Otago Region Greenhouse Gas Profile

Prepared for Otago Regional Council

12 May 2021

Building a better working world

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Acknowledgements

The development of a regionwide greenhouse gas emissions inventory is a complex process which requires input from a variety of stakeholders. Ernst & Young and the Otago Regional Council would like to thank contributors to this report; specifically, the Central Otago District Council, Clutha District Council, Dunedin City Council, Queenstown-Lakes District Council, Waitaki District Council, Statistics New Zealand – Tatauranga Aotearoa, Ministry for the Environment – Manatū Mō Te Taiao, PowerNet, Aurora Energy, Network Waitaki, KiwiRail, Ahika Consulting, Rockgas, Port Otago, Queenstown Airport and Dunedin Airport.

1. Executive Summary

Background and overview of work performed

The effects of climate change are already being observed in New Zealand. Average annual temperatures and sea levels are rising, glacier ice volumes are decreasing, and extreme weather events are more frequent. To avoid the worst effects of climate change, significant and urgent action is required to reduce and remove greenhouse gas (GHG) emissions in an effort to limit global warming to well below 2°C above pre-industrial levels. It is becoming increasingly important for governments, organisations, and communities to understand their sources of emissions so that efforts to reduce emissions are targeted and effective in order to mitigate the worst effects of climate change.

Governments and organisations all around the world use emission inventories to help determine and monitor significant sources of GHG emissions and to target mitigation efforts. It is the important first step on the path to reducing emissions and monitoring progress.

The Otago Regional Council's (ORC) long-term plan is to manage and mitigate climate change impacts. To support this, EY has developed an **Otago Region GHG Profile**. This inventory has been developed to enable ORC to better understand significant sources of GHG emissions across its five districts and the emissions profile of major industries for the latest applicable time period. The emissions inventory was developed for year ended 30 June 2019.[1] The results will help ORC and its districts to better understand and target climate change mitigation efforts.

The **Otago Region GHG Profile** was developed in line with the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories* (GPC) developed by the Greenhouse Gas Protocol for C40 Cities Climate Leadership Group, the World Resources Institute (WRI) and Local Governments for Sustainability (ICLEI)[2].

Key findings

Total gross emissions (excluding Land Use, Land Use Change and Forestry (LULUCF)) for the Otago region in 2019 are estimated to be **5,821,025 tCO_2e**. The LULUCF sector is a net emissions sink at -2,640,398 tCO_2e which offsets approximately 47% of the region's gross emissions resulting in total net emissions for the Otago region of **3,180,627 tCO_2e.**

The following key findings were noted by EY during development of the inventory:

What did EY find?		What does this mean for ORC?
	The primary source of emissions in the Otago region is the agriculture sector, which is consistent across four of the five districts (Central Otago, Clutha, Dunedin City, Waitaki). A large proportion of these emissions is related to cattle and sheep farming.	There may be opportunities to target emission reduction activities with livestock farming however the carbon intensity of this activity should be considered due to the relative size of this sector.
	Land use, land use change, and forestry (LULUCF) is a significant sink of emissions resulting in net negative emissions from this sector. Clutha district contributes the majority (59%) of this sequestration. However, all of the districts had net positive emissions profiles as the sources of emissions outweighed the sinks.	Although the LULUCF sector is a net emissions sink, forest harvest activities are a source of emissions. Forest conservation, regeneration and reforestation could be a significant contributor to balancing sources and sinks in the region.

[1] Whilst every effort was made to obtain activity data for the period 01 July 2018 – 30 June 2019 in some cases the latest available data was for a prior period. The latest available data was used.

[2] GHG Protocol, WRI, C40, ICLEI, Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, available at: https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

What did EY find?	What does this mean for ORC?
Transportation was more significant in the emissions profiles of Dunedin and Queenstown-Lakes (the transportation sector is the most significant source of emissions in Queenstown-Lakes). The most significant contribution to emissions is related to on-road petrol and diesel consumption.	Considering how people move and the modes of transport they choose will be important in tackling emissions from this sector. A shift to electric vehicles replacing traditional internal combustion engine powered transport may reduce emissions from this sector.
Electricity makes up a significant proportion of stationary energy emissions across all districts. However, where coal, liquified petroleum gas (LPG) or light fuel oil (LFO) boilers are used this creates a significant source of emissions.	There may be opportunities for fuel switching (e.g. to biomass) and/or electrification to reduce emissions from stationary energy sources.
The varied information sources required to collate a complete emissions inventory for the region may present an on-going challenge for ORC as it seeks to monitor its emissions and the effectiveness of mitigation actions. ORC relied on a number of third parties to obtain the activity data used in the emissions inventory.	To maintain and update the regional emissions inventory it may be beneficial for ORC to formalise its climate data management to ensure efficient and effective processes are in place to obtain timely data to support an evidence-based climate action strategy.

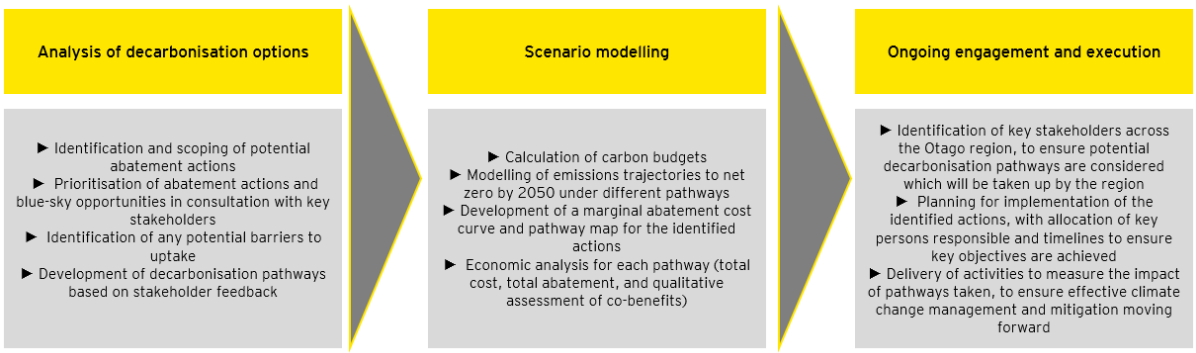
It should be noted that a number of assumptions were made during the development of ORC's GHG emissions inventory. These assumptions and associated limitations are outlined in the technical method presented in **Appendix A** of this report.

Proposed next steps

This regional dataset provides the ORC with an initial platform which can be used to initiate effective management and mitigation of climate change impacts.

Recommendations

1. Further analysis and modelling are required to turn the data into a tool for proactive planning. EY recommends both the development of 'business-as-usual' emissions projections to 2050 and the scenario modelling of mitigation options. This will assist in identification of effective mitigation and decarbonisation options and facilitate collective discussion of priorities for action and engagement, both at a regional and local level. Based on the development of options and scenario modelling, economic impacts of mitigation actions can also be estimated and used for planning, engagement and decision making. A quote for this section of work was included in the initial RFP.



2. The dataset will require maintenance and review to ensure its currency and accuracy. An approach to this will be required to be discussed and agreed by ORC and its districts.

3. In particular, efforts should be made to obtain better data for the following sources:

- Industrial processes and product uses
- Solid waste disposal
- Wastewater treatment and discharge.

This will improve the accuracy of the calculated emissions and projections (where applicable) ensuring decisions are made which reflect the actual impacts of climate change as a result of specific actions.

4. ORC and districts may wish to review their climate data management systems and processes in collaboration with third parties who also contribute, to ensure long term and timely access to the quality data on which this inventory relies. Good climate data management and established and reliable coordination arrangements with a range of stakeholders is needed to inform and improve climate policy design, implementation and decision-making.

2. Scope and Approach

EY developed a GHG emissions inventory for the Otago region, which comprises the following five districts:

- Central Otago
- Clutha
- Dunedin City
- Queenstown-Lakes
- Waitaki.

