Metlink bus fleet emissions 2021/22

Environmental impacts annual summary

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1. Summary 1

2. Bus fleet emissions indicators 2
2.1 Bus emissions tool 2
2.2 Performance indicators 2
2.2.1 Decarbonisation: CO_2-e tonnes per month 2
2.2.2 Service km by electric and diesel engine type 3
2.2.3 Decarbonisation: Total CO_2-e kg per service km per month 5
2.2.4 Harmful emissions: NOx total tonnes per month 5
2.2.5 Harmful emissions: Particulate matter (PM_{10}) total kg per month 6
2.2.6 Operator performance: Total CO_2-e emissions 7
2.2.7 Route performance: Percent of total network CO_2-e 8

3. Air quality environmental indicators 9
3.1 Air pollutants and monitoring 9
3.1.1 Monitoring programme revision 10
3.2 Environmental indicators 10
3.2.1 Diesel particulate air pollution 10
3.2.2 NO_2 air pollution 12

Appendix 1: Bus emissions tool inputs 14

Appendix 2: Air quality monitoring 16

1. Summary

Metlink is committed to delivering an environmentally friendly bus fleet across the region by reducing emissions of greenhouse gases and harmful air pollutants from buses whilst increasing patronage. Greater Wellington's target is for all core service bus routes[1] to be electric-only by 2030 is and working towards complete decarbonisation of the bus fleet by 2035.

This report summarises air monitoring and bus emissions tracking tool results up to 30 June 2022 and reports on monthly emissions and annual air quality performance indicators.

Key findings

- CO_2-e tonnes per month from the public bus network has trended down since September 2021 as the proportion of service km travelled by electric buses increased relative to diesel service km.

- Since September 2021, routes operated by NZ Bus and Tranzit have improved their carbon efficiency by replacing service km travelled by diesel buses with electric buses, resulting in lower total CO_2-e emissions.

- A network-wide increase in electric service km corresponded to a decrease in harmful emissions (NOx and particulate matter).

- An increase in the proportion of electric buses travelling on Manners Street was associated with reductions in harmful pollutants. Diesel particulate air pollution reduced by 28% and nitrogen dioxide (NO_2) by 18%.

Future reporting on the bus emission performance indicators will be based on an updated version of the bus emissions tool that is consistent with the Waka Kotahi national Vehicle Emissions Prediction Model (VEPM).

Air quality monitoring in 2023 may need to pause or relocate during the construction phase of Let's Get Wellington Moving along the Golden Mile. Construction activities and traffic diversions will make it more difficult to attribute air quality changes to bus decarbonisation.

[1] Routes 1, 2, 3, 7, 110, 120, 130, 220, AX

2. Bus fleet emissions indicators

2.1 Bus emissions tool

In early 2020, Metlink developed a bus fleet emissions estimation tool to calculate mass emissions of carbon dioxide equivalents[2] (CO_2-e) and harmful pollutants (NOx, particulate matter, carbon monoxide and hydrocarbons).

The tool tracks trends in bus emissions and measures Metlink's progress towards decarbonisation of the bus fleet, with an interim target for all core routes to be electric by 2030. In addition, the tool provides annual data for Greater Wellington's organisational carbon footprint reporting. As the bus fleet currently makes up 35% of Greater Wellington CO_2-e emissions footprint (2019-20[3]), electrification of the bus fleet is key to Greater Wellington meeting its 2030 carbon neutral target.

The tool can also track emissions data at fine scale (eg, by route or operator). Fine scale data can be used to optimize network design to reduce emissions, for example, by identifying high emitting routes that can be targeted for electrification.

While the tool provides precise and repeatable estimates of CO_2-e and harmful emissions, it cannot be used to directly evaluate air quality impacts of harmful emissions. Air quality information instead comes from monitoring along the bus corridor on the Golden Mile using sensors to determine trends in traffic-related air pollution (see Section 3).

Details of the bus fleet emissions estimation tool inputs are briefly described in Appendix 1.

