**CONFIDENTIAL**

**Critique of three different methodologies for calculating direct greenhouse gas emissions from use of transport fuel within the Dunedin City boundary**

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**Introduction**

A range of methods have been used to estimate the direct greenhouse gas (GHG) emissions from transport fuel use within the Dunedin boundaries[[1]](#footnote-1). Each method relies on a range of data sources and assumptions and so is an approximation to the actual GHG emissions. In this document we compare three methodologies and provide a recommendation to Dunedin City Council (DCC) on which one provides the best estimate. We use two criteria for this recommendation:

1. Accuracy
2. Ease of data access

We briefly summarize the three methods below, present an analysis of the pros and cons of each method and our recommendation.

**Summary of the three methods**

All three methods determine the GHG emissions by multiplying the volume of petrol and diesel consumed by Ministry for the Environment (MfE) emission factors. However they differ in how they calculate the petrol and diesel volume.

* The Dunedin Energy Study method has been used in 2018/2019 Dunedin Energy Study and previous versions of this report. This uses Otago regional data on petrol and diesel sales (in litres) that is used for fuel tax calculations. This data is aggregated over three territorial authorities (i.e., Waitaki District, Clutha District, and Dunedin City). Rate revenue across the three territorial authorities is used to determine the Dunedin city share of petrol and diesel use.
* The E&Y method was developed by Ernst and Young to estimate the Otago region’s 2018/2019 carbon footprint. This takes total fuel sales data for Dunedin City (not separated into diesel and petrol) from StatsNZ. National proportions (in energy) of petrol and diesel from the Energy Efficiency and Conservation Authority (EECA) End Use data base, MfE calorific values and Ministry of Business, Innovation and Employment (MBIE) average national fuel prices are then used to determine the quantities of petrol and diesel.
* The AECOM method was used by AECOM to determine the Dunedin City’s 2018/2019 Community Carbon Footprint (November 2020 update). This method also uses the fuel tax data like the Dunedin Energy study method, but determines the Dunedin City component by using vehicle kilometres travelled (VKT) data from the New Zealand Transport Agency (NZTA) for each of the three territorial authorities. The AECOM method also subtracts diesel used for stationary energy.

To better understand the three methods, we have used each method to try and reproduce the results reported in each of the above studies for the 2018/19 financial year. The detailed approach is provided in the Appendix. A table of the results of this analysis is shown in Table 1.

*Table 1: Summary of the results for the litres of petrol and diesel and associated GHG emissions for each of the three methods for the 2018/19 financial year*

|  |  |  |  |
| --- | --- | --- | --- |
| **Method** | **Dunedin Energy Study** | **E&Y** | **AECOM** |
| Dunedin City share of Petrol and Diesel | 70.4% | NA | 54.25% |
| Litres of Petrol | 76,797,000 (38%) | 51,517,000 (45%) | 59,179,000 (38%) |
| Litres of Diesel | 126,792,000 (62%) | 56,206,000 (55%) | 97,706,000 (64%) |
| kg CO2-e | 529,224,000 | 277,397,000 | 407,818,000 |
| kg CO2-e (excl. stationary) | NA | NA | 365,765,000 |

**Pros and Cons and Recommendation**

Analysis of the pros and cons of the three methods based on our two criteria is provided in Table 2.

*Table 2: Pros and Cons of the three methods*

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Dunedin Energy Study** | **E&Y** | **AECOM** |
| **Pros** | 1. Uses Otago Region Fuel Tax Data, which records actual litres of petrol and diesel sold in the Otago region.  2. Ease of data collection. Data direct from DCC (already in financial year). | 1. Fuel sales data for Dunedin City boundary from Stats NZ. | 1. Uses Otago Region Fuel Tax Data, which records actual litres of petrol and diesel sold in the region.  2. Ease of data collection. Data direct from DCC. |
| **Cons** | 1. Uses total rate income for each territorial authority to determine Dunedin City share. Rates are unlikely to be well correlated with fuel use.  2. In addition, proportion of diesel and petrol may not be the same for each territorial authority.  3. Fuel purchased in Dunedin is not necessarily used in Dunedin | 1. Need to request data from StatsNZ.  2. Complicated with many additional assumptions which potentially lead to inaccuracy (e.g. very sensitive to fuel prices)[[2]](#footnote-2).  3. Uses combination of EECA End Use Database and MBIE fuel prices to determine diesel and petrol share. These are both national averages and do not necessarily correspond to Dunedin/Otago - fuel prices, diesel/petrol split are likely to be different.  4. Fuel purchased in Dunedin is not necessarily used in Dunedin. | 1. Uses VKT data to determine Dunedin City share. Not perfect but probably more reflective of fuel use.  2. Proportion of diesel and petrol may not be the same for each district.  3. VKT data must be requested from NZTA. (Not clear if this is financial year).  4. Fuel purchased in Dunedin is not necessarily used in Dunedin.  5. Estimates GHG emissions from stationary use of fuel |

Based on this assessment, our recommendation is that the AECOM method provides the most accurate estimate. It uses Otago region fuel tax data, which records actual volume of petrol and diesel sold in the Otago region. It also uses VKT data to determine Dunedin City share, which is likely to be more accurate than using rates (Dunedin Energy Study method) which have no real relation to fuel use. We do not recommend any attempt to remove stationary energy from total petrol and diesel use as it is very difficult to do this systematically.

