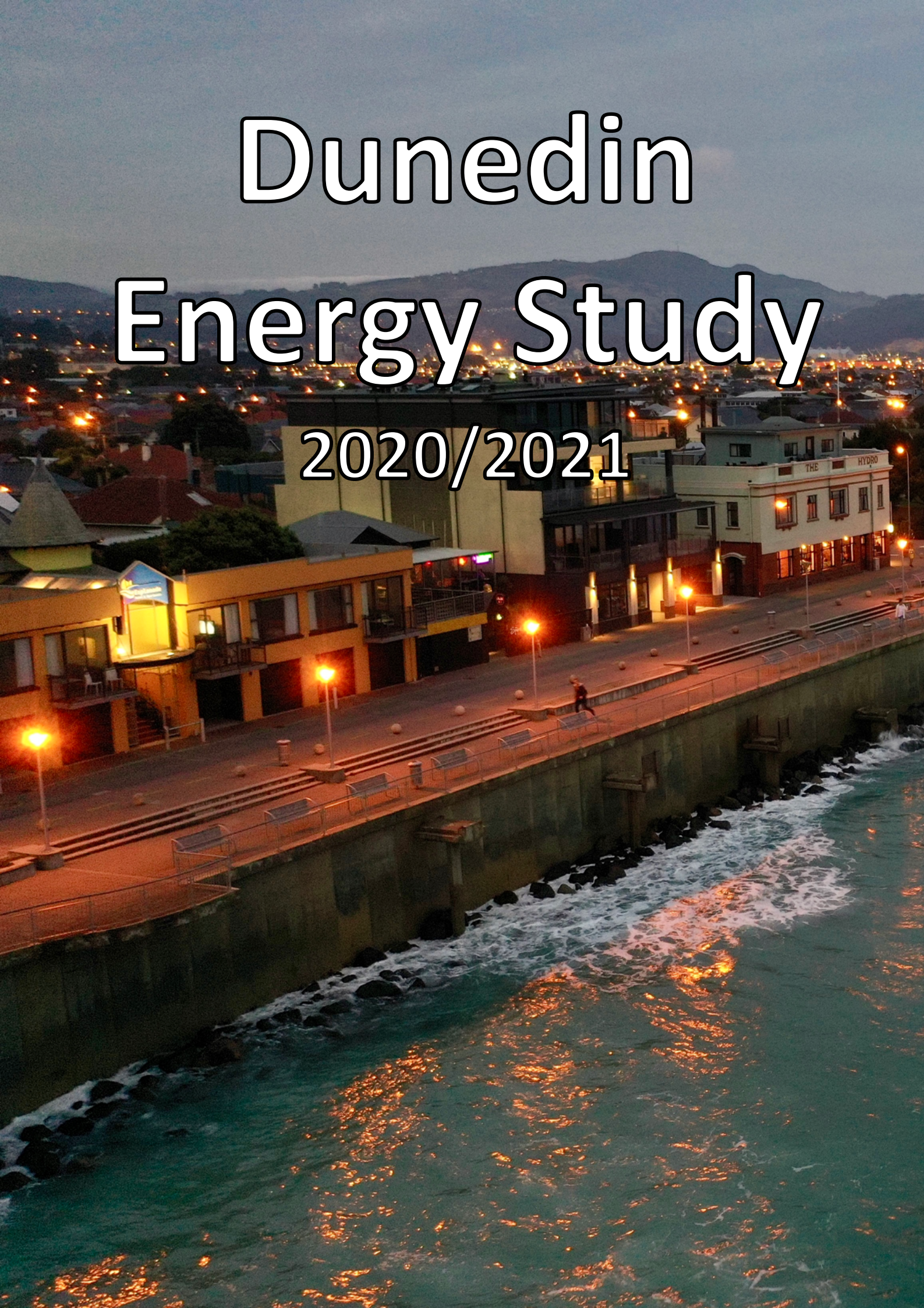
Dunedin Energy Study

2020/2021



Prepared for:

Dunedin City Council (DCC), New Zealand

Prepared by:

Carsten Dortans[1] and Michael Jack[2]

[1]Centre for Sustainability

[2]Department of Physics

PO Box 56, University of Otago

Dunedin, New Zealand

August 2022

Table of Contents

Executive summary

Dunedin City Council has developed ambitious targets for reducing greenhouse gas emissions across the city. Achieving these targets will require significant changes in energy use. It is important to have an accurate assessment of current energy use in the city and associated greenhouse gas emissions. This is necessary to be able to benchmark progress, determine areas of focus and to evaluate the impact of decarbonization initiatives.

The Dunedin Energy Study is a joint research project between the Dunedin City Council (DCC) and the University of Otago aimed at assessing energy inputs into the city of Dunedin and associated greenhouse gas emissions.

In this study, "Dunedin" refers to the area under jurisdiction of the Dunedin City Council (DCC), which is surrounded by Waitaki District in the north, Central Otago District in the west, Clutha District in the south and the Pacific Ocean in the east.

This is the seventh consecutive year this study has been run and investigates energy consumption within Dunedin during the 2020 financial year (2020FY), referring to the financial year period 1 July 2020 – 30 June 2021. Approximately one month of the study period was impacted by Covid19 restrictions.

This study was conducted between January 2022 and August 2022, and provides an estimation of the total amount of each energy type used within the city, along with an indication of the end uses of energy, and energy-related greenhouse gas emissions.

As accurate data on energy use within the Dunedin city boundary is not available, estimation methods are necessary. The study attempts to estimate demand for a certain fuel type using a bottom up analysis and then consolidates this with supply information. The study relies heavily on the willingness of many businesses and organisations who supplied data. The project's partners are extremely grateful to all participating individuals and organisations who dedicated a considerable amount of time to sourcing, compiling and providing relevant data.

Summary of energy inputs

A total of 11.82 PJ of energy was consumed in Dunedin during the 2020FY. This is a 6.7% increase from 2019FY.

Diesel is the single largest energy source consumed in Dunedin, making up 32% of all energy use within the city. This is followed by electricity (28%), petrol (17%), biomass (15%), coal (4%), LPG (3%), and sulphur (2%). These energy inputs are summarised in Figure 1.

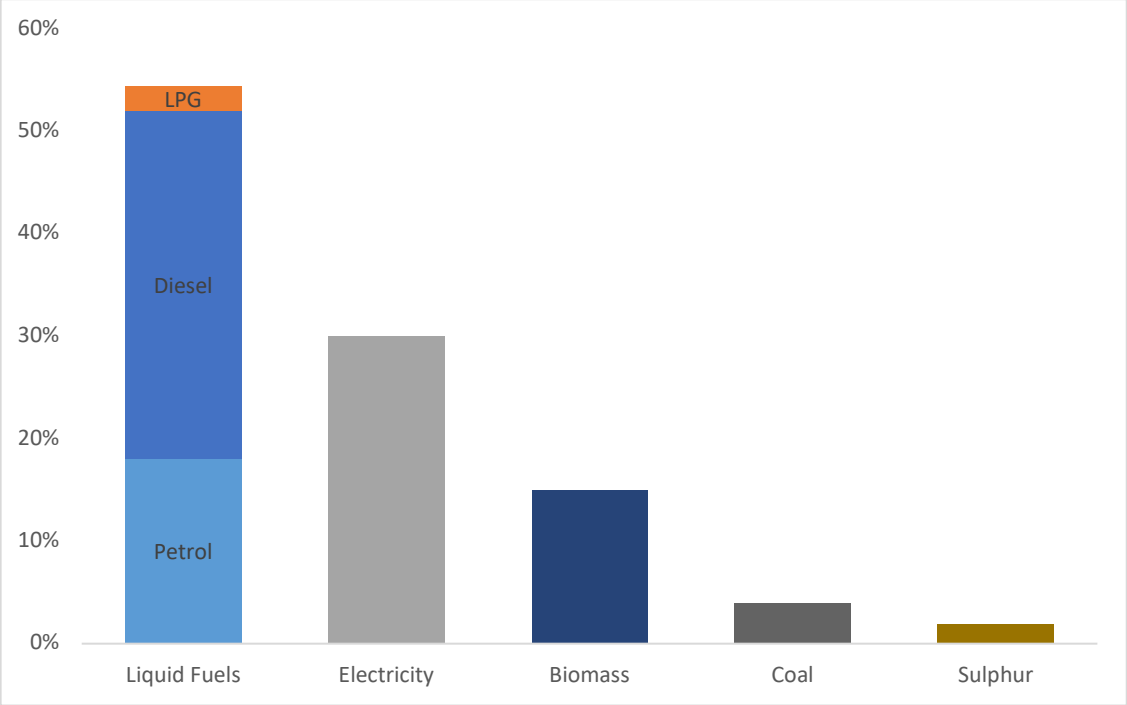


Figure 1: Energy consumption profile for Dunedin city during the 2020FY

Sources of energy

A total of 87% of the energy used in Dunedin during the 2020FY was sourced from outside the city boundaries. All petrol, diesel, LPG, coal and sulphur are imported into Dunedin from other regions in New Zealand or from overseas. The majority of Dunedin's electricity use (82%) is derived from the national grid, and nearly all wood pellets were imported from Taupō based processors.

All energy generated within the Dunedin City boundary (see below) is from renewable energy sources in the form of biomass (89% locally sourced) and electricity (18% locally sourced). During the 2020FY, 0.609 PJ of electricity was produced from locally embedded generators. It is assumed that firewood (self-collected and retail) is sourced from within the city boundaries. Approximately 0.802 PJ of firewood was consumed in Dunedin in the 2020FY.

Overall, 13% of the total energy used in Dunedin during the 2020FY was locally sourced. Locally embedded electricity generation accounted for 6% and biomass (mainly firewood and woodchips) accounted for 7% .

It should be noted that Waipori (hydro) and Mahinerangi (wind) power schemes are located outside the city limits but are considered 'local' as the generated electricity is fed directly into the Dunedin electricity network.

Renewable sources

Around 38% of Dunedin's total energy consumption was from renewable sources. 60% of this was from renewable electricity and 40% from biomass.

During the 2020FY, around 81% of electricity supplied to Dunedin was generated from renewable resources. For the purpose of this study, all biomass (predominately wood) fuels are also considered renewable.

Greenhouse gas emissions

During the 2020FY, approximately 551 kt CO_2-e (kilotonnes of CO_2-equivalent greenhouse gas emissions) was attributed to energy use in Dunedin. 75% of these emissions are attributed to liquid fossil fuel (petrol, diesel and LPG) consumption, 17% was attributed to electricity use in the city, and 6% to coal use.

Total CO2-e emissions were down 0.5% from the 2019FY.This was due to a reduction in transport fuel use, particularly petrol. Note that overall energy use increased mainly due to an increase in the use of electricity, which has much lower emissions per unit of energy. As a result, the carbon *intensity* (emissions per unit of energy used) of Dunedin's energy supply decreased.

