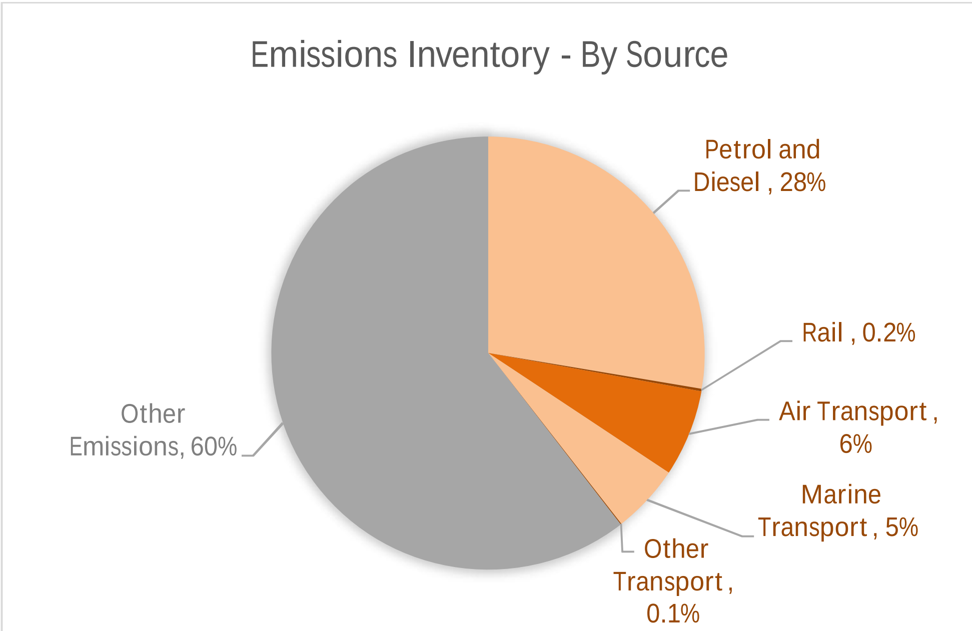


Figure 17 Total gross emissions breakdown, by source, highlighting transport emissions



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 for comparison of emissions with other cities around the world and to demonstrate the importance of regional-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 greenhouse gas emissions occurring outside the regional boundary as a result of activities taking place within the regional 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 6 BASIC and BASIC+ emissions

	Emissions tCO_2e
BASIC	2,538,308
BASIC per capita	4.8
BASIC+	4,190,050
BASIC+ per capita	7.9

Per capita emissions

The Wairarapa's particularly high per capita emissions are predominantly due to a large agricultural sector in that region, combined with a small population.

Figure 18 A comparison of per capita gross emissions (tCO_2e) between territorial areas in the Greater Wellington Region.