The Waka Kotahi national vehicle emissions prediction model (VEPM[4]) is used to estimate emissions from the vehicle fleet under typical road, traffic and operating conditions at road network level. The model includes emission factors for buses. The emission factors used by VEPM are constantly being updated with improved factors for new engine and exhaust treatment technologies, emerging issues and real-world effects. Metlink has recently commissioned technical advice about what is needed to ensure future consistency in the emissions factors and adjustments used by the bus emissions tool and VEPM. Therefore, the bus emissions tool will need to be updated with new emission and adjustment factors.

2.2 Performance indicators

2.2.1 Decarbonisation: CO_2-e tonnes per month

This high-level indicator shows total CO_2-e emissions across the network from all bus services and tracks progress towards decarbonisation. Greater

[2] Includes GHG methane (CH_4) and nitrous oxide (N_2O) emissions
[3] https://greaterwellington.sharepoint.com/sites/ClimateAction
[4] https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/air-quality-climate/planning-and-assessment/vehicle-emissions-prediction-model/

Wellington has committed to ensuring all core bus services[5] are electric by 2030 and is working towards complete decarbonisation of the bus fleet by 2035.

Figure 2.1 shows that from January 2017, CO_2-e emissions increased due to demand growth with the additional buses using more fuel to deliver an extra 1.3 million passenger trips in 2019[6]. Recently, CO_2-e emissions have begun to trend downwards as the distance travelled by electric buses has increased and distances travelled by diesel buses have decreased. Note the large reduction in CO_2-e emissions in March-April 2020 was due to fewer services running under COVID-19 restrictions.

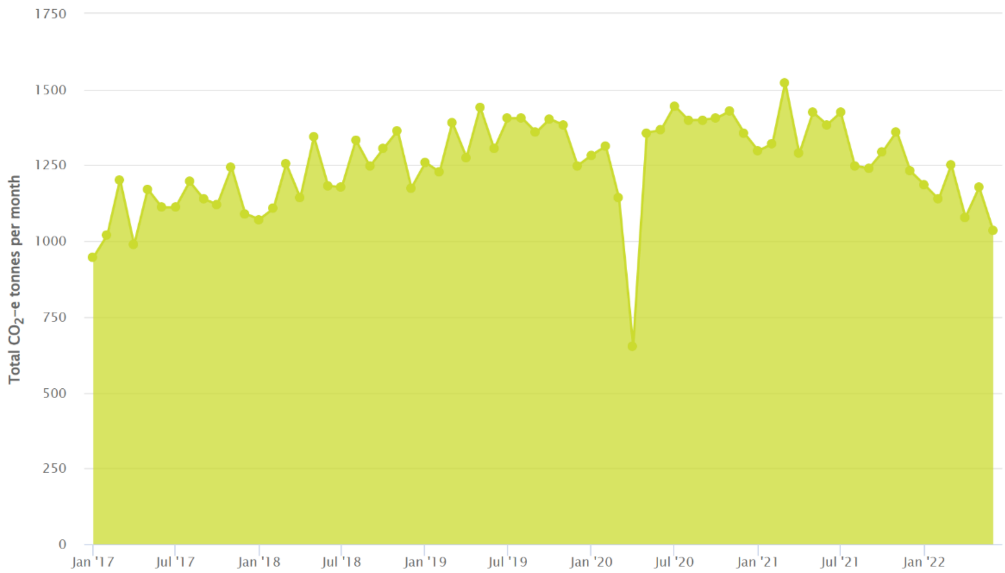

Figure 2.1: Bus fleet CO_2-e emissions from 4 January 2017 to 30 June 2022 (tonnes per month)

Greater Wellington's organisational carbon footprint reporting method[7] includes CO_2-e from electricity generation, but does not include CO_2-e emissions from the manufacture and supply of diesel fuel. Therefore, even with 100% electric fleet, CO_2-e emissions will be reported by the bus emissions tool. The tool estimates that CO_2-e emissions from electricity used by an electric bus are around 10% of emissions from a similar sized diesel bus.

2.2.2 Service km by electric and diesel engine type

This indicator tracks the distance travelled by electric and diesel buses. The quantity of CO_2-e and harmful emissions produced by the network is determined by how far the buses travel (daily service km) and the proportion of the distance travelled that is electric. Figure 2.2 shows that total service km by electric buses is increasing across the network, for example, from 2% in June 2021 to 22% in June 2022.