Whilst the *Otago Region GHG Profile* is broken down by district, it is noted that Dunedin City and Queenstown-Lakes have completed their own district level emissions inventories. Significant differences in results (due to method and assumption differences), are discussed in the relevant district chapters.

The GHG emissions inventory was developed across three key project phases, summarised below.

Figure 1 - Map of Otago Regional Council's boundaries (http://www.localcouncils.govt.nz/)

Phase	Key activities performed
Phase 1: Inception and planning	► A project inception meeting was facilitated. ► EY was introduced to key data owners across ORC's districts. ► A project plan was developed and used to track progress across the engagement.
Phase 2: Inventory development	► EY assessed the region's and individual districts' emissions boundaries and emissions sources in alignment with the GHG Protocol BASIC+ inventory reporting level. ► Key data sources and owners (landfill operators, large commercial and industrial sites, rail operators, government bodies and agencies etc.) were identified. ► Data was collected by performing desktop research and by contacting key stakeholders and data owners previously identified. ► EY assessed the data quality of each data source against GHG Protocol indicators and in line with the GHG Protocol's Global Protocol for Community-Scale Greenhouse Gas Emission Inventories and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. ► EY developed estimation methods for data gaps. These estimation methods were validated with ORC and are outlined within the technical method in **Appendix A** of this report as relevant. ► EY identified appropriate emission factors and developed the inventory calculation method. ► EY calculated the emission inventory for the whole-of-Otago region, broken down by sector and by each of the five districts in the regional GHG inventory Excel file.
Phase 3: Reporting and transmittal	► EY developed the emission inventory in an Excel file and an accompanying report (this report). ► EY provided the draft report to ORC for comment. ► EY addressed ORC's comments and finalised the emission inventory and report accordingly.

The technical approach to inventory development, including assumptions made and associated limitations, is presented in **Appendix A** of this report.

3. Results

In 2019, the Otago economy generated $14 billion in gross domestic product (GDP) (4.5% of NZ's GDP). The top 5 industries by GDP were Construction (9.1% of total Otago GDP), Agriculture, Forestry and Fishing (6.6%), Rental, Hiring and Real Estate Services (6.3%), Accommodation and Food Services (6.2%), and Healthcare and Social Assistance (6.1%). The residential population in Otago was estimated at 239,700 people.

Total gross emissions (excluding Land Use, Land Use Change and Forestry (LULUCF)) for the Otago region in financial year ended 30 June 2019 are estimated to be 5,821,025 tCO_2e. The LULUCF sector is a net emissions sink at -2,640,398 tCO_2e which offsets approximately 47% of the region's gross emissions resulting total net emissions for the Otago region of 3,180,627 tCO_2e.

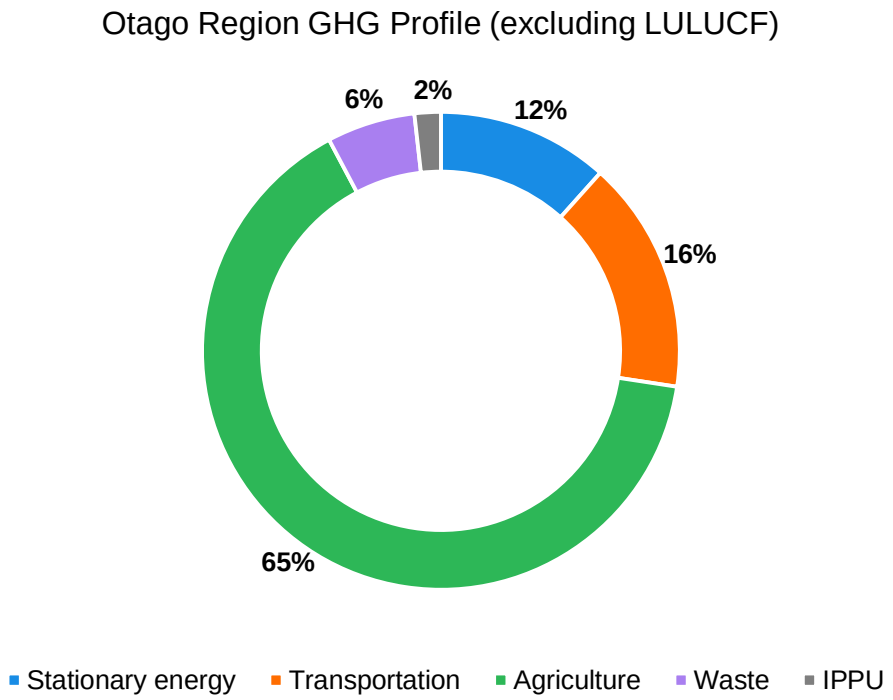


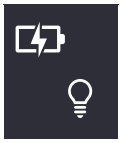
Figure 2 - Otago Region GHG Profile (excluding LULUCF)

	Emissions (tCO_2e)
Stationary energy	676,856
Transportation	918,438
Agriculture	3,774,184
Waste	348,036
Industrial Process and Product Use (IPPU)[3]	103,510
Gross emissions (exc. LULUCF)	**5,821,025**
LULUCF	-2,640,398
Net emissions (inc. LULUCF)	**3,180,627**

Table 1 – Otago Region GHG emissions by sector

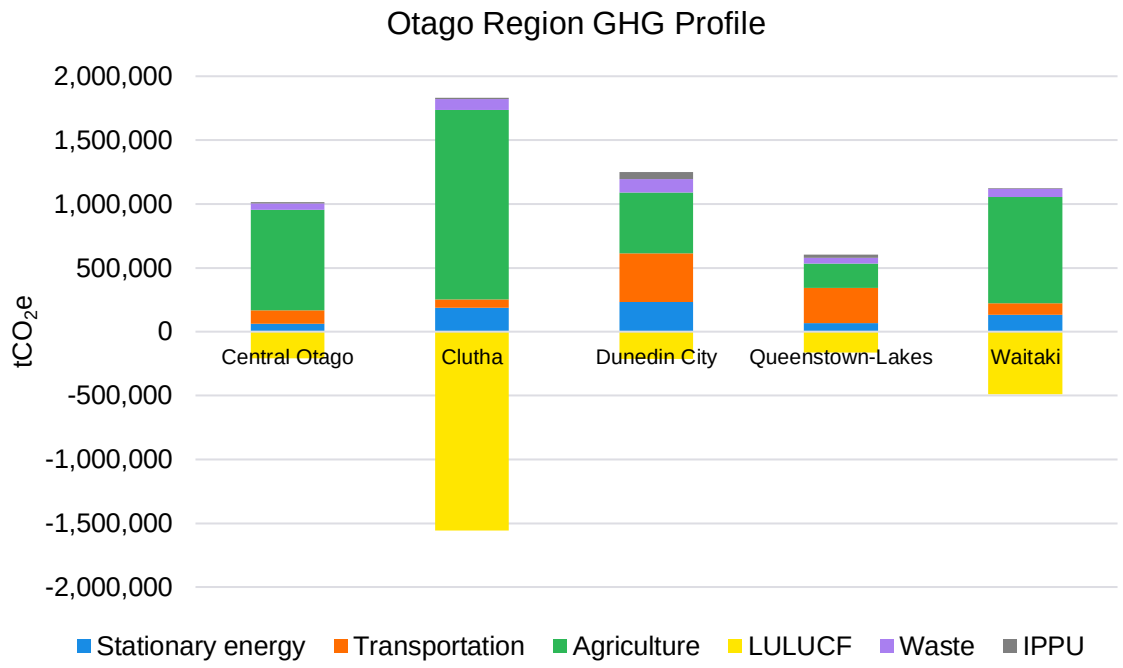
[3] IPPU covers the GHG emissions resulting from various industrial activities that produce emissions not directly the result of energy consumed during the process and the use of man-made greenhouse gases in products. Examples include the release of CO2 as a by-product of cement production and the use of fossil fuel (primarily natural gas) as a feedstock in ammonia production.