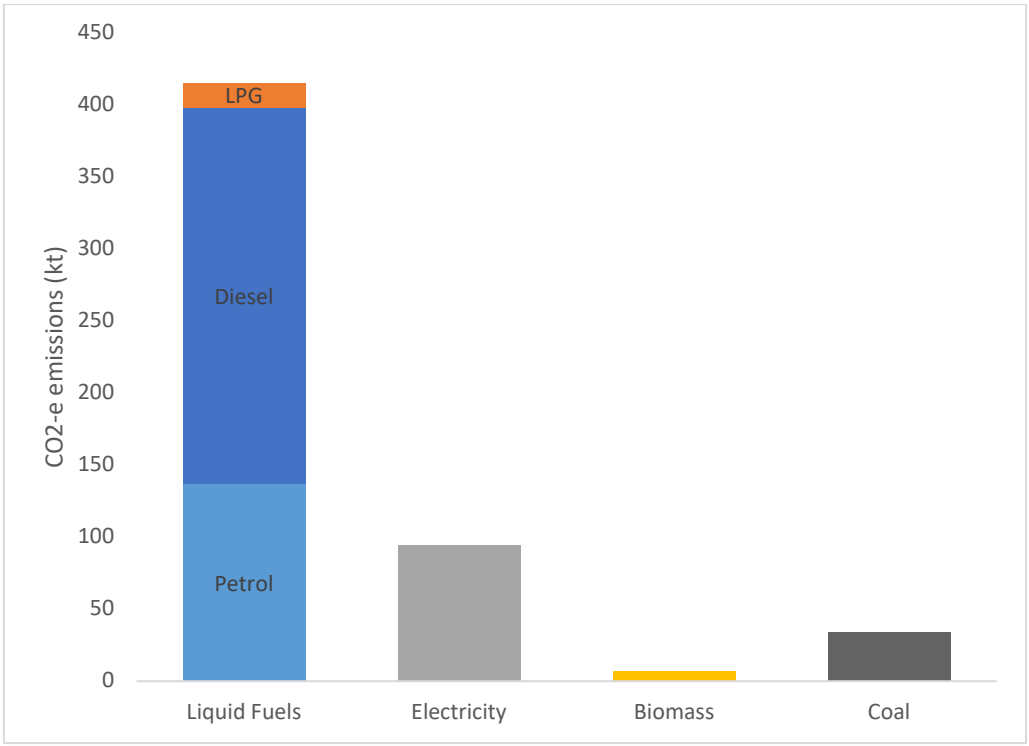


Figure 2: Greenhouse gas emissions associated with Dunedin's energy consumption during the 2020FY

Trends and comparability to previous Dunedin Energy Studies

In figure 3 we plot the trends in annual GHG emissions and total energy use over the past 6 years. A significant change in methodology was introduced in the 2019-20FY study, including a change in the transport energy methodology, and the approach to either using supply or demand data for greenhouse gas emissions calculations for other fuels. The changes are detailed in the 2019-20FY report. Due to these changes, it is difficult to compare the results of the current study with results prior to 2019-20FY. However, there are some trends worth noting. Firstly, the trend of increasing GHG emissions prior to 2020 (which is largely due to increasing use of transport fuel) is not evident in more recent years which have been significantly impacted by COVID lockdowns. It will be interesting to see if this trend continues in future years. Secondly, in 2021-22FY energy use increased without a corresponding increase in GHG emissions. This was due to an increase in less GHG-intensive energy, namely electricity. In fact, since 2015-16FY the GHG intensity of energy use in Dunedin has decreased almost 12% from 53 kt CO2-e/PJ to 47 kt CO2-e/PJ. With the increasing electrification of heat and transport it is likely that this will be an increasing trend in the future.

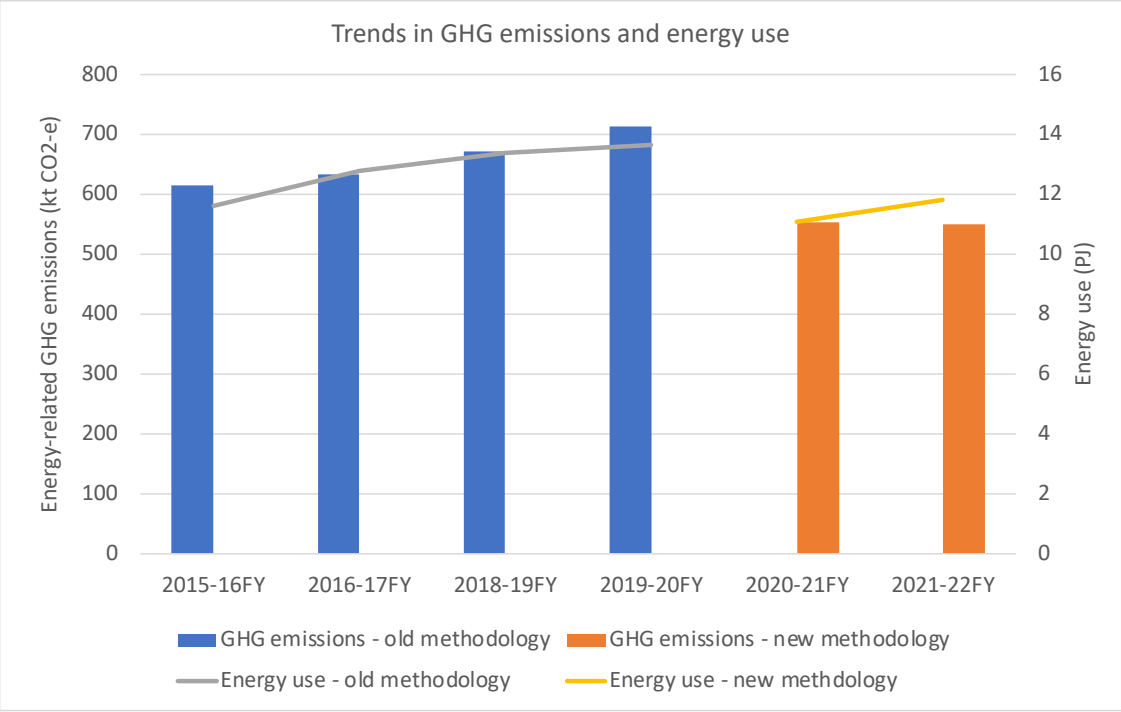


Figure 3: Trends in annual GHG emissions and energy use.

Overview

About Dunedin

In this study, "Dunedin" refers to the area under jurisdiction of the Dunedin City Council (DCC), which is surrounded by Waitaki District in the north, Central Otago District in the west, Clutha District in the south and the Pacific Ocean in the east (Figure 4).

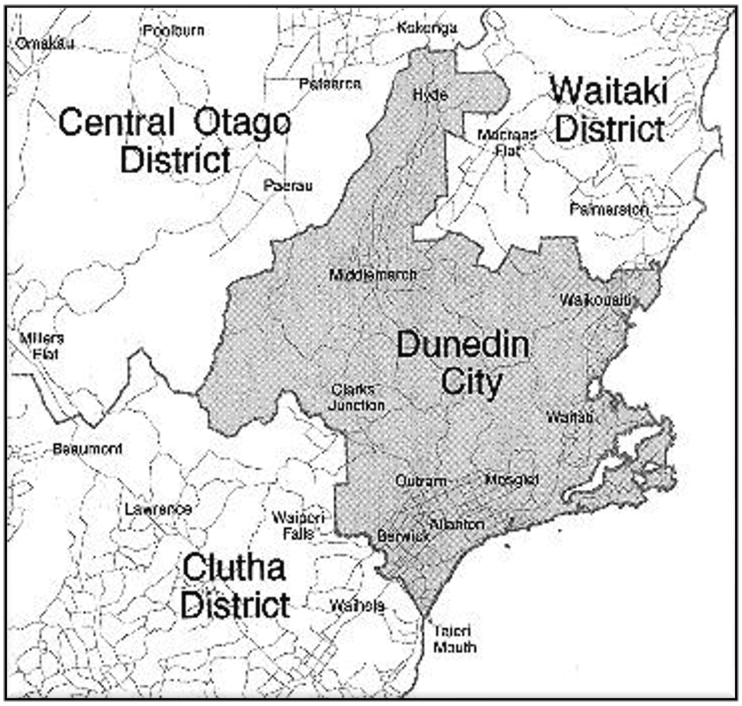


Figure 4: Dunedin City Boundaries

Both population and economic activity are usually positively correlated to energy consumption. It is important to keep this in mind when analysing the fuel use trends throughout this report.

Population

In 2020 Dunedin had an estimated[1] population of around 132,800 people, an increase of 0.4% over the previous year. Dunedin's population growth rate is typically lower than the national average, which was 0.6% for 2020[2].

[1] Source: http://nzdotstat.stats.govt.nz/wbos/Index.aspx?_ga=2.92875613.1183203119.1625432430-1036940433.1625432339

[2] Dunedin City Annual Economic Profile 2020 (https://ecoprofile.infometrics.co.nz/Dunedin%2bCity/PDFProfile#h8)

Dunedin's population represents 2.6% of New Zealand's total population[3] and is the second largest city in the South Island, the largest in the Otago Region and the 7th largest in geographic size of the 67 districts in New Zealand.

In terms of employment, the three largest industries in Dunedin during 2020 were Health Care and Social Assistance (10.3%), Education and Training (8.7%), and Professional, Scientific & Tech Services (6.8%). The industries that experienced the greatest increase in employment numbers from the previous year, were Health Care and Social Assistance (17 jobs), Electricity, Gas, Water and Waste Services (14 jobs) and Public Administration and Safety (13 jobs). The industry which experienced the greatest reduction in employment was Transport, Postal and Warehousing, which lost 57 jobs from 2019[4].

Economy

Dunedin had a gross domestic product (GDP) of $6.828 billion for the 2020 financial year[5]. This is down 1.2% on the previous year and higher than the national growth rate of -1.2% over the same period.

Across broad industry categories, Health Care and Social Assistance was the largest category in Dunedin City in 2019 accounting for 10.3% of total GDP. This was followed by Education and Training (8.7%), and Construction (8.5%).

About the Dunedin Energy Study

In 2014 the first Dunedin Energy Baseline Study was completed[6]. At the time, there was no single source of information of the amount of energy consumed in Dunedin – including households, transport, businesses, education, farming and industry. This information is important for informing the development of strategies for the future of the City. In 2014 the DCC joined the Global Covenant of Mayors (formerly Compact of Mayors), which is a global coalition of city leaders who have pledged to cut greenhouse gas emissions and prepare for the future impacts of climate change. The Dunedin Energy Study is an important action under the DCC's Energy Plan 1.0 to improve the understanding of energy consumption within the district.

---

[3] Source: http://infoshare.stats.govt.nz/ViewTable.aspx?pxID=9b1a6023-15f7-4831-a86e-7e8efdb76db6

[4] Dunedin City Annual Economic Profile 2020 (https://ecoprofile.infometrics.co.nz/Dunedin%2bCity/PDFProfile#h8)

[5] Dunedin City Annual Economic Profile 2020 (https://ecoprofile.infometrics.co.nz/Dunedin%20City/Gdp)

[6] Gabriel, C.-A., Stephenson, J., & Carrington, G. (2015). The Dunedin Energy Baseline Study (Commissioned Report for External Body). Centre for Sustainability, University of Otago. Retrieved from http://hdl.handle.net/10523/5921

The Dunedin Energy Study focuses on end use energy within Dunedin, as well as energy imported into Dunedin and energy produced/generated in Dunedin. The study looks at consumer energy inputs only, not energy embedded in goods and services.

The primary aim of the current Dunedin Energy Study is to build on previous studies to start to expose energy use trends. Further refinements to data collection and analysis have been made to help improve some of the data gaps or data accuracy issues from previous reports. The main data improvements in the current report relate to how quantities of petrol and diesel consumed in Dunedin are accounted for.

Data is presented for the 2020 financial year (2020FY - 1 July 2020 to 31 June 2021).

Much of the data collated in this report was not publicly available and relied on the participation and willingness of the businesses and organisations who supplied it. Where available, more in-depth data is presented to show temporal and spatial patterns of energy use.

The Energy End Use Database (EEUD), held by the Energy Efficiency and Conservation Authority (EECA), has been used to provide a comparison between the values presented in this study and national averages. The Energy End Use database has recently been updated to include an estimate for national energy use for the 2016 calendar year, but no longer has regionally specific data. A comparison between the findings of this report and those from the Energy End Use Database is included in the National Comparisons section of this report.

