

CO₂ emissions and energy consumption year 2018

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CO₂ emissions and energy consumed by the New Zealand vehicle fleet in the year 2018

The total of the CO₂ emissions and energy consumption by fleet type during the year 2018 is calculated using the 2018 statistics of the New Zealand vehicle fleet provided by the Ministry of Transport.¹

The number of vehicles, the distance driven per vehicle type, combined with average fuel consumption and corresponding carbon intensity, allows us to calculate how much energy was consumed and how much CO₂ was produced (Figure 1).²

¹ <https://www.transport.govt.nz/mot-resources/vehicle-fleet-statistics/>

The carbon intensity per km driven for light passenger vehicles (both diesel and petrol) is obtained from this report (Table 9.2 a,b), since the results of the WTW analysis of light passenger vehicles (calculated in the previous section), were for a specific vehicle. The carbon intensity for vehicles other than light passenger vehicles is obtained by scaling with the respective average fuel consumption.

² Tables used to generate the figures are in the Appendix.

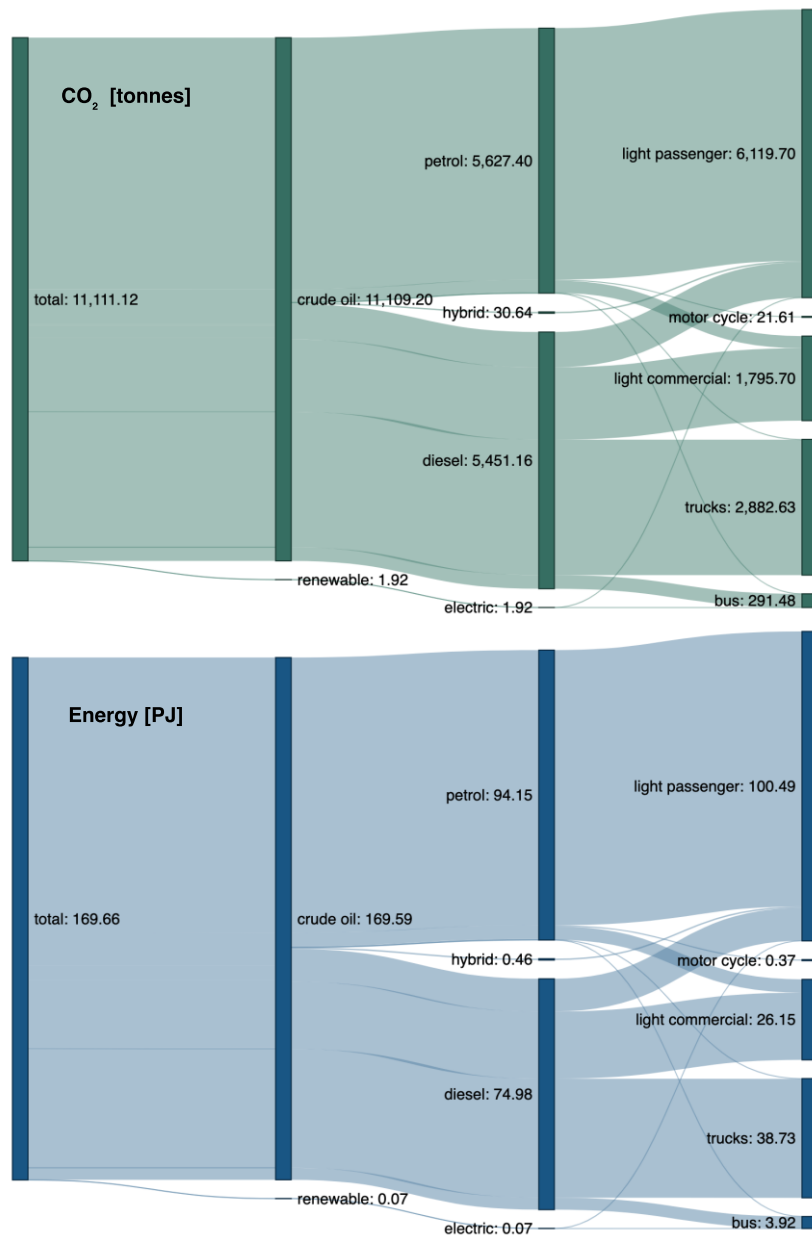


Figure 1. (Top) CO₂, in tonnes, emitted and (Bottom) energy, in PJ, consumed by the New Zealand vehicle fleet in the year 2018