Key findings

What did EY find?		What does this mean for ORC?
	The primary source of emissions in the Otago region is the agriculture sector, which is consistent across four of the five districts (Central Otago, Clutha, Dunedin City, Waitaki). A large proportion of these emissions is related to cattle and sheep farming.	There may be opportunities to target emission reduction activities with livestock farming however the carbon intensity of this activity should be considered due to the relative size of this sector.
	Land use, land use change, and forestry (LULUCF) is a significant sink of emissions resulting in net negative emissions from this sector. Clutha district contributes the majority (59%) of this sequestration. However, all of the districts had net positive emissions profiles as the sources of emissions outweighed the sinks.	Although the LULUCF sector is a net emissions sink, forest harvest activities are a source of emissions. Forest conservation, regeneration and reforestation could be a significant contributor to balancing sources and sinks in the region.
	Transportation was more significant in the emissions profiles of Dunedin and Queenstown-Lakes (the transportation sector is the most significant source of emissions in Queenstown-Lakes). The most significant contribution to emissions is related to on-road petrol and diesel consumption.	Considering how people move and the modes of transport they choose will be important in tackling emissions from this sector. A shift to electric vehicles replacing traditional internal combustion engine powered transport may reduce emissions from this sector.
	Electricity makes up a significant proportion of stationary energy emissions across all districts. However, where coal, liquified petroleum gas (LPG) or light fuel oil (LFO) boilers are used this creates a significant source of emissions.	There may be opportunities for fuel switching (e.g. to biomass) and/or electrification to reduce emissions from stationary energy sources.
	The varied information sources required to collate a complete emissions inventory for the region may present an on-going challenge for ORC as it seeks to monitor its emissions and the effectiveness of mitigation actions. ORC relied on a number of third parties to obtain the activity data used in the emissions inventory.	To maintain and update the regional emissions inventory it may be beneficial for ORC to formalise its climate data management to ensure efficient and effective processes are in place to obtain timely data to support an evidence-based climate action strategy.

District and National Comparisons

The below graph compares the five district GHG profiles that make up the total GHG profile for the Otago Region.



To enable meaningful comparison with the national inventory, international bunker fuels must be excluded. This exclusion affects the emissions of the Queenstown-Lakes and Dunedin City districts. However, to align with the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories*, the district breakdowns found in sections 3.1 to 3.5 of this report include emissions from international bunker fuels used in shipping and aviation.

Excluding international bunker fuels, total gross emissions for the Otago region are **5,708,198 tCO_2e** and net emissions are **3,067,800 tCO_2e**. The Otago region represents approximately 6.9% of New Zealand's 2019 gross emissions and 5.6% of New Zealand's net emissions. This compares with Otago accounting for approximately 5% of New Zealand's population and 4.5% of national GDP.

Emissions intensity, for example on the basis of population or GDP, has not been calculated. This decision was made to reflect the economic variability between districts, and that intensity-based metrics may be misleading. For instance, comparing primary production with services is not a fair comparison as economic activity in the services sector is relatively low emissions but often high GDP, and primary production is high emissions and lower GDP. Applying this to the districts, Dunedin is predominantly a service-based economy and has relatively low emissions and the highest GDP share in the region, whereas Clutha is focused on primary production and has the largest gross emissions and lowest GDP in the region.

3.1 Central Otago District

In 2019, the Central Otago economy generated $1.5 billion in GDP (11% of Otago's GDP). The economy is concentrated on the primary sector (Agriculture, Forestry and Fishing) and the Construction sectors, which both accounted for 14% of the district's total GDP share. The residential population in Central Otago was estimated at 23,100 people (10% of Otago's total population).

Key insights:

- Gross and net emissions for the Central Otago District are estimated at **1,013,444 tCO_2e** and **802,118 tCO_2e** respectively.
- The Agriculture sector accounts for most of the emissions in the district, reflecting the large number of sheep (over 1.3 million) in the district (contributing 58% to Agriculture emissions) followed by dairy and beef cattle which contribute 31% to Agriculture emissions.
- Transportation is the second largest source with on- and off-road transport contributing 106,925 tCO_2e.
- Stationary energy is the third largest source with electricity being the primary energy source.
- Central Otago has minimal waste emissions as solid waste is sent out-of-boundary for disposal to landfill.

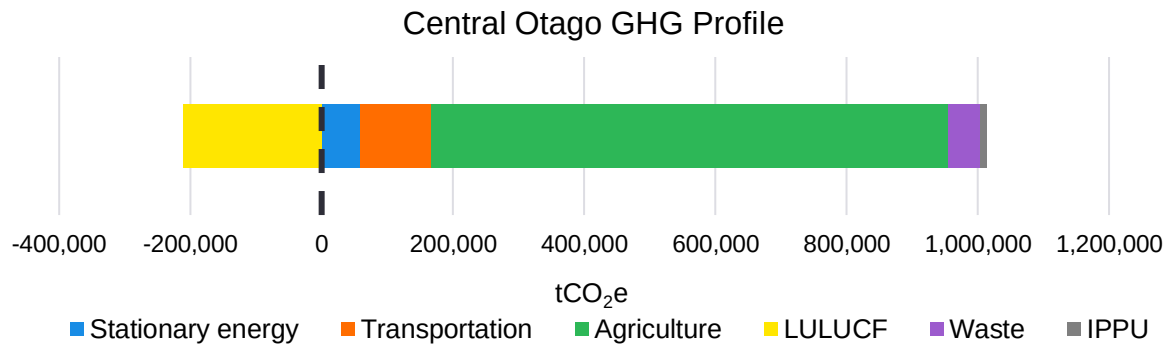


Table 2 Detailed GHG emissions breakdown for Central Otago by source

Source	Emissions (tCO_2e)	Contribution (%)
Agriculture		
Livestock	713,602	70.41%
Fertiliser	75,079	7.41%
Transportation		
On-road	78,978	7.98%
Off-road	27,948	2.82%
Railways	0	0.00%
Aviation	0	0.00%
Waterborne navigation	0	0.00%
Stationary energy		
Electricity	38,086	3.76%
Electricity T&D losses	3,266	0.32%

Coal	3,246	0.32%
Diesel	9,836	0.97%
Liquified petroleum gas	3,177	0.31%
Light fuel oil	34	0.00%
Wood	980	0.10%
Petrol	893	0.09%
Waste		
Solid waste disposal - Active landfills	0	0.00%
Solid waste disposal - Closed landfills	396	0.04%
Wastewater treatment and discharge	1,084	0.11%
Farm fills and rural waste	47,525	4.69%
Industrial processes and product uses		
Industrial processes and product uses	9,314	0.92%
Forestry		
Pre 1990 planted forest	-193,387	n/a
Post 1989 planted forest	-140,047	n/a
Regenerating natural forest	-888	n/a
Forest harvest	122,995	n/a

Table 2a Stationary energy emissions breakdown for Central Otago by subsector

Source	Subsector			
	Residential buildings	Commercial and institutional buildings and facilities	Manufacturing industries and construction	Agriculture, forestry, and fishing activities
Electricity	7,146	6,416	18,652	5,872
Electricity T&D losses	613	550	1,599	503
Coal	1,077	2,168	0	0
Diesel	40	184	0	9,612
Liquified petroleum gas	2,657	250	183	88
Light fuel oil	0	0	0	34
Wood	923	8	49	0
Petrol	0	0	0	893
Total	**12,456**	**9,576**	**20,483**	**17,002**

3.2 Clutha District

In 2019, the Clutha economy generated $1 billion in GDP (7% of Otago's GDP). Clutha's economy is heavily concentrated on the primary sector, which accounted for 33% of the district total GDP share. Manufacturing and Construction are the two other biggest sectors in Clutha, accounting for 10% and 6.4% of the district's GDP respectively. The residential population in Clutha was estimated at 18,150 people (8% of Otago's total population).

Key insights:

- Gross and net emissions for the Clutha District are estimated at **1,830,267 tCO_2e** and **270,491 tCO_2e** respectively.
- Clutha has the highest gross emissions out of all districts in the region but given its significant forest estate has the lowest net emissions in the region.
- Emissions come primarily from the Agriculture sector. Clutha has the highest number of sheep and dairy cattle in the region, each contributing 43% and 31% to Agriculture emissions respectively. Clutha also applies the largest amount of fertiliser, with fertiliser accounting for 15% of Agriculture emissions.
- Stationary energy is the next largest emitting sector, with large amounts of coal (59,882 tonnes) being used.

