Wellington City Council
23-Dec-2020

Wellington City Greenhouse Gas Inventory 2019/20

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Wellington City Greenhouse Gas Inventory 2019/20

Client: Wellington City Council

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Prepared by

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Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
1	7-Dec-2020	Final Draft	Ruth Williams Building Performance Lead NZ	
2	23-Dec-2020	Final	Anthony Hume Team Leader - Sustainability and Resilience	

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Executive Summary

Carbon emissions for Wellington City have been measured using the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC). The method includes emissions from stationary energy, transportation, waste, industrial processes and product use (IPPU), agriculture and forestry sectors. Figure 1 summarises Wellington City's greenhouse gas emissions inventory for the 2019/20 reporting year and includes the relative contribution of each emissions sector to Wellington's total gross emissions and the top contributing emissions sources for each sector. Figure 2 shows the rate of change in total emissions from each emissions sector from 2001 to 2020.

Figure 1 Summary of emissions in 2020 including top contributors to total gross emissions from each sector

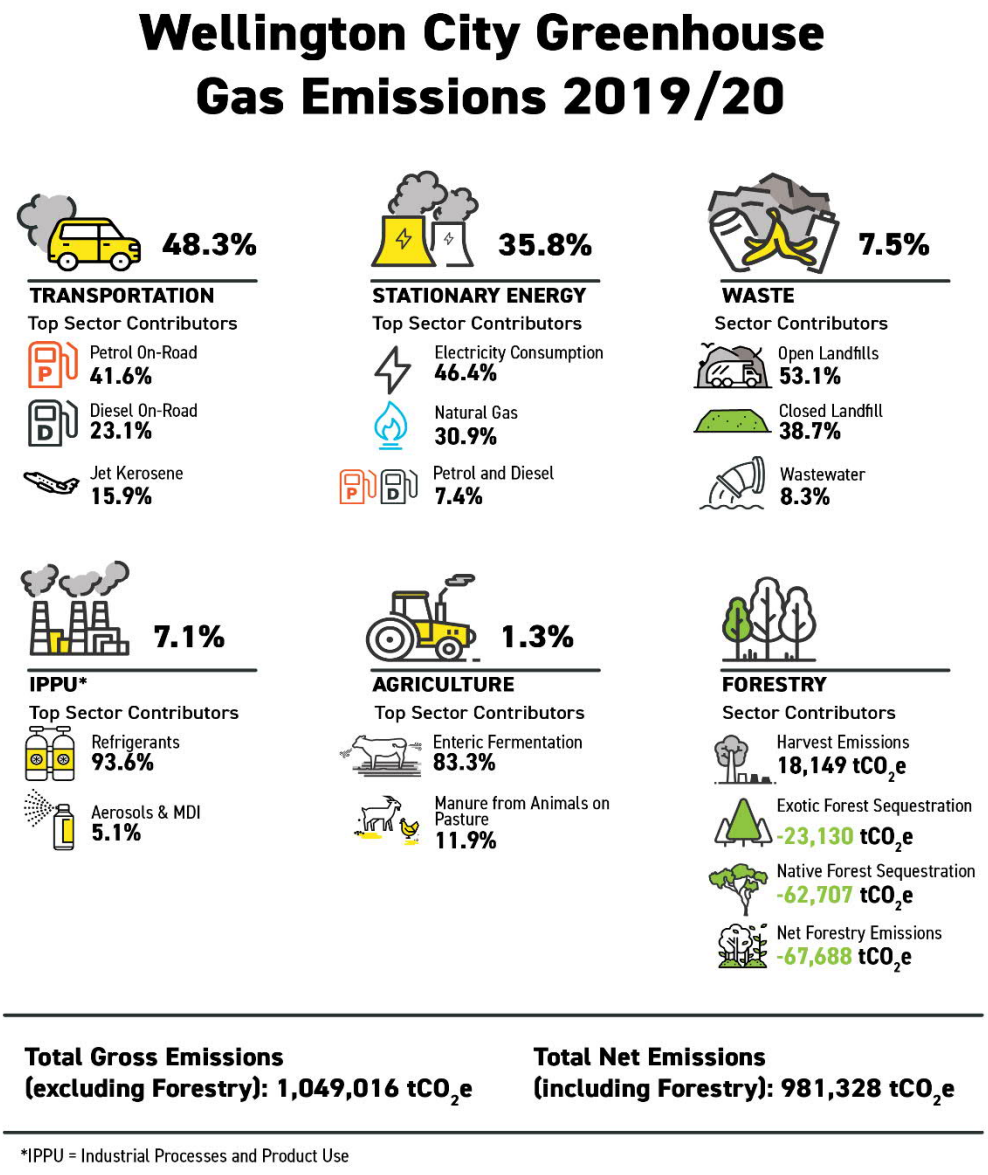
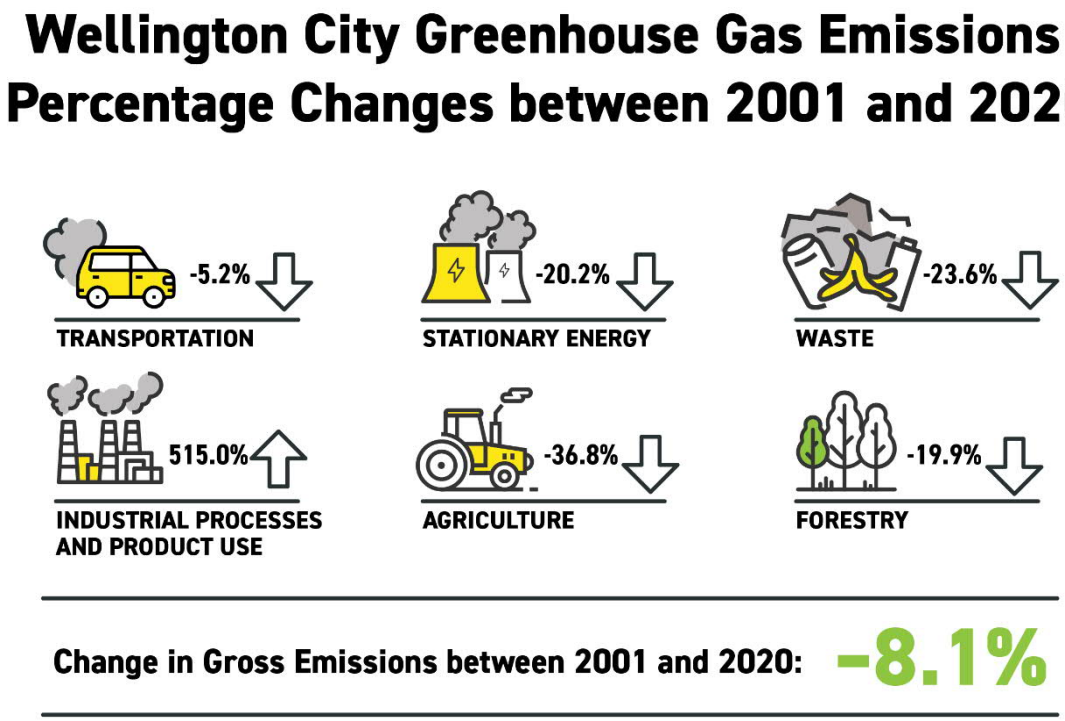


Figure 2 Summary of changes in emissions from each emissions sector from 2001 to 2020



The document is split into two parts. Part 1 of this document focusses on the results for the 2019/20 financial reporting year, referred to hereafter as 2020 for ease. Part 2 centres on emission trends in the last two decades 2000/01 to 2019/20 (or more simply 2001 to 2020). All emissions here are expressed in units of carbon dioxide equivalent (tCO_2e). Major findings of the project include:

PART 1 – 2020 Emissions Inventory

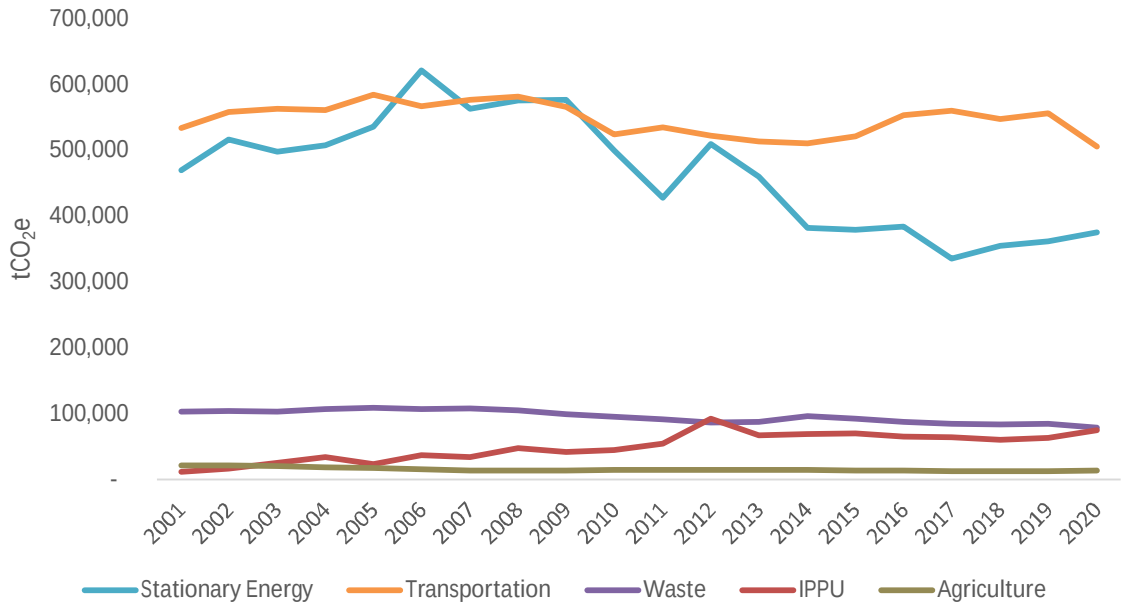
- In the 2020 reporting year, Wellington City emitted **gross 1,049,016 tCO_2e**.
- Transportation (e.g. road, rail, and air travel) is the biggest source of emissions accounting for 48.3% of total gross emissions.
- Stationary energy (e.g. electricity or gas consumption) is the second largest emitter, 35.8% of total gross emissions.
- Waste (7.5% of total gross emissions), IPPU (7.1% of total gross emissions) and agriculture (1.3% of total gross emissions) are the smaller sources of emissions in Wellington City.
- After consideration of carbon sequestration (carbon stored in plants or soil by forests), Wellington City emitted **net 981,328 tCO_2e** emissions.