[5] Routes 1, 2, 3, 7,110,120,130, 220, AX. Wellington Regional Public Transport Plan. https://www.gw.govt.nz/your-region/plans-policies-and-bylaws/plans-and-reports/transport-plans/wellington-regional-public-transport-plan-2021/

[6] Vallyon, C. et al. 2021. The new transport emissions toolset. Transportation 2021 Conference, 9-12 May, Hilton Auckland

[7] https://www.toitu.co.nz/our-members/members/greater-wellington-regional-council

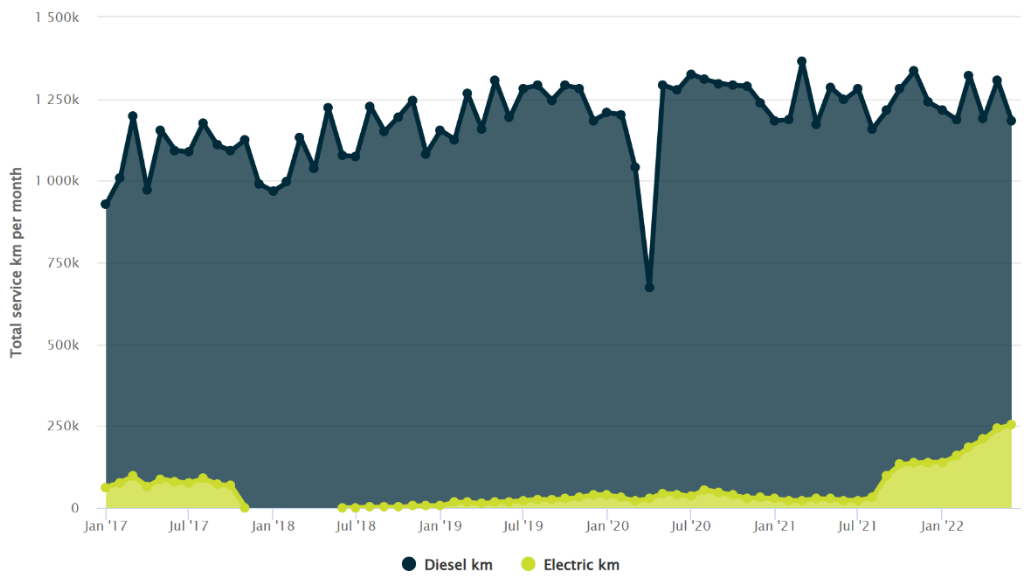

Figure 2.2: Bus network total service km per month by diesel and electric buses 4 January 2017 to 30 June 2022

A more detailed view of the trends in service km by engine type (Figure 2.3) shows that since September 2021 there's been fewer km travelled by EURO III (black) and increased km by electric buses (green).

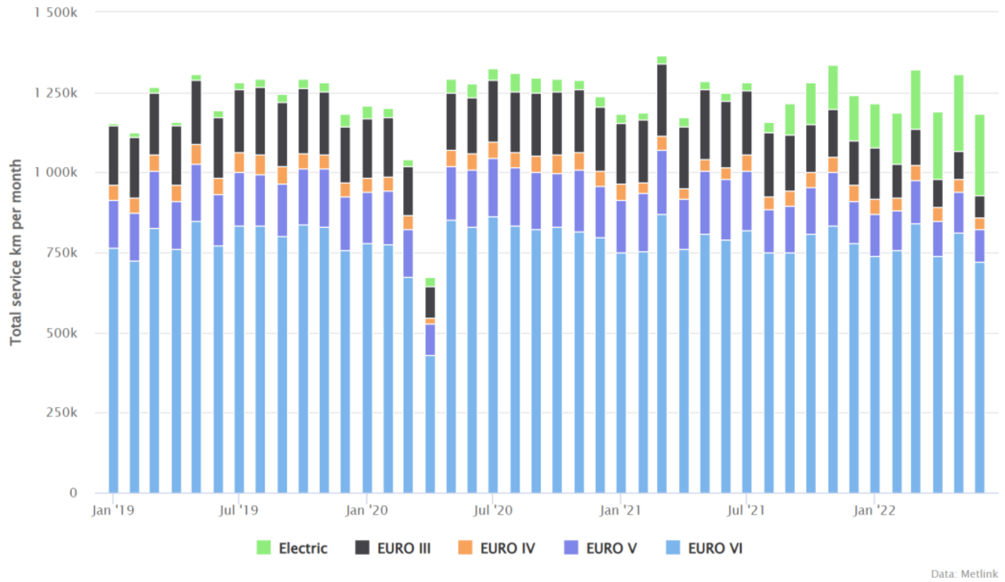

Figure 2.3: Bus network total monthly service km by engine type from 1 January 2019 to 30 June 2022