Research was undertaken by researchers at the University of Otago. The raw data collected is securely stored at the University of Otago and is only available to the study's primary investigators.

Conversion Factors

Energy data was originally gathered in the units used in that sector. To enable comparisons, all were converted to the common unit of petajoules (PJ). 1 PJ is equivalent to 1,000,000,000 MJ. Conversion factors based on net calorific values were used to convert fuel quantities from the originally reported units as follows:

Energy Form	Conversion[7]	Density[8]
Electricity	3.6 MJ/kWh	N/A
Petrol	35.08 MJ/L	0.73 kg/L
Diesel	38.45 MJ/L	0.83 kg/L
LPG	26.44 MJ/L	0.53 kg/L
Coal	24.303 MJ/kg	
Firewood	9.63 MJ/kg	556 kg/m^3
Wood pellets	17.17 MJ/kg	640 kg/m^3
Wood chips	9.63 MJ/kg	736 kg/m^3

[7]EECA Business "Biomass calorific value calculator" (https://www.eecabusiness.govt.nz/tools/wood-energy-calculators/biomass-calorific-value-calculator/); MfE Guidance for Voluntary Greenhouse Gas Reporting – 2016 (http://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/2016-guidance-for-voluntary-corporate-greenhouse-gas-reporting.pdf)

[8] New Zealand Centre for Advanced Engineering "New Zealand Energy Information Handbook" (https://ir.canterbury.ac.nz/bitstream/handle/10092/11527/EIH3.pdf?sequence=1)

Liquid fossil fuels

Methods and Assumptions

Liquid fuels used in Dunedin include petrol, diesel and liquefied petroleum gas (LPG). These fossil fuels are imported from outside the DCC area.

In this section, petrol and diesel are presented separately from LPG.

Petrol and diesel

Petrol and diesel supply in Dunedin

Petrol and diesel are imported into Dunedin through Port Otago. There are ten companies that sell petrol and diesel in significant quantities in Dunedin: BP NZ LTD, Chevron CALTEX, Exxon MOBIL, Z Energy, McKeown & Graham, Allied Petroleum, CRT Farmlands Fuel, RD Petroleum Ltd, GULL NZ Ltd and Nelson Petroleum Distributors (NPD).

From the 2019FY an improved methodology was adopted for estimating petrol and diesel consumption. This new methodology uses petrol and diesel sales data collected by DCC. DCC collects a Local Authorities Fuel Tax under the Local Government Act 1974, whereby all quantities of these fuels sold (that comply with the Act) need to be disclosed and tax files returned. This includes fuel that is distributed through retail and wholesale outlets, but does not include fuel used for stationary uses, aviation fuel, LPG, or fuels used for commercial shipping.

The data is collected by DCC for the Tax Area of Coastal Otago (Dunedin City, Waitaki District, and Clutha District), and includes both the quantities of petrol and diesel sold and the corresponding tax payable. The Tax Area of Coastal Otago includes geographical regions outside the jurisdiction of DCC (and therefore outside the study area). This is further highlighted in Figure 5.

To determine the Dunedin City consumption, we proportion the petrol and diesel sales data to Dunedin City based on information from the New Zealand Transport Agency on Vehicle Kilometres Travelled (VKT) for both State Highways and Local Roads by territorial authority. The resulting litre amounts of diesel and petrol for Dunedin City are then multiplied by emission factors to calculate the greenhouse gas emissions.

Figure 5: Otago Region and District Boundaries.[9]

Using the VKT method, for the 2020FY the Dunedin City share of VKT was 55% and the quantities of petrol and diesel consumed in Dunedin were 55.7 M Litres and 97.3 M Litres, respectively. The quantity of petrol and diesel consumed in Dunedin in PJ is shown in Figure 6. We also show how these results compare with those calculated in the 2019FY Dunedin Energy Study.

This does not reflect the actual consumption of these fuels but is as close an approximation as can be achieved based on currently available data.

[9] Source: Otago Regional Council, 2012: https://www.orc.govt.nz/media/1458/regional-plan-coast-for-otago.pdf

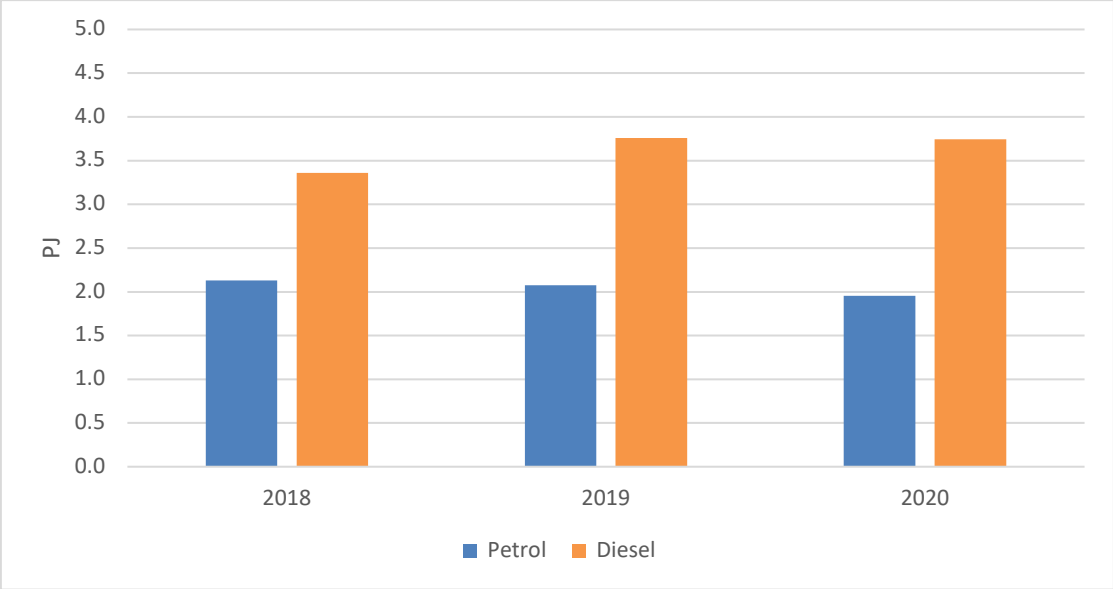


Figure 6: Annual petrol and diesel energy use in Dunedin. This graph also shows a comparison between the 2018FY to 2020FY.

Petrol and diesel consumption in Dunedin

Most of the petrol and diesel consumed within Dunedin is used as transport fuels for on-road use.

As of October 2021, there were 141,334 vehicles registered to Dunedin residents[10]. This includes all company vehicles and those that own more than one vehicle. 73% of these vehicles are petrol powered and 23% are diesel powered.

A total 5.70 PJ of fuel, comprised of 1.96 PJ of petrol and 3.74 PJ of diesel, was consumed within Dunedin during the 2020FY. This is a 5.8% decrease in petrol and 0.5% decrease in diesel consumption compared to 2019FY.

Electricity used for transportation

Electricity is also used for transportation in Dunedin. This has been taken into account in the electricity section of this report but is noted here as a comparison to traditional transport fuels and how this sector is changing.

[10] New Zealand Transport Agency, Motor Vehicle Register API: https://opendata-nzta.opendata.arcgis.com/datasets/NZTA::motor-vehicle-register-api/explore

Dunedin has one of the highest rates of electric vehicle ownership in New Zealand at around 9.27 vehicles per thousand people, compared to an Otago regional average of 8.45 and a national average of 7.61 vehicles per thousand people. Regional pure electric vehicle (EV) and plug-in hybrid electric hybrid vehicle (PHEV) ownership rates across New Zealand are shown in Figure 7[11].

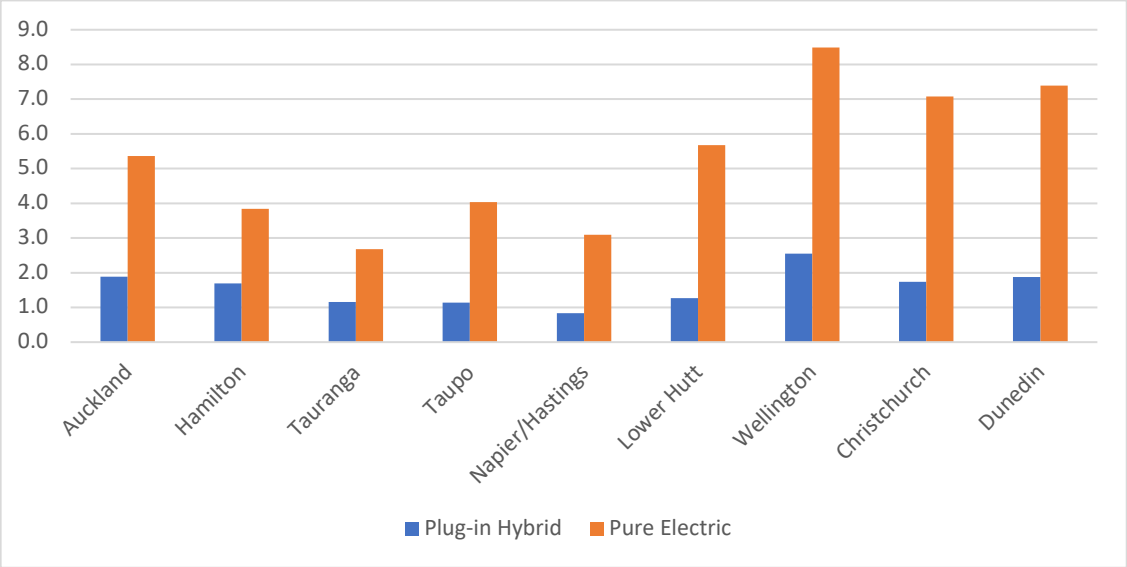


Figure 7: Electric vehicle ownership per 1000 regional people in selected cities as of June 2021.

The electric vehicle fleet in Dunedin has tripled in size between 2018 and 2021 (Figure 8).[12] 11% of electric vehicles are company owned with the remaining 89% for personal use.

11 Ministry of Transport, EV Tableau Public: https://public.tableau.com/views/EVv3/Story1?:embed=yes&:showVizHome=no&:tabs=no&:toolbar=no/mot-resources/vehicle-fleet-statistics/monthly-electric-and-hybrid-light-vehicle-registrations/nz-light-ev-registration-by-brand-may-2013-june-2019

12 Ministry of Transport, Monthly electric and hybrid light vehicle tables: https://www.transport.govt.nz/mot-resources/vehicle-fleet-statistics/monthly-electric-and-hybrid-light-vehicle-registrations-2/

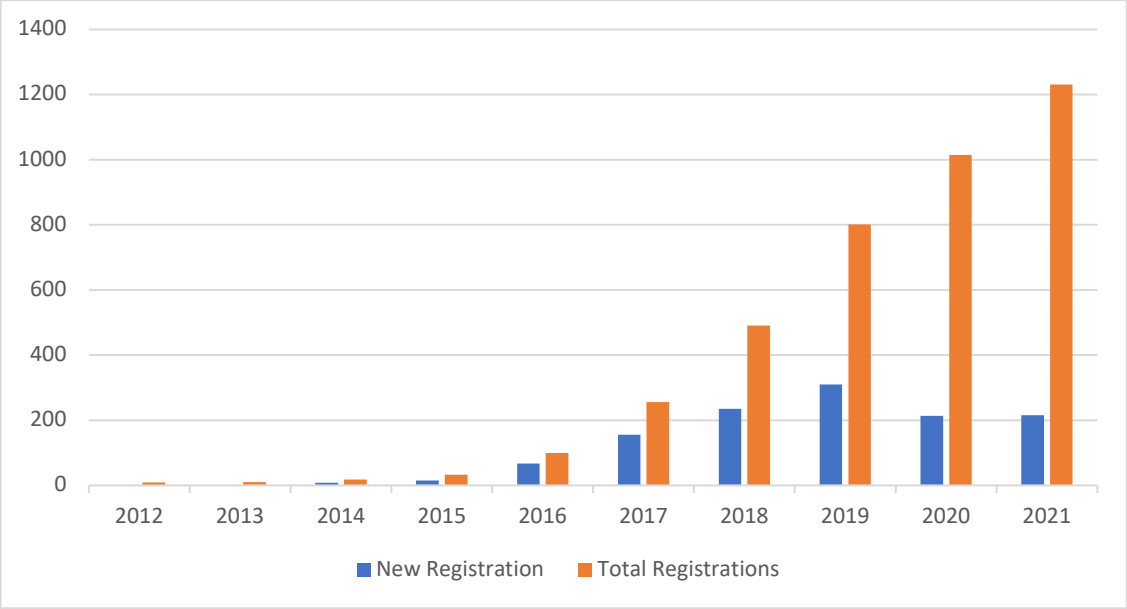


Figure 8: Electric Vehicle Registrations in Dunedin by Financial Year.