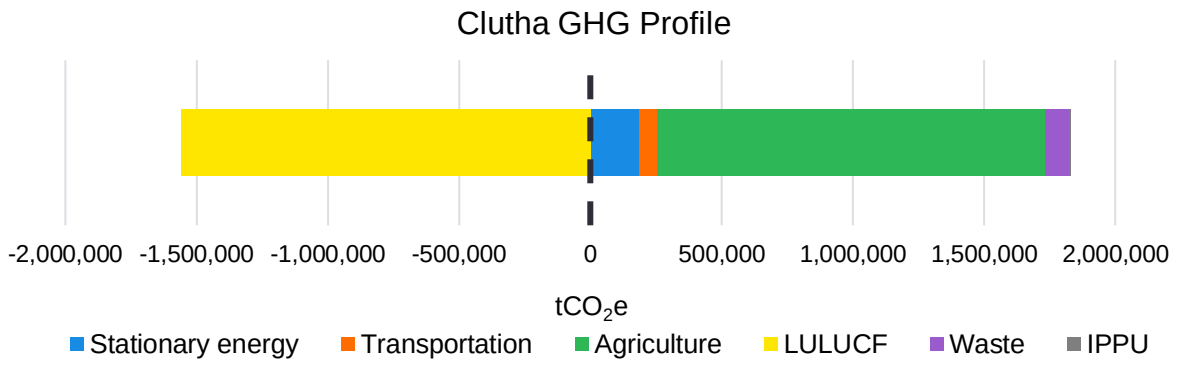


Table 3 Detailed GHG emissions breakdown for Clutha by source

Source	Emissions (tCO_2e)	Contribution (%)
Agriculture		
Livestock	1,262,817	69.00%
Fertiliser	219,086	11.97%
Transportation		
On-road	46,940	2.56%
Off-road	16,610	0.91%
Railways	3,975	0.22%
Aviation	0	0.00%
Waterborne navigation	0	0.00%
Stationary energy		
Electricity	19,551	1.07%

Electricity T&D losses	1,676	0.09%
Coal	120,371	6.58%
Diesel	16,587	0.91%
Liquified petroleum gas	24,216	1.32%
Light fuel oil	56	0.00%
Wood	1,988	0.11%
Petrol	1,469	0.08%
Waste		
Solid waste disposal - Active landfills	6,947	0.38%
Solid waste disposal - Closed landfills	0	0.00%
Wastewater treatment and discharge	3,386	0.18%
Farm fills and rural waste	78,221	4.27%
Industrial processes and product uses		
Industrial processes and product uses	6,369	0.35%
Forestry		
Pre 1990 planted forest	-2,024,590	n/a
Post 1989 planted forest	-1,125,359	n/a
Regenerating natural forest	-27,962	n/a
Forest harvest	1,618,135	n/a

Table 4a Stationary energy emissions breakdown for Clutha by subsector

Source	Subsector			
	Residential buildings	Commercial and institutional buildings and facilities	Manufacturing industries and construction	Agriculture, forestry, and fishing activities
Electricity	6,352	1,994	5,573	5,632
Electricity T&D losses	545	171	478	483
Coal	4,148	6,141	110,082	0
Diesel	33	733	0	15,821
Liquified petroleum gas	2,177	3,582	18,313	144
Light fuel oil	0	0	0	56
Wood	803	2	1,183	0
Petrol	0	0	0	1,469
Total	**14,057**	**12,623**	**135,629**	**23,606**

3.3 Dunedin City District

In 2019, the Dunedin economy generated $6.6 billion in GDP (47% of Otago's GDP). Compared to other districts in the region which have a strong concentration on one sector, Dunedin's economy is diversified, with similarly sized top industries; Health Care and Social Assistance sector (9.8% of Dunedin's total GDP), Education and Training (9.2%), Construction (8.5%), Professional, scientific and Technical Services (6.7%), and Retail Trade (5.9%). The residential population in Dunedin was estimated at 132,200 people (55% of Otago's total population).

Key insights:

- Gross and net emissions for the Dunedin City District are estimated at **1,250,047 tCO_2e** and **1,033,802 tCO_2e** respectively. Dunedin City contributes the most to emissions in the region on a net basis.
- Agriculture accounts for the largest share of gross emissions (38%).
- Transport emissions are a large emission source for the district (30%). Scope 3 emissions from domestic and international flights departing Dunedin Airport and container vessels departing Port Otago account for 29% of transport emissions. On- and off-road transport accounts for 70%.
- Stationary energy emissions account for 18% of the district's emissions. The primary energy sources are electricity (43% of emissions for the sector), coal (22%), LPG (16%) and diesel (15%).
- The waste sector generates a large amount of emissions relative to other districts. It should be noted that Dunedin City has implemented landfill gas collection and destruction at the Green Island Landfill which has reduced emissions in this sector.
- Dunedin City has the highest industrial process and product use emissions in the region (57,337 tCO_2e), accounting for 5% of gross emissions, coming primarily from hydrofluorocarbons used in refrigeration and air conditioning.

Dunedin City have completed their own district level emissions inventory. Key differences between their and this analysis are as follows:

- On- and off-road transport: This analysis estimates lower emissions from this source. This is expected to be a result of different methodologies and data sets utilised for the Dunedin City inventory.
- Waterborne navigation: This analysis estimates lower emissions from this source. An expected reason for this difference cannot be provided.
- Forest harvest: This analysis estimates higher emissions from this source. An expected reason for this difference cannot be provided.

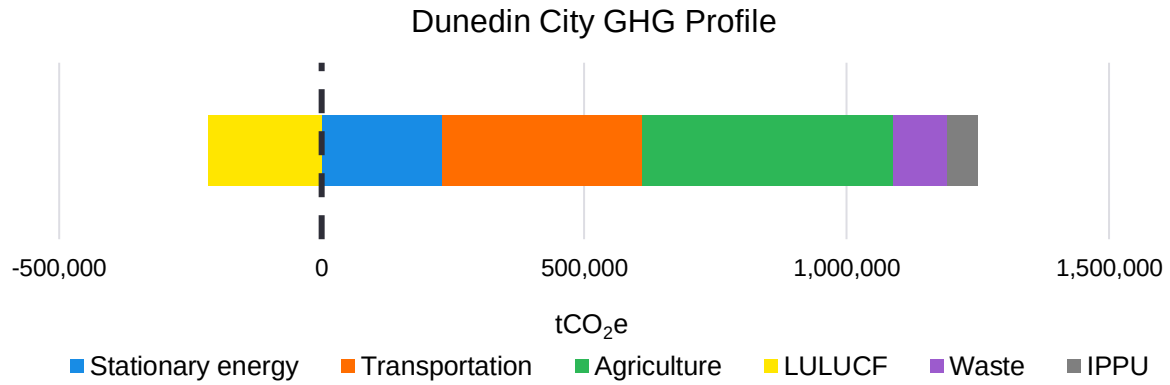


Table 5 Detailed GHG emissions breakdown for Dunedin City by source

Source	Emissions (tCO_2e)	Contribution (%)
Agriculture		
Livestock	426,568	34.12%
Fertiliser	51,106	4.09%
Transportation		
On-road	196,930	15.75%
Off-road	69,687	5.57%
Railways	3,269	0.26%
Aviation	35,118	2.81%
Waterborne navigation	75,375	6.03%
Stationary energy		
Electricity	87,415	6.99%
Electricity T&D losses	7,495	0.60%
Coal	50,289	4.02%
Diesel	34,335	2.75%
Liquified petroleum gas	35,968	2.88%
Light fuel oil	9,844	0.79%
Wood	4,602	0.37%
Petrol	714	0.06%
Waste		
Solid waste disposal - Active landfills	49,005	3.92%
Solid waste disposal – Closed landfills	3,116	0.25%
Wastewater treatment and discharge	13,852	1.11%
Farm fills and rural waste	38,020	3.04%
Industrial processes and product uses		
Industrial processes and product uses	57,337	4.59%
Forestry		
Pre 1990 planted forest	-534,087	n/a
Post 1989 planted forest	-155,708	n/a
Regenerating natural forest	-9,055	n/a
Forest harvest	482,606	n/a