2.2.3 Decarbonisation: Total CO_2-e kg per service km per month

This indicator (Figure 2.4) shows the amount of CO_2-e emitted per km travelled in service each month. It helps track carbon use efficiency, which has been improving across the network since September 2021 as more distance is travelled by electric buses relative to diesel buses.

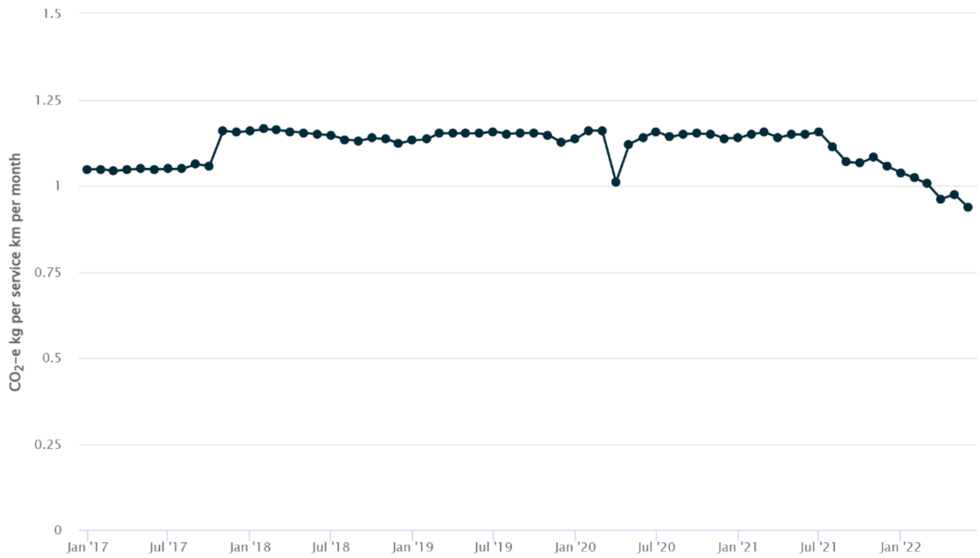

Figure 2.4: Bus fleet CO_2-e emissions (kg per service km per month) from 4 January 2017 to 30 June 2022

2.2.4 Harmful emissions: NOx total tonnes per month

NOx emissions[8] can lead to harmful levels of NO_2 pollution. This indicator tracks the levels of NOx emissions across the entire the bus fleet, and Section 3.2.2 tracks the levels of NO_2 pollution on a road corridor affected by bus emissions.

Figure 2.5 shows the impact that upgrading the bus fleet to later EURO models and increasing service km by electric buses has had on the production of NOx emissions. The bus fleet contains a mix of bus ages, with the newest buses manufactured to meet EURO VI emission standards that have significantly lower allowable limits of NOx emissions than the older EURO III buses. Network-wide NOx emissions were substantially reduced when many of the older more polluting buses (ie, EURO I, II and pre-EURO) were removed from the fleet in July 2018.

Fewer bus services in March-April 2020 due to COVID-19 resulted in lower emissions. From September 2021 onwards, higher NOx emitting EURO III buses were replaced with electrics leading to a recent downward trend in NOx emissions across the network.

[8] NOx emissions include NO and NO_2. NO (nitric oxide) is relatively harmless but transforms to NO_2 (which is harmful) in the presence of ozone in the air. For transport sources, emission factors can be easily derived for NOx but NO_2 is more difficult to quantify.