An approximation has been made to account for the transboundary use of transport fuels. Some of the petrol and diesel purchased in Dunedin service stations will be used in vehicles that drive beyond the city, and some vehicles coming into the city will have purchased their petrol and diesel elsewhere. For the purposes of this study it has been assumed that these quantities would be similar and therefore cancel each other out.

Some diesel is used for short-term electricity generation in stationary generators. This is not subject to the DCC tax levy and therefore is not included in the above figures. During periods of high electricity demand, the local network company can request large users to reduce their consumption, which they are compensated for. This is known as congestion period demand (CPD) and there are usually 20-30 requests per annum. CPD periods in the 2020FY were up to 135 hours[13] for some sites in Dunedin. Various locations around Dunedin consume diesel to run electrical generators for this purpose and as emergency backup. It is estimated that an additional 0.0023 PJ of diesel was consumed for electricity generation during the 2020FY, which represents a very small proportion (0.05%) of total fuel use. This represents a negligible component compared to transport fuels.

Some additional petrol and diesel is used for running stationary machinery, on farm use and for home heating. This is also not subject to the DCC tax levy and not included in the above figures. An effective method of estimating these quantities has not been developed and is an ongoing shortcoming for this annual report.

[13] Aurora Energy Ltd., Large customer demand management: https://www.auroraenergy.co.nz/get-connected/large-customer-demand-management/

LPG

LPG supply in Dunedin

There are four LPG wholesalers in Dunedin: Genesis, Contact (Rockgas – sold to First Gas in November 2018), Elgas and Ongas. This is distributed to customers either in bottles, tanks or on the local reticulated LPG network.

Most LPG arrives in Dunedin via coastal shipping from the Taranaki gas fields, however some LPG is imported from Australia during winter/gas field outages. LPG is imported into the city in large shipments and stored at a logistics handling company in Dunedin or in ISO containers. Import records will therefore show large monthly variations and will not always directly relate to LPG consumption.

All wholesalers receive their LPG supply via this method, while one wholesaler also receives LPG supplies via rail directly from the gas fields in Taranaki. In previous years, KiwiRail has provided information about the amount of LPG unloaded in Dunedin, however, due to commercial sensitivity they are no longer able to provide this data.

A total of 0.669 PJ of LPG was supplied to Dunedin during the 2020FY. Based on updated values, this represents a decrease of approximately 9% from the 2019FY.

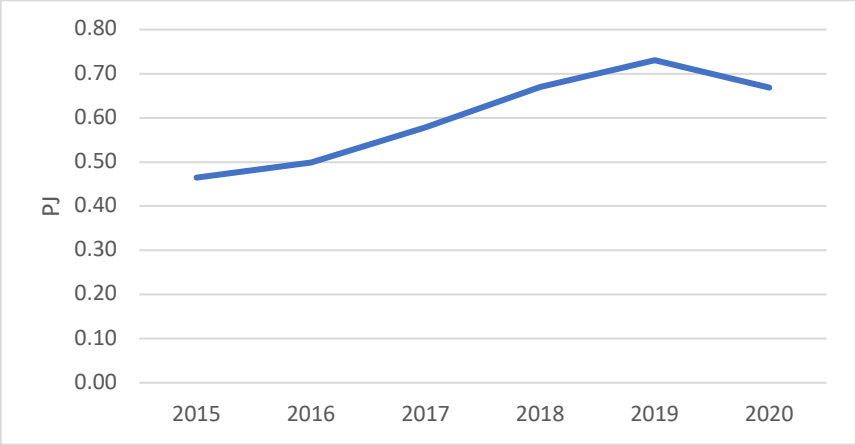


Figure 9. *Estimated annual supplies of LPG to Dunedin*

Figure 9 shows an overall increase in the amount of LPG supplied in Dunedin since the Dunedin Energy Study began with a slight decrease in the 2020FY.

LPG consumption in Dunedin

LPG is used in Dunedin for multiple purposes including industrial applications, residential use and transport.

Monthly data of LPG consumption and moving average data of imports has been used to analyse consumption patterns; this is currently the best representation of actual LPG usage for Dunedin.

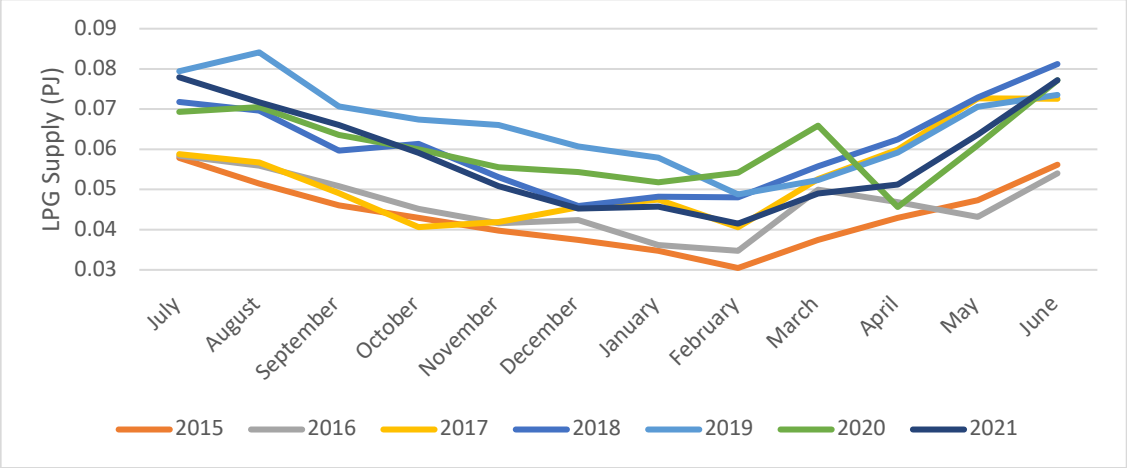


Figure 10: Annual LPG supply trends

Figure 10 shows the monthly trends of LPG supplied to Dunedin. These are very consistent between years and show an increase in consumption over winter months as LPG is a common heating fuel source in the city. In recent years, an increase in LPG supply can be observed.

Commercial LPG use in Dunedin

EECA has a Heat Plant Database that contains public information about boilers in New Zealand[14]. A similar dataset was obtained from Ahika and the Bioenergy Association of New Zealand (BANZ).

Commercial LPG demand was equivalent to 0.207 PJ during the 2020FY.

Residential LPG use in Dunedin

Many households in Dunedin use LPG for water heating, space heating and cooking. There is currently no straightforward way of determining exactly how much LPG is used residentially and for what exact purpose the LPG is being used in the household. Approximations have been made based on previous census results from 2018.

A linear (polynomial) regression of census data from 2001, 2006, 2013 and 2018 was used to estimate that 1,984 Dunedin households used bottled or reticulated gas as a heating fuel in 2020FY.

[14] The EECA heat plant database was last reviewed in 2014 and there may be subsequent changes which have not been captured on this list.

The Home Heating Report[15] from 2005 estimates that households that use gas would use an average of 2kg of gas per day across both winter and non-winter months.

Dunedin's residential LPG use was approximately 0.072 PJ in the 2020FY.

LPG used for transport in Dunedin

LPG is also used as a transport fuel. In Dunedin, there are four petrol stations that sell LPG. These are Burnside Service station, Green Island; Complete Auto Repairs Ltd, Hillside Road, Caltex City North and Mobil Anzac Ave.

Data obtained from the New Zealand Transport Association (NZTA) reveals that as of June 2021 there are 14 LPG passenger and goods vehicles registered in Dunedin. This corresponds to approximately 168,000[16] of travel by LPG vehicles. LPG vehicles use 10-20% more fuel than petrol vehicles and so an LPG consumption of 8.671 litres per 100 km has been assumed.

Approximately 0.00039 PJ of LPG is used for transportation in Dunedin on an annual basis.

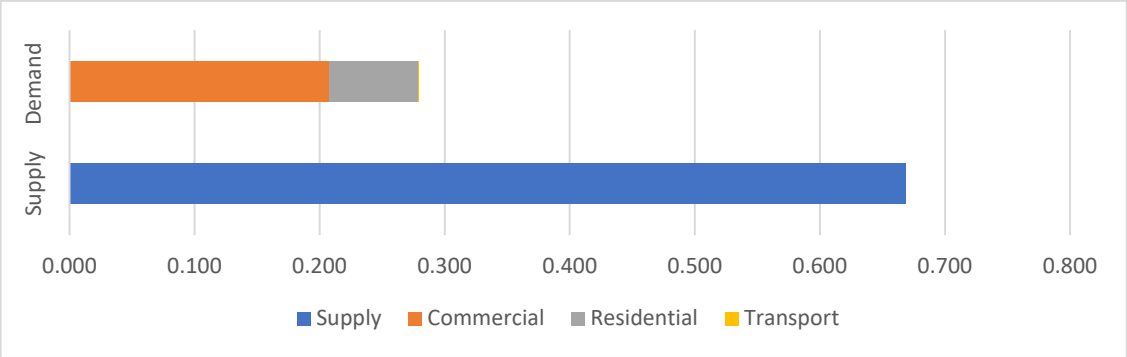


Figure 11: Comparison of LPG supply and demand in Dunedin for the 2020FY

In the 2020FY, only 42% of the assumed LPG supply is accounted for by the calculated demand for LPG in Dunedin. Some of the LPG imported through Dunedin is distributed to other locations beyond the city boundaries (e.g. Central Otago). The discrepancy between supply and accounted-for demand in Figure 11 is likely to represent LPG consumed outside of Dunedin.

[15] Source: Ministry for the Environment, 2005. Warm Homes Technical Report: Home Heating Methods and Fuels in New Zealand. (Prepared by Emily Wilton)

[16] Source: http://www.transport.govt.nz/assets/Uploads/Research/Documents/New-Zealand-Vehicle-fleet-stats-final-2013.pdf

A total LPG demand of 0.280 PJ was calculated for Dunedin during the 2020FY. The descrepancy between calculated supply and demand represents one of the largest uncertianties in this report and requires further research.

Electricity

Methods and assumptions

The data on electricity used in Dunedin comes from the lines companies, the energy advisory company Energy Link and the Electricity Authority database of installed capacity[17] of distributed generation.

There are two main lines companies that operate in Dunedin: Aurora and Otago PowerNet. Aurora operates in the urban and suburban areas of Dunedin whereas Otago PowerNet operates in the rural outskirts surrounding the Dunedin urban centre. Dunedin, which includes the settlements of Hyde, Middlemarch, Clarks Junction, Hindon, Waitati and Karitane, represents only a small portion of Otago PowerNet's territory.