Table 4a Stationary energy emissions breakdown for Dunedin City by subsector

Source	Subsector			
	Residential buildings	Commercial and institutional buildings and facilities	Manufacturing industries and construction	Agriculture, forestry, and fishing activities
Electricity	44,464	16,722	24,096	2,132
Electricity T&D losses	3,813	1,434	2,066	183
Coal	8,639	22,962	18,688	0
Diesel	235	18,224	8,186	7,690
Liquified petroleum gas	15,560	9,259	11,079	70
Light fuel oil	0	9,220	596	27
Wood	3,599	348	655	0
Petrol	0	0	0	714
Total	**76,310**	**78,168**	**65,368**	**10,816**

3.4 Queenstown-Lakes District

In 2019, the Queenstown-Lakes economy generated $3.3 billion in GDP (24% of Otago's GDP). Queenstown-Lakes' economy heavily relies on tourism-associated industries; its top three sectors in 2019 were accommodation and Food Services (17.6% of the districts' GDP), Construction (11%), and Rental, Hiring and Real Estate Services (10.2%). The residential population in Queenstown-Lakes was estimated at 44,800 people (19% of Otago's total population).

Key insights:

- Gross and net emissions for the Queenstown-Lakes District are estimated at **600,895 tCO_2e** and **438,591 tCO_2e** respectively.
- Transport is the highest emitting sector, accounting for 45% of gross emissions. On- and off-road transport accounts for 60%, and aviation accounts for 38% of sector emissions. The coal fired TSS Earnslaw, which operates on Lake Wakatipu, is estimated to generate 4,076 tCO_2e, or 1% of total transport emissions for the district.
- Stationary energy accounts for 11% of gross emissions and is dominated by electricity consumption (contributing 68% to sector emissions).
- Waste contributes a similar amount, 7% of gross emissions. This is largely due to solid waste disposal to landfills.
- Queenstown-Lakes has the second highest industrial process and product use emissions, accounting for 4% of gross emissions.

Queenstown-Lakes have completed their own district level emissions inventory. Key differences between their and this analysis are as follows:

- On- and off-road transport: This analysis estimates lower emissions from this source. This is expected to be a result of using fuel sales data and making no adjustment for resident population and visitor numbers.
- Aviation: This analysis estimates higher emissions from this source. This is expected to be due to the inclusion of international flights.
- Solid waste disposal - Active landfills: This analysis estimates lower emissions from this source. This is expected to be due to the utilisation of a First Order Decay method in this analysis and the resulting slow decomposition of degradable organic carbon over time.

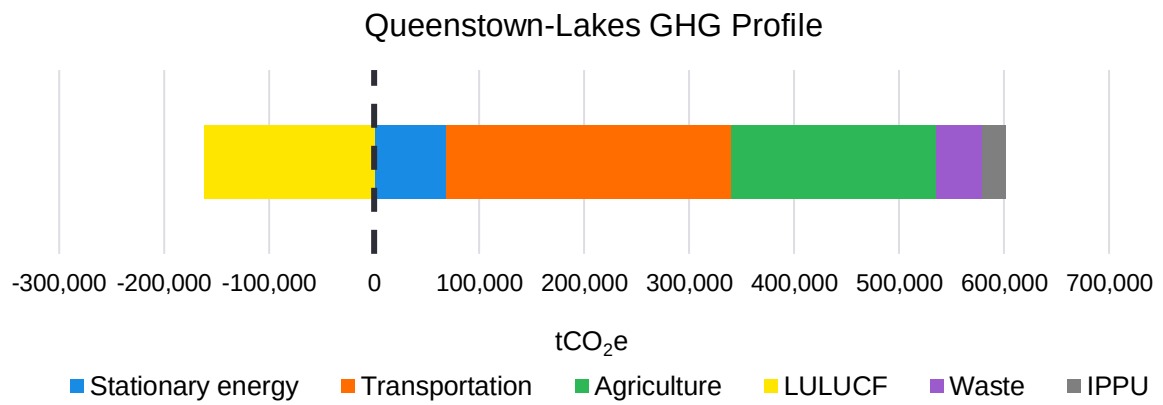


Table 6 Detailed GHG emissions breakdown for Queenstown-Lakes by source

Source	Emissions (tCO_2e)	Contribution (%)
Agriculture		
Livestock	175,034	29.13%
Fertiliser	19,827	3.30%

Transportation		
On-road	120,895	20.12%
Off-road	42,781	7.12%
Railways	0	0.00%
Aviation	104,190	17.34%
Waterborne navigation	4,076	0.68%
Stationary energy		
Electricity	42,729	7.11%
Electricity T&D losses	3,664	0.61%
Coal	2,621	0.44%
Diesel	3,273	0.54%
Liquified petroleum gas	14,696	2.45%
Light fuel oil	9	0.00%
Wood	1,193	0.20%
Petrol	229	0.04%
Waste		
Solid waste disposal - Active landfills	26,684	4.44%
Solid waste disposal - Closed landfills	120	0.02%
Wastewater treatment and discharge	5,005	0.83%
Farm fills and rural waste	12,191	2.03%
Industrial processes and product uses		
Industrial processes and product uses	21,678	3.61%
Forestry		
Pre 1990 planted forest	-86,070	n/a
Post 1989 planted forest	-67,112	n/a
Regenerating natural forest	-46,903	n/a
Forest harvest	37,781	n/a

Table 5a Stationary energy emissions breakdown for Queenstown-Lakes by subsector

Source	Subsector			
	Residential buildings	Commercial and institutional buildings and facilities	Manufacturing industries and construction	Agriculture, forestry, and fishing activities
Electricity	13,498	13,680	14,592	959
Electricity T&D losses	1,157	1,173	1,251	82
Coal	668	829	1,124	0
Diesel	73	661	73	2,466
Liquified petroleum gas	8,971	5,703	0	22
Light fuel oil	0	0	0	9
Wood	1,170	24	0	0
Petrol	0	0	0	229
Total	**25,536**	**22,070**	**17,041**	**3,767**

3.5 Waitaki District

In 2019, the Waitaki economy generated $1.7 billion in GDP (12% of Otago's GDP). Waitaki's economy is heavily concentrated on the Mining sector (28.3% of the district's GDP) and the primary sector (12.4%). The residential population in Waitaki was estimated at 23,200 people (10% of Otago's total population).

Key insights:

- Gross and net emissions for the Waitaki District are estimated at **1,126,372 tCO_2e** and **635,625 tCO_2e** respectively.
- Agriculture is a dominant source of emissions for Waitaki, contributing 74% of the district's gross emissions. Dairy cattle and sheep together produce 595,539 tCO_2e or 72% of total agriculture emissions.
- Waitaki's coal use accounts for 66% of the emissions from stationary energy. Most of the remaining emissions are attributable to electricity use and the associated transmission and distribution losses.
- Waste emissions are almost entirely attributable to farm fill and rural waste (79%) while solid waste in active landfills only produces 0.02% of waste emissions with much of Waitaki's waste sent out of district. 1% of total gross emissions in Waitaki come from closed landfills within the district boundary.
- Despite Waitaki having the third largest gross emissions, the size of its forest estate enables the district to also have the third lowest net emissions.