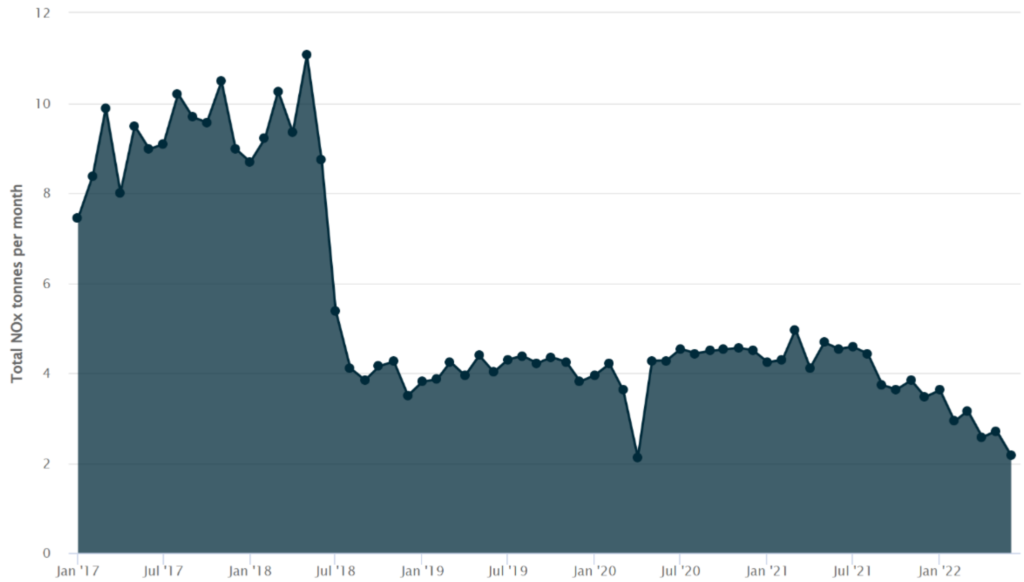

Figure 2.5: Bus fleet NOx emissions (tonnes per month) from 4 January 2017 to 30 June 2022

2.2.5 Harmful emissions: Particulate matter (PM_{10}) total kg per month

This indicator (Figure 2.6) shows emissions of harmful particulate matter (PM). As with NOx emissions trends, these results also demonstrate the positive impact of modernising the bus fleet and replacing the EURO III models with electrics on PM emissions.

This indicator currently focusses on exhaust emissions of PM and does not include particulate emissions originating from brake and tyre wear. Future reporting is planned to include such emissions. Including non-exhaust emissions in the bus emissions tool means that even with a fully electric fleet, there will still be a potential air quality impact (or emissions penalty) for PM. Further research is needed to quantify non-exhaust emission factors for New Zealand, and the effects of heavier weight of electric vehicles and impact of regenerative braking on emissions[9].

[9] Waka Kotahi NZ Transport Agency research report 683. 2021. Determining the ecological and air quality impacts of particulate matter from brake and tyre wear and road surface dust. NIWA. https://www.nzta.govt.nz/resources/research/reports/683/