Two low-emission future scenarios

In this section, two possible future scenarios are sketched. One scenario where a large amount of battery-powered electric vehicles (BEVs) are introduced and a second scenario where also fuel cell electric vehicle (FCEV) make up a significant portion of the amount of New Zealand vehicles. The goal of this analysis is to determine the potential of lowering the CO₂ emission by introducing more BEV and FCEV in New Zealand and secondly to determine the resulting demand of renewable energy generators.

Scenario 1: 60% of all diesel and petrol vehicles become battery electric

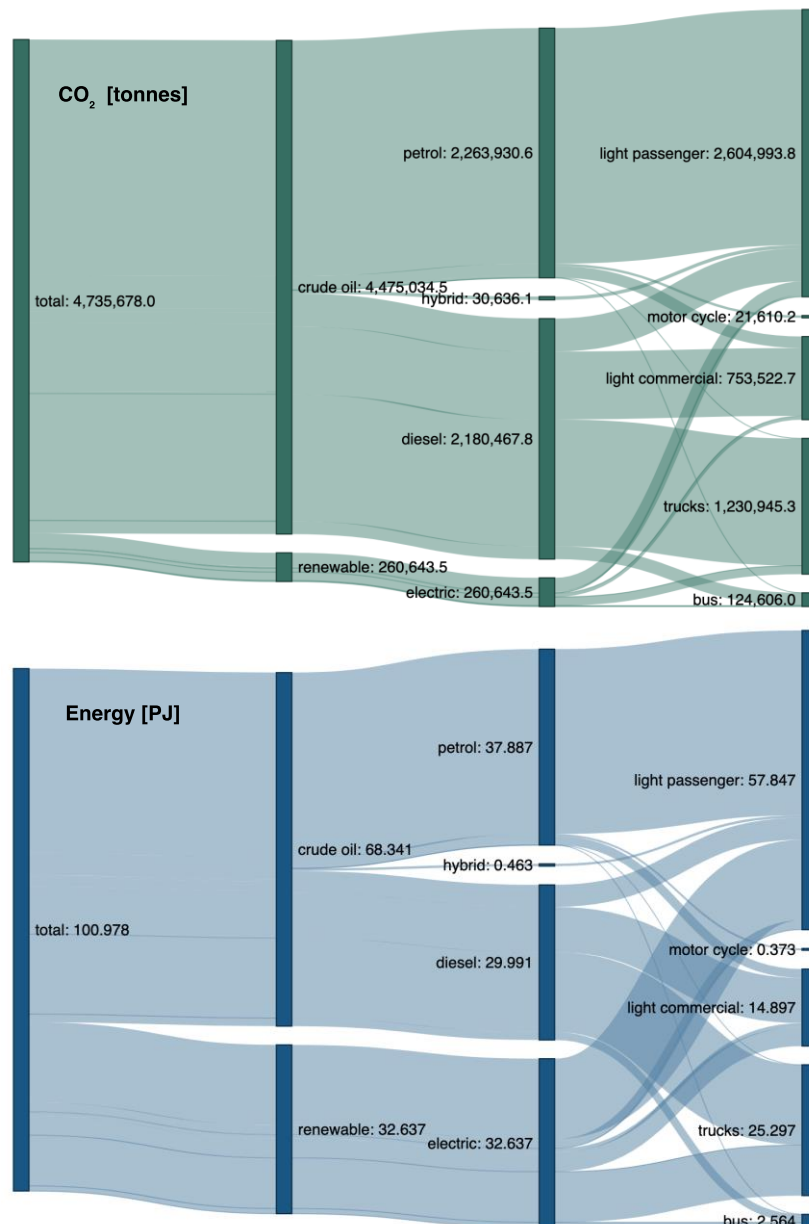


Figure 2. (Top) CO₂, emitted (in tonnes) and (Bottom) energy, consumed by the New Zealand vehicle fleet according to scenario 1, where is assumed that 60 % of all diesel and petrol vehicles become battery electric (in PJ).