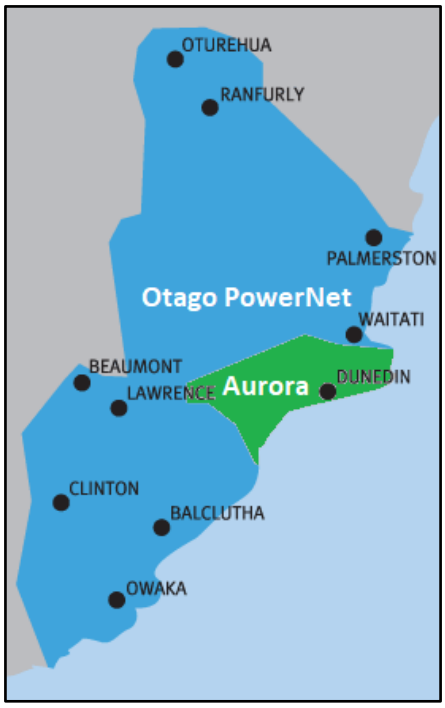


Figure 12: Location of the Aurora network (green) and Otago PowerNet network (blue) in relation to Dunedin

[17] Installed capacity is the maximum production capacity.

In Aurora's 2020 disclosure year[18] there were 55,877 ICPs[19] on their network, while PowerNet had a total of 3,108 ICPs in Dunedin as of March 2021[20]. The total number of ICPs has increased by approximately 0.5% since the 2019FY.

Electricity supply in Dunedin

Dunedin was supplied with a total of 3.352 PJ of electricity during the 2020FY. This is an increase of 8% from the 2019FY.

Electricity supply from the national grid

During the 2020FY, Dunedin consumed 3.352 PJ of electricity. This was comprised of 2.743 PJ (82%) from the national grid and 0.609 PJ (18%) supplied by generation embedded in the local network.

Although Dunedin's electricity is largely generated from renewable South Island locations, it is integrated within the wider national grid where all demands and supplies are connected. If a certain demand was therefore removed from the system, the excess electricity would be used elsewhere within the network. For this reason, national averages have been used for the renewable proportion of electricity generation, as well as the subsequent emissions factors for this generation, regardless of whether it was generated locally or supplied by the national grid. However, research on this is continuously evolving[21].

81.1% of New Zealand's electricity generation was from renewable sources during the 2019FY[22]. This is 1.3 percentage points lower than the 2019FY.

Local Generation

There are a variety of different electricity generators embedded within the Dunedin electricity network. Table 1 provides a summary of the known local generators and the energy sources they use.

[18] Auroras reporting period is from 1st April to 31st March whereas the financial year for the rest of this report is 1st July to 31st June.

[19] An ICP is an individual connection point; this is the physical point of connection on a network at which a retailer will be deemed to supply electricity to a consumer. (Electricity Authority, 2016 - http://www.ea.govt.nz/glossary/)

[20] There is no monthly breakdown of ICPs on the PowerNet network.

[21] https://www.nature.com/articles/s41893-020-00652-9

[22] Source: Ministry of Business, Innovation & Employment, 2021. Energy in New Zealand 2021: https://www.mbie.govt.nz/dmsdocument/16820-energy-in-new-zealand-2021

To describe these locally embedded generators more fully, we have split them into three scales: large generators (over 50 MW); mid-scale generators (0.1 MW to 5 MW) and small-scale (less than 0.1 MW).

Table 1: Local electricity generation in Dunedin for the 2020FY

	Name of connected generator	Generating company	Energy type	Total electricity supplied (MWh)	Total installed capacity (MW)
Large generators	Waipori 33kV – Deep Stream 1A, 2A	TrustPower Ltd	Hydro	69,187	53
	Waipori 33kV - Mahinerangi	TrustPower Ltd	Wind	100,009	36
Mid-scale generators	Ravensdown Generation	Ravensdown Ltd	Process steam	557	3
	Container Port	Port Otago Ltd	Liquid fuel	9	1.6
	Waste Water Treatment Plant	Dunedin City Council	Biomass	273	1
	Dunedin Airport	Dunedin International Airport Ltd	Liquid fuel	0	0.6
Small-scale generators	Various Distributed Generators	329 Individual connections	Solar	3,976[23]	1.59
	Various Distributed Generators	7 Individual connections	Wind	2.7[24]	0.023
Total				**174,014**	**98**

Large generation schemes

There are two large generation schemes that supply Dunedin with electricity. These are the Waipori hydropower scheme and the Mahinerangi wind power scheme. These two systems work in synergy with each other, allowing water to be preserved while the wind farm is generating. Although both generation schemes lie outside of Dunedin, they feed directly into Dunedin's 33 kV network and have therefore been included in the local generation for Dunedin.

The Waipori hydropower scheme has total of four stations along the Waipori River with a combined installed capacity of 84 MW, plus an additional 5 MW of capacity at the

[23] Solar calculations are based on assumption that the solar panels are north facing at are tilted at 45 degrees. The solar calculator at https://www.energywise.govt.nz/tools/solar-calculator/ was used to find a conversion rate of 1100kWh/kW a year.

[24] Energywise assumes that small wind turbines generate at on 10 to 40% of their rated capacity every hour and so for this study it has been assumed that on average wind turbines operate at 25% capacity. Therefore, a conversion rate of 2190kWh/kW a year. https://www.energywise.govt.nz/at-home/generating-energy/small-wind-turbines/ - Energyoutputofsmallwindturbines

Deep Stream hydro scheme. Only 53 MW of this is connected directly into Dunedin's Aurora network via a 33 kV transmission network from the Waipori 1A, 2A and Deep Stream generators to the Halfway Bush substation. Excess generation from the Waipori 2A, 3 and 4 generators, is fed into the national grid via a 110 kV transmission line to the Berwick substation located on the Taieri plains.

Stage 1 of the Mahinerangi wind farm was commissioned in 2011 and contains 12 turbines with a total installed capacity of 36 MW. These were tied into the 33 kV transmission network from Deep Stream and subsequently all 36 MW of capacity is fed into the Dunedin network via the Halfway Bush substation. Consent has been granted for an additional 160 MW of wind generation at the Mahinerangi site, although this would require upgrades to the transmission network.

The 33 kV Waipori transmission network is currently insufficient to support the full generating capacity of all the generators installed on it. The various generators are therefore operated in synergy with each other to allow hydro capacity to be stored while the Mahinerangi wind farm is generating, all while working within the limits of the transmission system. To balance out any excess generation, Waipori 2A is connected to both the local Dunedin network and the national grid so that no generating capacity is wasted.

In Aurora's April 2020 – March 2021 financial year Dunedin was supplied with 69,187 MWh (0.249 PJ) of hydro-generated electricity from the Waipori/Deep Stream system and 100,009 MWh (0.360 PJ) of wind-generated electricity from Mahinerangi. This is a 25% increase in hydro generation, but a 0.5% decrease in wind generation, resulting in an overall increase of local large scale generation of 8.7% from the 2020FY.

Data is presented in Figure 13 for electricity supplied into the local Dunedin network from the Waipori, Deep Stream and Mahinerangi generation schemes over the previous five disclosure years. Some variation is present in both the hydro and wind generated electricity which is supplied to Dunedin, however any long-term trends may be influenced by the transmission limits more so than the generation potential.

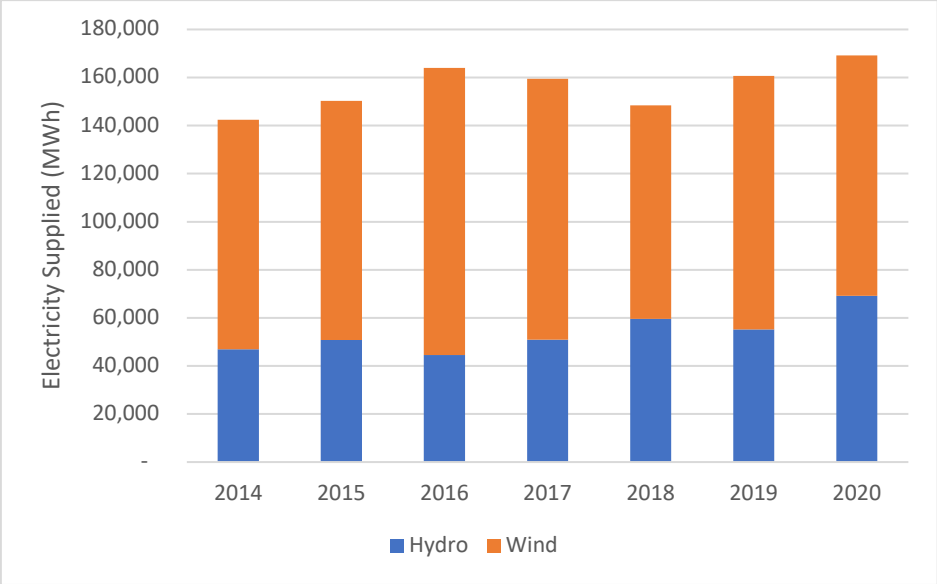


Figure 13: Electricity supplied directly into Dunedin's local network from Waipori/Deep Stream (hydro) and Mahinerangi (wind) generators.

Mid-scale generation

Mid-scale local generators of electricity are those that have 0.1 MW to 5 MW in capacity. These include Ravensdown Ltd (from process steam), Port Otago's container port (from liquid fuels), and the DCC's waste treatment plant (from biogas). The Dunedin Airport also has 0.6 MW of synchronised generation capacity (from liquid fuels) but does not export any into the local network.

Electricity that is exported from biogas (methane) at the Green Island landfill and wastewater treatment plant was 273 MWh in the 2020FY. This is a decrease of 64% from the 2019FY.

The amount of mid-scale generation in Dunedin is therefore largely determined by the industrial processes at Ravensdown Ltd and the Green Island wastewater treatment plant. In this context, Ravensdown Ltd generates electricity from process steam which is a by-product created during the production of fertiliser.

There was a 40% decrease in mid-scale generation from 1,390 MWh (0.005 PJ) for the 2019FY, to 839 MWh (0.003 PJ) for the 2020FY due to less exported electricity from the Green Island landfill.

Small-scale distributed generation

Small-scale generators of electricity are those that produce less than 0.1 MW.

As of the 31st of March 2021, there were 485 solar systems and seven wind turbines connected to the Dunedin electricity network. This is an additional 68 solar systems (+16%), resulting in a 15% increase in installed capacity, from the end of the 2020FY. In addition to the increase in installed systems, the average size of individual solar systems

being installed has also increased. The calculated electricity generation of these small-scale generators equates to 2,034 MWh (0.0073 PJ) from solar and 50.6 MWh (0.00018 PJ) from wind for the 2020FY.

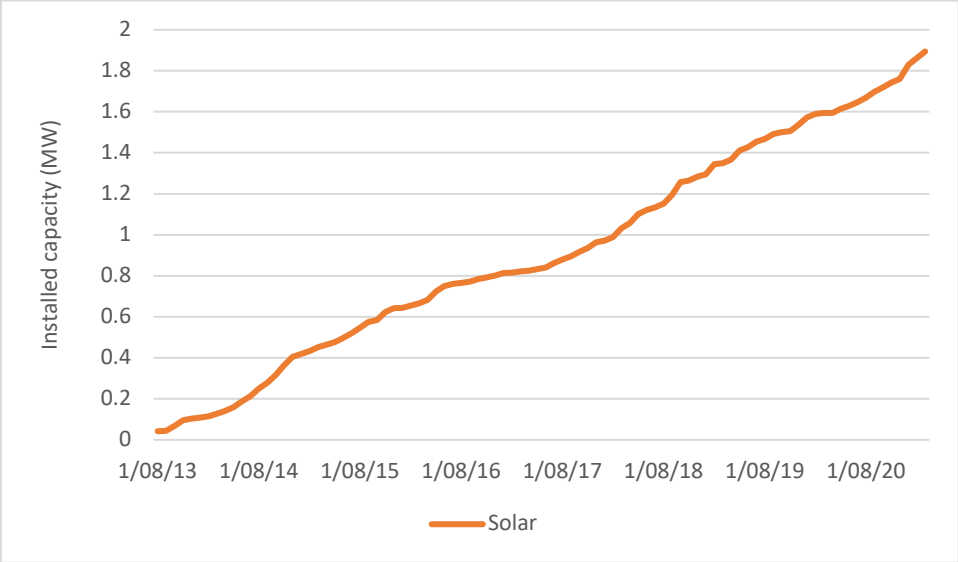


Figure 14: Cumulative small-scale installed solar capacity on the local Dunedin network.

