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Christchurch Community Carbon Footprint 2016/17

Final Results

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Client: Christchurch City Council

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Prepared by

AECOM New Zealand Limited
Level 3, 80 The Terrace, Wellington 6011, PO Box 27277, Wellington 6141, New Zealand
T +64 4 896 6000 F +64 4 896 6001 www.aecom.com

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Prepared by Rita Martin and Sarah Lindberg

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Revision History

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			Name/Position	Signature
A	27-Oct-2017	Draft for Client Review	Kerry Griffiths Technical Director Sustainability	
B	23-Feb-2018	Final	Maurice Marquardt Principal Consultant Sustainability	
C	17-Jul-2018	Final	Kerry Griffiths Technical Director Sustainability	

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List of Abbreviations and Definitions

AFOLU	Agriculture, forestry and other land use
CH_4	Methane
CoM	Global Covenant of Mayors for Climate and Energy
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EF	Emission Factor
GHG	Greenhouse Gas
GPC	Global Protocol for Community Scale Carbon Foot printing
Gross Emissions	Gross emissions are emissions from all sources, excluding forestry related emissions
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
IPPU	Industrial processes and product use
LCDB4	Land Cover Data Base 4 (2012)
LFG	Landfill gas
LPG	Liquefied Petroleum Gas
LULUCF	Land use, land use change and forestry
N_2O	Nitrous oxide
NEFD	National Exotic Forest Description
Net Emissions	Net emissions are emissions from all sources including forestry (sinks and sources).
PFC	Perfluorocarbons
Scope 1	Direct emissions from owned or controlled sources (e.g. diesel use for road transport).
Scope 2	Indirect emissions from the generation of purchased energy
Scope 3	Emissions occurring outside the city (e.g. waste sent to Kate Valley landfill) or transboundary travel e.g. air travel
SF_6	Sulphur hexafluoride
SO_2	Sulphur dioxide
T&D	Transmission and Distribution
UNFCCC	United Nations Framework Convention on Climate Change
WWTP	Wastewater treatment plant

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Executive Summary

Christchurch City Council (Council) commissioned AECOM New Zealand Limited (AECOM) to assist in the development of a community carbon footprint for Christchurch district, including Banks Peninsular (hereafter referred to as Christchurch) during the period 1 July 2016 – 30 June 2017. This report provides Council with a snapshot of Christchurch's emission profile for the 2016/17 financial year reporting period, identifying key emission sources and their relative contribution. The report will:

- Help Council understand Christchurch's local emissions profile;
- Enable informed decision making and policy development; and
- Identify key emission sectors and stakeholders that could be encouraged to reduce local emissions.

The methodology used to calculate emissions follows the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory, published by the World Resources Institute (2015). The Global Protocol assesses both direct (production-based) emission sources within the geographic area and indirect emissions (consumption-based emission sources associated with goods and services imported into the geographic area). Key data assumption and limitations are detailed in the report.

The assessment calculates that during the 2016/17 reporting period, Christchurch emitted 2,485,335 t CO_2e (excluding forestry sequestration) which equates to 6.6 t CO_2e/person. This is below recent per capita estimates for Dunedin City and Auckland City but above the per capita estimates for Tauranga and Wellington (see Figure below).

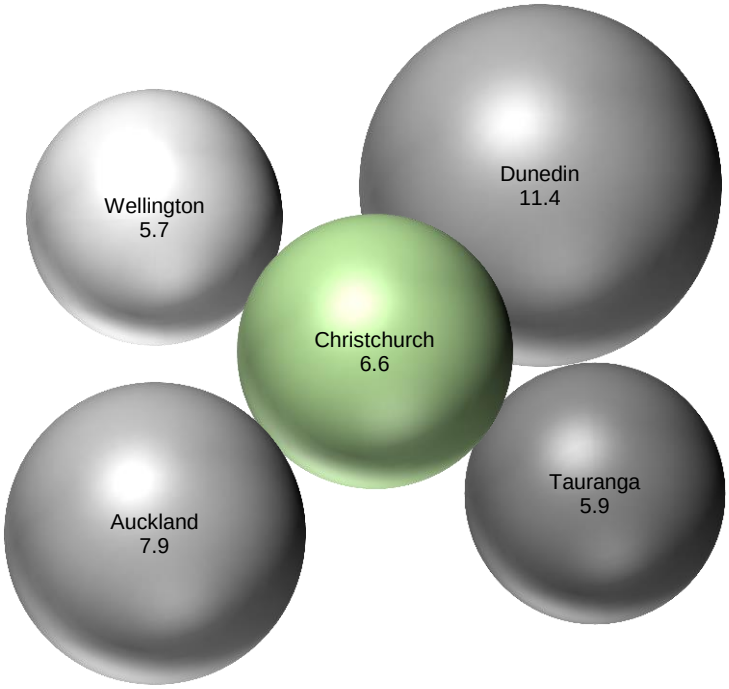

Figure 1 Per capita emissions for selected New Zealand cities

Other findings include:

- Transportation represents 53.1% of Christchurch's emissions followed by Stationary Energy (22.7%), Agriculture (10.5%), Waste (9%) and Industry (4.7%).
- The emissions from land use and forestry activities in Christchurch are -362,679 t CO_2e, which reduces Christchurch's gross emissions from 2,485,335 t CO_2e to net emissions of 2,122,656 t CO_2e.

- Transport related emissions (road, rail, aviation and marine) are Christchurch's largest emission source and represent a significant opportunity for reductions.

This report provides a high level baseline data set of the emissions for Christchurch and will help the Council to understand Christchurch's emissions profile and support the identification of key emission sources. This in turn provides a solid basis for developing appropriate mitigation responses. Regular reporting, e.g. every 3-4 years, will help the Council to measure the emission trends and to assess the effectiveness of any mitigation implemented.

Table 1 Emission summary by sector

Sector	Emissions (t CO_2e)	Percentage Gross Emissions Contribution
Transportation	1,318,889	53.1%
Stationary Energy	564,908	22.7%
Agriculture	260,309	10.5%
Waste	223,244	9.0%
IPPU (Industry)	117,985	4.7%
Total gross emissions (excl. forestry)	**2,485,335**	
Forestry	-362,679	
Total net emissions (incl. forestry)	**2,122,656**	

1.0 Introduction

AECOM New Zealand Limited (AECOM) has been commissioned by the Christchurch City Council (Council) to assist in the development of a community carbon footprint for the Christchurch district, (hereafter referred to as Christchurch). The study boundary is defined as the area under the Council's jurisdiction, i.e. Christchurch district, which includes Banks Peninsula.