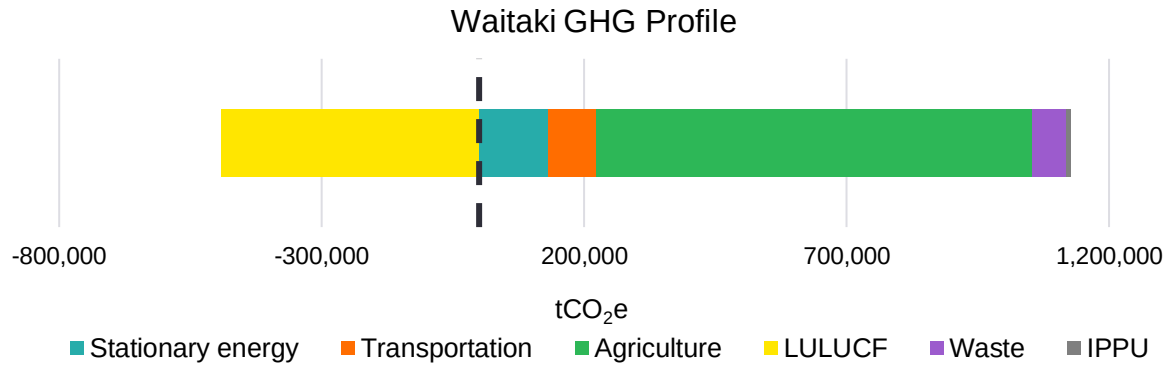


Table 7 Detailed GHG emissions breakdown for Waitaki by source

Source	Emissions (tCO_2e)	Contribution (%)
Agriculture		
Livestock	728,690	64.69%
Fertiliser	102,374	9.09%
Transportation		
On-road	65,933	5.85%
Off-road	23,331	2.07%
Railways	2,401	0.21%
Aviation	0	0.00%
Waterborne navigation	0	0.00%

Stationary energy		
Electricity	24,748	2.20%
Electricity T&D losses	2,122	0.19%
Coal	86,820	7.71%
Diesel	11,928	1.06%
Liquified petroleum gas	4,528	0.40%
Light fuel oil	35	0.00%
Wood	1,236	0.11%
Petrol	928	0.08%
Waste		
Solid waste disposal - Active landfills	177	0.02%
Wastewater treatment and discharge	11,766	1.04%
Farm fills and rural waste	1,156	0.10%
Industrial processes and product uses		
Industrial processes and product uses	8,812	0.78%
Forestry		
Pre 1990 planted forest	-317,319	n/a
Post 1989 planted forest	-542,679	n/a
Regenerating natural forest	-8,422	n/a
Forest harvest	377,673	n/a

Table 6a Stationary energy emissions breakdown for Waitaki by subsector

Source	Subsector			
	Residential buildings	Commercial and institutional buildings and facilities	Manufacturing industries and construction	Agriculture, forestry, and fishing activities
Electricity	7,940	1,736	12,929	2,144
Electricity T&D losses	681	149	1,109	184
Coal	1,040	1,486	84,293	0
Diesel	41	0	1,898	9,988
Liquified petroleum gas	2,749	461	1,227	91
Light fuel oil	0	0	0	35
Wood	1,047	5	184	0
Petrol	0	0	0	928
Total	**13,499**	**3,837**	**101,640**	**13,370**

3.6 Waste transfer

In accordance with the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories*, districts should account for scope 3 emissions from waste generated by the district but disposed of at a facility outside the district boundary.

Collecting this data is challenging. As such, it hasn't been quantified as part of the GHG emissions inventory. However, the following provides some commentary on waste transfer in the Otago region, with the aim to provide a starting point for further work in this area.

Central Otago

Central Otago has no active landfills. Therefore, all of its waste is exported and disposed of elsewhere. Waste is primarily sent to the Victoria Flats landfill in Queenstown-Lakes. Some waste is sent to the AB Lime landfill in Southland and a landfill in the Timaru District.

In FY19, Central Otago generated 7,865 tonnes of general solid waste, 2,669 tonnes of sludge and 70 tonnes of screenings. To put this into context, the Victoria Flats landfill received over 50,000 tonnes of waste in FY19.

Clutha

No data is kept by the Clutha District Council on waste generated in the district boundary and sent to other districts.

Waste is no longer accepted from out of district.

Dunedin

Some Dunedin waste is transported to Southland for disposal.

The Green Island landfill does not accept any out of district waste. No data is kept on whether other landfills in Dunedin are receiving waste from outside Dunedin's boundary.

Waitaki

Waitaki sends an estimated 11,000 tonnes of waste to the AB Lime landfill in Southland.

No waste is received from outside Waitaki's boundary.

Queenstown-Lakes

Queenstown-Lakes disposes of most of its own waste, other than sludge which is sent to the AB Lime landfill in Southland.

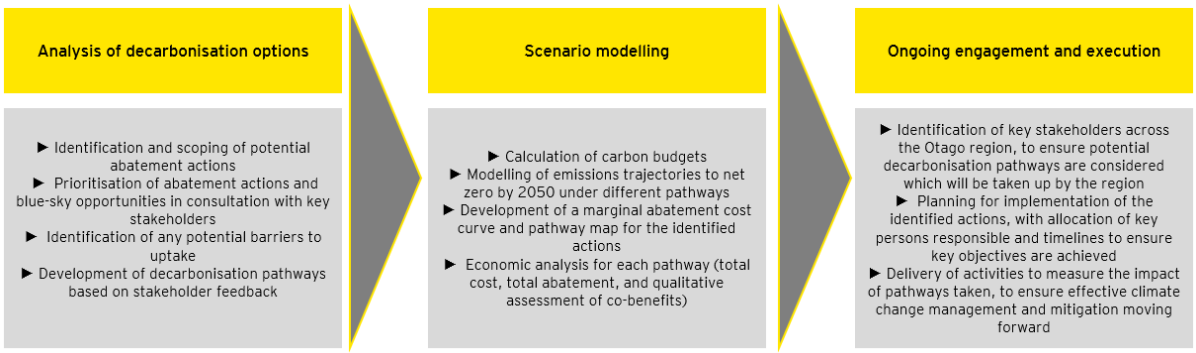
Queenstown-Lakes receives some waste from the neighbouring districts (e.g. Central Otago).

4. Proposed next steps

This regional dataset provides Otago with an initial platform which can be used to initiate effective management and mitigation of climate change impacts.

<u>Recommendations</u>

1. Further analysis and modelling are required to turn the data into a tool for proactive planning. EY recommends both the development of 'business-as-usual' emissions projections to 2050 and the scenario modelling of mitigation options. This will assist in identification of effective mitigation and decarbonisation options and facilitate collective discussion of priorities for action and engagement, both at a regional and local level. Based on the development of options and scenario modelling, economic impacts of mitigation actions can also be estimated and used for planning, engagement and decision making. A quote for this section of work was included in the initial RFP.



2. The dataset will require maintenance and review to ensure its currency and accuracy. An approach to this will be required to be discussed and agreed by ORC and its districts.

3. In particular, efforts should be made to obtain better data for the following sources:

    - Industrial processes and product uses
    - Solid waste disposal
    - Wastewater treatment and discharge.

    This will improve the accuracy of the calculated emissions and projections (where applicable) ensuring decisions are made which reflect the actual impacts of climate change as a result of specific actions.

4. ORC and districts may wish to review their climate data management systems and processes in collaboration with third parties who also contribute, to ensure long term and timely access to the quality data on which this inventory relies. Good climate data management and established and reliable coordination arrangements with a range of stakeholders is needed to inform and improve climate policy design, implementation and decision making.

5. Limitations

The services provided to ORC by EY were advisory in nature and thus did not constitute an audit, a review, or an engagement to perform agreed-upon procedures in accordance with the New Zealand Auditing Standards. Findings have been concluded based on examination of information provided to EY by ORC and key data owners across the region.

This assessment does not constitute certification to the GHG Protocol or any other standard. ORC shall be fully and solely responsible for applying independent judgment with respect to the services and work product provided by EY, to make decisions, if any, and to determine further courses of action with respect to any matters addressed in our report.

Ernst & Young is a registered trademark. Our report may be relied upon by ORC for the purpose of understanding the Otago region's greenhouse gas emissions profile only pursuant to the terms of our engagement letter dated 20 November 2020. We disclaim all responsibility to any other party for any loss or liability that the other party may suffer or incur arising from or relating to or in any way connected with the contents of our report, the provision of our report to the other party or the reliance upon our report by the other party.