PART 2 – Changes in Emissions Inventory, 2001 to 2020

Wellington City's emissions fell by 8.1%, from **gross 1,141,628 tCO2e** to gross **1,049,016 tCO_2e (-92,612 tCO_2e)** between 2001 and 2020. Figure 3 shows Wellington City's annual GHG emissions by sector from 2001 to 2020 in tCO_2e.

- Transportation emissions reduced between 2001 and 2020 by 5.2% (from 46.8% to 48.3% of the City's total gross emissions). Within the transportation sector road emissions from petrol and diesel use decreased by 9.9% from 2001 to 2020.
- Stationary energy emissions reduced between 2001 and 2020 by 20.2% (from 41.2% to 35.8% of the City's total gross emissions). The greater use of renewable energy to provide electricity has reduced the influence of stationary energy on total emissions.
- Waste emissions reduced between 2001 and 2020 by 23.6% (from 9.1% to 7.5% of the City's total gross emissions). The use of landfill gas capture has driven the fall in emissions from waste.
- IPPU emissions increased between 2001 and 2020 by 515.0% (from 1.1% to 7.1% of the City's total gross emissions). In the IPPU sector most emissions are caused by industrial refrigerant use which has increased by 581.9% in this period.
- Agriculture emissions reduced between 2001 and 2020 by 36.8% (from 1.9% to 1.3% of the City's total gross emissions). Agriculture emissions reduced in percentage terms more than any sector mainly due to a reduction in the number of livestock animals farmed within the city area.
- The reduction in stationary energy emissions is the largest real change (rather than proportionate change) in emissions, decreasing by 94,902 tCO_2e between 2001 and 2020. The increase of 62,375 tCO_2e in emissions from IPPU was the second biggest real change.
- Net emissions for Wellington City fell by 7.2%, from **net 1,057,119 tCO_2e** to **net 981,328 tCO_2e** between 2001 and 2020. The slightly lower change in net emissions compared to the change in gross emissions is due to a rise in emissions from harvesting of forest.

Figure 3 Wellington City's annual GHG emissions by sector from 2001 to 2020 (tCO_2e)



We encourage councils to use the results of this study to update current climate action plans. For example, the data clearly highlights the need for rapid action to tackle the growth in emissions from petrol and diesel (mainly used in transportation), and natural gas and electricity consumption (mainly used in the stationary energy sector).

Emission changes are driven by changes in national policy, local council actions, global market shifts and by individual behaviour changes. An effective combination of these aspects is required to reduce emissions at the City level.

1.0 Introduction

AECOM New Zealand Limited (AECOM) has been commissioned by Wellington City Council (WCC) to assist in the development of a greenhouse gas footprint for the City for the 2019/2020 financial year. The study boundary incorporates the "jurisdiction" of Wellington City.

The results of this study are split into two parts. Part 1 of this document explains the results for the 2019/20 financial reporting year, referred to hereafter as 2020 for ease. Part 2 centres on emission trends in the last two decades 2000/01 to 2019/20, (or more simply 2001 to 2020).

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) in 2014. The GPC includes emissions from stationary energy, transportation, waste, IPPU, agriculture and forestry activities within the City's boundary. The sector calculations for agriculture, forestry, solid waste and wastewater are based on the Intergovernmental Panel on Climate Change (IPCC) workbooks and guidance for emissions measurement. Sector calculations 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 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. 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. 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 city-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.
- Transportation emissions:
    - Transportation 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 transportation mode.
    - Shipping emissions due to the movement of logs and timber were allocated based on the relative contribution of each territorial authority 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. Wellington City Council operates two landfill sites (Southern Landfill and Northern Landfill) and sends waste to Spicer Landfill in the Porirua District. 21.5% of Spicer Landfill is allocated to Wellington City.
- Wastewater emissions:
    - Wastewater from the North Wellington Sewage Catchment treated in Porirua is included in the Wellington City figures. 27.6% of Porirua Wastewater Treatment Plant's emissions is allocated to Wellington City.
- 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 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 2019/20 may be different to those previously reported.
    - Wastewater treatment emissions and open landfill emissions have been recalculated from 2001 to 2019 to be consistent with 2020 method. For details refer to the overall results in Section 3.1.

3.0 2020 Emissions Inventory

This section (Part 1) deals with emissions results for the reporting year 2020. The paragraphs, figures and tables below explain the overall emissions and emissions from each sector. The focus of the information presented is 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.

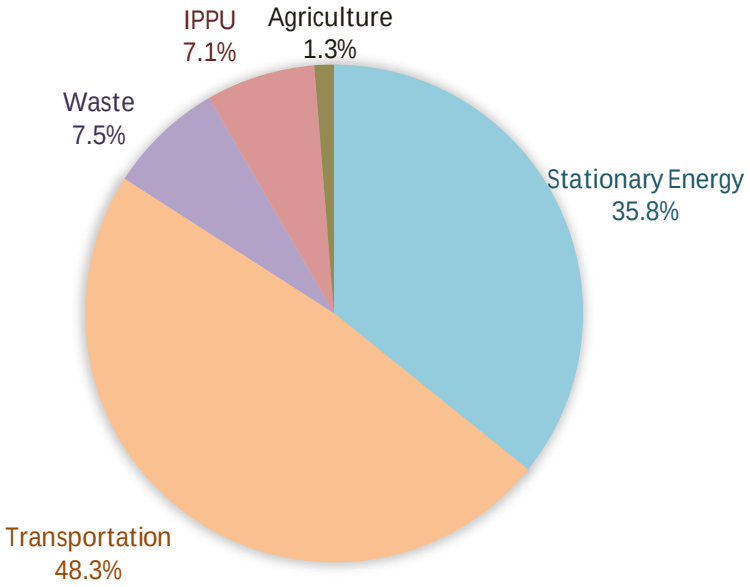
Discussion of per capita emissions is limited to when it is useful for comparing emission figures across the region or with other territorial authorities. Net emissions including results from forestry resources are reported separately.

3.1 Overall results

During the 2020 reporting period, Wellington City (WC) emitted **gross 1,049,016 tCO_2e** and **net 981,328 tCO_2e** emissions.

The population in 2020 was approximately **214,537** people, resulting in per capita gross emissions of **4.9 tCO_2e/person.** Transportation emissions are the largest contributor to the inventory for the City, followed by stationary energy (refer to Figure 4 and Table 1).

Figure 4 Wellington City's GHG gross emissions split by sector (tCO_2e)



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

Transportation: The highest emitting sector, transportation, produced 506,584 tCO_2e in the reporting year (48.3% of Wellington City's gross total emissions). Most of these emissions can be attributed to On and Off-Road transportation (Petrol and Diesel) within the City, which produced a total of 355,016 tCO_2e (70.1% of the sector's emissions and 33.8% of Wellington City's total gross emissions). The rest of the transportation emissions are produced by Wellington City's share of the emissions associated with air, port activities, rail, LPG and bus electricity and totalling 151,568 tCO_2e (29.9% of the sector's total emissions and 14.4% of WC's total gross emissions).

Stationary Energy: Producing 375,463 tCO_2e in 2020, stationary energy was Wellington City's second highest emitting sector (35.8% of total gross emissions). Electricity consumption was the cause of 174,263 tCO_2e, or 16.6% of the City's total gross emissions.

- Industrial stationary energy consumption accounts for 52.9% of stationary energy emissions (198,488 tCO_2e) and 18.9% of total gross emissions.

- Residential stationary energy consumption accounts for 22.2% of stationary energy emissions (83,376 tCO_2e) and 7.9% of total gross emissions.
- Commercial stationary energy consumption accounts for 17.4% of stationary energy emissions (65,352 tCO_2e) and 6.2% of total gross emissions.
- The remaining 7.5% of stationary energy emissions (28,246 tCO_2e, 2.7% of gross emissions) were produced by diesel and petrol and burning of biogas at Southern Landfill, which were not allocated to the above categories.

Waste (solid waste & wastewater): Waste originating in Wellington City (solid waste and wastewater) produced 78,958 tCO_2e in 2020 which comprises 7.5% of the City's total gross emissions. Solid waste produced the bulk of this, 72,437 tCO_2e in 2020, making up 91.7% 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 41,899 tCO_2e (4.0%) and closed landfills 30,538 tCO_2e (2.9%) to gross emissions respectively.

The landfill gas recovery rate applied in Southern Landfill has been updated from 2001 to 2019 to be consistent with 2020 calculation. This has resulted in increase of open landfill emissions as the previous landfill gas recovery rate used in Southern Landfill overestimated the amount of methane recovered.

Wastewater produced 6,522 tCO_2e making up 8.3% of total waste emissions. Wastewater 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 with emissions depending on the efficiency and scale of landfill gas capture.

Wastewater treated in centralised treatment plants produced 5,183 tCO_2e (6.6% of the waste sector's GHG emissions and 0.5% of Wellington's total gross GHG emissions) while individual wastewater treatment systems (i.e. septic tanks) produced 1,339 tCO_2e (1.7% of the waste sector's GHG emissions and 0.1% of Wellington City's total gross GHG emissions).

Industrial Processes and Product Use (IPPU): This sector includes emissions associated with the consumption of greenhouse gases (GHGs) for refrigerants, foam blowing, fire extinguishers, aerosols, metered dose inhalers and Sulphur Hexafluoride for electrical insulation and equipment production. The IPPU sector includes emissions associated with industrial activity within the City, 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 Wellington City produced 74,487 tCO_2e in 2020, contributing 7.1% to the City's total gross emissions.

Agriculture: The agricultural sector emitted 13,524 tCO_2e in 2020. Unsurprisingly, this is the smallest contributor to Wellington City's total gross emissions (1.3%). Enteric fermentation produced 83.3% of Wellington City's agricultural emissions (11,271 tCO_2e). Most of the remaining agricultural emissions were produced from manure from grazing animals on pasture (1,610 tCO_2e) representing 11.9% of Wellington City's agricultural emissions.