Shortcomings of the method are:

1. the inaccuracy of VKT data for determining Dunedin City’s share of fuel use[[3]](#footnote-3). For example, the EY method using Stats NZ fuel sales data estimates Dunedin’s relative share of the total regional fuel to be 28% compared to AECOM’s 54%.
2. the method uses the same ratio of diesel and petrol for all 3 territorial authorities. Dunedin City is likely to use a smaller share of diesel than more rural areas. The ratio of petrol to diesel from the Otago region fuel tax data is 38%:64%. The AECOM method assumes that this same ratio applies to Dunedin City. This is likely to be an over estimate of the diesel proportion as the NZ national ratio for petrol to diesel in litres is 45%:55% (based on EECA End Use Database).
3. the method uses national figures for determining the percentage allocated to stationary fuel. This is likely to vary from region to region and it is difficult to determine what percentage of petrol and diesel purchased from the locations in the fuel tax data is used for stationary applications as many have dedicated delivery.

The first two of these shortcomings are likely to lead to the AECOM method overestimating the GHG emissions. However, of the 3 methods analysed, the AECOM method is likely to be the most accurate. A more accurate method would require fuel sales for both petrol and diesel (in litres) to be collected for the Dunedin City area. Note that all methods suffer from the limitation that fuel purchased in Dunedin is not necessarily used in Dunedin. However, this is similar to the situation for many other sources of energy.

**Appendix**

Dunedin Energy Study Methodology

This methodology uses Dunedin City Council (DCC) data on fuel use used for fuel tax calculations. This methodology has been used in recent years to apportion fuel use for Dunedin City in the Dunedin Energy Study.

DCC data was received from Jessie Wu (Jessie.Wu@dcc.govt.nz) on the 1st of July 2021. The provided spreadsheet is organised in financial years. For this report, the 2018/2019 financial year (01.07.2018-30.06.2019) is considered.

In a first step, petrol and diesel supplied from petrol stations (in litres per month) are summed to an annual total. This data is provided for the entire Otago region (i.e. made up of 3 territorial authorities: Waitaki District, Clutha District, and Dunedin City). The proportion of petrol and diesel supplied to Dunedin City alone is based on yearly rates. For the 2018/2019 financial year the following rates were received in each territorial authority:

|  |  |  |
| --- | --- | --- |
| **Territorial Authority** | **Annual rates received** | **Proportion** |
| Dunedin City | $125,394,000 | 70.4% |
| Waitaki District | $29,138,320 | 16.3% |
| Clutha District | $23,479,287 | 13.3% |

Based on this data the Dunedin City share of diesel and petrol is estimated to be 70.4%. The annual petrol and diesel supplies for Dunedin City and the Otago region respectively are:

|  |  |  |
| --- | --- | --- |
| **Territorial Authority** | **Petrol received (litres)** | **Diesel received (litres)** |
| Dunedin City (70.4%) | 76,796,746 | 126,792,354 |
| Otago Region | 109,086,288 | 180,102,776 |

Using the following emission factors[[4]](#footnote-4):

Petrol (litre): 2.45 kg CO2-e

Diesel (litre): 2.69 kg CO2-e

Diesel and Petrol consumption in the 2018/2019 financial year caused an estimated 529,224,000 kg CO2-e in Dunedin City.

AECOM Methodology

This methodology uses Vehicle Kilometres Travelled (VKT) as the basis for estimation.

The VKT method incorporates two data sets. The first data set is provided by the Dunedin City Council (DCC) and contains information on petrol and diesel sales for the Otago region (i.e. Waitaki District, Clutha District, and Dunedin City) by financial year. This data was received on the 1st of July 2021, provided by Pete Hebden (DCC Facilities) [pete.hebden@dcc.govt.nz](mailto:pete.hebden@dcc.govt.nz).

The second data set is provided by the New Zealand Transport Agency. This second data set includes information on VKT for both State Highways and Local Roads by territorial authority and financial year. Data was provided by Ernest Zheng (NZTA) [ernest.zheng@nzta.govt.nz](mailto:ernest.zheng@nzta.govt.nz/) on the 16th August 2021.