1.1 Setting the scene

In 2016, representatives of 196 nations negotiated the Paris Agreement, committing to reduce global warming to less than 2 degrees and striving for no more than 1.5 degrees global warming[1].

To achieve this goal, globally we need to transition towards a low carbon economy by the second half of this century (refer Figure 2). This requires reducing global emissions by about 60-80% by 2050.

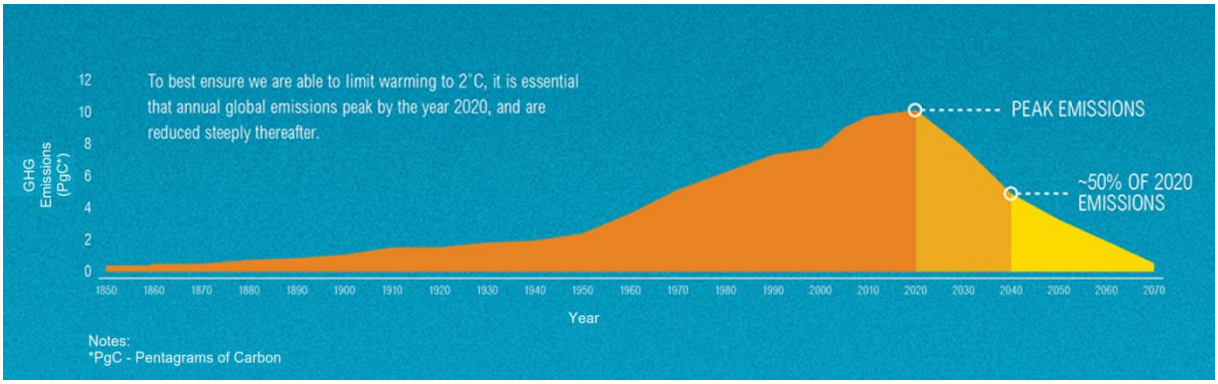

Figure 2 Global Carbon Budget (Source: World Resources Institute)

New Zealand signed the Paris Accord in 2016 and ratified it in 2017, supporting global action to reduce impacts from climate change. Action on climate change is however not limited to national governments and will require action on all levels from national government, to local government, cities, business and individuals. Over the last decade local governments globally have increasingly recognised their role in taking action on climate change both around mitigation and adaptation.

Globally more than 7,400 cities and local governments have signed up to the Global Covenant of Mayors for Climate and Energy[2] (reporting on their community greenhouse gas emissions and emission reduction measures).

54 Mayors and Regional Council Chairs of New Zealand have recently re-confirmed their 2015 Climate Change Declaration and the key commitments and actions that Councils plan to undertake[3].

1.2 Report overview

This report provides Christchurch with a snapshot of their emission profile for the 2016/17 financial year reporting period and identifies key emission sources and their relative contribution.

The principal aims of this report are to:

- Help the Council understand Christchurch's emissions profile;
- Enable informed decision making and policy development;
- Identify key emission sectors and stakeholders that could be encouraged to reduce local emissions.

[1] As of August 2017 196 nations have signed and 160 have ratified the agreement. The agreement has come into force in November 2016.
[2] Bringing together the Compact of Mayors and the Covenant of Mayors to advance city-level transition to a low emission and climate resilient economy (www.globalcovenantofmayors.org)
[3] LGNZ (20017), Local Government Leaders' Climate Change Declaration,

Globally emissions will need to reduce significantly over the next 30 years. Cooperating and working with stakeholders in each emission sector will be crucial to achieving this target. This document summarises the findings from the data collection and calculations and also outlines the underlying assumptions and limitations.

1.3 Scope and Approach for Community Carbon Footprint

This inventory report follows the methodology outlined in the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC), published by the World Resources Institute (WRI 2015) and includes emissions from stationary energy, transport, waste, industry, agriculture and forestry activities within the district boundary.

This is the same methodology used for other community scale greenhouse gas (GHG) inventories around New Zealand (e.g. Auckland, Dunedin, Tauranga and Wellington) and internationally.

This inventory assesses both direct (production-based) emission sources within the geographic area (Scope 1) and indirect (consumption-based) emission sources associated with goods and services imported into the geographic area. Examples of indirect emission sources include electricity from the national grid (Scope 2), transport that originates or terminates outside the district boundary e.g. aviation (Scope 3). Examples of consumption based emission sources are emissions from product use occurring within the district such as refrigerants used in air conditioning as well as petrol and diesel consumed within the district boundary. The GPC methodology[4] represents international best practice for city and community level GHG emissions reporting.

The following aspects are worth noting in reviewing the inventory:

- Emissions are expressed on a carbon dioxide-equivalent basis including climate change feedbacks using the 100-year GWP (Global Warming Potential) values including climate-carbon feedback from the Intergovernmental Panel on Climate Change Fifth Assessment Report: Climate Change 2013[5];
- Total emissions are reported as gross emissions (excluding forestry) and net emissions (including forestry);
- While emissions are reported by sector, the report should be read in full. Emissions from various sources should be assessed across the whole city as some sources were not able to be split up and proportions attributed to each relevant sector, e.g. diesel use is reported under the road transport in the Transportation sector includes diesel used for on and off-road transport and recreational boating.
- Due to data limitations, this inventory estimates emissions from industrial product use by scaling national emissions from industrial product use on a population basis;
- Due to data limitations, this inventory estimates solid waste emissions from both open and closed landfills and national inventory figures on a population basis;
- 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; and,
- It is likely that the overall carbon balance of the forest sector within the district boundary is relatively stable over a 50-100 year period. However on an annual basis the emissions and sequestration values vary significantly depending on the level of harvesting taking place. Emissions associated with land-use change have not been included, due to the lack of real time data. Only carbon sequestered in standing forests, grey shrubs (e.g. Matagouri), Gorse and Broom have been included (as per LCDB4). As a result, the effects from the 2017 Banks Peninsula fires were not taken into account.