Forestry: Wellington City has a regenerative native forested area which includes Manuka, Kanuka and Broadleaved Hardwoods. Regenerating natives occupy 11,845 ha with exotics occupying a further 574 ha of land. In total, 85,837 tCO_2e were sequestered by forests in Wellington City in 2020.

Of the total sequestered CO_2, native forests sequestered 62,707 tCO_2e while exotic forests sequestered 23,130 tCO_2e in 2020. With emissions produced from harvesting of forestry producing 18,149 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 City's gross emissions split by sector and associated sub-categories

Sector	tCO_2e	% Gross	% Sector
Transportation			
Petrol (On and Off Road)	214,063	20.4%	42.3%
Diesel (On and Off Road)	140,953	13.4%	27.8%
Jet Kerosene	80,297	7.7%	15.9%
Marine Diesel	51,184	4.88%	10.10%
Light Fuel Oil	14,036	1.34%	2.77%
Rail Emissions	5,496	0.5%	1.1%
LPG	271	0.03%	0.05%
Aviation Gas	236	0.02%	0.05%
Bus (Electricity)	48	0.005%	0.01%
Total:	506,584	48.3%	100.0%
Stationary Energy			
Electricity Consumption	174,263	16.6%	46.4%
Natural Gas	116,166	11.1%	30.9%
Stationary Petrol & Diesel Use	27,649	2.6%	7.4%
Natural Gas T&D Loss	18,542	1.8%	4.9%
LPG	15,667	1.5%	4.2%
Electricity T&D Loss	15,331	1.5%	4.1%
Coal	3,806	0.4%	1.0%
Biofuel / Wood	3442	0.3%	0.9%
Burning of Biogas (Southern Landfill)	597	0.1%	0.2%
Total:	375,463	35.8%	100.0%
Waste			
Solid Waste Disposal	72,437	6.9%	91.7%
Wastewater	6,522	0.6%	8.3%
Total	78,958	7.5%	100.0%
IPPU			
IPPU Emissions	74,487	7.1%	100%
Total	74,487	7.1%	100.0%
Agriculture			
Agriculture	13,524	1.3%	100.0%
Total	13,524	1.3%	100.0%
Forestry			
Exotic Forest Sequestration	-23,130	N/A	N/A
Native Forest Sequestration	-62,707	N/A	N/A
Harvest Emissions	18,149	N/A	N/A
Total	-67,688	N/A	100.0%

Total Emissions	**tCO_2e**
Total Net Emissions (incl. forestry)	**981,328**
Total Gross Emissions (excl. forestry)	**1,049,016**

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 to Biogenic CO_2. 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	36,105	t CO_2
Biodiesel	-	t CO_2
Landfill Gas	843	t CO_2
Burning of Biogas (Southern Landfill)	5,135	t CO_2
Total Biogenic CO_2	**42,083**	**t CO_2**

Table 3 Biogenic Methane (Included in gross emissions)

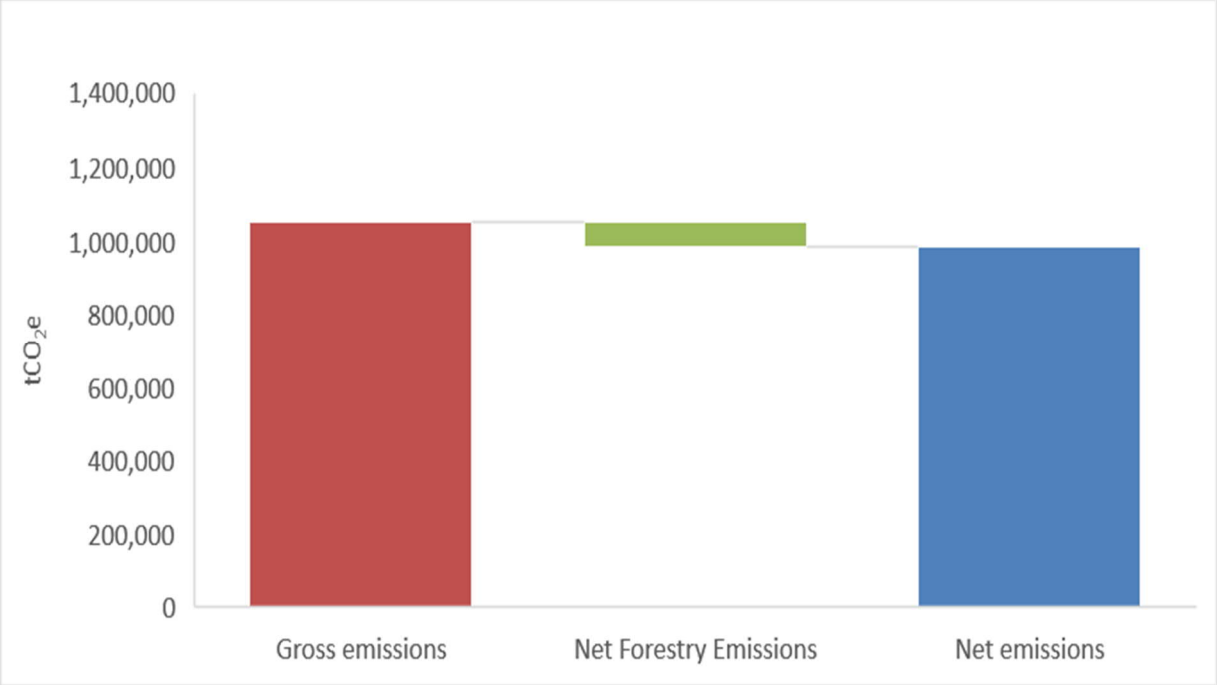
Biogenic Methane (Included in gross emissions)		
Biofuel	91	t CH_4
Biodiesel	-	t CH_4
Burning of Biogas (Southern Landfill)	0.05	t CH_4
Landfill Gas	2,130	t CH_4
Wastewater Treatment	39	t CH_4
Enteric Fermentation	332	t CH_4
Manure Management	4	t CH_4
Total Biogenic CH_4	**2,596**	**t CH_4**

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 reduces total gross emissions.

Overall, forestry is a net negative source of emissions of -67,688 tCO_2e due the sequestration of carbon mostly by native forest. Net negative emissions from forestry reduce gross emissions by 6.9% to a total of 981,328 tCO_2e net emissions. Figure 5 shows gross emissions versus net emissions in 2020 and the impact of sequestration by forestry.

Figure 5 Gross versus Net emissions including forestry



Carbon sequestered by forestry can be viewed as a liability/risk needing careful consideration, for example 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 Changes in Emissions Inventory, 2001 to 2020

PART 2 considers the trends in emissions from 2001 to 2020. 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

Wellington City's GHG inventory data covers 2001 to 2020. Figure 6 shows the change in gross annual emissions for each sector in the years between 2001 and 2020. Figure 7 and Figure 8 show the relative proportion of gross emissions from each sector in 2001 and 2020 respectively. Figure 9 shows the change in annual emissions from Wellington City's most major emissions sources from 2001 to 2020. These sources are electricity, natural gas, petrol (transportation), diesel (transportation), air transport and marine transport.

Figure 6 Gross emissions per year (excluding forestry) from 2001 to 2020

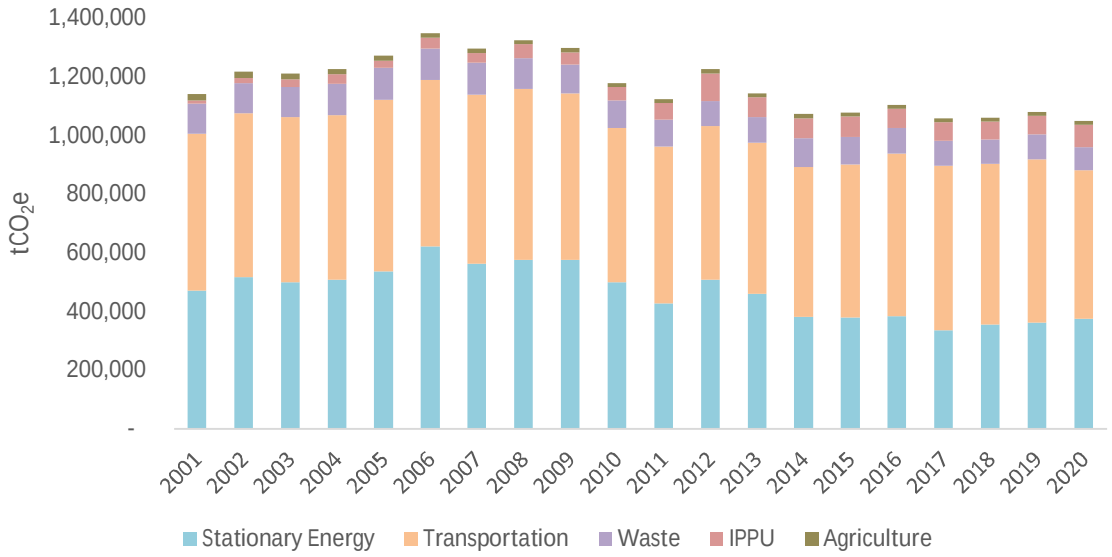


Figure 7 2001 Wellington City's GHG gross emissions split by sector (tCO_2e)

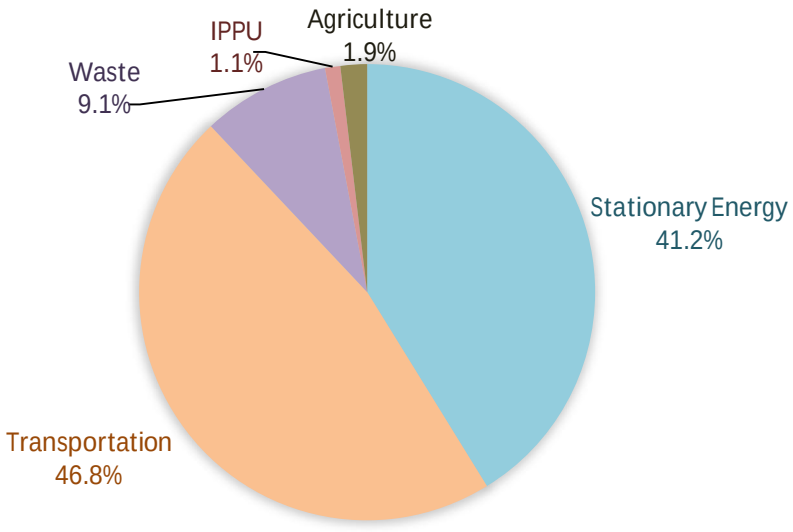


Figure 8 2020 Wellington City's GHG gross emissions split by sector (tCO_2e)