In a first step, petrol and diesel sales from the DCC data set are extracted for the financial year 2018/2019 ending on the 30th of June 2019. This is as follows:

Petrol use 2018/2019: 109,086,288 Litres

Diesel use 2018/2019: 180,102,776 Litres

It is worth mentioning that this is for the Otago region consisting of the Waitaki and Clutha District as well as Dunedin City. The next step aims to estimate the share of petrol and diesel use pertinent to Dunedin City using the VKT data.

In the NZTA data set we find information on VKT for State Highways and Local Roads for each of the territorial authorities making up the Otago region[[5]](#footnote-5). For the 2018/2019 year this is as follows:

|  |  |  |
| --- | --- | --- |
| **Territorial Authority** | **State Highway VKT 2018/2019** | **Local Roads VKT 2018/2019** |
| Dunedin City | 439,035,229 | 467,370,000 |
| Waitaki District | 305,885,371 | 110,680,000 |
| Clutha District | 234,579,806 | 113,330,000 |

The sum of both State Highway and Local Road VKT gives us the total VKT in the Otago region in the 2018/2019 financial year. This is 1,670,880,406 kilometres travelled. Now we can calculate the VKT share for Dunedin City. This is the sum of State Highway and Local Road VKT for Dunedin City divided by the total VKT in the Otago region. For the 2018/2019 year the Dunedin City share of VKT is 54.25%. This matches with AECOM results.

(439,035,229 + 467,370,000) / 1,670,880,406 = 54.25%

The share of 54.25% linked to Dunedin City is now applied on the petrol and diesel use of the 2018/2019 financial year. This is:

Petrol: 109,086,288 Litres \* 0.5425 = 59,179,311 Litres

Diesel: 180,102,776 Litres \* 0.5425 = 97,705,756 Litres

Using the following emission factors[[6]](#footnote-6)

Petrol (litre): 2.45 kg CO2-e

Diesel (litre): 2.69 kg CO2-e

the total emissions from petrol and diesel use in Dunedin City for the 2018/2019 year equate to 407,818,000 kg CO2-e.

Some of this fuel use could be for stationary use rather than transport. From the Energy Efficiency and Conservation Authority (EECA) End Use data base we estimate that in the 2018/2019 year, 16% of national diesel use was for stationary use. This estimate was found by:  
1) Filtering by fuel type “Diesel”

2) Filtering by technology group “Mobile Motors”

3) Summing the energy values for the period ending on the 31st of December 2018

4) Repeating this for “Stationary Motors”

This process is then repeated for fuel type “Petrol”

This process results in:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Stationary TJ | Mobile TJ | % stationary |
| Petrol | 406 | 113,265 | 0% |
| Diesel | 26,499 | 138,332 | 16% |

Petrol stationary use is negligible. Assuming this percentage also holds for Dunedin City, and deducting this stationary fuel use, emissions caused by diesel and petrol for transport equal 365,765,000 kg CO2-e. This compares with the reported figure from AECOM (385,702,000 kg CO2-e). Differences in the final number result from a different estimate of the proportion of fuel used for stationary applications. There does not seem to be a systematic process for making this allocation.

E&Y Methodology

This method incorporates three data sets. The first data set provides data on fuel sales for Dunedin City from classified petrol stations within the district including self-pump stations. This is StatsNZ data received on the 24th of August 2021 from Kathy Hicks (kathy.hicks@stats.govt.nz). It not clear how this data is collected The second data set is provided by EECA providing a national breakdown on petrol and diesel use[[7]](#footnote-7). Finally, quarterly national fuel prices were obtained from MBIE for both diesel and petrol[[8]](#footnote-8).

Fuel sales data from StatsNZ does not distinguish between petrol and diesel sales. We utilise the national share of diesel and petrol use in combination with fuel prices to transform fuel sales into petrol and diesel use in litres. On this basis, emission caused by diesel and petrol use in Dunedin City can be estimated. In the following, this process is elucidated.

Fuel sales data does not include GST. In a first step, we thus deduct GST from quarterly petrol prices. MBIE provides a sales-weighted average of regular and premium petrol. Here we use the this average from the “quarterly c per unit (real)” tab. In terms of diesel, commercial prices are used (they already exclude GST). For the 2018/2019 financial year the GST exempt fuel prices are as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fuel excl. GST** | **Q3 2018 ct/l** | **Q4 2018 ct/l** | **Q1 2019 ct/l** | **Q2 2019 ct/l** |
| Petrol | 197.84 | 196.26 | 182.56 | 191.97 |
| Diesel | 111.81 | 104.41 | 95.49 | 102.26 |

In a second step, a national breakdown for diesel and petrol use is calculated using EECA’s energy end-use database. For both diesel and petrol we filter by Fuel Type, Land Transport End Use, and Date reflecting the 2018/2019 most appropriately. A sum is built over all sectors for each fuel type. This equates to:

|  |  |
| --- | --- |
| **Fuel Type** | **Use in TJ in 2018** |
| Petrol | 113,264 |
| Diesel | 138,331 |