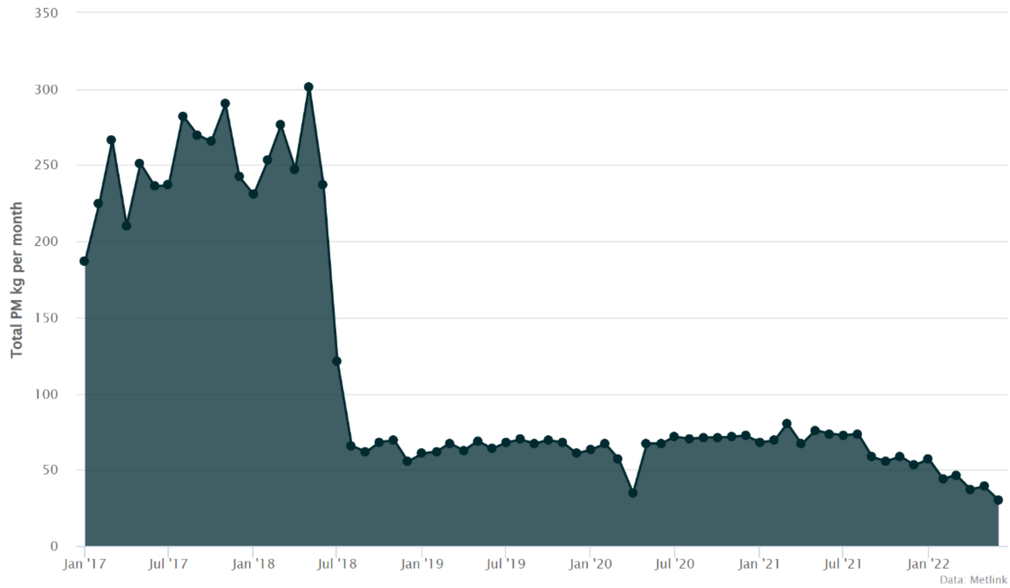

Figure 2.6: Bus fleet PM (particulate matter) emissions (kg per month) from 4 January 2017 to 30 June 2022

2.2.6 Operator performance: Total CO_2-e emissions

Figure 2.7 shows carbon use by operator calculated as total CO_2-e kg per month. Since September 2021, NZ Bus total CO_2-e production has dropped significantly as the number of electric buses operated increased by 51, allowing diesel service km to be replaced by electric service km.

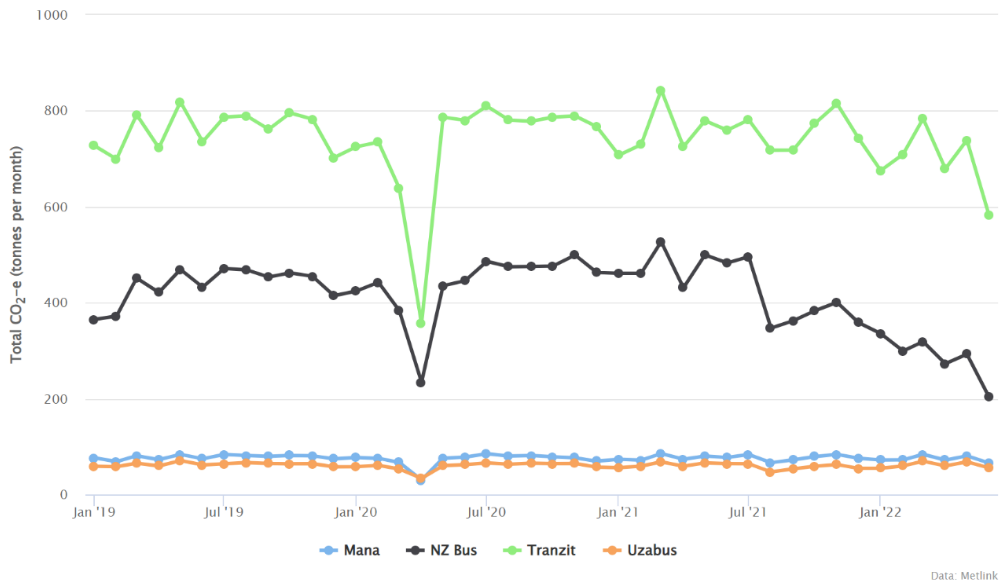

Figure 2.7: Operator total CO_2-e kg per month from 1 January 2019 to 30 June 2022

2.2.7 Route performance: Percent of total network CO_2-e

Figure 2.8 shows the contribution of CO_2-e emissions from each route to the total network emissions for 2021/22 Quarter 4 (1 April 2022 to 30 June 2022).

This indicator is shown as a three-month snapshot, but can be produced for any time interval. The indicator includes CO_2-e from upstream electricity generation used by electric buses operating on the route.