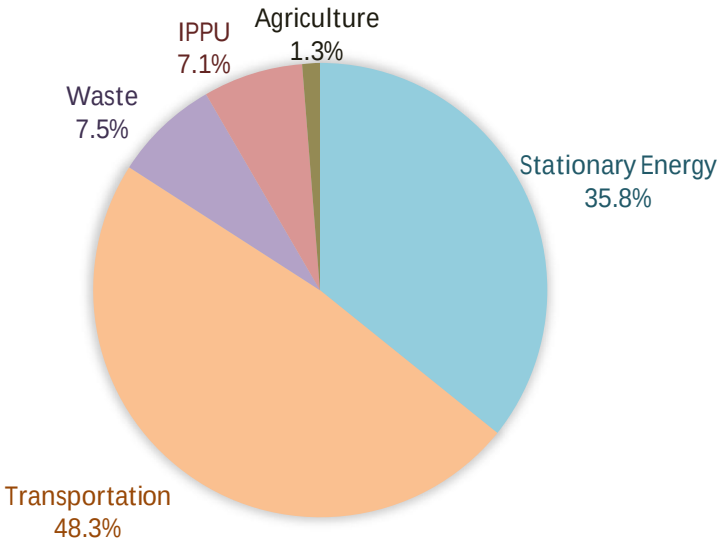
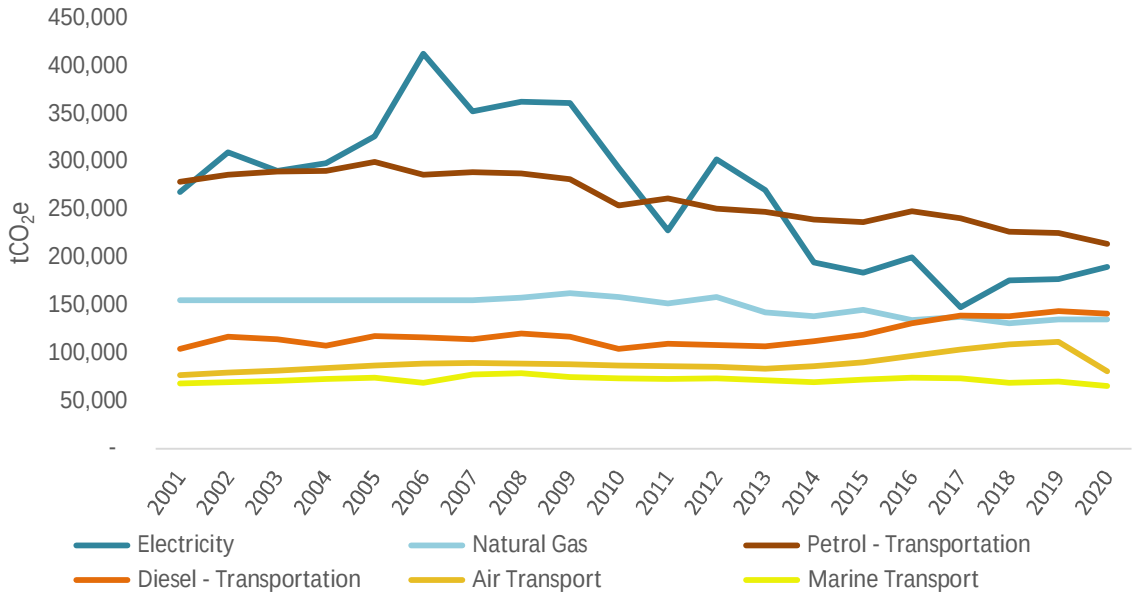


Figure 9 Emissions per year from 2001 to 2020 from major emissions source



Total gross emissions fell by 8.1%, from 1,141,628 tCO2e in 2001 to 1,049,016 tCO2e in 2020. Reductions in emissions from stationary energy, agriculture, transportation and waste are responsible for the fall in total gross emissions.

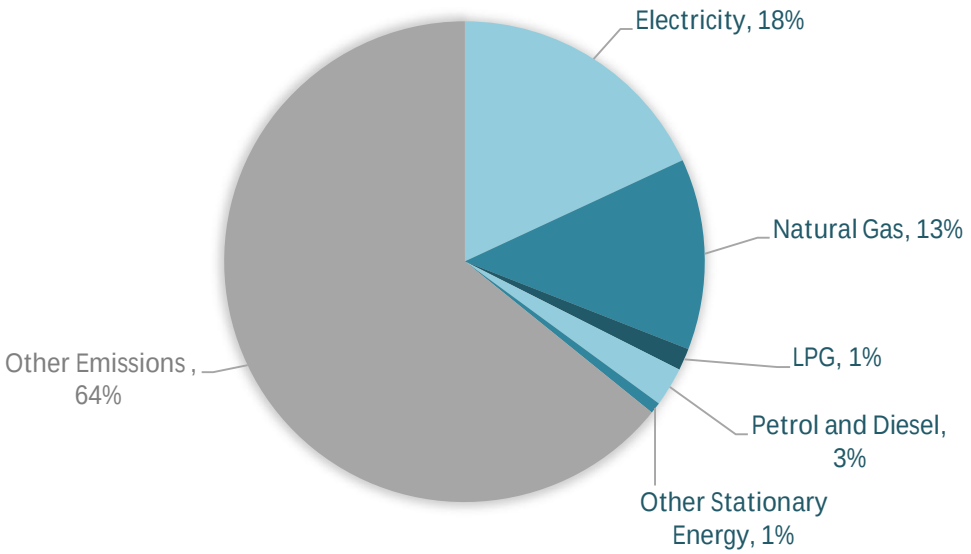
As Wellington City's population has risen, per capita gross emissions have reduced by 27.1% from 6.7 tCO_2e in 2001 to 4.9 tCO_2e in 2020.

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 470,365 tCO_2e (41.2% of total gross emissions) to

375,463 tCO_2e (35.8% of total gross emissions), a fall of 20.2%. Figure 10 outlines stationary energy gross emissions by source as a proportion of Wellington's total gross emissions in 2020.

Figure 10 2020 total gross emissions breakdown, by source, highlighting stationary energy emissions



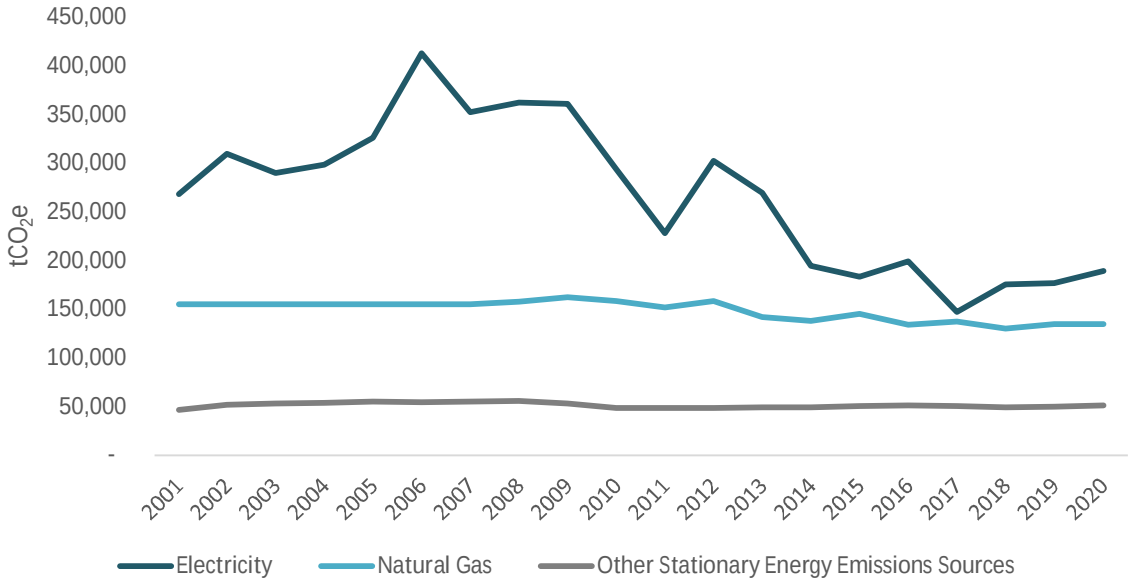
Emissions from residential stationary energy consumption shrank over the measurement period by 26.3% (113,180 tCO_2e to 83,376 tCO_2e). Emissions from commercial stationary energy consumption decreased by 23.9% (85,913 tCO_2e to 65,352 tCO_2e). Industrial stationary energy emissions decreased by 20.6% (249,974 tCO_2e to 198,488 tCO_2e).

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 2020. The electricity consumption (kWh) between 2001 and 2020 decreased by 1% while associated emissions reduced by 29.3% (268,055 tCO_2e to 189,594 tCO_2e), see Figure 11. 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 consumption lowered by 13.1% from 155,009 tCO_2e in 2001 to 134,708 tCO_2e in 2020 (see Figure 11).