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Appendix A Technical Method

The following pages list the key assumptions applied in this analysis.

Biogenic carbon dioxide emissions have been calculated but are excluded from the totals. Global warming potentials are sourced from the IPCC Fourth Assessment Report.

Agriculture, forestry and other land use	
Livestock	The latest available livestock numbers were obtained from the Stats NZ *Agricultural Production Census*. Livestock numbers were obtained by district for dairy cattle, beef cattle, sheep, pigs, deer, horses, goats, alpacas and llamas. Emission factors for enteric fermentation, manure management and agricultural soils were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://www.stats.govt.nz/information-releases/agricultural-production-statistics-june-2017-final https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Fertiliser	The latest available fertiliser application numbers were obtained from the Stats NZ *Agricultural Production Census*. Fertiliser use was obtained by district for urea (with and without inhibitor), diammonium phosphate, sulphate of ammonia, dolomite, lime and all other fertiliser. Emission factors for urea nitrogen fertiliser (with and without urease inhibitor coating), non-urea nitrogen fertiliser, dolomite and limestone were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://www.stats.govt.nz/information-releases/agricultural-production-statistics-june-2017-final https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Forestry	The latest version of the LUCAS New Zealand Land Use Map (LUM) was intersected with district boundaries using GIS software to obtain land use. Hectare information was obtained for Planted Forest - Pre 1990, Post 1989 Forest and Natural Forest. In the absence of better data, the Ministry for the Environment recommends applying the national split of Tall versus Regenerating Natural Forest. This split of 84% and 16% respectively was applied. Emission factors for pre 1990 and post 1989 planted forest were obtained from the Ministry for the Environment's *New Zealand's Greenhouse Gas Inventory 1990-2018*. Emission factors for regenerating natural forest and tall natural forest were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://data.mfe.govt.nz/layer/52375-lucas-nz-land-use-map-1990-2008-2012-2016-v008/

	https://datafinder.stats.govt.nz/layer/105153-territorial-authority-2021-generalised/ https://www.mfe.govt.nz/publications/climate-change/new-zealands-greenhouse-gas-inventory-1990-2018 https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Forest harvest	Wood supply by district and age class was obtained from the *National Exotic Forest Description*. 95% of trees in the age class of '26-30 years' were assumed to be harvested. The emission factor for planted forest harvest and deforestation was obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://www.mpi.govt.nz/forestry/new-zealand-forests-forest-industry/forestry/new-zealands-forests-statistics/ https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Transportation	
On- and off-road	Quarterly fuel sales by district was provided by Stats NZ. The proportion of petrol versus diesel use was calculated by using the Energy Efficiency and Conservation Authority's *Energy End Use Database*. The proportions calculated from the EECA database were then price-weighted using energy prices from the Ministry of Business, Innovation and Employment. Fuel sales was then converted to fuel consumption. Fuel consumption was apportioned into on- versus off-road using the Energy Efficiency and Conservation Authority's *Energy End Use Database*. Emission factors for petrol and diesel were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://tools.eeca.govt.nz/energy-end-use-database/ https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-prices/ https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Railways	Fuel consumption by district was provided by KiwiRail. The emission factor for diesel was obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Aviation	This source is limited to departing flights from Dunedin Airport, Queenstown Airport and Wanaka Airport, as these are considered the most material activities within this source.

	Flight schedule information was obtained for all of the aforementioned airports, and distances were obtained for each of the routes flown. Fuel consumption was calculated using fuel economy estimates (by aircraft type), sourced from ICAO. The results are categorised into domestic and international aviation based on the destination. The emission factor for aviation fuel (kerosene) was obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://www.flightradar24.com/data/airports/new-zealand https://www.distance.to/ https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Waterborne navigation	This source is limited to departing container vessels from Port Otago, as this is considered the most material activity, and emissions from coal-fired waterborne navigation on Lake Wakatipu. The shipping schedule for a 49-day period was obtained from Port Otago. Container vessels were found to be departing to Napier, Lyttelton and Tanjung Pelepas in Malaysia. The distance to these ports was calculated and the average gross registered tonnage of the container vessels (provided by Port Otago) was used to determine tonne.kms. The results were then extrapolated to cover a full year. Freight to Napier and Lyttelton is considered domestic and freight to Tanjung Pelepas is international. Emission factors for domestic coastal freight - container freight and international sea travel - container ship – average were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Emissions from coal-fired waterborne navigation on Lake Wakatipu were calculated using publicly available information. Links: http://ports.com/sea-route/ https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Stationary energy	
Electricity	Electricity delivered by networks in the Otago region was provided by the network management providers; Aurora Energy, PowerNet and Network Waitaki. Aurora Energy data was broken down by district, except for the Cromwell grid exit point (GXP). Electricity delivered through this GXP was split evenly between Central Otago and Queenstown-Lakes. PowerNet data was not broken down by district and has been apportioned by EY, except for Dunedin City for which electricity data was provided separately. The Network Waitaki network extends outside of the Waitaki district boundary, to the Hakataramea Valley and the strip of land just north of the Waitaki river. These areas are primarily farmland with irrigation. When dry

	weather dominates, the irrigation load can be substantial, and load in these areas outside of the Waitaki district could stretch to about 5% of total consumption in some years, more typically it would be around 3.5% of total kWh load. This additional load is included in this analysis. Emission factors for electricity and transmission and distribution losses were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Electricity usage was then apportioned at the district level into residential, commercial, industrial and agriculture usage. Residential usage was obtained from the Electricity Authority's Electricity Market Information website which provides total residential usage for the Otago region. This was apportioned based on the population of each district and subtracted from the total electricity usage figures provided by the network providers. Commercial, industrial and agriculture sector electricity consumption used national electricity consumption figures from MBIE. The classification of an "agriculture", "commercial" or "industrial" electricity consumer utilised level 1 industry ANZSIC codes to ensure alignment with MBIE's classifications. Usage was apportioned across the districts based on the percentage that each sector in each district contributed to the total New Zealand GDP value for that sector. The apportioned amounts were then compared, at the district level, to the total electricity usage figures provided by network providers (minus residential usage). Any differences were apportioned across the agriculture, commercial and industrial sectors in each district based on the proportion of electricity use that each sector represented in that district. Differences were not applied to residential consumption due to a higher quality of data provided by the EMI website reports. Links: https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020 https://www.emi.ea.govt.nz/Retail/Reports/DUOM0B?DateFrom=20180701&DateTo=20190630&RegionType=REG_COUNCIL&Show=Tot&_si=v|3 https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/ https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-modelling/ https://ecoprofile.infometrics.co.nz/Waitaki%20District/Gdp/Structure https://ecoprofile.infometrics.co.nz/Clutha%20District/Gdp/Structure https://ecoprofile.infometrics.co.nz/Central%20Otago%20District/Gdp/Structure https://ecoprofile.infometrics.co.nz/queenstown-lakes%2bdistrict/Gdp/Structure https://ecoprofile.infometrics.co.nz/Dunedin%2bCity/Gdp/Structure
Commercial and Industrial sector energy demand	Energy demand (by district, sector and fuel type) from boilers with capacity greater than 100 kW was provided by Ahika Consulting. Information is based on Ahika's internal boiler database for the region which was cross-referenced with: ► ORC Air Discharge Permits via the ORC Open Data Platform ► 2017-2020 Permit information provided by ORC