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

2.0 Christchurch Community Carbon Footprint

2.1 Key Messages

- During the 2016/17 reporting period, Christchurch was responsible for **2,485,335 t CO_2e** gross emissions
- Christchurch's per capita gross emissions are **6.6 t CO_2e/person.**
- These per capita emissions are below the per capita estimates for Dunedin City 2014/15 (11.4 t CO_2e) and Auckland City 2014 (7.9 t CO_2e), and above the per capita estimates for Tauranga 2015/16 (5.9 t CO_2e) and Wellington 2014/15 (5.7 t CO_2e).
- Christchurch has below the national average per capita gross emissions for Stationary Energy, Waste, Industry and Agriculture.
- Christchurch is above the national average per capita gross emissions for Transportation.
- Transport related emissions (road, rail, aviation and marine) across the district represent 53.1% of the overall gross emissions, and are the district's largest emission source.
- Emissions from air travel contributed 7.3% and shipping contributed 4.1% of the district's total gross emissions, respectively. As both Christchurch Airport and the Port of Lyttelton provide a service to communities outside Christchurch, only part of the total emissions from both sources has been allocated to Christchurch.
- Forestry emissions are significantly driven by the amount of harvesting and planting that takes place in any given year. In the 2016/17 reporting period the amount of harvesting that took place in Christchurch (including Banks Peninsula) resulted in forestry-related sequestration of -362,679 t CO_2e, bringing the total net emissions for Christchurch to **2,122,656 t CO_2e**.

2.2 Potential next steps

- The report findings will help the Council to understand Christchurch's emissions profile and support the identification of key emission sources in Christchurch. This in turn provides a solid basis for developing appropriate mitigation responses;
- This report provides a high level summary of the emission results.
- This carbon footprint provides a baseline data set for developing or enhancing low carbon policies and plans.
- For some emission sources local data was not available during the development of the carbon footprint (e.g. actual fuel use for air travel and international shipping). These data gaps have been overcome by either using national level data on a per capita basis (i.e. Industrial product use emissions) or by estimating the emissions based on proxy data. For example, air travel emissions were estimated based on the number of flights arriving and departing from Christchurch airport and their origin or destination, type of aircraft and average fuel consumption figures. We recommend collecting Christchurch specific aviation fuel consumption data for future inventories where possible;
- Ongoing reporting on an annual basis will not be required. However, regular reporting, e.g. every 3-4 years as required under the Global Covenant of Mayors for Climate and Energy will help the Council to determine the emission trends and to assess the effectiveness of the mitigation responses implemented.

3.0 Overall Results

During the 2016/17 reporting period, Christchurch was responsible for **2,485,335 t CO_2e** gross emissions and **2,122,656 t CO_2e** net emissions (refer Table 2).

The population in 2016/17 was approximately 374,990 people[6], resulting in per capita gross emissions of **6.6 t CO_2e/person**[7].

Table 1 summarises the results using the following emissions sectors:

- Transportation including emissions from petrol and diesel sold within the district boundary, rail diesel use, jet kerosene and aviation gas used for aviation and LPG used for road transport.
- Stationary energy including emissions from electricity consumed by residential, commercial and industry users, electricity generated from non-renewable sources (i.e. landfill gas combustion), as well as consumption of petrol, diesel, coal, gas, biodiesel and wood.
- Agriculture includes emissions from livestock, crops and fertiliser use.
- Waste includes emissions from the treatment of wastewater, the disposal of solid waste and composting of organic material.
- Industrial processes and product use (IPPU) covers emissions associated with the consumption of GHGs for refrigerants, foam blowing, fire extinguishers, aerosols, metered dose inhalers and Sulphur Hexafluoride (SF_6) for electrical insulation and equipment production.
- The forestry sector includes carbon sequestered from commercial exotic forests and other native forest cover, as well as emissions from harvested trees.

Emissions from transportation represent the largest emissions source for Christchurch over the reporting period, contributing 53.1% to the overall emissions. The majority of the transportation emissions are a result of road transport, with petrol use contributing 20.7% and diesel use 20.5% to Christchurch's gross emissions (this includes a small percentage of emissions from off-road transport and recreational boating).

Stationary energy related emissions represent the second largest emissions sector for the district, contributing 22.7% to the overall emissions. The majority of the stationary energy emissions result from electricity consumption; contributing 12.5% to the Christchurch's gross emissions (refer Figure 3). Stationary petrol and diesel use (e.g. for generators) is responsible for approximately 4% of the overall gross emissions.

Agricultural emissions represent 10.5% of the district's gross emissions, waste emissions (mainly solid waste) represent 9% and industrial emissions represent 4.7%.

[6] Population data was supplied by the Christchurch City Council, original source - Statistics New Zealand.

[7] Gross emissions exclude forestry related emissions, whilst net emissions also consider the effects of forestry (sinks and sources). This distinction has been made in the carbon footprints where the forestry sectors sequester more carbon than they emit (i.e. through harvesting trees) and thereby offset some of the other district wide emissions.

Table 2 Summary of Overall Results by Source 2016/17

Sector/Category Source		Emissions (t CO_2e)		Percentage Gross Emissions Contribution
Transportation	Petrol	513,947	1,318,889	53.1%
	Diesel	509,884		
	Jet Kerosene (large aircraft)	180,676		
	Shipping Fuels (e.g. bunker fuels)	99,879		
	Liquid petroleum gas (LPG)	10,790		
	Rail Emissions (diesel)	1,795		
	Aviation Gas (small aircraft)	1,115		
	Marine Diesel	803		
Stationary Energy	Electricity Consumption	310,524	564,908	22.7%
	Stationary Petrol & Diesel	99,831		
	Liquid petroleum gas (LPG)	72,600		
	Coal	51,474		
	Electricity Transmission & Distribution (T&D) Loss	30,290		
	Landfill gas	107		
	Biodiesel	57		
	Biofuel (Wood)	25		
Agriculture		260,309		10.5%
Waste	Solid Waste Disposal	216,968	223,244	9.0%
	Waste Water	6,276		
IPPU (Industry)		117,985		4.7%
Total gross emissions (excl. forestry)		**2,485,335**		100%
Forestry	Exotic Forest Sequestration	-374,633	-362,679	
	Native Forest Sequestration	-108,393		
	Total Harvest Emissions	120,347		
Total net emissions (incl. forestry)		**2,122,656**		