Photovoltaic solar installations in Dunedin appear to be increasing at a roughly linear rate of around 62 connections per annum. The average installed capacity for new solar systems in Dunedin during the 2020FY was 8.3 kW, up from 4.3 kW during the 2019FY.

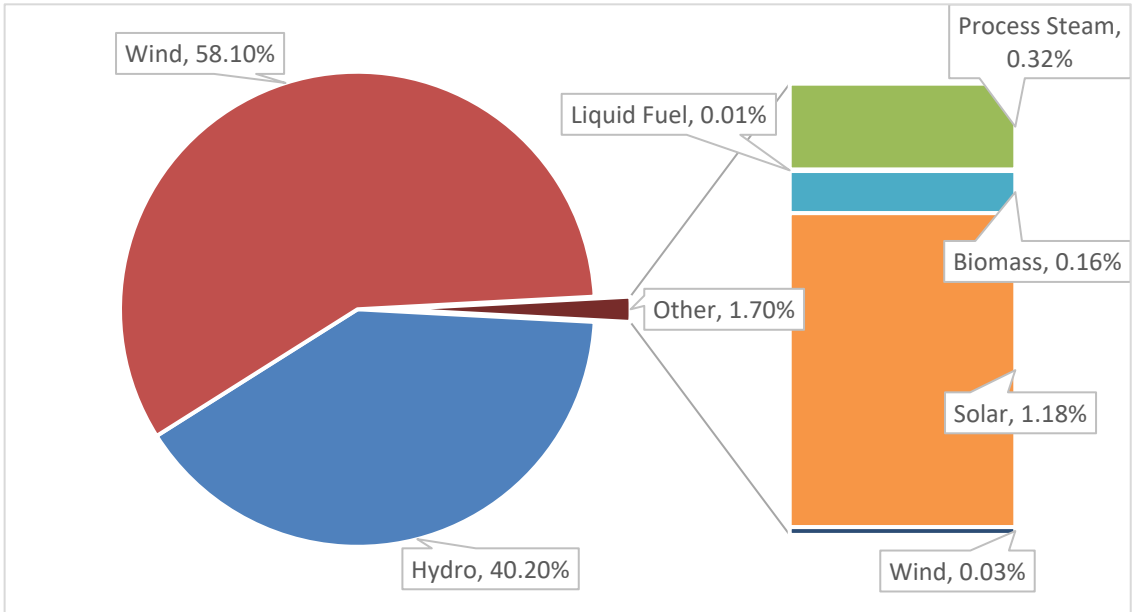


Figure 15: Electricity generated within the Dunedin network during the 2020FY.

Figure 15 shows the comparative production from locally embedded generators. The mid-scale and small-scale generators make up around 2% of the total local generation, with solar producing the majority of this.

Electricity demand in Dunedin

In the 2020FY, Aurora reported that 52% (409 GWh) of the electricity distributed on its network was consumed by 48,940 residential connection points; 47% (369 GWh) was consumed by the 6,934 non-domestic connection points and 1% (6 GWh) was used for street lighting.

Average network losses for the Aurora network during the 2020FY were 6.2%. Network losses are caused by heat generation in powerlines and transformers, and represents the difference between the amount of electricity which enters the local grid and that which is delivered to customers. All these values are similar to those during the 2019FY, with a slight increase in line loses (+0.2%).

The Otago PowerNet network had 3,108 ICPs within Dunedin which consumed 70 GWh of electricity with average network losses of 7.5%.

During the 2020FY 93.3% of Dunedin's electricity was supplied by Aurora. This network includes most of the urban areas of Dunedin and is served by the Halfway Bush and South Dunedin grid exit points. The remaining 6.7% of Dunedin's electricity was supplied by PowerNet, which mainly includes the rural areas within the city boundary and is served by the Halfway Bush and Naseby grid exit points. The relative share supplied by PowerNet has decreased by 0.6 percentage points from the 2019FY.

Biomass

There are three main categories of wood that are used in Dunedin: wood pellets, woodchips and firewood. These three wood fuels are used in different ways with woodchips primarily being used for industrial boilers, whereas wood pellets and logs (i.e. firewood) are used in both boilers and residential heating.

Wood fuels have multiple retail outlets, as well as direct commercial contracts with forestry owners and self-collection possibilities. The extremely varied nature in which wood fuels enter, and are used, in Dunedin make them very difficult to quantify.

Significant uncertainties arise from the distributed nature of both the supply and demand of wood fuels.

Wood pellets

Wood pellet supply in Dunedin

Wood pellets are supplied from a variety of retailers and industrial suppliers around the city.

These pellets are imported into the city from manufacturers in Taupō (Nature's Flame) and Nelson (AzWood) as well as smaller manufacturers from Timaru, Tapanui and Invercargill.

Due to the distributed nature of wood pellet imports, it is difficult to determine the exact quantity supplied to consumers within Dunedin. In 2019FY, personal communication with industry representatives suggested that the annual residential pellet supply was around 1,750 tonnes (0.030 PJ), and annual industrial pellet supply was around 1,040 tonnes (0.018 PJ). Due to difficulties obtaining this data in the 2020FY we have assumed that the wood pellet consumption is the same as last year.

Dunedin was therefore supplied with approximately 0.048 PJ of wood pellets during the 2020FY.

Wood pellet demand in Dunedin

Wood pellet boilers in Dunedin

Information was compiled from personal communications, the EECA boiler list and data provided by Ahika and BANZ to establish a database of commercial boilers in Dunedin. This database was used to estimate the total installed capacity and fuel demand for different boiler fuel types within Dunedin. There are eight known wood pellet boilers used at educational facilities within the city.

Overall there was 0.048 PJ of wood pellets used in commercial boilers within the city during the 2020FY.

Residential wood pellet demand

There are two main installers of pellet fires in Dunedin; Otago Pellet Fires and The Dunedin Fireplace. Comprehensive pellet fire data was not available from all installers, but at least 498 new pellet fires were installed during 2019 which brings the total number of recorded pellet fires in Dunedin up to 2261.

It is estimated that 0.03 PJ of wood pellets were used by Dunedin residents during the 2020FY.

A total of 0.08 PJ of wood pellets were consumed in Dunedin during the 2020FY. However, there is significant uncertainty in residential wood pellet use as it based on an estimate by Otago Pellet Fires.

Woodchips

Woodchip supply in Dunedin

Wenita and City Forests are the two main forestry owners and suppliers of wood fuels in the Dunedin area (Figure 16). These two firms provide logs for firewood and woodchips to wholesalers or directly to customers. Wholesalers may sell these wood products directly or pass them on to one of the many retailers of firewood in Dunedin. A 50/50 split was assumed between woodchips and firewood where more accurate records were not available.

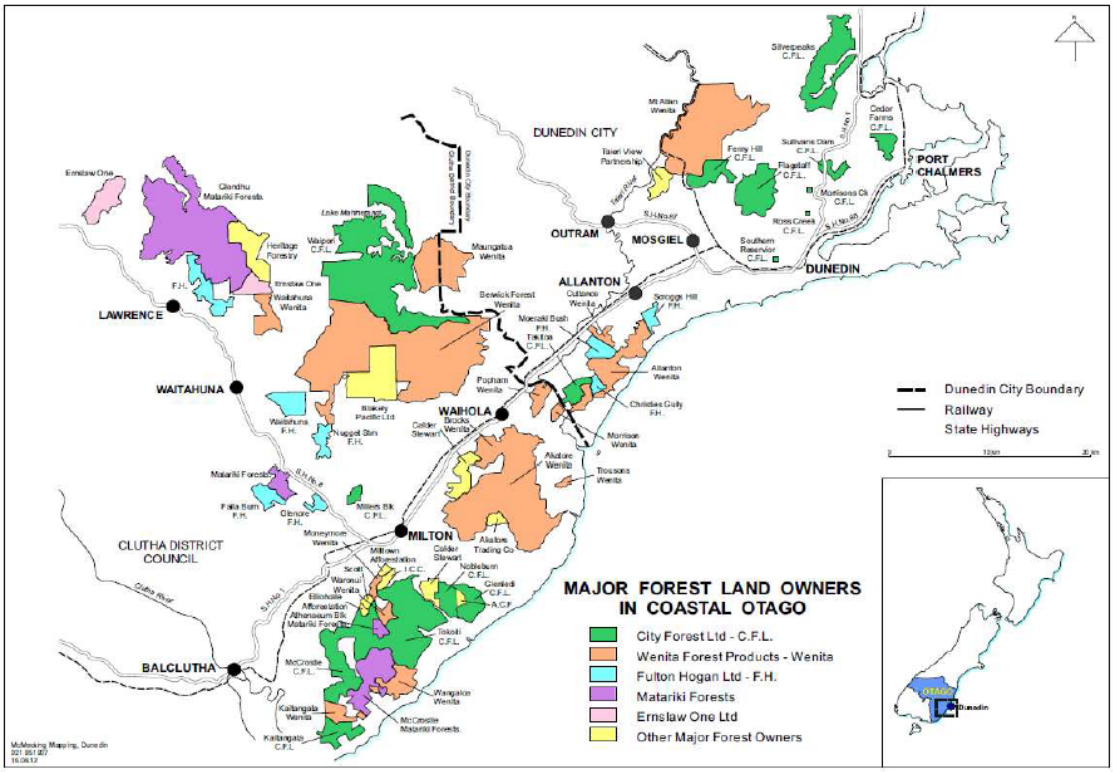


Figure 16: Major forest land owners in Coastal Otago.

It is estimated that at least 0.727 PJ of woodchips were supplied to Dunedin consumers by wood chip and pellet suppliers during the 2020FY.

Woodchip demand in Dunedin

Commercial demand

Several data sources were used to calculate the woodchip energy consumed in organisational boilers within Dunedin. Where available, direct energy consumption data was used to improve the accuracy of this study. Data was also derived from the 2011 EECA Heat Plant Database, updated with information from Ahika and BANZ. This

identified 11 other boilers in Dunedin that use woodchips as their primary fuel type. This includes the Dunedin Energy Centre. EECA is currently developing and updated Regional Heat Plant Database but this is not finalised for Dunedin yet.[25] During the 2020FY it is estimated that 0.934 PJ of woodchips were consumed in these boilers. Note that most of this consumption was at wood processing sites which use their own processing residues as fuel. Therefore this consumption is not reflected in supply numbers.

The University of Otago and the Southern District Health Board also use woodchips in a number of their boilers. During the 2020FY, the university and affiliated residential colleges consumed 0.015 PJ of woodchip and the hospitals consumed 0.01 PJ of woodchip.

Overall, 0.934PJ of woodchips were consumed in commercial boilers within Dunedin during the 2020FY. This is a 1.5% increase from 2019FY.