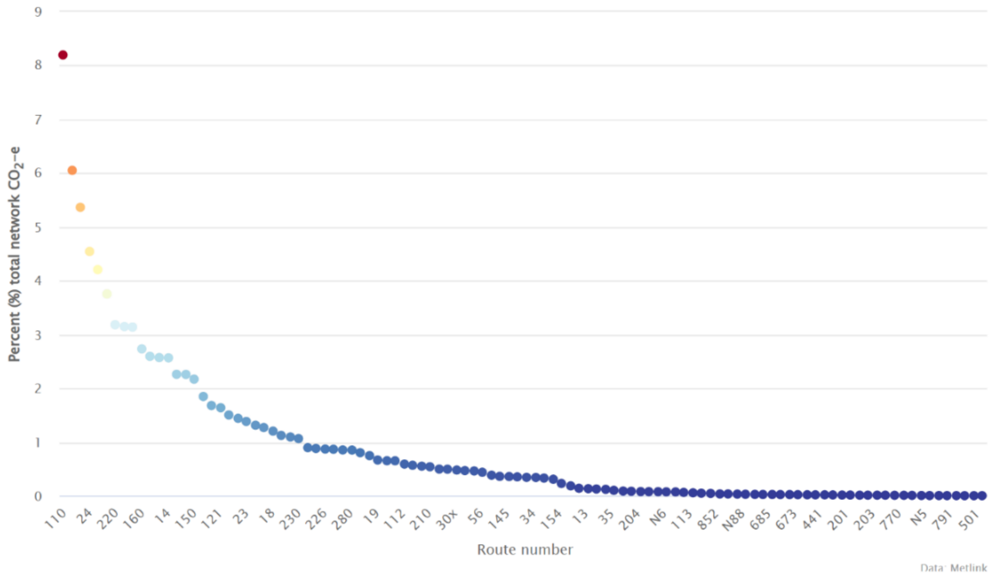

Figure 2.8: Bus fleet percent of total CO_2-e by route for 1 April 2022 to 30 June 2022

The top 10 highest CO_2-e producing routes accounted for 45% of all bus network emissions. During 2021/22 Q4, these were:

- Route 110 = 8.2%
- Route 1 = 6.1%
- Route 83 = 5.4%
- Route 24 = 4.6%
- Route 130 = 4.2%
- Route 3 = 3.8%
- Route 220, 52 & 120 = 3.2% (each)
- Route 160 = 2.7%

3. Air quality environmental indicators

3.1 Air pollutants and monitoring

Levels of two harmful pollutants, black carbon (fine soot particles) and NO_2 (nitrogen dioxide), were monitored beside a bus-only street segment on Manners Street in Wellington city in order to track impacts of bus fleet electrification on air quality along the Golden Mile.

Black carbon is a by-product of incomplete fuel combustion and is a strong marker of diesel particulate emissions. Most of the $PM_{2.5}$ (particles that are smaller than 2.5 µm and are readily inhaled and penetrate deeply into the lungs) emitted by diesel vehicle exhaust is in the form of black carbon. The fraction of black carbon in $PM_{2.5}$ depends on the effectiveness of the vehicle exhaust emissions control system. Older EURO III buses are high emitters of black carbon compared to the newer EURO IV models that are required to be equipped with exhaust particulate filters.

Although there are no air quality guidelines for black carbon, the World Health Organization concludes that black carbon acts as a universal carrier of a wide range of combustion-derived chemicals of varying toxicity to humans[10].

NO_2 is a harmful air pollutant arising from NOx emissions produced by diesel and petrol vehicles. Diesel vehicles are the main source of NOx with heavy duty diesel vehicles being the dominant source. The EURO IV buses have exhaust after treatment systems designed to meet very stringent NOx emission limits that are substantially lower than that allowed from EURO III buses.

Narrow, inner city streets that are sheltered by tall buildings on either side of the road provide an environment that can restrict the dispersion of NOx from diesel bus emissions, leading to elevated NO_2. For this reason, the Golden Mile experiences the highest NO_2 concentrations in the region.

Daily counts of buses by engine type (EURO III, EURO IV, EURO VI and electric) that travelled through the segment of Manners Street, where the air monitoring sensors were located, were extracted from the bus emissions tool and compared to air quality measurements on Manners Street. Manners Street air quality was also compared to Wellington central monitoring site – which acts as a control to represent air pollution impacts from the general traffic fleet on a busy arterial road. This comparison provided insight about how the bus fleet changes are affecting local air quality on Manners Street and the wider Golden Mile.

Details of the air quality pollutants, monitoring locations and methods are briefly described in Appendix 2.