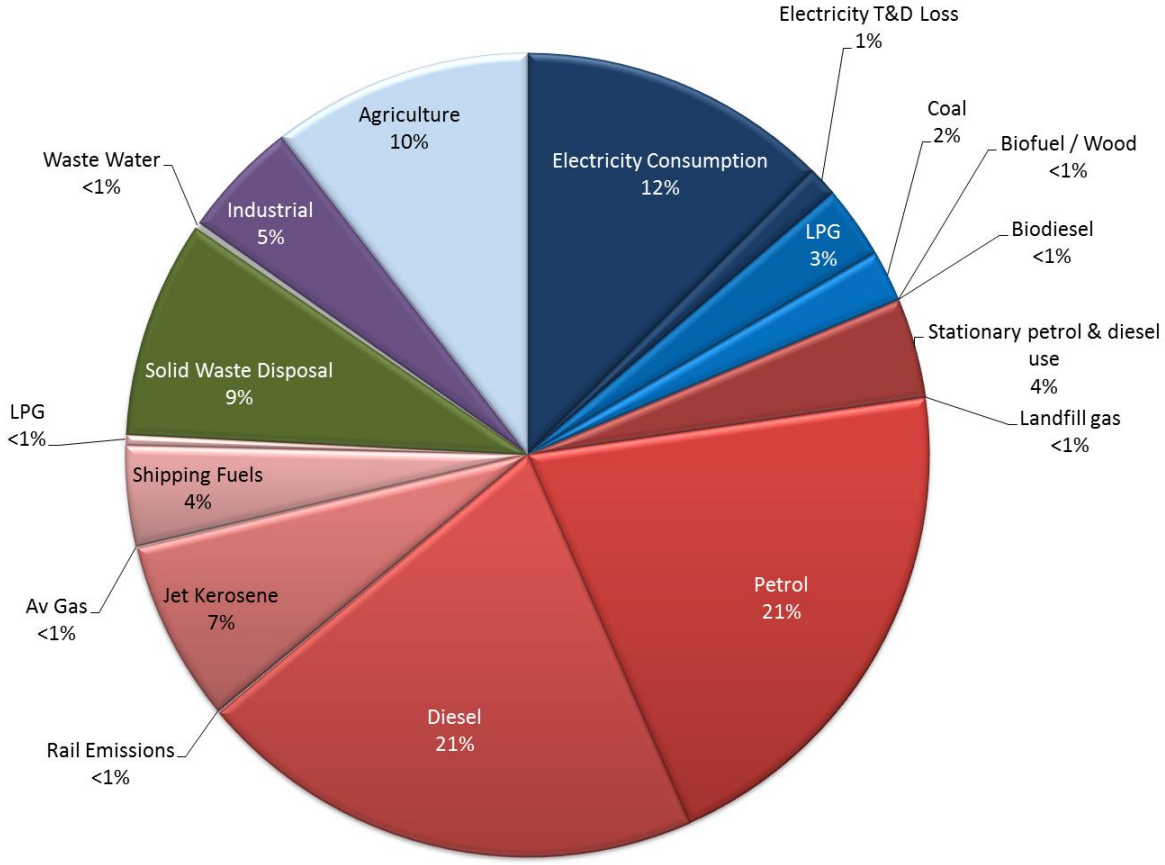

Figure 3 Summary of 2016/17 Overall Gross Emissions by Source

3.1 Transportation Emissions

In 2016/17 transportation sources contributed **1,318,889 t CO_2e**, representing 53.1% of Christchurch's overall gross emissions. Transportation was the highest sector contributing to Christchurch's GHG emissions.

The emissions profile for transportation sources is dominated by diesel and petrol used for on and off-road transport (predominantly Scope 1) contributing the majority of the transportation emissions during the reporting period. Fuel use for on and off-road transport is responsible for 78.4% of all transport emissions.

The remainder of the emissions generated in the transportation sector included air travel (13.8%), international and coastal shipping (7.6%) and rail (0.1%) (refer to Table 3 and Figure 4 below).

Emissions from air travel have been estimated based on the number of flights arriving and departing from Christchurch Airport and the assumed fuel consumption[8] during these flights. Half of the emissions were allocated to Christchurch and the other half to the airport of origin or destination.

Emissions from international and coastal shipping have been estimated based on the number of ships departing from Port of Lyttelton and their assumed fuel consumption[9] to their next destination[10].

[8] Aircraft fuel consumption was estimated based on aircraft type, average burn rate and flight distance.
[9] Fuel consumption from international and coastal shipping was estimated based on ship size and average fuel consumption per tkm.
[10] The GPC framework suggests estimating emissions from international and coastal shipping based on the distance travelled from the seaport within the city to the next destination.

Table 3 Summary of Transportation Emissions by Source 2016/17

Sector/Category Source		Emissions (t CO_2e)		Sector Percentage Contribution
Transportation	On-road, off-road and recreational boating (Petrol, Diesel and LPG)	1,034,621	1,318,889	78.4%
	Air travel	181,791		13.8%
	Marine	100,682		7.6%
	Rail	1,795		0.1%

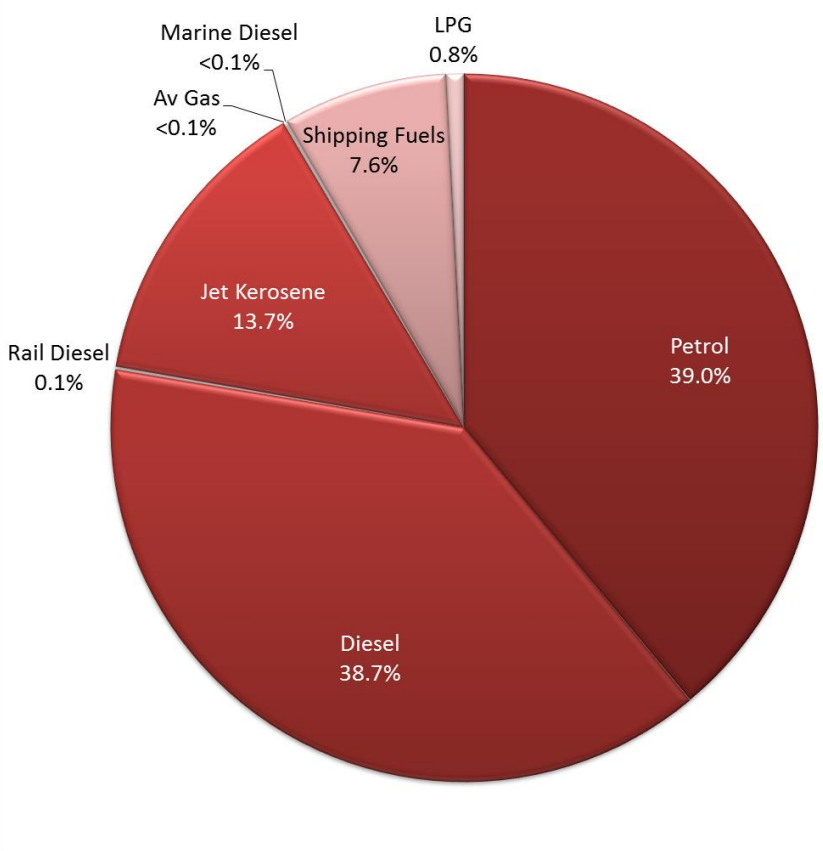

Figure 4 Summary of Transportation Emissions by Source 2016/17

3.2 Stationary Energy Emissions

Stationary energy use in Christchurch is responsible for **564,908 t CO_2e** in 2016/17; representing 22.7% of the Christchurch's gross emissions. Stationary energy was the second highest sector contributing to Christchurch's GHG emissions.