Scenario 2: 30% of the diesel and petrol vehicles to become electric and 20% run on hydrogen

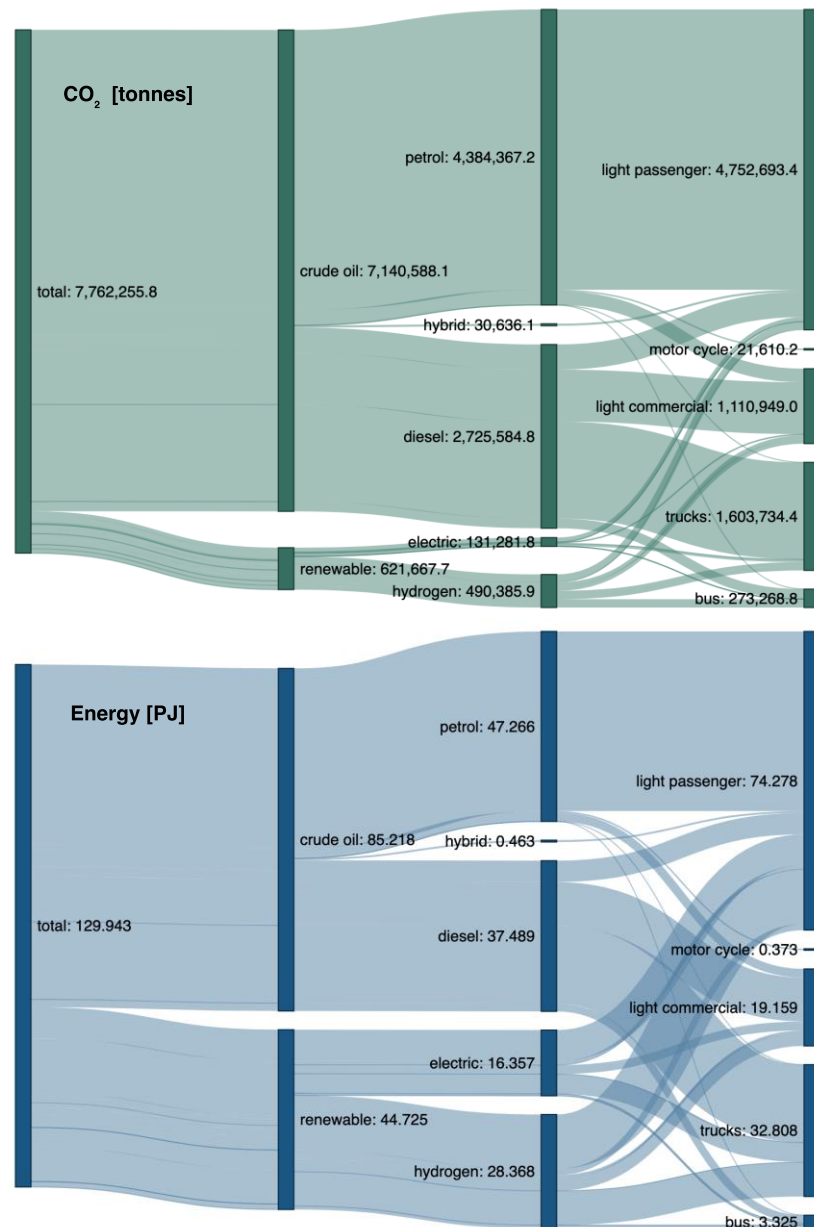


Figure 3. (Top) CO₂, emitted (in tonnes) and (Bottom) energy, consumed by the New Zealand vehicle fleet according to scenario 2, where is assumed that 30% of the diesel and petrol vehicles become electric and 20% run on hydrogen (in PJ).