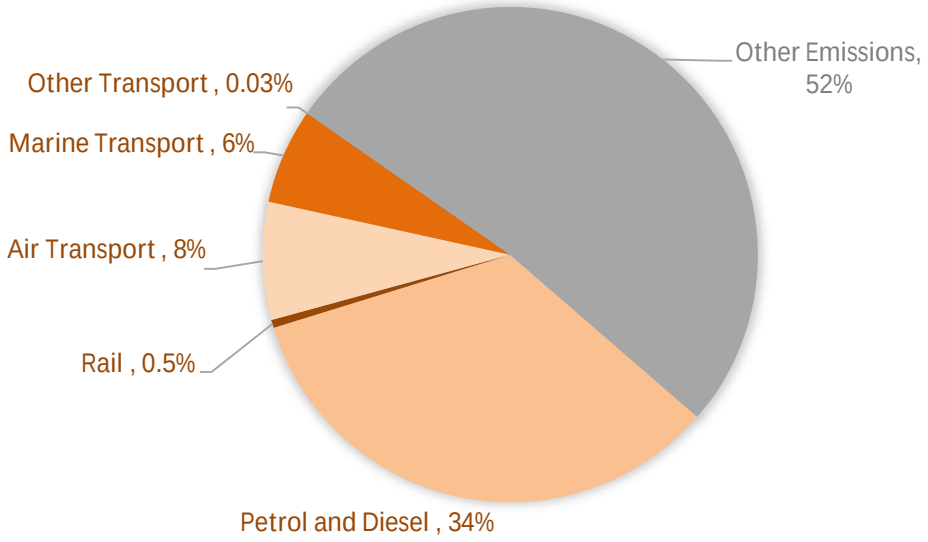
The emissions from petrol and diesel used for stationary energy have different trends between 2001 and 2020. Petrol emissions fell by 23.4% from 2,064 tCO_2e to 1,581 tCO_2e. In the same years, diesel emissions increased from 19,234 tCO_2e to 26,069 tCO_2e, a rise of 35.5%.

Figure 11 Emissions per year from 2001 to 2020 from stationary energy emissions sources



- **Transportation:** Emissions from transportation decreased in number, and as a proportion of total gross emissions between 2001 and 2020, from 534,353 tCO_2e (46.8% of total gross emissions) to 506,584 tCO_2e (48.3% of total gross emissions), a reduction of 5.2%. Figure 12 outlines transportation gross emissions by source as a proportion of Wellington's total gross emissions in 2020.

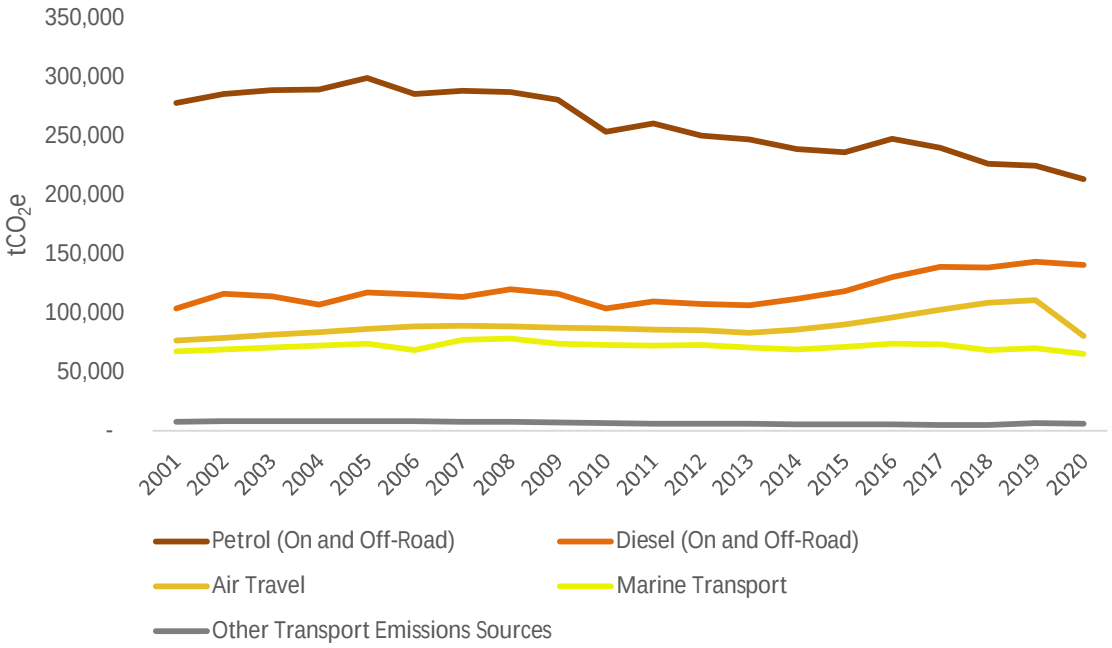
Figure 12 2020 total gross emissions breakdown, by source, highlighting transportation emissions



Road transportation is the highest emitting activity within the transportation sector. Road emissions decreased overall by 9.7% between the start and end of the measurement period. Petrol emissions reduced by 23.1%, from 274,322 tCO_2e in 2001 to 210,959 tCO_2e in 2020 and diesel emissions rose by 35.5% (30,741 tCO_2e), from 86,521 tCO_2e to 117,262 tCO_2e (see Figure 13). As the vehicle kilometres travelled (VKT) within the City was consistent and changed by less than 1% from 2010 to 2019 (based on VKT data availability), it is likely the reduction in transportation emissions is related to improved emissions performance in vehicle engines.

Air travel emissions increased by 4.9% (3,753 tCO_2e) from 76,780 tCO_2e in 2001 to 80,533 tCO_2e in 2020. However, without the 28% reduction in air transport emissions between 2019 and 2020 due to reduced flight numbers caused by COVID-19 we may have seen a much higher rate of growth in emissions between 2001 and 2020 (see Figure 13). Marine transportation emissions reduced by 3.3%, down from 67,451 tCO_2e in 2001 to 65,220 tCO_2e in 2020.

Figure 13 Emissions per year from 2001 to 2020 from transportation emissions sources



- **Waste (solid waste & wastewater):** Waste emissions are an important measure of progress for reducing environmental impact for many stakeholders. Overall waste emissions dropped by 23.6% from 103,408 tCO_2e in 2001 to 78,959 tCO_2e in 2020. The landfill gas recovery rate applied in Southern Landfill has been updated from 2001 to 2020 from an average of 85.6% to 54.6% (for actual percentage each year refer to solid waste sector calculator). This has resulted in increase in open landfill emissions as the previous landfill gas recovery rate used for Southern Landfill overestimated the amount of methane recovered.

  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 2020). Solid waste emissions from closed landfill sites reduced by 55.7% (38,438 tCO_2e) from 68,976 tCO_2e in 2001 to 30,538 tCO_2e in 2020. In 2001 solid waste from closed landfill sites made up 66.7% of total waste emissions for Wellington City. By 2020 emissions from the same emission source had reduced greatly but still accounted for 38.7% of total waste emissions.

  Solid waste emissions from currently open landfill sites increased by 46.0% from 28,684 tCO_2e in 2001 to 41,899 tCO_2e in 2020. Emissions from solid waste entering landfill with gas capture were 27.7% of total waste emissions in 2001. This figure had risen to 53.1% of total waste emissions by 2020.

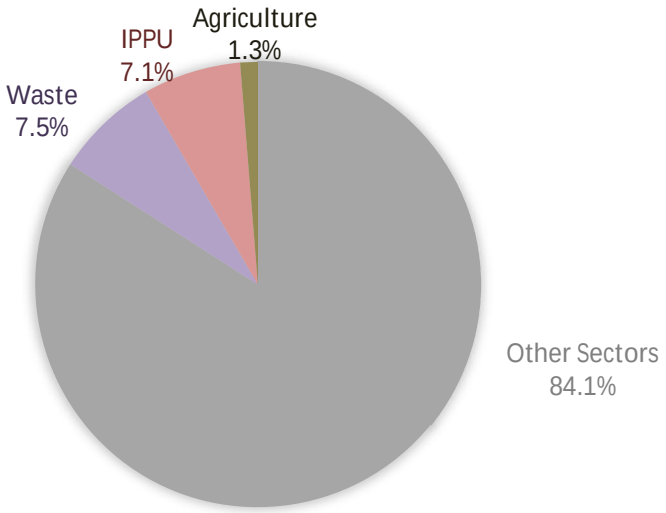
  Wastewater emissions are the smallest cause of emissions in the waste sector. As the population of the City has grown (by 26.0% between 2001 and 2020), associated emissions from the treatment of wastewater have trended upward. Wastewater emissions increased from 5,748 tCO_2e in 2001 to 6,522 tCO_2e in 2020, 13.5% higher. Emissions from wastewater accounted for 5.6% of total waste emissions in 2001. In 2020 wastewater made up 8.3% of total waste emissions.

- **Industrial Processes and Product Use (IPPU):** IPPU emissions between 2001 and 2020 were a relatively small part of total gross emissions (representing 1.1% and 7.1% of total emissions in 2001 and 2020 respectively). Emissions from IPPU sources jumped to 74,487 tCO_2e from 12,111

tCO_2e in this time, an increase of 515.0%. The increase in the IPPU emissions follows developments at the national level in NZ where emissions have risen.

- **Agriculture:** Agriculture contributed least to emissions in the City's footprint and dropped by 36.8%, from 21,390 tCO_2e to 13,524 tCO_2e, between 2001 and 2020. The number of farm animals within the City area which include cattle (both dairy and non-dairy), sheep, goats, horse deer and pigs fell from 33,348 to 17,513 [3]in this period. However, while agricultural emissions are low, they remain an important source of biogenic methane targeted as a reduction opportunity in the Climate Change Response (Zero Carbon) Amendment Act. Figure 14 shows Wellington's 2020 total gross emissions breakdown, by sector, focussing on waste, IPPU and agriculture emissions.