The main source of emissions from stationary energy is electricity consumption (Scope 2) contributing approximately 55.0% towards the total sector emissions, with a further 5.4% from electricity transmission and distribution (T&D) losses. Emissions from petrol and diesel use generate approximately 17.7%

Bottled LPG use (Scope 1) contributed approximately 12.9% and coal usage contributed approximately 9.1% towards total stationary energy sector emissions. CH_4 and N_2O emissions from combustion of landfill gas and natural gas from the waste water treatment plant are included in the Stationary Energy Emissions (a requirement of the GPC standard). A detailed breakdown of the stationary energy emission sources is provided in Table 4 and Figure 5 below.

Table 4 Summary of Stationary Energy Emissions by Source 2016/17

Sector/Category Source		Emissions (t CO_2e)		Sector Percentage Contribution
Stationary Energy	Electricity Consumption	310,524	564,908	55.0%
	Stationary petrol and diesel	99,831		17.7%
	LPG	72,600		12.9%
	Coal	51,474		9.1%
	Electricity T&D Loss	30,290		5.4%
	Landfill gas (and natural gas from WWTP)	107		0.019%
	Biodiesel	57		0.010%
	Wood biofuel	25		0.004%

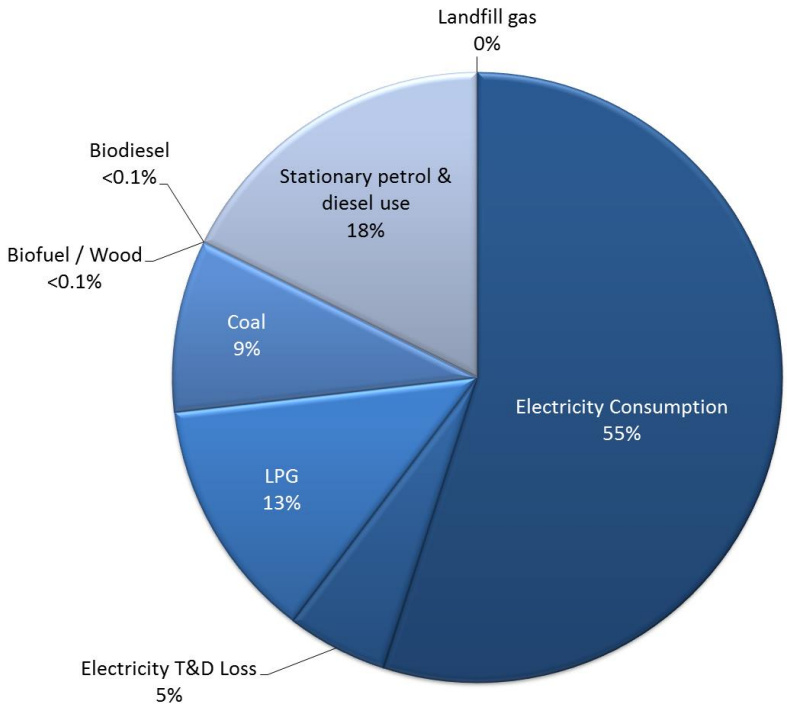

Figure 5 Summary of Stationary Energy Emissions by Source 2016/17

3.3 Agricultural Emissions

In 2016/17 agricultural GHG emissions contributed **260,309 t CO_2e** (10.5%) of Christchurch's gross emissions.

Methane (CH_4) is the most significant agricultural emission source (75%), predominantly from gas released during digestion of organic material (e.g. from cows and sheep). Nitrous oxide (N_2O) emissions from farming of animals, manure management and agricultural soils contributed approximately 25% of agricultural emissions in 2016/17. Figure 6 presents a breakdown of agricultural emissions by source.

The majority of agricultural emissions in Christchurch are attributed to dairy and beef farming (52%) and sheep farming (44%).

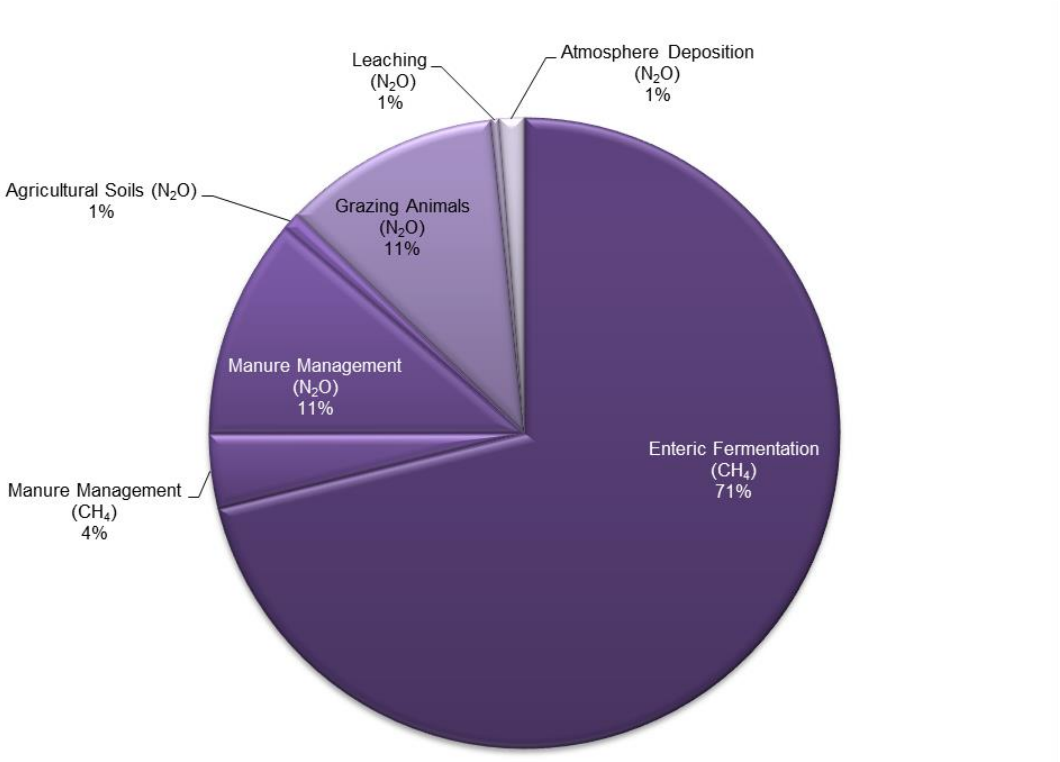

Figure 6 Summary of Agricultural Emissions by Source 2016/17

3.4 Waste Emissions

In 2016/17 waste emissions contributed **223,244 t CO_2e**, representing 9.0% of the Christchurch's overall gross emissions. Waste emissions are dominated by solid waste disposal contributing approximately 97% of the overall waste related emissions (refer Table 5).