Comparison of scenario 1 & 2

- In scenario 1 (40% internal combustion engines [ICE], 60% BEV), the carbon emission decreases by 58%, from 11.1 million tonnes CO₂ to 4.7 million tonnes CO₂. Thirty-three PJ of electricity would need to be generated with an average carbon intensity of 28 gCO₂/kWh.
- In scenario 2 (50% ICE, 30% BEV, 20% FCEV), the carbon emission decreases by 45% to 6.1 million tonnes CO₂. Forty-five PJ of electricity would need to be generated with an average carbon intensity of 28 gCO₂/kWh.
- However, the question arises if it would be achievable to supply enough low-emission energy for one of these two scenarios to become a reality and what the timeframe for such a scenario would be. According to scenario 1, the new electricity that would need to be generated would equate to something of the order of 192 km² of new windfarm parks and new 50 km² of solar parks needing to be built in New Zealand.

Appendices

Tables for emissions and energy use scenarios

Appendix 1: Table for vehicle emissions and energy use 2018

| | | distance | quantity | distance per vehicle | carbon intensity | total carbon intensity | total carbon intensity | fuel consumption | energy consumption | total fuel | total energy | total energy |
|------------------|-----------------------|--------------------|----------------|----------------------|------------------------------|---------------------------------|------------------------------|------------------|--------------------|---------------------|-----------------|---------------|
| | | million kilometres | Year 2018 | km/vehicle/year | Average gCO ₂ /km | kgCO ₂ /vehicle/year | tonnes CO ₂ total | L/km | kWh/km | million litres | GWh | PJ |
| light passenger | petrol | 31979 | 3157190 | 10129 | 167 | 1691 | 5338920 | 0.08 | | 2558.35 | 24815.96 | 89.34 |
| | diesel | 3690 | 297079 | 12421 | 203 | 2519 | 748455 | 0.08 | | 295.21 | 2952.12 | 10.63 |
| | electric | 77 | 8816 | 8762 | 22 | 191 | 1688 | | 0.23 | | 17.38 | 0.06 |
| | hybrid | 295 | 33619 | 8762 | 104 | 911 | 30636 | 0.05 | | 13.26 | 128.58 | 0.46 |
| | total | 36041 | 3496704 | 10307 | | | 6119699 | | | | 27914.05 | 100.49 |
| light commercial | petrol | 1548 | 161011 | 9612 | 167 | 1605 | 258374 | 0.08 | | 123.81 | 1200.95 | 4.32 |
| | diesel | 7580 | 486288 | 15587 | 203 | 1722 | 1537332 | 0.08 | | 606.37 | 6063.68 | 21.83 |
| | total | 9127 | 647299 | 14100 | | | 1795706 | | | | 7264.64 | 26.15 |
| motor cycle | total (petrol) | 414 | 179761 | 2304 | 52 | 120 | 21610 | 0.03 | | 10.36 | 103.55 | 0.37 |
| trucks | petrol | 9 | 3023 | 3030 | 837 | 2535 | 7662 | 0.35 | | 3.21 | 31.10 | 0.11 |
| | diesel | 3065 | 150373 | 20383 | 938 | 19119 | 2874970 | 0.35 | | 1072.75 | 10727.50 | 38.62 |
| | total | 3074 | 153396 | 20041 | | | 2882632 | | | | 10758.60 | 38.73 |
| bus | petrol | 1 | 192 | 5261 | 837 | 4401 | 845 | 0.35 | | 0.35 | 3.43 | 0.01 |
| | diesel | 310 | 11215 | 27607 | 938 | 25895 | 290413 | 0.35 | | 108.36 | 1083.63 | 3.90 |
| | electric | 2 | 92 | 18017 | 140 | 2527 | 233 | | 1.48 | | 2.45 | 0.01 |
| | total | 312 | 11499 | 27157 | | | 291490 | | | | 1089.51 | 3.92 |
| | total vehicles | 4488659 | | | | | 11111137 | | | total energy | 47130 | 170 |

Distance covered per vehicle, quantity of vehicles, total CO₂ emission, fuel consumption and total energy consumed by fleet type. Year 2018.