Figure 14 Total gross emissions breakdown, by sector, highlighting waste, IPPU and agriculture emissions



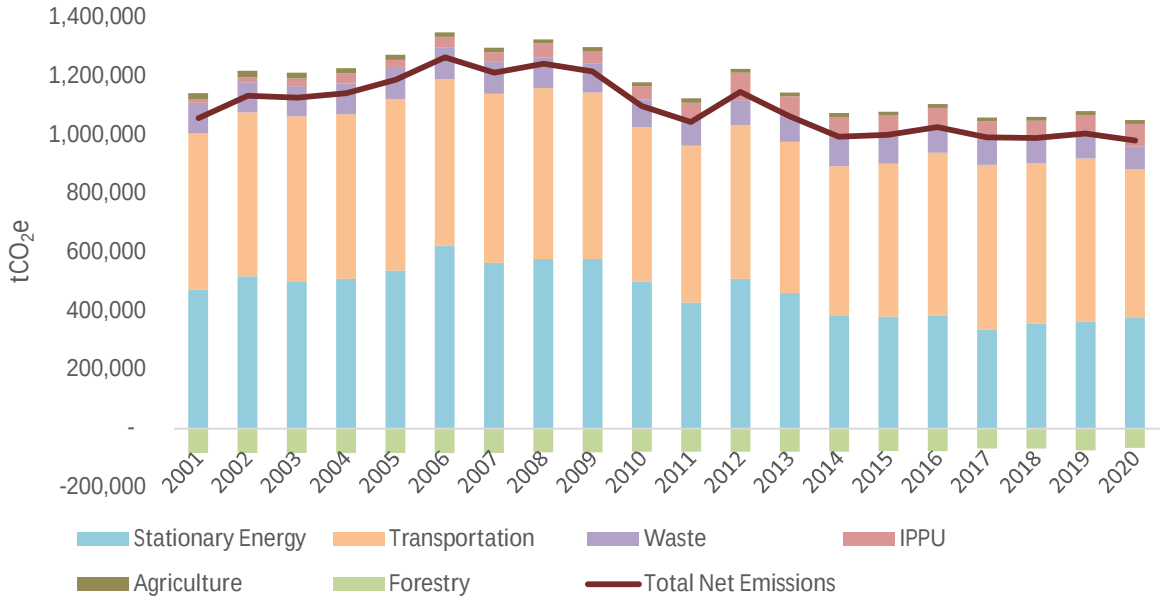
- **Forestry:** For the last two decades sequestration levels from regenerating forest have been steady. Sequestration by native forest was main source of capturing carbon in this time. Native forests e.g. Mānuka and Kānuka stored 62,125 tCO_2e and 62,707 tCO_2e, in 2001 and 2020 respectively; a change of just 0.9%. Carbon stored by exotic forestry (e.g. pine) rose by 3%, sequestering 23,130 tCO_2e in 2020 compared to 22,384 tCO_2e in 2001.

  Data availability and quality for harvest emissions has rapidly improved in recent years. Harvesting emissions increased from 140 tCO_2e in 2006 to 18,149 tCO_2e in 2020. The growth in harvesting emissions potentially means exotic trees are being removed in greater numbers.

[3] The number of livestock animals in Wellington in 2020 is taken from the 2017 Agriculture Census published by Statistics New Zealand. This is the latest agriculture survey available at the time of reporting. Livestock numbers were reported incorrectly in the 2019 inventory. The same number of livestock animals has been used for agriculture calculations in the 2019 inventory and the 2020 inventory.

Figure 15 shows the impact of sequestration in the forestry sector on reducing net emissions. Net forestry sequestration remained steady in Wellington City and the change in net emissions follows the same pattern as gross emissions.

Figure 15 Emissions per year showing gross and net emissions (including forestry) from 2001 to 2020



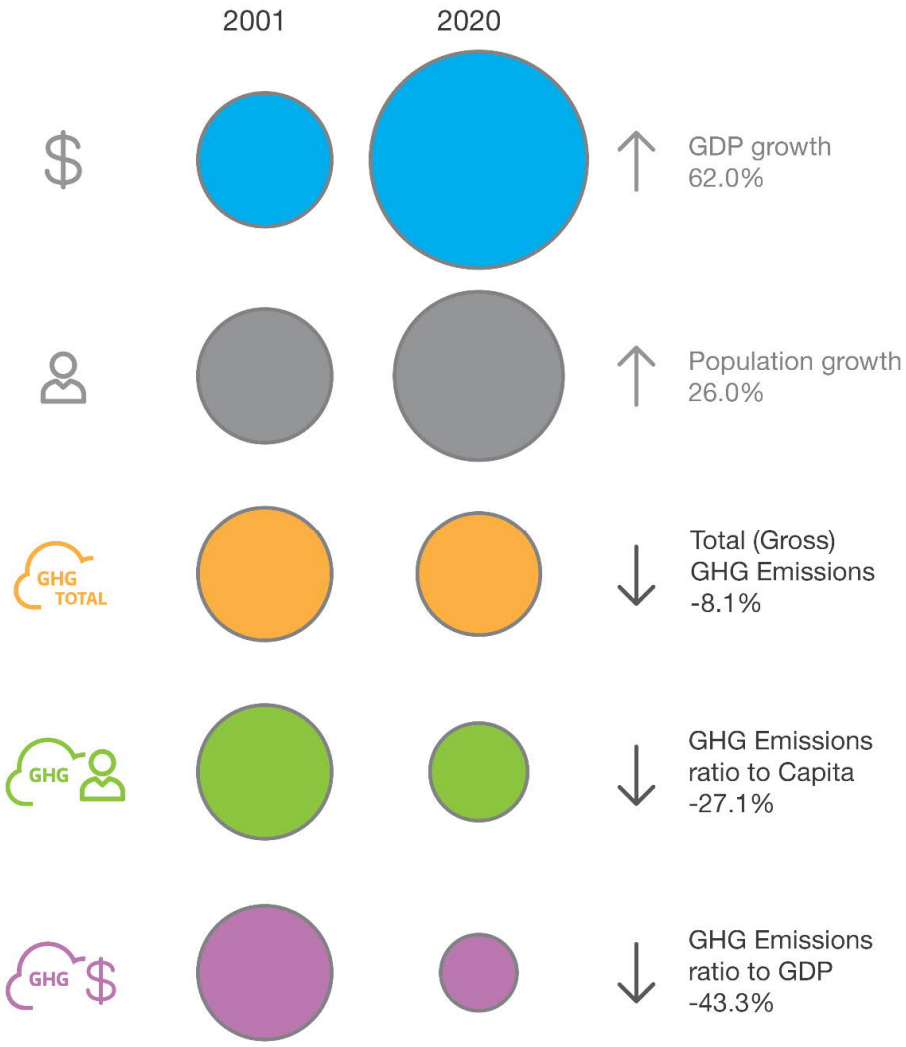
5.0 Emissions and other metrics

Figure 16 shows the change in gross emissions when compared to changes in other metrics of interest between 2001 and 2020. Total gross emissions have reduced by 8.1%, against the backdrop of a 26.0% growth in population within the Wellington City. 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 16 suggest at a high-level decoupling has occurred in the last two decades. GDP was 62.0% higher in 2020 than in 2001 while emissions per unit of GDP declined by 43.3%.

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, transportation 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.

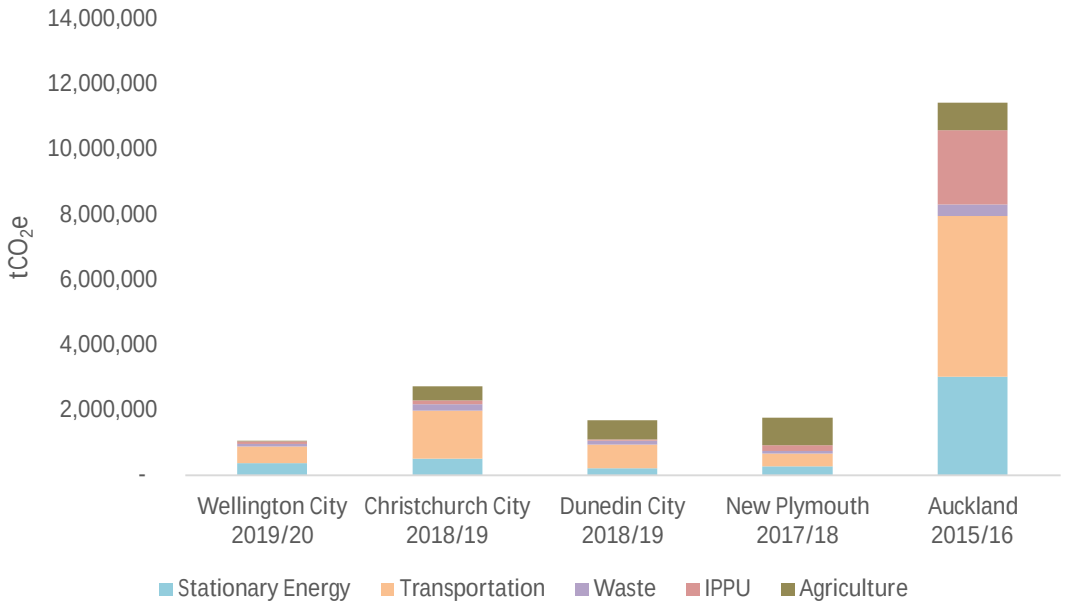
Figure 16 Change in total gross emissions compared to other metrics of interest