Table 5 Summary of Waste Emissions by Source 2016/17

Sector/Category Source		Emissions (t CO_2e)		Sector Percentage Contribution
Waste	Solid Waste Disposal	216,968	223,244	97.2%
	Waste Water	6,276		2.8%

3.4.1 Solid Waste Details

Solid Waste emissions generated **216,968 t CO_2e** which represents around 8.7% of the total gross emissions for Christchurch. Solid waste emissions were estimated using a 1st-order decay model that requires waste volume estimates for the last 50 years. Due to the lack of specific data on waste volumes deposited at Bexley and Sawyers Arms Landfills between 1967 and 1984 the national average, as reported by Ministry for the Environment (MfE), has been used to estimate the total waste volumes for Christchurch. From 1985 to the present, waste volumes were provided by Christchurch City Council or specific landfill operators. National and city population figures have been used as reported by Statistics New Zealand and extrapolated where necessary.

During the 2016/17 reporting period approximately 302,303 tonnes of municipal solid waste generated within Christchurch was disposed of at Kate Valley Landfill in Teviotdale, Canterbury (Scope 1), representing the majority of solid waste generated by Christchurch. In addition to this, approximately 61,471 tonnes of organic waste was collected and sent to the Living Earth Organics Processing Plant to generate compost.

Figure 7 summarises the waste emissions by source. Emissions from landfills with landfill gas collection systems (i.e. Burwood and Kate Valley) are responsible for approximately 84% of the Christchurch's emissions from waste sector (refer Figure 7). It is understood that 100% of Kate Valley Landfill area captures LFG and it is assumed Kate Valley Landfill achieves 90% LFG recovery efficiency. LFG at Burwood Landfill was first captured and flared in 2003 to 2007, and from 2008 onwards the gas was flared or burnt at various Council facilities. The area of LFG extraction at Burwood has changed in the last year with the addition of 10 new wells which were commissioned on 28 February 2017. It is assumed Burwood Landfill achieves 20% LFG recovery. CH_4 and N_2O emissions from combustion of landfill gas are reported under stationary energy (landfill gas). CO_2 emissions from the combustion are reported outside the community carbon footprint, as these are considered to be biogenic.

The remaining emissions are from closed landfills without landfill gas collection that have been used in the past but are still emitting landfill gas.

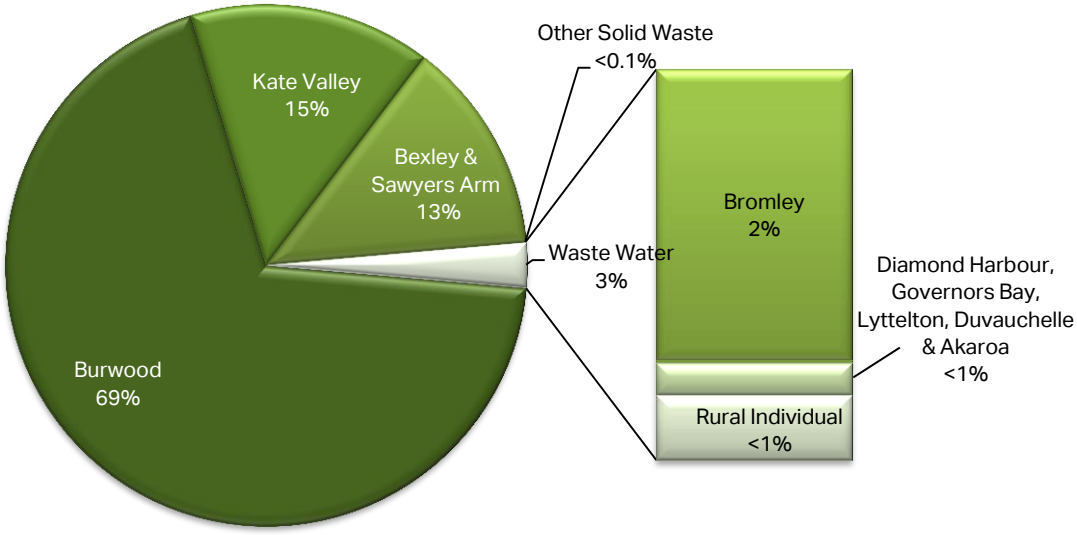

Figure 7 Summary of Waste Emissions by Source

3.4.2 Waste Water Details

Waste water treatment generated **6,276 t CO_2e** which represents less than 1% of the total gross emissions for Christchurch.

Waste water treated within Christchurch falls into two broad categories: waste water treated in waste water treatment plants (WWTP) and individual rural treatment systems (i.e. septic tanks). The majority of waste water in Christchurch is treated by advanced waste water treatment systems at one of six WWTPs in Christchurch resulting in very low emissions. These facilities include Bromley, Lyttelton, Governors Bay, Diamond Harbour, Akaroa and Duvauchelle.

Table 6 shows the emissions contribution by each of these wastewater treatment facilities.

Emissions from waste water treatment are based on the calculations outlined in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This includes N_2O emissions from treated waste water released into aquatic systems (e.g. the Christchurch ocean outfall) and in in line with New Zealand's national GHG inventory.

Around 16% of the waste water related emissions are emitted from individual rural treatment systems (i.e. septic tanks) (refer Figure 8). These systems service less than 2% of Christchurch's population.

Similar to the Solid Waste sector, CH_4 and N_2O emissions from combustion of natural gas collected at the Bromley WWTP are reported under stationary energy (landfill gas). CO_2 emissions from the

combustion are reported outside the community carbon footprint, as these are considered to be biogenic.