	► CRL Energy Ltd Study 2007 ► Bioenergy Association NZ and EECA Heat Plant Study 2009 ► Aircomm Frankton Heating Study 2010 ► Central Otago Energy Database 2013 (Ahika) ► Heat-plant Database 2016 (MBIE and EECA) ► Otago Energy Database 2017 (Ahika) ► Dunedin School Boiler Database 2019 (Ahika) ► South Island Boiler Database 2021 (Transpower). Boilers with unknown capacity were excluded from this analysis and boilers with unknown fuel type were assumed to use coal. Boilers that use electricity have been excluded to avoid double counting with the above source. Further assumptions have been made around run time hours based on sector. Emission factors for coal, diesel, light fuel oil, liquefied petroleum gas and wood were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Rockgas Ltd provided LPG usage estimates for Queenstown-Lakes which superseded the estimates made from this and the below source for LPG. Links: https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Agriculture sector energy demand	National energy balance data for the Agriculture sector was apportioned to each of the districts using GDP data. The energy balance was sourced from the Ministry of Business, Innovation and Employment, and GDP data was sourced from Stats NZ. Calorific values for diesel, petrol, light fuel oil and liquefied petroleum gas were obtained from the Ministry for the Environment's *2020 Detailed Guide*. Emission factors for diesel, petrol, light fuel oil and liquefied petroleum gas were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-balances/ https://www.stats.govt.nz/information-releases/regional-gross-domestic-product-year-ended-march-2020 https://environment.govt.nz/publications/measuring-emissions-detailed-guide-2020/ https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020
Residential sector energy demand	LPG sales data for the South Island was provided by the LPG Association of New Zealand (LPANZ). LPANZ estimated 50% of this would relate to residential use. The sales data was apportioned using district population estimates from the 2018 census data and applying the 50% assumption. Per capita daily coal and wood use was obtained from the *Home heating emission inventory and other sources evaluation (Wilton et al. 2015)*. Fuel usage figures used were Urban Otago and Rural South Island. Per capita values are provided as winter/non-winter and rural/urban. The rural versus urban district splits were obtained from Stats NZ's *Subnational population*

	estimates (urban rural). Urban areas in each district was determined using the Statistics NZ SSGA18 standard for geographical areas. Main types of household heating by district were obtained from Stats NZ and provided the number of wood and coal burners in each district. These burners were apportioned by the rural/urban split. Wood and coal consumption were calculated based on the number of urban/rural wood and coal burners using the per capita urban/rural consumption figures. National residential diesel consumption was obtained from the Ministry of Business, Innovation and Employment's *Energy balances*, and apportioned using district population estimates from the 2018 census. Emission factors for liquefied petroleum gas, coal, wood and diesel were obtained from the Ministry for the Environment's *2020 Emission Factors Workbook*. Links: https://www.mfe.govt.nz/sites/default/files/media/Air/national-air-emissions-inventory.pdf http://nzdotstat.stats.govt.nz/WBOS/Index.aspx?DataSetCode=TABLECODE7981 https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-balances/ https://www.mfe.govt.nz/publications/climate-change/measuring-emissions-summary-of-emission-factors-2020 https://www.emi.ea.govt.nz/Retail/Reports/DUOM0B?DateFrom=20180701&DateTo=20190630&RegionType=REG_COUNCIL&Show=Tot&_si=v|3 https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/electricity-statistics/ https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-modelling/ https://ecoprofile.infometrics.co.nz/Waitaki%20District/Gdp/Structure https://ecoprofile.infometrics.co.nz/Clutha%20District/Gdp/Structure https://ecoprofile.infometrics.co.nz/Central%20Otago%20District/Gdp/Structure https://ecoprofile.infometrics.co.nz/queenstown-lakes%2bdistrict/Gdp/Structure https://ecoprofile.infometrics.co.nz/Dunedin%2bCity/Gdp/Structure
Waste	
Solid waste disposal - Active landfills	Emissions from active landfills were estimated using a First Order Decay method. This method assumes that the degradable organic component in waste decays slowly over decades. Key modelling assumptions include:

Waste composition	Degradable organic carbon proportion	Fraction of carbon that disseminates	k value
Food	0.15	0.84	0.06
Paper and paper board	0.40	0.49	0.04
Garden and park	0.20	0.47	0.05
Wood and wood waste	0.43	0.23	0.02
Textiles	0.24	0.50	0.04
Sludge	0.05	0.50	0.06

Nappies	0.24	0.50	0.04
Rubber and Leather	0.39	0.50	0.04
Concrete, metal, plastic and glass	0.00	NA	NA
AWT Residue	0.08	0.50	0.04

Where possible, actual data on historical waste to landfill was provided by district councils. When unavailable, assumptions were made to fill the gaps. Waste composition over the life of the landfill is held constant using the latest available data.

Emissions reduction as a result of landfill gas collection and destruction at the Green Island Landfill in Dunedin has been modelled. Information to support this modelling was provided by the Dunedin District Council.

The same approach was adopted for closed landfills. Only landfills closed after 2000 were considered. The Waikouaiti Closed Landfill was excluded due to missing waste volume information, as was the closed landfill site at Fairfield because it's privately operated and the data is commercially sensitive. Given closed landfill waste volume is expressed in cubic metres, density assumptions were made to convert it to a mass basis. These assumptions were derived from the Draft 16 UK Waste Classification Scheme by DETR (now DEFRA).

Links:

https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

https://www.sustainabilityexchange.ac.uk/conversion_factors_for_calculation_of_weight_to_vo

Wastewater treatment and discharge

Emissions for all districts except for Queenstown-Lakes were calculated following IPCC guidelines. The number of people covered by different wastewater treatment plants and types (e.g. septic, aerobic, anaerobic) was provided by the district councils.

Assumptions were largely drawn from the IPCC. Some assumptions are New Zealand-specific and were obtained from the Ministry for the Environment's *New Zealand's Greenhouse Gas Inventory 1990-2018*, for example the annual per capita protein consumption and per capita biochemical oxygen demand.

Wastewater emissions for Queenstown-Lakes were calculated by Tonkin & Taylor in collaboration with Deta Consulting. Tonkin & Taylor used a volume-based methodology along with site specific emission factors (developed by Bloomberg et al., 2018) to calculate emissions from each of the 5 wastewater treatment plants in the Queenstown-Lakes district. This approach results in a more detailed emissions output for each of the sites compared to the population-based IPCC approach used for the other districts.

Link:

https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol5.html

https://www.mfe.govt.nz/publications/climate-change/new-zealands-greenhouse-gas-inventory-1990-2018

https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

Farm fills and rural waste

Stats NZ have provided emissions from farm fills and rural waste. These are first estimated at the national level by using data from the Ministry for the Environment to allocate unmanaged waste disposal sites and rural waste (both parts of the waste sector) to industry. These are allocated across the

	four main agriculture industries: Horticulture and fruit growing; Sheep, beef cattle and grain farming; Dairy cattle farming; Poultry, deer and other livestock farming. The allocation to region is made using land use data by industry from the Agricultural Production Survey. Implicit in this approach is an assumption of equal emissions intensity per hectare by industry (farm type) across regions, but emissions intensity per hectare may vary across industries. Finally, this estimate was apportioned into districts on the basis of agricultural GDP.
Industrial processes and product uses	
Industrial processes and product uses	National industrial process and product use (IPPU) emissions were obtained from the Ministry for the Environment's *New Zealand's Greenhouse Gas Inventory 1990-2018*. District-level Gross Domestic Product (GDP) data was obtained from the Ministry of Business, Innovation and Employment. Each sector was assessed for relevance to IPPU emissions. For the sectors deemed relevant, each district's contribution to national GDP was calculated. National IPPU emissions were then apportioned using these contribution amounts. Additionally, included are emissions from household use of industrial products and emissions from disposal of industrial products. Stats NZ have provided this data from their greenhouse gas emissions by region (industry and household) series. The allocation of these emissions is first made at the national level by allocating GHG inventory data to households and industry based on the type of product, and then apportioned to region using population data for households and economic output for the waste industry. Household and international visitor emissions from industrial products associated with road transport (i.e. mobile air conditioning and lubricant use) are proportionate to the use of vehicles by these groups. Links: https://www.mfe.govt.nz/publications/climate-change/new-zealands-greenhouse-gas-inventory-1990-2018 https://www.mbie.govt.nz/business-and-employment/economic-development/regional-economic-development/modelled-territorial-authority-gross-domestic-product/modelled-territorial-authority-gdp-2020-release/

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