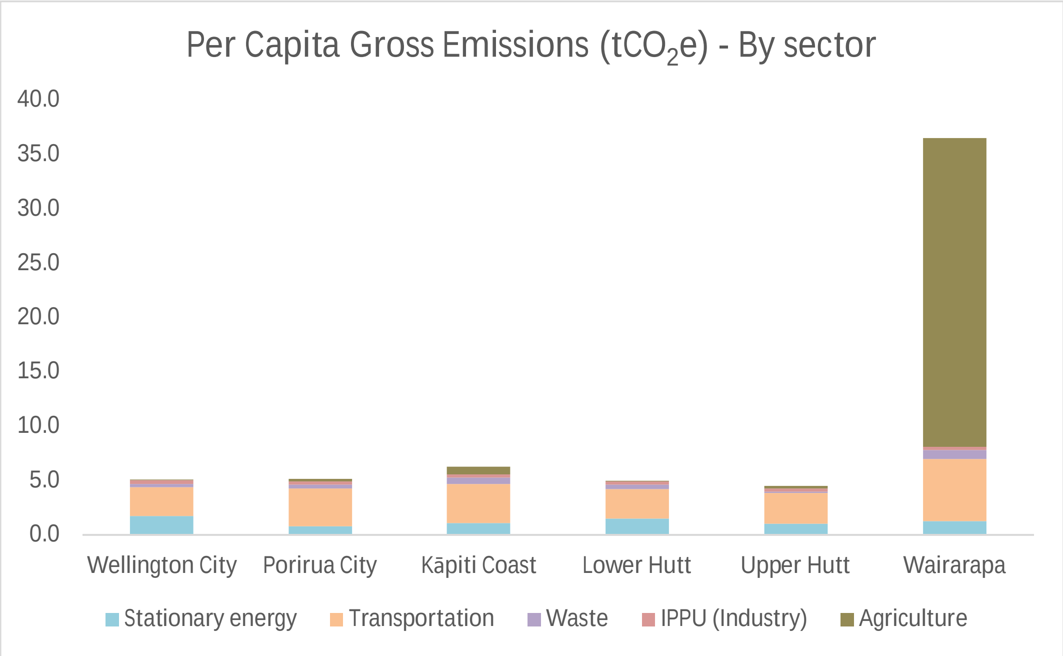


Figure 19 A comparison of per capita gross emissions (tCO_2e) between territorial areas in the Greater Wellington Region, excluding the Wairarapa.

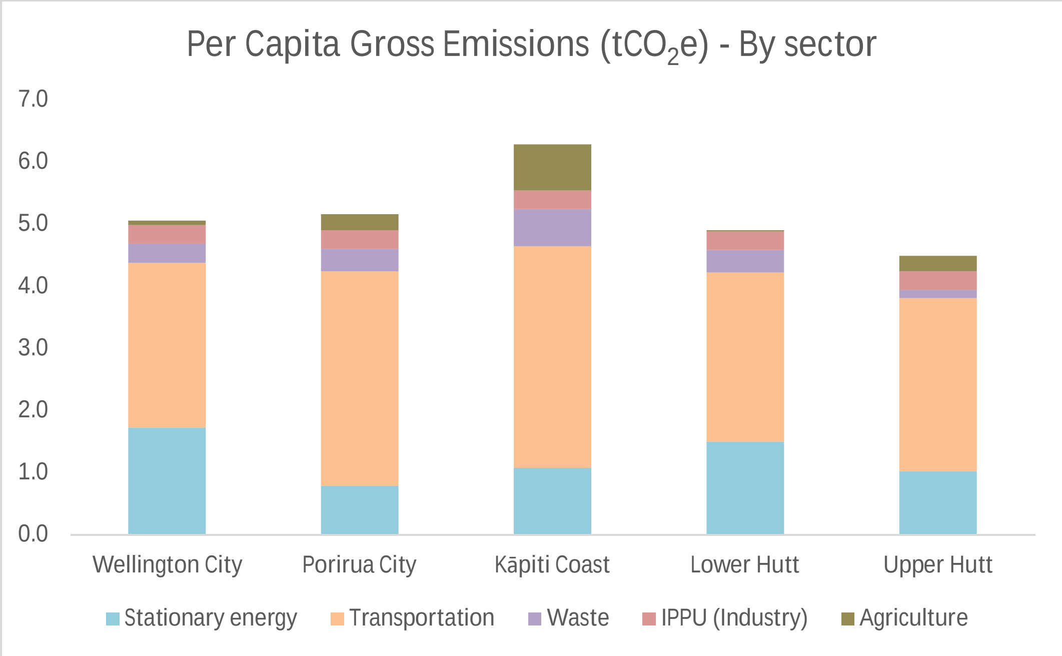
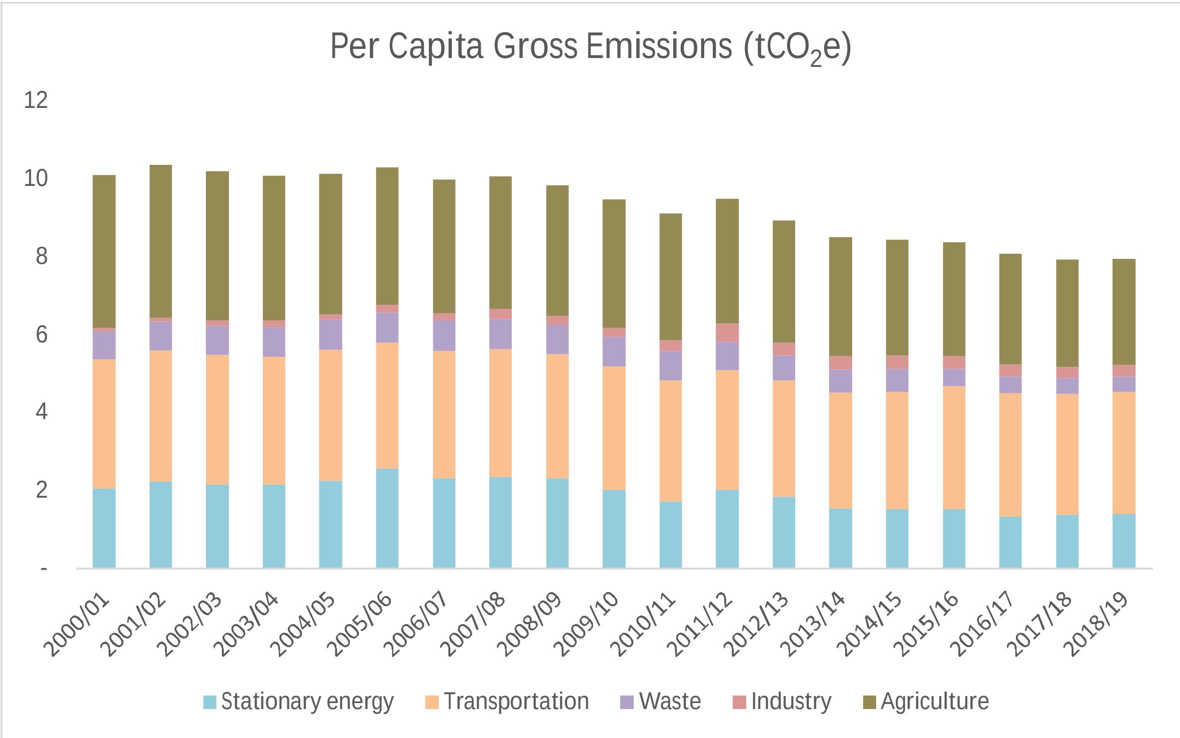