6.0 Comparison with other New Zealand cities and regions

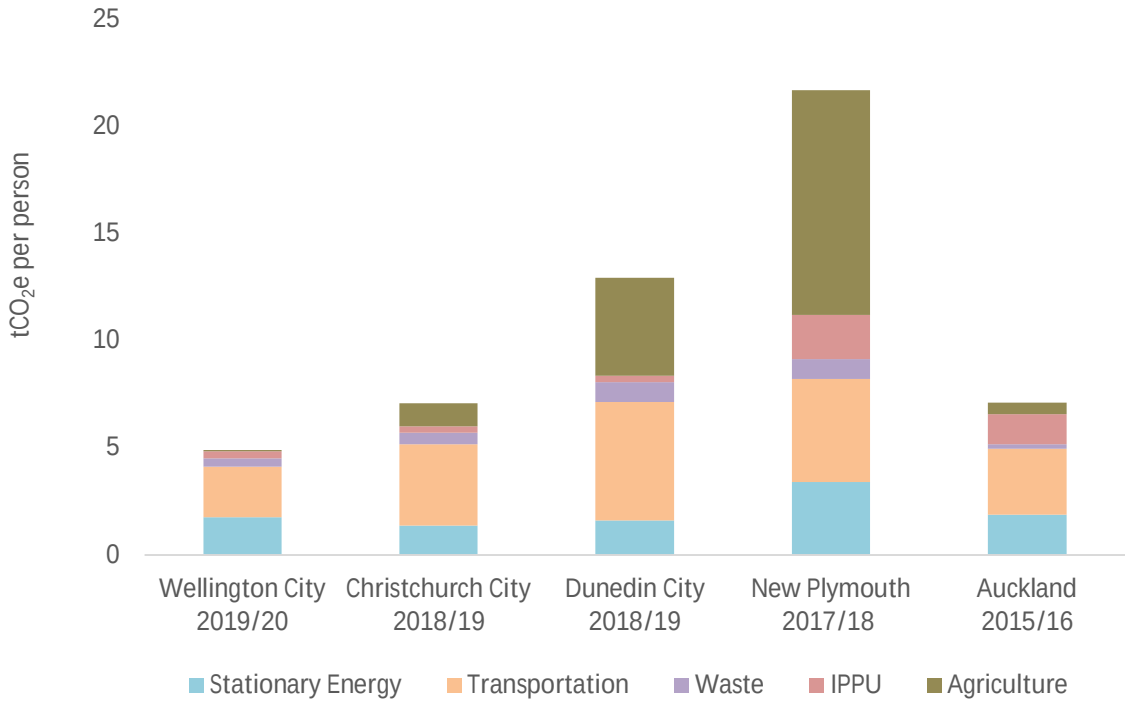
Figure 17 shows a comparison of gross emissions (excluding forestry) for Wellington City with other territorial authorities in New Zealand, split by sector. When compared with other greenhouse gas inventory studies, Wellington City has the lowest gross emissions when compared with Christchurch, Dunedin, New Plymouth and Auckland. Note that the compared studies were conducted at differing geographic levels and in differing timeframes.

Figure 17 A comparison of Wellington City's GHG emissions with other regions of New Zealand by gross emissions (tCO_2e)



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. Figure 18 shows Wellington City has the lowest per capita gross emissions when compared with Christchurch, Dunedin, New Plymouth and Auckland.

Figure 18 A comparison of Wellington City's GHG emissions with other regions of New Zealand on a per capita basis (tCO_2e)



7.0 Closing statement

Wellington City'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 City Council, their stakeholders and the wider community**.** Sector-level data allows the City Council to target and work with those sectors, e.g. transportation, which contribute the most emissions to the footprint.

Understanding of the extensive and long-lasting effects of climate change is 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 action plans. For example, these results clearly highlight the need for rapid action to tackle the growth in emissions from diesel consumption for all purposes. Emission reductions strategies should be also focussed on those sources which contribute the highest emissions in the City. These include, petrol and diesel (mainly used in transportation), and natural gas and electricity consumption (mainly used in the stationary energy sector).

Stationary energy accounts for around a third of emissions and has driven the reduction in total emissions from 2001 to 2020. The emissions reduction from stationary energy is primarily due to an increase in renewables in the national grid rather than significant localised behaviour change (electricity consumption fell by just 1% while associated emissions fell by 29%). There is an ongoing risk that as electricity demand rises, due to population and consumption increases, emissions will rise unless New Zealand can generate a larger percentage of renewable power. The alternative is to influence behaviour change to limit, or reduce, demand.

Similarly, emissions from on-road transportation have decreased faster than the decrease in kilometres travelled by vehicles. This is attributable to more fuel-efficient vehicles rather than behaviour change. Across most sectors, there is a need to drive behaviour change to reduce emissions.

Emission changes are driven by changes in national policy, local council actions, global market shifts and by individual behaviour changes. All of these aspects are required to reduce emissions at the City level.

8.0 Limitations

AECOM New Zealand Limited (AECOM) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of **Wellington City Council** and only those third parties who have been authorised in writing by AECOM to rely on this Report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report. It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated **6th July 2020**.

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Appendix A

Emission Breakdowns

Appendix A Emission Breakdowns

The pie chart in Figure 19 below shows a breakdown of gross emissions by proportion for each sector and source. The following pie chart is focussed on the sources of emissions from stationary energy.

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

Figure 19 Total gross emissions breakdown, by source (emissions representing less than 1% of total emissions are not shown)

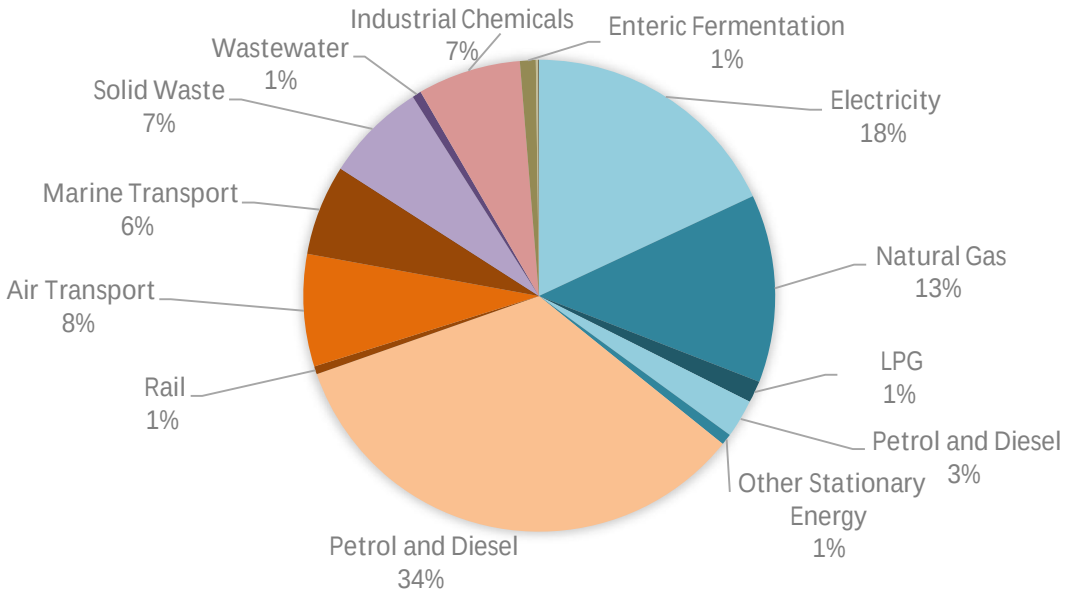
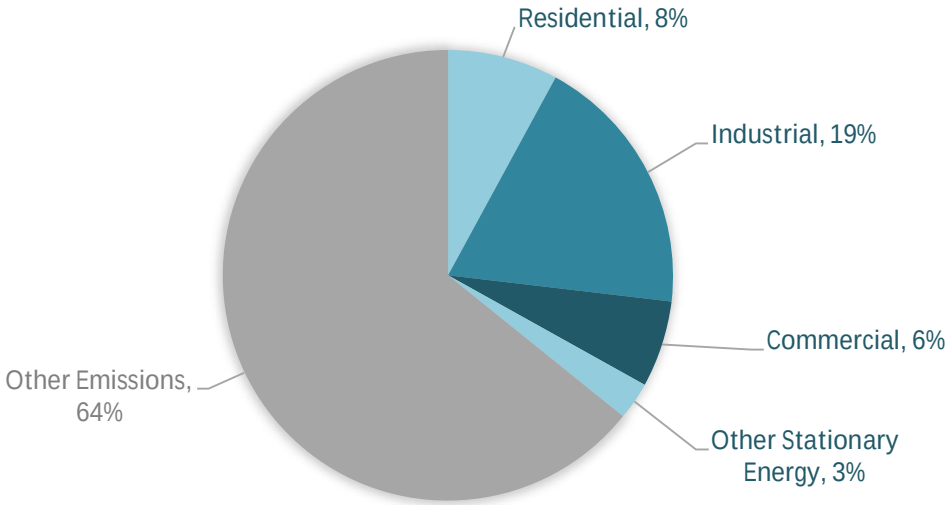


Figure 20 Total gross emissions breakdown, by source, highlighting stationary energy emissions (broken down by stationary energy sector)



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 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 greenhouse gas emissions occurring outside the city boundary as a result of activities taking place within the city 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 4 BASIC and BASIC+ emissions

	Emissions tCO_2e
BASIC	927,132
BASIC per capita	4.3
BASIC+	1,049,016
BASIC+ per capita	4.9

Per capita emissions

On a per capita basis, Wellington City has gross emissions of 4.9 tCO_2e/person. As the City's population has risen, per capita gross emissions have reduced by 27.1% from 6.7 tCO_2e in 2001 to 4.9 tCO_2e in 2020 (see Figure 21 and Figure 22).

Figure 21 Per capita gross emissions, by sector (2001-2020)