These energy values are then converted into litres ensuring that not energy but quantity is reflected in the proportionate share of fuel use. The following conversion rates were applied[[9]](#footnote-9):

|  |  |
| --- | --- |
| **Fuel Type** | **MJ/L** |
| Petrol | 35.28 |
| Diesel | 38.21 |

This equates to a national fuel use in litres of:

* 3,620,282,649 litres of diesel
* 3,210,430,839 litres of petrol

used in the financial year of 2018/2019. By using the average price of petrol and diesel over the quarters constituting the financial year of 2018/2019 we can calculate the national share of diesel and petrol sales. The average price for petrol and diesel uses the fuel prices from above.

|  |  |
| --- | --- |
| **Fuel Type** | **Average ct/l FY2018/19** |
| Petrol | 192.16 |
| Diesel | 103.50 |

Multiplying these prices with the national fuel use in litres equates to a national fuel sales of:

* 3,210,430,839 litres of petrol\*1.9216$/l = $6,169,163,900 (petrol)
* 3,620,282,649litres of diesel\*1.0350$/l = $3,746,992,542 (diesel)

In other words, the national share of fuel sales is **63% for petrol** and **37% for diesel**.

The next step uses StatNZ’s fuel sales data and applies the aforementioned share of diesel and petrol sales (assuming that the national share is a good approximation to the regional share). This is reflected in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| **Year and Quarter** | **StatNZ Dunedin City fuel sales in $** | **Diesel sales (37%) in $ for Dunedin City** | **Petrol sales (63%) in $ for Dunedin City** |
| 2018 Q3 | 43,003,380 | 15,911,251 | 27,092,129.4 |
| 2018 Q4 | 34,968,881 | 12,938,486 | 22,030,395 |
| 2019 Q1 | 37,722,381 | 13,957,281 | 23,765,100 |
| 2019 Q2 | 41,364,561 | 15,304,888 | 26,059,673 |

With this information generated, quarterly fuel prices are applied to convert fuel sales from $ to litres by simply dividing diesel and petrol sales ($) by the fuel prices ($/litre). This equates to:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year and Quarter** | **Diesel sales in $ for Dunedin City** | **Petrol sales in $ for Dunedin City** | **Diesel price in $/litre** | **Petrol price in $/litre** | **Litres of Diesel** | **Litres of Petrol** |
| 2018 Q3 | 15,911,251 | 27,092,129.4 | 1.1181 | 1.9784 | 14,230,615 | 13,693,959 |
| 2018 Q4 | 12,938,486 | 22,030,395 | 1.0441 | 1.9626 | 12,391,999 | 11,225,107 |
| 2019 Q1 | 13,957,281 | 23,765,100 | 0.9549 | 1.8256 | 14,616,484 | 13,017,692 |
| 2019 Q2 | 15,304,888 | 26,059,673 | 1.0226 | 1.9197 | 14,966,642 | 13,574,867 |

In total, for the 2018/2019 financial year this is 56,205,739 litres of Diesel and 51,511,625 litres of Petrol used in Dunedin City.

Using the following emission factors[[10]](#footnote-10):

Petrol (litre): 2.45 kg CO2-e

Diesel (litre): 2.69 kg CO2-e

Diesel and Petrol consumption in the 2018/2019 financial year caused an estimated 277,397,000 kg CO2-e in Dunedin City. This is matches well with the reported E&Y figure of 277,256,000 kg CO2-e.

1. MfE Guidance for Voluntary GHG Reporting 2018 https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Quick-Guide-2020-final.pdf [↑](#footnote-ref-1)
2. Calculating transport fuel based on dollars spent is not recommended by MfE. See Sec 4.1.3 of https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Quick-Guide-2020-final.pdf [↑](#footnote-ref-2)
3. Background Discussion of Regional Vehicle-Kilometres Travelled (VKT) Data in New Zealand - July 2019 - MoT Analytics. [↑](#footnote-ref-3)
4. MfE 2020, https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf [↑](#footnote-ref-4)
5. https://www.transport.govt.nz/assets/Uploads/Discussion/Background-Discussion-of-VKT-Data-20190716.pdf [↑](#footnote-ref-5)
6. MfE 2020, https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf [↑](#footnote-ref-6)
7. https://tools.eeca.govt.nz/energy-end-use-database/ [↑](#footnote-ref-7)
8. https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/energy-prices/ [↑](#footnote-ref-8)
9. Ministry for the Environment (2020), Measuring Emissions: A Guide for Organisations, https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf [↑](#footnote-ref-9)
10. MfE 2020, https://environment.govt.nz/assets/Publications/Files/Measuring-Emissions-Detailed-Guide-2020.pdf [↑](#footnote-ref-10)