Appendix 2: Table for transport emissions and energy use in Scenario 1

| scenario 1 | | distance | quantity | distance per vehicle | carbon intensity | total carbon intensity | total carbon intensity | fuel consumption | energy consumption | total fuel | total energy | total energy |
|------------------|-----------------------|--------------------|------------------|----------------------|------------------------------|---------------------------------|------------------------------|------------------|--------------------|---------------------|--------------|--------------|
| | | million kilometres | Year 2018 | km/vehicle/year | Average gCO ₂ /km | kgCO ₂ /vehicle/year | tonnes CO ₂ total | L/km | kWh/km | million litres | GWh | PJ |
| light passenger | petrol | 12792 | 1262876 | 10129.0 | 167 | 1691.0 | 2135568.0 | 0.08 | | 1023.338535 | 9926 | 35.73 |
| | petrol to electric | 19188 | 1894314 | 10129.0 | 6 | 65.2 | 123472.2 | | 0.225 | | 4317 | 15.54 |
| | diesel | 1476 | 118831.6 | 4968.6 | 203 | 1007.8 | 299381.9 | 0.08 | | 118.084924 | 1181 | 4.25 |
| | diesel to electric | 2214 | 178247.4 | 4968.6 | 6 | 32.0 | 14247.7 | | 0.225 | | 498 | 1.79 |
| | electric | 77.2 | 8816.0 | 8762.3 | 22 | 191.5 | 1687.9 | | 0.225 | | 17 | 0.06 |
| | hybrid | 294.6 | 33619.0 | 8762.3 | 104 | 911.3 | 30636.1 | 0.045 | | 13.25602248 | 129 | 0.46 |
| | total | 36041.3 | 3496704.0 | 10307.2 | | | 2604993.8 | | | | 16069 | 57.85 |
| light commercial | petrol | 619 | 64404.4 | 9611.9 | 167 | 1604.7 | 103349.6 | 0.08 | | 49.52387235 | 480 | 1.73 |
| | petrol to electric | 929 | 96606.6 | 9611.9 | 6 | 61.9 | 5975.4 | | 0.225 | | 209 | 0.75 |
| | diesel | 3032 | 194515.2 | 15586.7 | 203 | 1721.9 | 614932.8 | 0.08 | | 242.5473514 | 2425 | 8.73 |
| | diesel to electric | 4548 | 291772.8 | 15586.7 | 6 | 100.3 | 29264.9 | | 0.225 | | 1023 | 3.68 |
| | total | 9127 | 647299 | 14100.5 | | | 753522.6 | | | | 4138 | 14.90 |
| motor cycle | total (petrol) | 414 | 179761 | 2304.2 | 52 | 120.2 | 21610.2 | 0.025 | | 10.3553425 | 104 | 0.37 |
| trucks | petrol | 4 | 1209.2 | 3029.9 | 837 | 2534.5 | 3064.8 | 0.35 | | 1.282327563 | 12 | 0.04 |
| | petrol to electric | 5 | 1813.8 | 3029.9 | 42 | 128.0 | 232.1 | | 1.48 | | 8 | 0.03 |
| | diesel | 1226 | 60149.2 | 20382.6 | 938 | 19118.9 | 1149988.0 | 0.35 | | 429.1 | 4291 | 15.45 |
| | diesel to electric | 1839 | 90223.8 | 20382.6 | 42 | 860.8 | 77660.4 | | 1.48 | | 2715 | 9.78 |
| | total | 3074 | 153396 | 20040.7 | | | 1230945.2 | | | | 7027 | 25.30 |
| bus | petrol | 0.404049803 | 76.8 | 5261.1 | 837 | 4400.9 | 338.0 | 0.35 | | 0.141417431 | 1 | 0.00 |
| | petrol to electric | 0.606074705 | 115.2 | 5261.1 | 42 | 222.2 | 25.6 | | 1.48 | | 1 | 0.00 |
| | diesel | 123.8434306 | 4486 | 27606.6 | 938 | 25895.0 | 116165.1 | 0.35 | | 43.34520071 | 433 | 1.56 |
| | diesel to electric | 185.7651459 | 6729 | 27606.6 | 42 | 1165.8 | 7844.8 | | 1.48 | | 274 | 0.99 |
| | electric | 1.657548082 | 92 | 18016.8 | 140 | 2527.3 | 232.5 | | 1.48 | | 2 | 0.01 |
| | total | 312.2762491 | 11499 | 27156.8 | | | 124606.0 | | | | 712 | 2.56 |
| | total vehicles | 4488659 | | | | | 4735678 | | | total energy | 28050 | 101 |