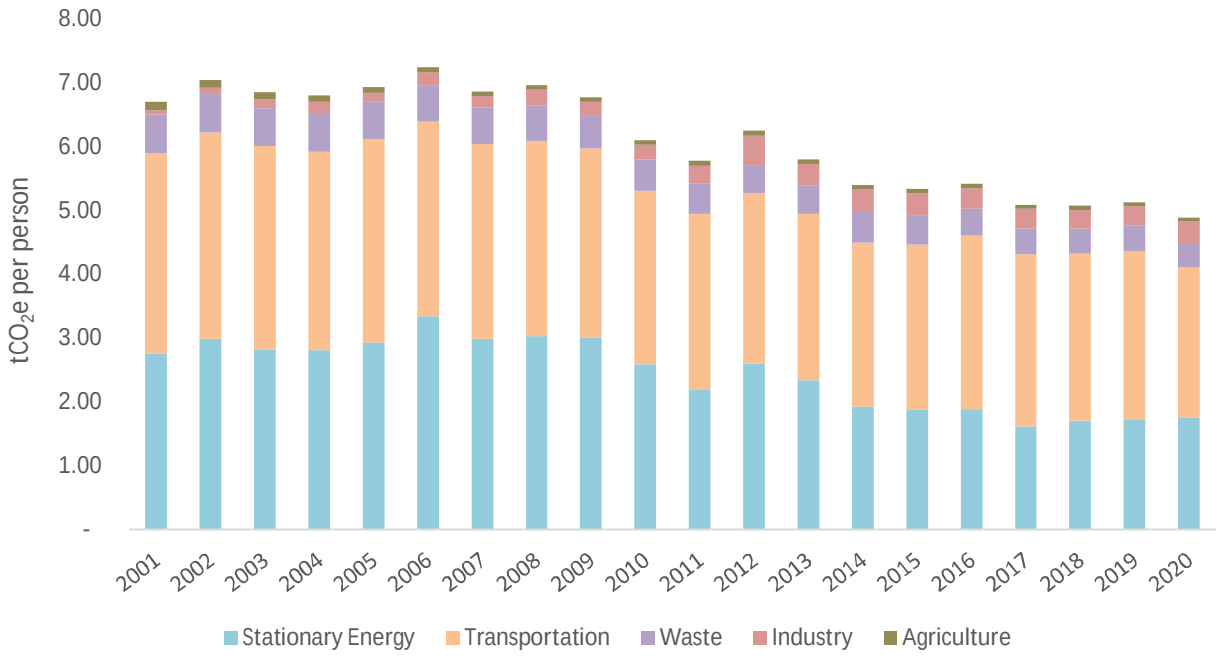
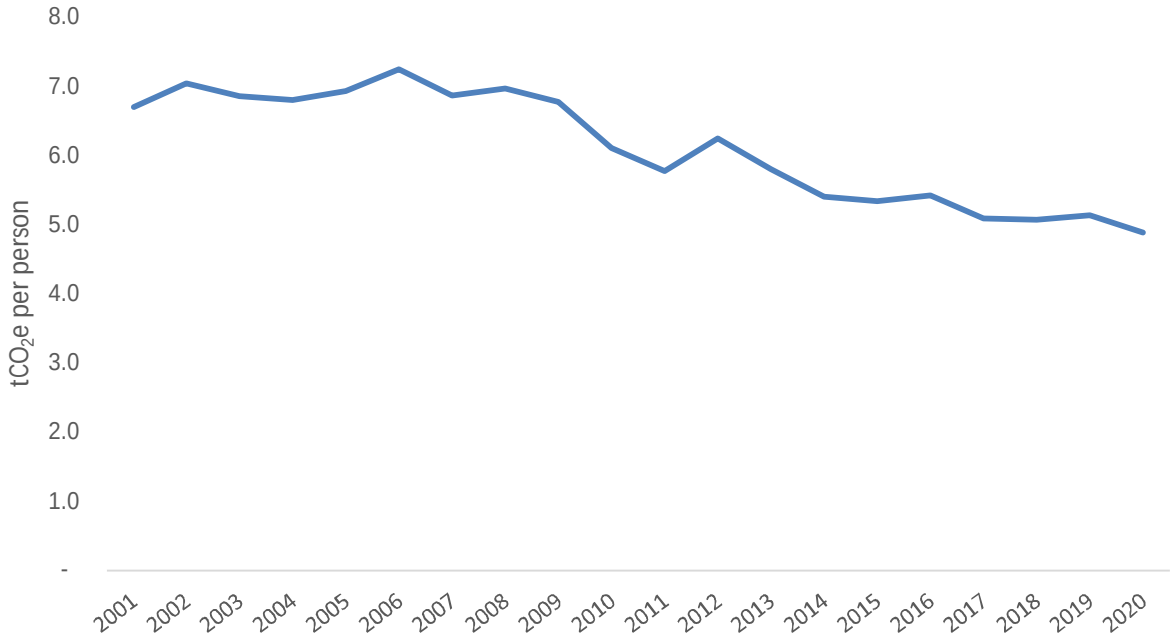


Figure 22 Per capita gross emissions (2001-2020)



Appendix B

Assumptions

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:	Wellington City fuel sales figures provided by Wellington City Council were used. 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) from the 2016 database. Figures derived from the 2020 database are the most recent available, but figures derived from the 2016 database have been used for comparison purposes with the calculated emissions for the period 2001-2020. On-road is defined as all standard transportation vehicles used on roads (e.g. cars, bikes, buses). Off-road is defined as machinery and vehicles used off roads (e.g. in agriculture, construction and other industries). 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.
Rail Diesel	Consumption was calculated by Kiwi Rail using the Induced Activity method. The following assumptions were made: - Net Weight is product weight only and excludes container tare (the weight of an empty container) - The Net Tonne-Kilometres (NTK) measurement has been used. NTK is the sum of the tonnes carried multiplied by the distance travelled. - National fuel consumption rates have been used to derive litres of fuel for distance. - Type of locomotive engine used, and jurisdiction topography, have not been incorporated in the calculations. Using the induced activity method, the trans-boundary routes were determined, and the number of stops taken along the way derived. The total amount of litres of diesel consumed per route was then split between the departure district, arrival district and any district the freight stopped at along the way. If the freight travelled through but did not stop within a district, no emissions were allocated.
Jet Kerosene	Calculated using the Induced Activity method as per rail diesel and jet fuel data provided by Wellington Airport. Wellington Airport serves the entire Wellington Region and therefore its associated emissions have been split on a per capita basis to calculate Wellington City's emissions.

	Scope 2 electricity use by the airport / planes are incorporated within the general electricity consumption data for the district.
Aviation Gas	The total volume of aviation gas consumed by Wellington Airport has been split between the districts on a per capita basis. This reflects the assumption made that Wellington Airport serves the entire Wellington region and not just the district in which it is situated. Aviation 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 or departures were allocated to Wellington Port (CPL). The remaining 50% of each leg was allocated to the originating or destination port. - Wellington City Council and Hutt City Council share equally the emissions generated by the East by West ferries. - International shipping passing through Wellington Port (CPL) was split by weight of cargo into 'Logs' and 'All other cargo'. Emissions generated by 'All other cargo' has been allocated on a per capita basis between all districts in the Wellington Region. Emissions generated by 'logs' (over 50% of total international shipping emissions) was split between districts, proportionally, by the percentage share of district forest area of harvestable age (>26 years old).
Light Fuel Oil	Calculated using the Induced Activity method as per rail and aviation data. Does not include fuel use for private boating. Most private marine vessels use fuel purchased at vehicle fuel stations. Petrol and diesel used in private marine vessels was included in off-road transportation.
LPG	National LPG sales data has been provided by the LPG Association. The North Island consumption figure was used. Consumption and associated emissions have been split on a per capita basis for Wellington City.
Bitumen	Not calculated
Lubricants	Not calculated
Stationary Energy Emissions	
Electricity Demand	Electricity demand has been calculated using grid demand trends from the EMI website (www.emi.ea.govt.nz) to obtain raw grid exit point data for Wellington City. Reconciled demand has been used as per EMI's confirmation. 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. As public transport systems cross district boundaries, data has been provided at the regional level and broken down on a per capita basis for Wellington City.
Coal Production	Not Calculated: There are no active coal mines within the region. (NZP&M 2019)
Coal Consumption	Consumption estimates are based on per capita using national Commercial and Residential consumption for the reporting years. Industrial coal consumption was not included for Wellington City as the majority of national industrial coal was used in Huntly power station and by Fonterra (dairy

	processing), outside Wellington City. It was agreed with Wellington City Council that there are no major coal users in Wellington City. Consumption and associated emissions have been split on a per capita basis for Wellington City.
Biofuel and Wood Consumption	Consumption estimates are based on national Commercial and Residential emissions for biofuel use (provided from New Zealand Greenhouse Gas Emissions 1990 -2018 (MfE 2020). Industrial biofuel and wood consumption were not available. Consumption and associated emissions have been split on a per capita basis for Wellington City.
LPG Consumption	National LPG sales data has been provided by the LPG Association. The North Island consumption figure was used. Consumption and associated emissions have been split on a per capita basis for Wellington City.
Natural Gas Consumption	No assumptions were made around the Wellington City's general consumption data received from Vector. The split for gas consumed by Industrial, Commercial and Residential activities was based on MBIE 2020.
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 -2018 (MfE 2020)). Industrial biofuel and wood consumption were not available. Consumption and associated emissions have been split on a per capita basis for Wellington City.
Agricultural Emissions	
General	No assumptions were made during the collection of agricultural data as it was sourced from district-specific data provided by Statistics NZ and the Ministry for the Environment National Inventory.
Solid Waste Emissions	
Open Landfills	Wellington City Council operates two landfill sites (Southern Landfill and Northern Landfill - closed) and sends waste to Spicer Landfill in the Porirua District. 21.5% of Spicer landfill (Porirua) is allocated to Wellington City.
Landfill Gas Recovery	From 2015 to 2020, the percentage of landfill gas collected provided by Southern Landfill has been used. Prior to this, the national average percentage of methane recovered across all municipal landfills, sourced from New Zealand National Inventory Report (NIR), has been used. The national average percentage of methane recovered was not easily found between 2000 and 2008's NIR therefore the same percentage as 2009 was used.
Closed Landfills	Data was sourced at the district level from previous inventory.
Wastewater Emissions	
Wastewater Volume	There are two sewage treatment plants in Wellington - Moa Point and the Western Treatment Plant (Karori). The Council also has a 27.6% share in the Porirua Treatment Plant which treats sewage from Wellington's northern suburbs. Therefore 27.6% of wastewater treatment emissions from Porirua Treatment Plant has been allocated to Wellington City.

	The Western Wastewater Plant associated emissions were missing from previous years' inventories. Emissions from 2016 to 2020 have been added. No data was available for the Western Wastewater Plant prior to 2016. To ensure consistency with the 2020 calculation, wastewater treatment emissions for 2001 to 2019 have been recalculated by applying septic tank use to 3% of the City's population with 97% of the City's population connected to centralised treatment plants. The percentage of the population using septic tanks was previously calculated ranging from 11% to 14%. The change in ratio was agreed with Wellington City Council following more up to date research.
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 meters.
Population Connected to Wastewater Treatment Plant and Septic Tanks	The population connected to wastewater treatment plant and septic tanks has been provided by Wellington City Council. As agreed with Wellington City Council, it is assumed that 3% of the city's population use septic tanks and 97% of the city's population are connected to a centralised treatment plant.
Industrial Emissions	
Industry & Solvent Emissions	Calculated from MfE 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	No information could be obtained from Industry representatives within the city. National level data has been used and split on a per capita basis for Wellington City.
Forestry Emissions	
Exotic Wood Harvested	District figures were calculated using the assumed percentage share of district forest area of harvestable age (>26 years old) in the region, in the reporting year.
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 EFs have been applied.