Oat husks

Oat husk demand in Dunedin

Combined data from the 2011 EECA Heat Plant Database, Ahika and BANZ, has identified two boilers that use oat husks as a fuel source. These boilers are located at Harraway & Sons Ltd and are fuelled by the waste husks from their own processing line.

During the 2020FY, it is estimated that 0.043 PJ of oat husks were consumed in these two boilers.

Firewood

Firewood supply in Dunedin

Commercial firewood supplies are largely met by the two local forestry companies, Wenita and City Forests (Figure 16). These two firms provide logs for firewood to several of the main retailers in Dunedin.

In the 2020FY there was 0.123 PJ of logs sold for firewood by forestry owners in Dunedin. This is a 27% decrease to the previous financial year.

[25] https://www.eeca.govt.nz/insights/data-tools/regional-heat-demand-database/

Residential firewood demand

A linear regression of census data from 2001, 2006 and 2013 was used to predict that approximately 21,404 Dunedin households used wood as a heating fuel in the 2020FY.

Firewood can either be purchased or obtained from private sources. Data on self-collected firewood is harder to obtain as it is not recorded anywhere. A survey that the Ministry for the Environment[26] carried out in 2005 concluded that over 60% of wood used in solid fuel burners and 40% of wood used in multi-fuel burners was self-collected. Previous Dunedin Energy studies either did not include any self-collected firewood, or used Peoples panel survey results to estimate firewood sources and quantities.

In 2016, a 'People's Panel' survey was created through the DCC and collected data from 349 Dunedin residents. The results showed that of those who used firewood[27], 58% obtained it through non-retail channels and 42% bought it from a retailer. The results of this survey correlate well with the 2005 findings from the Ministry for the Environment.

The People's Panel survey showed that on average, each household that used firewood would consume 7.17 cubic metres per year. This includes households that only use firewood for heating and those that use firewood and other fuels for heating purposes.

It is estimated that Dunedin residents consumed 0.792 PJ of firewood in the 2020FY. This is similar to the previous financial year.

[26] Source: Ministry for Environment, 2005. Warm Homes Technical Report: Home Heating Methods and Fuels in New Zealand.

[27] 221 out of the 349 respondents to the Peoples Panel survey used firewood in 2016.

Total wood fuels

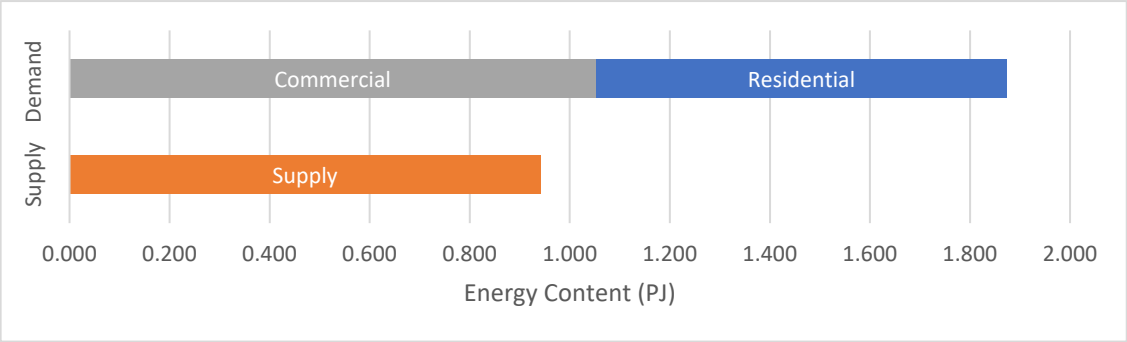


Figure 17: Comparison of commercial and residential wood fuel demand and supply by large commercial suppliers (not self collected or small-scale suppliers) in Dunedin during the 2020FY.

Figure 17 shows the ratio of commercial wood fuel use to residential wood fuel use in Dunedin. During the 2020FY, 56% of wood fuels were used by large commercial boilers and 44% of wood fuels were used by residential households. Note supply includes an estimate of the wood fuels used from onsite supply in the wood processing industry.

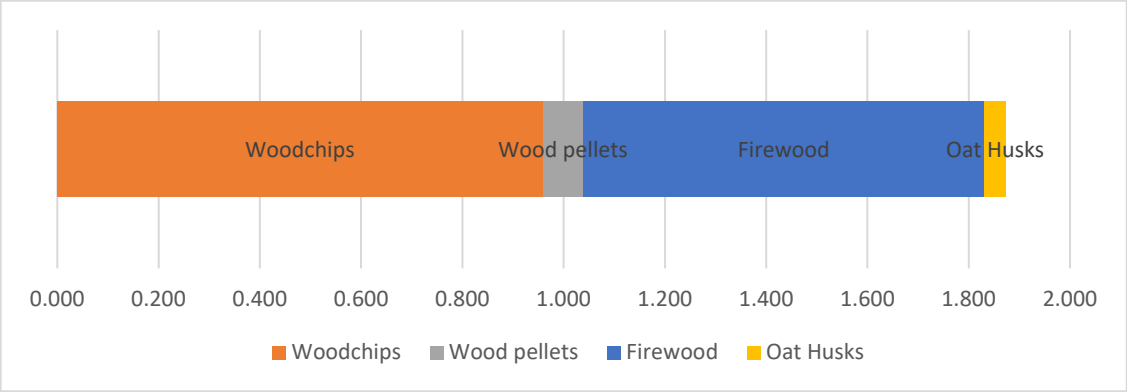


Figure 18: Wood fuel use by type during the 2020FY in Dunedin.

Figure 18 shows the breakdown of wood fuel use by type in Dunedin. During the 2020FY, 51% of wood fuels were woodchips, 42% were firewood, 4% were wood pellets and the remaining 2% were oat husks used by a local food processor.

Figure 19 provides an annual comparison in wood fuel use over the past four years, with historic values updated to the current calorific value and methodology. This shows that there have been only minor variations in the amount and type of wood fuels consumed in Dunedin since 2015.

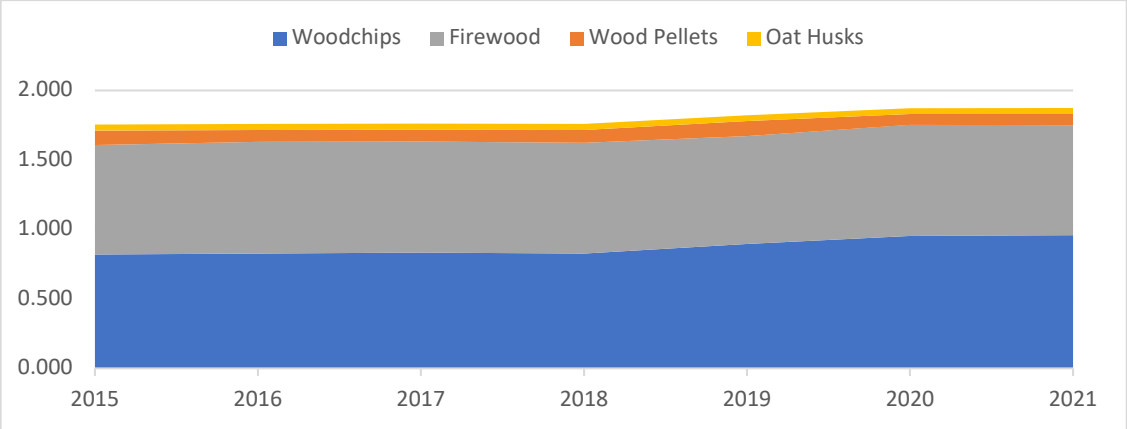


Figure 19: Wood fuel use in Dunedin by type from 2015 to 2020FY.

Coal

Coal supplies in Dunedin

There are no active coal mines in Dunedin. The closest mine is Kai Point Coal, which is located near Kaitangata. Personal communications suggest that the majority of coal supplied within the city is sourced from Kai Point Coal (Otago), Ohai Coal (Southland) and New Vale Coal (Southland). Some coal may also have been sourced from West Coast mines[28].

Data could not be obtained for the amount of coal supplied to Dunedin-based customers, so an approximation has been calculated based on coal demand within the city.

Coal demand in Dunedin

Commercial demand

Data was sourced from the EECA Heat Plant Database, Ahika and BANZ to create a database of known coal boilers within Dunedin. Where applicable, updated information on boiler sizes and fuel demands has been used to update the boiler database.

49 boilers were identified for which no specific coal consumption data could be obtained. 41 of these boilers are used for space heating of primary and secondary schools and it is estimated that they consumed 0.039 PJ of coal during the 2020FY. This is similar to 2019FY consumption levels. The remaining eight boilers were used for heating rest homes, food processing and in the chemical industry. It was calculated that these boilers consumed 0.183 PJ of coal during the 2020FY.

Exact coal consumption data was provided by several organisations. In these cases the boiler list was not used for estimating coal use.

The Dunedin Energy Centre is the only district heating scheme in Dunedin and provided steam for process and space heating to several organisations, including the University of Otago, the Southern District Health Board and Cadburys (now closed). Dunedin Energy Centre burns a combination of coal and woodchips to provide this heat to their consumers. It was calculated that 0.184 PJ of coal was consumed at this site, a decrease of 20% to the 2019FY of around 0.231 PJ. This was due to a shift from coal to woodchip.

[28] See https://www.nzpam.govt.nz/our-industry/nz-minerals/minerals-data/coal/operating-mines/ for a description of all New Zealand coal mines.

The University of Otago also uses coal at a number of its sites. During the 2020FY, the University consumed 0.015 PJ of coal. No coal was consumed at any of the University-affiliated residential colleges.

Approximately 0.421 PJ of coal was consumed in Dunedin boilers during the 2020FY.

Residential demand

Previous Dunedin Energy Studies used a linear model to estimate residential coal consumption in Dunedin. In this current study the census data from 2018 was used to estimate coal consumption.

It was predicted that approximately 2,434 Dunedin households used coal as a heating fuel in the 2020FY.

It is estimated that Dunedin residents consumed 0.021 PJ of coal in the 2020FY.

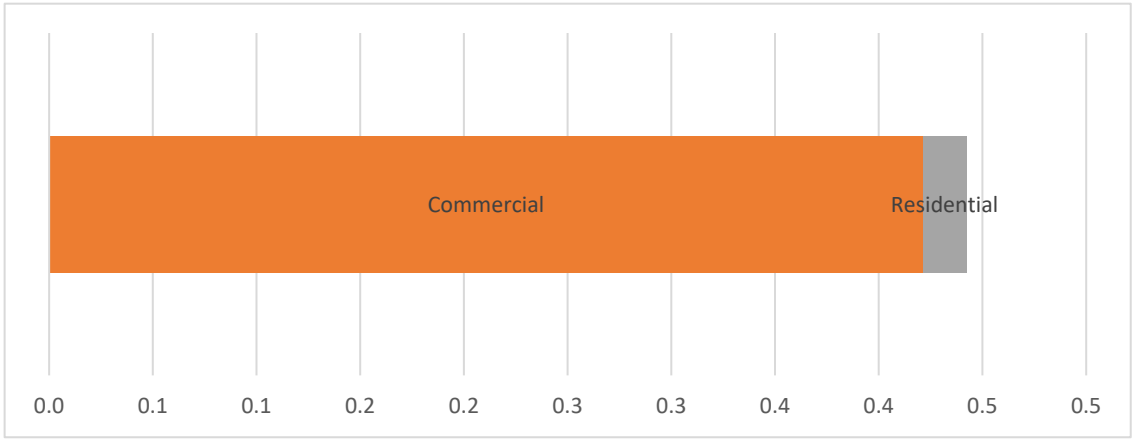


Figure 20: Comparison of commercial and residential coal use in Dunedin during the 2020FY.