Table 6 Summary of Waste Water Treatment Emissions by Treatment Source 2016/17

Sector/Category Source		Emissions (t CO_2e)		Sector Percentage Contribution
Waste Water	Bromley	4,726	6,276	75.3%
	Rural Individual (septic tanks)	1,006		16.0%
	Akaroa	501		8.0%
	Lyttelton	24		0.4%
	Diamond Harbour	9		0.1%
	Governors Bay	7		0.1%
	Duvauchelle	5		0.1%

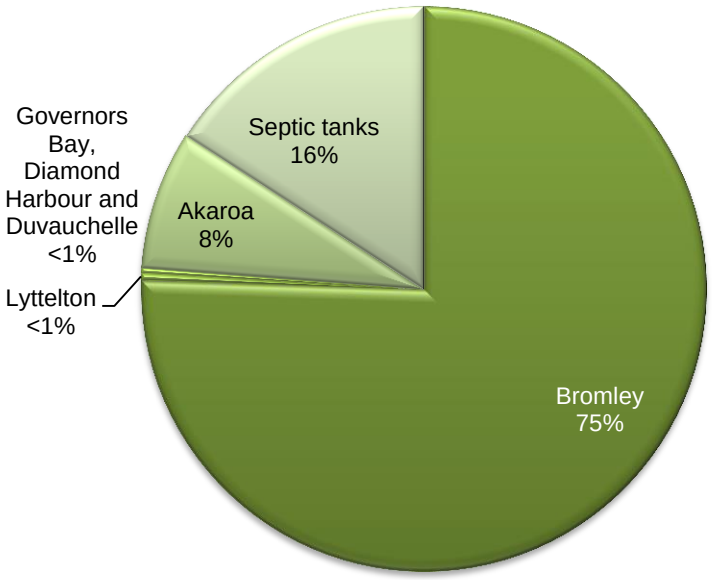

Figure 8 Summary of Waste Water Treatment Emissions by Treatment Source 2016/17

3.5 Industrial Emissions

In 2016/17 industrial GHG emissions contributed **117,985 t CO_2e** (4.7%) towards Christchurch's gross emissions. The emissions for industrial product use include emissions from hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (Scope 1). Nitrogen trifluoride emissions do not occur in New Zealand, and therefore are not included in this report.

Emissions from industrial product use were estimated based on New Zealand's average industrial product use emissions per capita and Christchurch's population.

No emissions from industrial processes have been included in the industrial emissions. It is understood that there are no large industrial operations within the district's boundary that result in significant GHG emissions. Ravensdown Limited manufactures super phosphorus fertilisers and sulphuric acid resulting in some indirect emissions (SO_2). However, in accordance with the national

inventory and the United Nations Framework Convention on Climate Change (UNFCCC) these are not included in the overall emissions calculations. It is assumed that these SO_2 emissions are insignificant for Christchurch.

Energy used in industrial manufacturing processes has been included in the relevant stationary energy sector (e.g. coal, electricity and/or petrol and diesel use).

3.6 Forest Carbon Sequestration and Emissions

The net emissions from land use, land use change and forestry (LULUCF) activities in Christchurch are **-362,679 t CO_2e**. Figure 9 presents a breakdown of forestry emissions by source.

Indigenous and exotic forests sequester an estimated **483,026 t CO_2e.** The majority of carbon is sequestered by exotic forest plantations (78%), while still maturing native forests (i.e. Manuka and Kanuka) sequestered the remaining 22%.

Harvesting related emissions were estimated based on harvesting volumes reported by Statistics New Zealand and Ministry for Primary Industries (MPI) National Exotic Forest Description (NEFD) data for 2016, and resulted in **120,347 t CO_2e**[11] of forestry emissions. Emissions associated with land-use changes have not been included, due to the lack of real time data. Only carbon sequestered in standing forests, grey shrubs (Matagouri) and Gorse and Broom have been included (as per LCDB4). As a result, the effects from the 2017 Banks Peninsula fires were not taken into account.

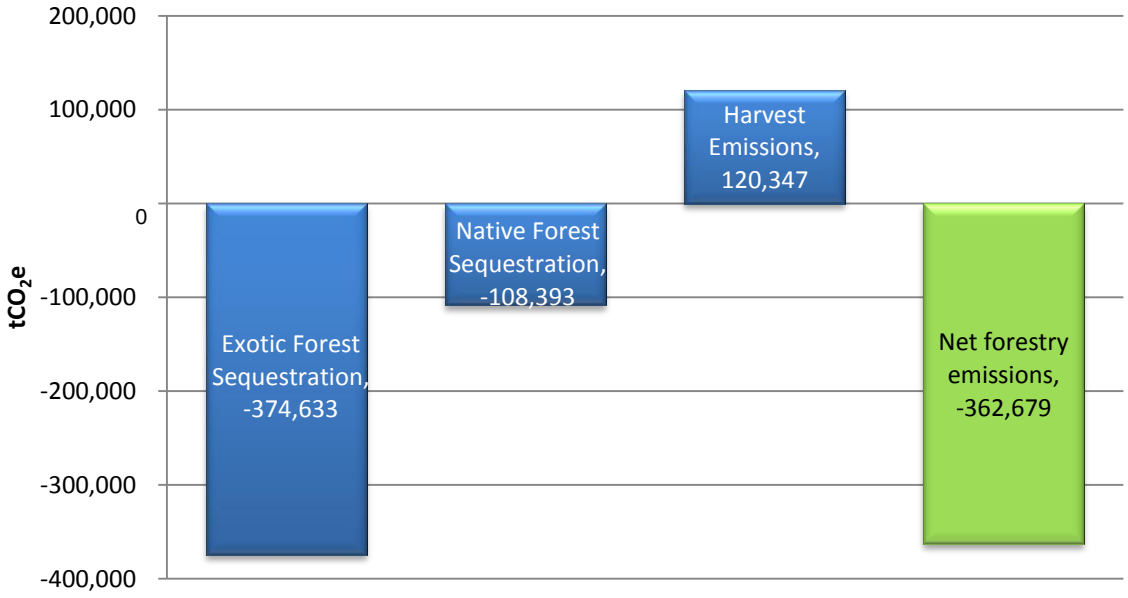

Figure 9 Summary of Forestry Emissions and Sequestration by Source 2016/17

3.7 Biogenic emissions

Biogenic CO_2 emissions, such as the combustion or digestion of biological materials, are part of the natural carbon cycle and do not directly contribute to climate change. The GPC Standard recommends reporting these emissions outside of the total greenhouse gas emissions. Christchurch generated approximately **29,414 t CO_2** from biogenic sources (i.e. from combustion of firewood and flaring of landfill gas). CH_4 and N_2O emissions from these sources are included in the overall GHG emissions, due to their higher radiative forcing.

[11] Due to the accounting method chosen for this report, all carbon stored in harvested trees, including in the wood products removed, below ground and in residues left on site, is assumed to result in emissions in the harvesting year.

3.8 Data Quality

The results reported here include some uncertainty, both for the activity data (e.g. agricultural animal numbers are based on Statistics New Zealand data for 2012, the last year animal numbers were published), as well as for the emissions factors (e.g. the carbon sequestration rates for indigenous and exotic forests are based on the national averages reported for 5 year age classes).