Figure 20 Per capita gross emissions per year, by sector (2001-2018/19)



Appendix B

Assumptions

Nova Sector / Category	Assumption and Exclusions
General	
Geographical Boundary	LGNZ local council mapping boundaries have been applied
Population	Where district-level data was not accessible, information was calculated via a per capita break-down of national or regional level data. This is detailed in each emission section below.
Transport Emissions	
Petrol and Diesel:	Regional sales figures were used. The transport vs stationary energy share of the fuel was calculated using national inventory data. The on-road and off-road split of petrol and diesel was calculated using the Energy Efficiency and Conservation Authority (EECA) national percentage split. On-road is defined as all standard transportation vehicles used on roads e.g. cars, bikes, buses. Off-road is defined as machinery for agriculture, construction and other industry used off-roads.
Rail Diesel	Consumption was calculated by Kiwi Rail using the Induced Activity method for system boundary. The following assumptions were made: - Net Weight is product weight only and excludes container tare (the weight of an empty container) - The Net Tonne-Kilometres (NTK) measurement has been used. NTK is the sum of the tonnes carries multiplied by the distance travelled. - National fuel consumption rates have been used to derive litres of fuel for distance. - Type of locomotive engine used, and jurisdiction topography, have not been incorporated in the calculations. Using the induced activity method, the trans-boundary routes were determined, and the number of stops taken along the way derived. The total amount of litres of diesel consumed per route was then split between the departure region, arrival region and any region the freight stopped at along the way. If the freight travelled through but did not stop within a region, no emissions were allocated.
Jet Kerosene	Calculated using the Induced Activity method as per rail diesel. - All flight-path distances between the airport and the destination / origin airport were calculated. - A density for kerosene of 0.81g/cm^3 was applied to all trips. - Fuel Burn (kgCO_2e/km) for each model of aircraft was sourced were accessible. Where not available, the national inventory average figures were applied. - As per the induced activity method, only 50% of emissions calculated per one-way arrivals and departures were allocated to the airport. The remaining 50% of each leg was allocated to the originating or destination airport.