Distance covered per vehicle, quantity of vehicles, total CO₂ emission, fuel consumption and total energy consumed by fleet type. Scenario 1 assumed that 60% of all diesel and petrol vehicles (with exception of the motor vehicles) become electric.

Appendix 3: Table for transport emissions and energy use in Scenario 2

| scenario 2 | | distance | quantity | distance per vehicle | carbon intensity | total carbon intensity | total carbon intensity | fuel consumption | energy consumption | total fuel | total energy | total energy |
|------------------|-----------------------|--------------------|------------------|----------------------|------------------------------|---------------------------------|------------------------------|------------------|--------------------|---------------------|--------------|--------------|
| | | million kilometres | Year 2018 | km/vehicle/year | Average gCO ₂ /km | kgCO ₂ /vehicle/year | tonnes CO ₂ total | L/km | kWh/km | million litres | GWh | PJ |
| light passenger | petrol | 15990 | 1578595 | 10129.0 | 167 | 1691.0 | 2669460.0 | 0.08 | | 1279.17 | 12408 | 44.67 |
| | petrol to electric | 9594 | 947157 | 10129.0 | 6 | 65.2 | 61736.1 | | 0.23 | | 2159 | 7.77 |
| | petrol to hydrogen | 6396 | 631438 | 10129.0 | 17 | 170.3 | 107558.0 | | 0.59 | | 3761 | 13.54 |
| | diesel | 1845 | 148539.5 | 4968.6 | 203 | 1007.8 | 374227.4 | 0.08 | | 147.61 | 1476 | 5.31 |
| | diesel to electric | 1107 | 89123.7 | 4968.6 | 6 | 32.0 | 7123.8 | | 0.23 | | 249 | 0.90 |
| | petrol to hydrogen | 738 | 59415.8 | 4968.6 | 17 | 83.6 | 12411.3 | | 0.59 | | 434 | 1.56 |
| | electric | 77.2 | 8816.0 | 8762.3 | 22 | 191.5 | 1687.9 | | 0.23 | | 17 | 0.06 |
| | hybrid | 294.6 | 33619.0 | 8762.3 | 104 | 911.3 | 30636.1 | 0.045 | | 13.26 | 129 | 0.46 |
| | total | 36041.3 | 3496704.0 | 10307.2 | | | 3264840.6 | | | | 20632 | 74.28 |
| light commercial | petrol | 774 | 80505.5 | 9611.9 | 167 | 1604.7 | 129187.0 | 0.08 | | 61.90 | 600 | 2.16 |
| | petrol to electric | 464 | 48303.3 | 9611.9 | 6 | 61.9 | 2987.7 | | 0.23 | | 104 | 0.38 |
| | petrol to hydrogen | 310 | 32202.2 | 9611.9 | 17 | 65.2 | 61736.1 | | 0.59 | | 182 | 0.66 |
| | diesel | 3790 | 243144 | 15586.7 | 203 | 1721.9 | 768666.0 | 0.08 | | 303.18 | 3032 | 10.91 |
| | diesel to electric | 2274 | 145886.4 | 15586.7 | 6 | 100.3 | 14632.4 | | 0.23 | | 512 | 1.84 |
| | diesel to hydrogen | 1516 | 97257.6 | 15586.7 | 17 | 65.2 | 61736.1 | | 0.59 | | 891 | 3.21 |
| | total | 7611 | 647299 | 11758.6 | | | 1038945.2 | | | | 5322 | 19.16 |