A complete list of the data sources, data limitations, as well as general assumptions and limitations is provided in Appendix A (reported separately).

The overall data quality for the reported results is high. Approximately 81% of the emissions reported are based on measured data using robust (M1) or satisfactory (M2) reporting systems. Of which 76% are rated as M1 and 26% as M2.

About 19% of the emissions are based on derived data (D1). For example jet kerosene fuel use is based on the average burn rate per plane type and the overall travel distance, while emissions from industrial product use have been estimated based on the national per capita average and Christchurch population.

Less than 0.1% of the total emissions are based on estimated data using questionable reporting systems (E3). Av Gas use for smaller plane and helicopters has been estimated to be approximately double the amount reported for Tauranga airport. A detailed description of the data quality guide is provided in Table 7 below.

Table 7 Data Quality Guide

Data management	Data collection		
	Measured	**Derived**	**Estimated**
Robust	M1	D1	E1
Satisfactory	M2	D2	E2
Questionable	M3	D3	E3

Measured = Data directly provided by a service provider, contractor or directly obtained from a monitoring device. For example electricity invoices, contractor receipts, emissions monitoring equipment, incident reports, consultant reports etc.

Derived = Data obtained from calculations, mass balances, use of physical/chemical properties, use of coefficients and emission factors etc. For example converting cubic meters of waste into tonnes

Estimated = Usually where there is no other available method for obtaining the data. Such data could be prorated on previous results, use of precedents or historical data, or even a calculated guess

Robust = Evidence of sound, mature and right reporting system, where room for error is negligible. Examples would include use of spread sheets, databases and on-line reporting

Satisfactory = Examples would include manual, but structured keeping of records, files and results. Some potential for error or loss of data.

Questionable = No logical or structured approach to data or record keeping. High potential for error &/or loss of data. Data may appear to differ from those initially reported.

4.0 Discussion and Data Comparison

4.1 New Zealand Context

Figure 10 shows a comparison of the gross per capita emissions (excluding forestry) for Christchurch with other cities in New Zealand and against the New Zealand national average per sector.

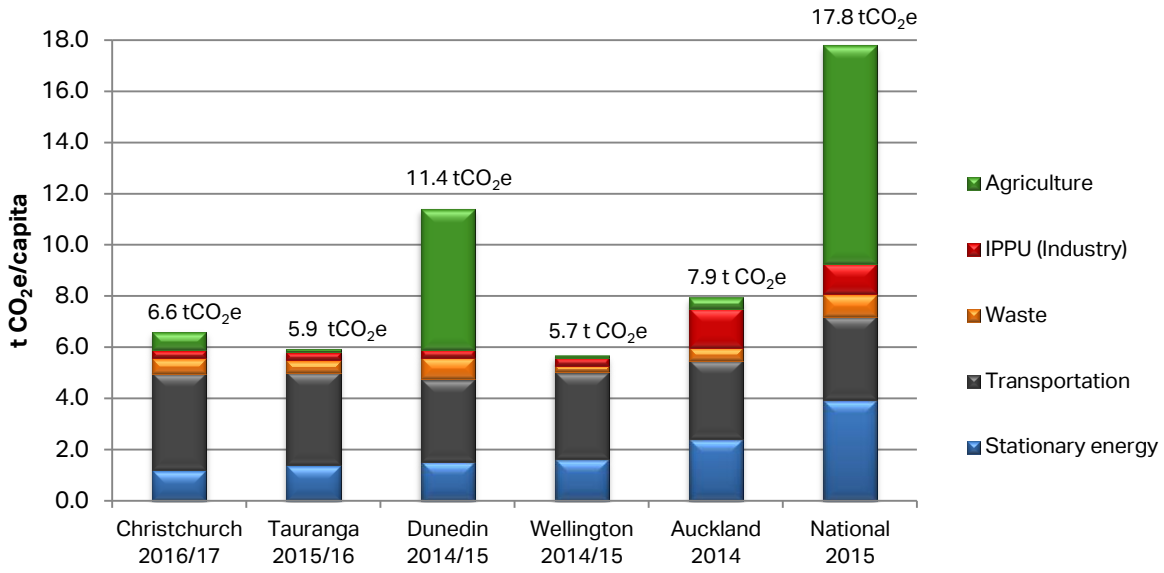

Figure 10 Comparison of Christchurch's per capita emissions with selected New Zealand cities and the National Average[12]

On a per capita basis Christchurch's emissions are lower than the national average and Dunedin City and Auckland City emissions. This is mainly due to the low agricultural emissions from Christchurch and the lack of large industries producing GHG emissions.

Christchurch's per capita transport emissions are higher than those estimated for the national average and each of the cities compared above, with the exception of Tauranga. Transport emissions represent a significant opportunity for emission reductions.

Christchurch's per capita stationary energy emissions are lower than those reported for each of the cities compared above and lower than the national average.

Christchurch's waste emissions are similar to each of the cities compared above and the national average.

Christchurch's per capita agricultural emissions are slightly higher than Tauranga, Wellington and Auckland, but are significantly lower than Dunedin and the national average.

[12] Ministry for the Environment (2017), New Zealand Greenhouse Gas Emissions 1990 - 2015

5.0 Report - Standard Limitations

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6.0 References

EECA 2018	Energy Efficiency and Conservation Authority (2018), Energy Enduse Database - 2015 calendar year data https://www.eeca.govt.nz/resources-and-tools/tools/energy-end-use-database/
LGNZ 2017	Local Government New Zealand (2017), Local Government Leaders' Climate Change Declaration.
MBIE 2017a	Ministry for Business, Innovation and Employment (2017) http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-in-new-zealand
MBIE 2017b	Ministry for Business, Innovation and Employment (2017) http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity
MfE 2017	Ministry for the Environment (2017), New Zealand Greenhouse Gas Emissions 1990 - 2015
MfE 2016	Ministry for the Environment (2016), Guidance for voluntary greenhouse gas reporting - 2016: Data and methods for the 2014 calendar year
MPI, 2016	Ministry for Primary Industries (2016), National Exotic Forest Description as at 1 April 2016
StatsNZ 2016a	Agricultural Production Census (Final Results): Summary of Livestock Numbers by Type and Territorial Authority 2012
StatsNZ 2016b	Agricultural Production Statistics: June 2016
StatsNZ 2016c	Total Regional Harvest Volume for 2016
WRI 2015	World Resources Institute (2015), *Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC)*, World Resources Institute
WRI 2014	World Resources Institute (2014), Infographic: The Global Carbon Budget, World Resources Institute http://www.wri.org/resources/data-visualizations/infographic-global-carbon-budget