	- Light aircraft emissions were not calculated. Only a very small number occur, so assumed to be insignificant. Wellington Airport: - Departures and arrivals information, and aircraft models, were used to calculate flight numbers and represent the models of aircraft for the years between 2016 and 2019. - Fuel use data for aviation was also collected and used when possible to provide consistency with previous reporting. Kapiti Coast Airport (Paraparaumu): - The total number of annual scheduled flights, and aircraft models, has been used to calculate total fuel use for the reporting year. Scope 2 electricity use by airport / planes are incorporated within the general electricity consumption data for the district.
Aviation Gas	Av Gas consumption was estimated based on community carbon footprints developed for other regions in New Zealand.
Marine Diesel	Port Operations: - As per the induced activity method, only 50% of emissions calculated per one-way arrivals and departures were allocated to Wellington Port (CPL). The remaining 50% of each leg was allocated to the originating or destination port.
Light Fuel Oil	Calculated using the Induced Activity method as per the rail and aviation data. Does not include fuel use for private boating
LPG	North Island national consumption figures were used. LPG consumption and associated emissions have been split on a per capita basis to the region.
Bitumen	Not calculated
Lubricants	Not calculated
Stationary Energy Emissions	
Electricity Demand	Electricity demand has been calculated using national-level demand figures (kWh) from the MBIE, broken down on a per capita basis to the region. The breakdown into sectors is based on NZ average consumption per sector (residential, commercial and industrial).
Electricity Generation	There is electricity generation in the Wellington region, 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.
Public transport electricity	There are electrified public transport systems in the Wellington region. Data has been provided at the regional level.
Coal production	Not Calculated: There are no active coal mines within the region. (NZP&M 2019)
Coal Consumption	Consumption estimates based on national Commercial and Residential consumption for reporting years. Consumption and associated emissions have been split on a per capita basis to the region.

Biofuel and Wood Consumption	Consumption estimates based on national Commercial and Residential emissions for biofuel use (provided New Zealand Greenhouse Gas Emissions 1990 -2015 (MfE 2017). Consumption and associated emissions have been split on a per capita basis to the region.
LPG Consumption	National LPG sales data has been provided by the LPG Association. Consumption and associated emissions have been split on a per capita basis to the region.
Natural Gas Consumption	No assumptions were made around the region's general consumption data received from Vector. This information includes gas consumed by industrial, commercial and residential activities.
Coal Fugitive Emissions	Not Calculated: There are no active coal mines within the region. (NZP&M 2019)
Oil and Gas Fugitive Emissions	Not Calculated: There are no gas or oil processing plants within the region.
Biogenic Emissions	Consumption estimates based on national Commercial and Residential emissions for biofuel use (New Zealand Greenhouse Gas Emissions 1990 -2017 (MfE 2019). Consumption and associated emissions have been split on a per capita basis to the region.
Agricultural Emissions	
General	District-specific data provided by Statistics NZ and the Ministry for the Environment National Inventory. District emissions totalled to provide the region total.
Solid Waste Emissions	
Open Landfills	District-specific data used and then totalled to provide the region total. Emissions from landfill originating in the Region but sent outside the Region, at Bonny Glen and Levin sites, is included in the Wellington Region emissions inventory and discounted from the destination region's emissions inventory.
Landfill Gas Recovery	LFG efficiency has been estimated based on LFG generation from waste deposited and reported LFG extraction volumes.
Closed Landfills	Data provided at the district level.
Waste Water Emissions	
Waste Water Volume	Data was provided in calendar year only. District-specific data used and then totalled to provide the region total. No wastewater crosses regional boundaries.
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. BOD has been assumed using influent composite samples and inlet flow metres.
Population connected to WWTP or Septic tanks	Population connected to waste water treatment plant or septic tanks has been provided at the district level.
Industrial Emissions	
Industry & Solvent Emissions	Calculated from MfE National Inventory data, as this the latest, most recently available data on the required solvents for the calculations to be undertaken. Emissions are estimated on a per capita basis.
Industrial Activity	No information could be obtained from Industry representatives within the region. National level data has been used and split on a per capita basis to the region.
Forestry Emissions	

Exotic Wood harvested	Data provided at a regional level.
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.
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 EF have been applied.