Sulphur

Ravensdown Fertiliser Co-operative Limited combusts elemental sulphur in the boiler at its plant in Ravensbourne. The combustion products are processed into acid for use in the manufacturing of fertiliser at this plant.

The combustion of sulphur produces heat and steam as co-products which are used for electricity generation and industrial heat. Ravensdown Ltd generated 557 MWh of electricity in the 2020FY. This electricity is included in the electricity section of this report.

Based on previous studies, it is estimated that around 0.222 PJ of sulphur would have been consumed by Ravensdown Ltd during the 2020FY.

Greenhouse Gas Emissions

Emissions factors[29] were used to determine the greenhouse gas (GHG) emissions in terms of the energy use (kg CO_2-e/unit), as follows:

- Petrol (litre): 2.45
- Diesel (litre): 2.69
- LPG (kg): 3.02
- Electricity (kWh): 0.101
- Wood – residential (kg): 0.067
- Wood – industrial (kg): 0.015
- Coal – default (kg): 1.88

The conversion of sulphur to sulphuric acid at Ravensdown Ltd's Dunedin factory does not produce any carbon dioxide emissions. However, fluoride and sulphur dioxide emissions are released during this process. The exact quantities of these are unknown and are subsequently not included in the following greenhouse gas inventory for the city. Collaboration with other fertilizer factories either international or national should be pursued to develop an understanding of the greenhouse gas emissions of this plant.

Energy-related greenhouse gas emission from refrigerants were also not included in the study due to lack of data.

[29] Emissions factors were based on those supplied in the Ministry for the Environment's *Measuring Emissions: A Guide for Organisations– 2020: https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf*

Table 2: CO_2-equivalent emissions from energy use in Dunedin during the 2020FY.

Fuel	Total energy (PJ)	Total CO2-e (kt)	Share of emissions	Share of energy inputs
Petrol	1.960	136.89	24.8%	16.9%
Diesel	3.740	261.65	47.5%	32%
LPG	0.280	17.14	3.1%	2.4%
Electricity	3.352	94.04	17.1%	28.9%
Wood - Residential	0.802	5.58	1.0%	7%
Wood - Industrial	1.025	1.56	0.3%	9%
Coal	0.442	34.19	6.2%	4%
Total	11.601	551		

A total of 551 kt of CO_2-equivalent were emitted from Dunedin-based energy consumption during the 2020FY.

This is an overall decrease in emissions of 0.5% from 2019FY. A more detailed comparison of changes between years are show in Table 1 of the Appendix.

National Comparisons

Comparisons were made with two national datasets: the energy balance tables produced by MBIE[30], and the energy end use database produced by EECA[31]. These datasets have been converted to a per capita basis, based on the latest New Zealand Statistics estimates for the relevant area's population.

Energy Balance Tables

This study is compared with national data for the 2020 calendar year. The compared periods are six months out of alignment but this was the most recent data available and should provide a close approximation. This comparison is displayed in Table 3.

It should be noted that the national figures cover a much more varied set of activities than occur in Dunedin. For this reason, not all fuels are available and used in the same way in Dunedin as they may be in the rest of New Zealand. Specific examples are noted below.

Table 3: Comparison of per capita energy use of Dunedin residents in the 2020FY to national averages from 2020.

Fuel	Dunedin Energy Study (MJ/person)[32]	National Energy Balance (MJ/person)	Dunedin Proportion of National Average[33]
Petrol	14,759	20,030	74%
Diesel	28,162	25,761	109%
LPG	2,108	1,777	186%
Electricity	25,240	28,341	89%
Wood	13,758	5,341	258%
Coal	3,328	4,579	73%

Dunedin uses significantly less petrol and significantly more wood than the national per capita average.

LPG usage is much more prevalent in the South Island due to the reticulated natural gas network servicing a large proportion of the North Island. No natural gas is distributed in the South Island. This helps explain why Dunedin consumes 86% more LPG than the

[30] Source: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-balances/

[31] Source: https://www.eeca.govt.nz/resources-and-tools/tools/energy-end-use-database/

[32] Source: https://ecoprofile.infometrics.co.nz/Dunedin%20City/Population/Growth

[33] Source: https://www.stats.govt.nz/information-releases/national-population-estimates-at-30-june-2021

national average, which is widely used for cooking and water/space heating. In terms of greenhouse gas emissions, natural gas emits slightly fewer emissions than LPG (natural gas: 54tCO_2/TJ; LPG: 60tCO_2/TJ)[34].

During the 2020FY, Dunedin used 11% less electricity than the national average and 27% less coal. Nationally, coal is largely used for industrial processes such as steel manufacturing, electricity generation and milk drying. Because Dunedin does not have any of these large coal based industrial processes, it is predicted that per capita consumption should be slightly lower than the national average.

During the 2020FY, 38% of Dunedin's energy was from renewable sources. This is similar to the previous year and compares to a national average of 40%.

Greenhouse gas emissions

The EECA energy end use database also provides estimates of GHG emissions associated with reported energy use. The most recent version of this database at the national level is from 2020. This is compared to the findings from the current study on a per capita basis in Table 4.

Table 4: Comparison of per capita energy emissions of Dunedin residents in the 2020FY to national averages from 2020.

Fuel	Dunedin Energy Study (t CO_2-e/person)	National End Use Emissions (t CO_2-e/person)	Dunedin Proportion of NZ Average
Petrol	1.030	1.373	75%
Diesel	1.970	1.873	105%
LPG	0.123	0.113	109%
Electricity	0.708	0.983	72%
Wood	0.054	0.037	146%
Coal	0.257	0.440	58%

The per capita emissions are in proportion to the amount of each of the different types of fuel used in Dunedin and nationally (Table 3). Emission factors and calorific values for

[34] Ministry for the Environment: *Measuring Emissions: A Guide for Organisations– 2020: https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf*

all fuels have been updated in the current study to the latest MfE figures for calculating emissions[35].

Conclusions

This study has attempted to gather data on all energy inputs into Dunedin. This has been used to provide a snapshot of energy use in the city and to investigate any potential trends by comparing to previous Dunedin Energy Studies.

During the 2020 financial year (1st July 2020 to 30th June 2021) a total of 11.8 PJ of energy was used within Dunedin. This is a 6.5 % increase from the 2019FY. More detailed comparison of changes between years are show in Table 1 of the Appendix.

48% of the city's total energy consumption was from petrol and diesel, 28% from electricity, 15% from biomass, 4% from coal, 3% from LPG, and 2% from sulphur. These proportions are similar to previous studies, with the major variations being a slight reduction in diesel and petrol energy consumption increase in biomass consumption. Previous studies have identified minor reductions in these fuels, so these annual variations may not always be indicative of longer-term trends.

38% (4.55 PJ) of Dunedin's total energy consumption during the 2020FY was from renewable sources. This is five percentage points more than the 2019FY renewable proportion for Dunedin.

Some of the data collection and analysis methods have been improved from previous studies, so it is not always possible to draw direct conclusions about long term trends for all fuel types.

The developments and limitations of this study are summarised below, along with the implications.

Developments and Limitations

Although several improvements have been made over previous studies, there remain significant data gaps and uncertainties that require further research.

In particular:

[35] Emissions factors were based on those supplied in the Ministry for the Environment's *Measuring Emissions: A Guide for Organisations– 2020: https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf*

- The Local Authority Fuel Tax collected by the Dunedin City Council provides a good record of transport fuels for the Tax Area of Coastal Otago. However, the proportion of this consumed within the Dunedin City boundary is estimated. In addition:
  - Petrol and diesel consumed for stationary purposes is not accurately known
  - Aviation fuel consumption is not known
  - Transport LPG consumption is not accurately known
- The proportion of households still using coal needs to be assessed. Data from coal suppliers in Dunedin would improve the accuracy of these estimates.
- Commercial use of coal requires better understanding. Current information is based on the outdated EECA Heat Plant Database.
- Evaluating emissions from wood fuels in a Dunedin context for both residential and commercial uses needs to account for local transport.

The level of confidence linked to data incorporated in this study varies across fuel sources. This confidence differs between supply and demand data and is highlighted in Table 5. The choice of whether to use supply or demand to estimate greenhouse gas emissions is also identified.

Table 5: Level of confidence by fuel type during the 2020FY

Fuel type	**Confidence level**	**Comment**	**Source for GHG calculation**
Petrol	Medium	Based on fuel sales in the Otago Region. Dunedin portion estimated.	Supply
Diesel	Medium	Based on fuel sales in the Otago Region. Dunedin proportion Diesel used in stationary generation estimated from hospital and university data	Supply
LPG	Medium	Supply data based on imports into Dunedin. Demand based on boiler capacity and population estimates. Confidence has increased in the current study due to comparing to preliminary EECA results for the Regional Heat Demand Database.	Demand
Electricity	High	Incorporates accurate information on electricity supplied to/from ICPs via Aurora and OtagoNet network.	Supply

Wood pellets	Low	Supply based on industry estimates. Demand based on installed boiler capacities.	Supply
Wood chips	Medium	Supply data provided by two major fuel suppliers. Total demand is based on supply data plus estimates for fuel consumed by wood processors.	Demand
Oat Husks	Low	Based on boiler capacity of food processing industry.	Demand
Firewood	Medium	High confidence in Wenita and City Forest supply data, but small suppliers unknown. Demand is based on Census 2018 information.	Demand
Coal	Low	Residential coal use based on Census 2018 data. Commercial use based on information from the main coal users and boiler capacities. Confidence in commercial use has decreased due to comparison with preliminary EECA results from the Regional Heat Demand Database.	Demand

This study made progress on further identifying the end uses of some of the energy used in the city. However, better knowledge of end uses would assist in identifying opportunities for fuel shifting and efficiencies.

As this study continues, various trends are starting to emerge for some fuels. For others methodology changes mean that comparison across years is not possible. However these methodology changes mean that the study results are more comparable to other council initiatives.

Outlook

EECA are currently developing a Regional Heat Demand Database to replace the outdated 2011 Heat Plant Database. A version of the Heat Plant Database (kept updated using local knowledge) is the basis for some of the estimates for commercial LPG, coal and biomass consumption used in the current study. EECA's Regional Heat Demand Database is expected to be completed for the South Island by the end of 2022. In future Dunedin Energy Studies the Regional Heat Demand Database should be used to update this information. This should be done in such a way that it takes into account local knowledge as the EECA work may also have limitations. In parallel, direct contact should be made with known large boiler owners to determine any updates to their boilers. This is particularly relevant for coal and biomass.

Appendix

*Table 1: Energy use by fuel type across multiple years; * indicates a change in methodology. The change in Firewood in 2020 is based on a change to using demand for estimates rather than supply.*

Fuel Type	**2016 FY (PJ)**	**2017 FY (PJ)**	**2018 FY (PJ)**	**2019 FY (PJ)**	**2019 FY (PJ) old method**	**2020 FY (PJ)**
Petrol	2.65	2.76	2.69	2.08*	2.41	1.96
Diesel	3.89	4.36	4.89	3.76*	4.95	3.74
LPG	0.45	0.43	0.73	0.31*	0.73	0.28
Electricity	3.15	3.17	3.19	3.10	3.10	3.35
Wood Pellets	0.24	0.24	0.25	0.05	0.05	0.05
Woodchips	0.07	0.07	0.13	0.95	0.95	0.93
Oat Husks	0.04	0.04	0.04	0.04	0.04	0.04
Firewood	0.07	0.10	0.09	0.08	0.08	0.802*
Coal	0.68	0.67	0.53	0.49	0.49	0.44
Sulphur	0.20	0.28	0.25	0.22	0.22	0.22
TOTAL (PJ)	**11.44**	**12.12**	**12.79**	**11.08**	**13.02**	**11.82**