| motor cycle | total (petrol) | 414 | 179761 | 2304.2 | 52 | 120.2 | 21610.2 | 0.025 | | 10.36 | 104 | 0.37 |
| trucks | petrol | 5 | 1511.5 | 3029.9 | 837 | 2534.5 | 3831.0 | 0.35 | | 1.60 | 16 | 0.06 |
| | petrol to electric | 3 | 906.9 | 3029.9 | 42 | 128.0 | 116.0 | | 1.48 | | 4 | 0.01 |
| | petrol to hydrogen | 2 | 604.6 | 3029.9 | 110 | 65.2 | 61736.1 | | 3.86 | | 7 | 0.03 |
| | diesel | 1532.5 | 75186.5 | 20382.6 | 938 | 19118.9 | 1437485.0 | 0.35 | | 536.38 | 5364 | 19.31 |
| | diesel to electric | 919.5 | 45111.9 | 20382.6 | 42 | 860.8 | 38830.2 | | 1.48 | | 1358 | 4.89 |
| | diesel to hydrogen | 613 | 30074.6 | 20382.6 | 110 | 65.2 | 61736.1 | | 3.86 | | 2365 | 8.52 |
| | total | 2461 | 153396 | 16044.5 | | | 1603734.4 | | | | 9114 | 32.81 |
| bus | petrol | 0.505062254 | 96 | 5261.1 | 837 | 4400.9 | 422.5 | 0.35 | | 0.18 | 2 | 0.01 |
| | petrol to electric | 0.303037352 | 57.6 | 5261.1 | 42 | 222.2 | 12.8 | | 1.48 | | 0.45 | 0.002 |
| | petrol to hydrogen | 0.202024902 | 38.4 | 5261.1 | 110 | 65.2 | 61736.1 | | 3.86 | | 1 | 0.003 |
| | diesel | 154.8042883 | 5607.5 | 27606.6 | 938 | 25895.0 | 145206.4 | 0.35 | | 54.18 | 542 | 1.95 |
| | diesel to electric | 92.88257296 | 3364.5 | 27606.6 | 42 | 1165.8 | 3922.4 | | 1.48 | | 137 | 0.49 |
| | diesel to hydrogen | 61.92171531 | 2243 | 27606.6 | 110 | 65.2 | 61736.1 | | 3.86 | | 239 | 0.86 |
| | electric | 1.657548082 | 92 | 18016.8 | 140 | 2527.3 | 232.5 | | 1.48 | | 2 | 0.01 |
| | total | 312.2762491 | 11499 | 27156.8 | | | 273268.8 | | | | 923 | 3.32 |
| | total vehicles | 4488659 | | | | | 6202399 | | | total energy | 36095 | 130 |

Distance covered per vehicle, quantity of vehicles, total CO₂ emission, fuel consumption and total energy consumed by fleet type. Scenario 2 assumed that 30% of the diesel and petrol vehicles become electric and 20% will run on hydrogen.

Appendix 4: Energy output and carbon intensity for the year 2018, for a scenario where 60% of the ICE are substituted with BEVs (scenario 1), and for a scenario where 30% are substituted with BEVs and 20% with FCEVs (scenario 2)

| ICE/BEV/FCEV | 2018 | scenario 1 0.4/0.6/0.0 | scenario 2 0.5/0.3/0.2 |
|----------------------|--|--|--|
| | carbon intensity tonnes CO ₂ | carbon intensity tonnes CO ₂ | carbon intensity tonnes CO ₂ |
| low emission | 1920 | 260643 | 621668 |
| petrol/diesel/hybrid | 11109217 | 4475034 | 5580732 |
| total | 11111137 | 4735678 | 6202399 |
| | Energy PJ | Energy, PJ | Energy, PJ |
| low emission | 0.1 | 33 | 45 |
| petrol/diesel/hybrid | 170 | 68 | 85 |
| total | 170 | 101 | 130 |