[10] World Health Organization. 2012. Health effects of black carbon. https://apps.who.int/iris/handle/10665/352615

3.1.1 Monitoring programme revision

The changes that Let's Get Wellington Moving (LGWM) plans for the Golden Mile will have a significant impact on the air monitoring programme. Construction activities starting from mid-2023, relocation of bus stop 5006 where the black carbon sensor is currently located, and consequential changes to traffic (ie, restrictions on private motor vehicles and parking) and infrastructure (street design changes, removal of some bus stops, bus priority lanes) will change emission sources affecting the monitoring results. Therefore, the monitoring programme may need to be paused or relocated during the construction phase as these urban design and traffic change interventions may make it difficult to isolate air quality changes related to bus decarbonisation.

3.2 Environmental indicators

3.2.1 Diesel particulate air pollution

To date, black carbon monitoring suggests that changes to introduce more electric and lower emission diesel buses to the Metlink fleet are reducing levels of harmful particles in the air along the Golden Mile.

Case study: fewer services during bus driver strike

A bus driver strike (Friday 23 to Saturday 24 April 2021) resulted in bus numbers on Manners Street being halved with most EURO III buses being taken off the route. Despite some variability due to the weather, this 'natural experiment' shows that black carbon concentrations on Manners Street (bus only lane) respond strongly to changes in bus fleet configuration and that there were low levels of black carbon infiltration from traffic sources on nearby streets unaffected by the strike (Figure 3.1).

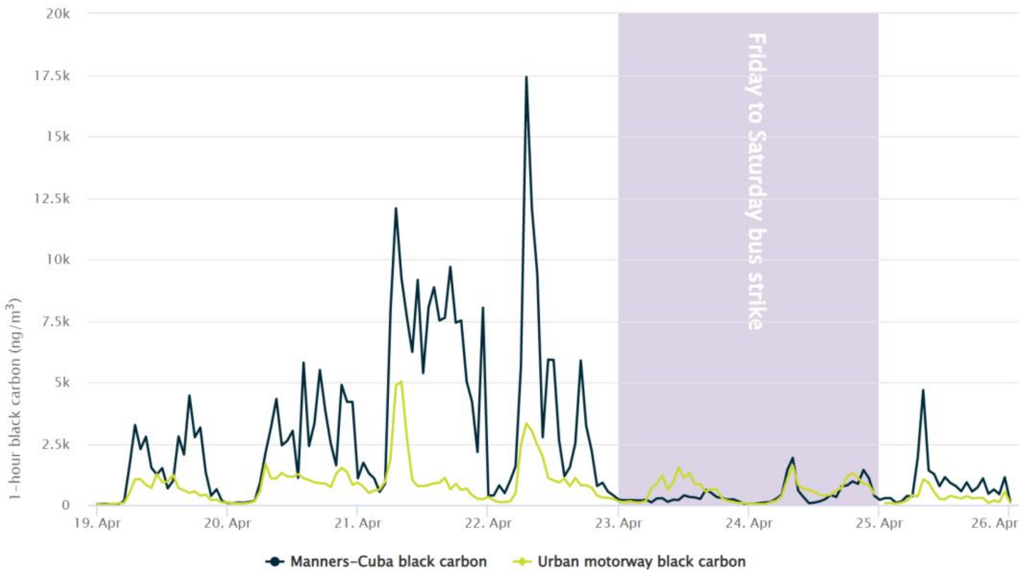

Figure 3.1: Hourly average black carbon from Monday 19 to Sunday 25 April 2021.

Case study: black carbon trends before and after increase in bus electrification

Black carbon has been monitored on Manners Street (bus only segment) since late July 2020 to assess impacts of bus fleet electrification on diesel particulate emissions and air quality. To account for seasonality in black carbon levels and the possibility of a wood burning influence, the response of black carbon levels to changes in the bus fleet travelling through Manners Street was compared to changes in black carbon levels at a 'control' site (urban motorway). This control site represents urban motorway traffic and nearby local roads that have been largely unaffected by changes in proportion of electric buses on Manners Street.

Figure 3.2 shows the changing fleet profile of buses operating on Manners Street based on the number of buses travelling past bus stop 5006 (northbound) and stop 5510 (northbound). From July 2020 to August 2021, on average, electric buses made up 5% of the bus movements on Manners Street. The proportion of electric buses increased from 17 % in September 2021 to 43% in June 2022.

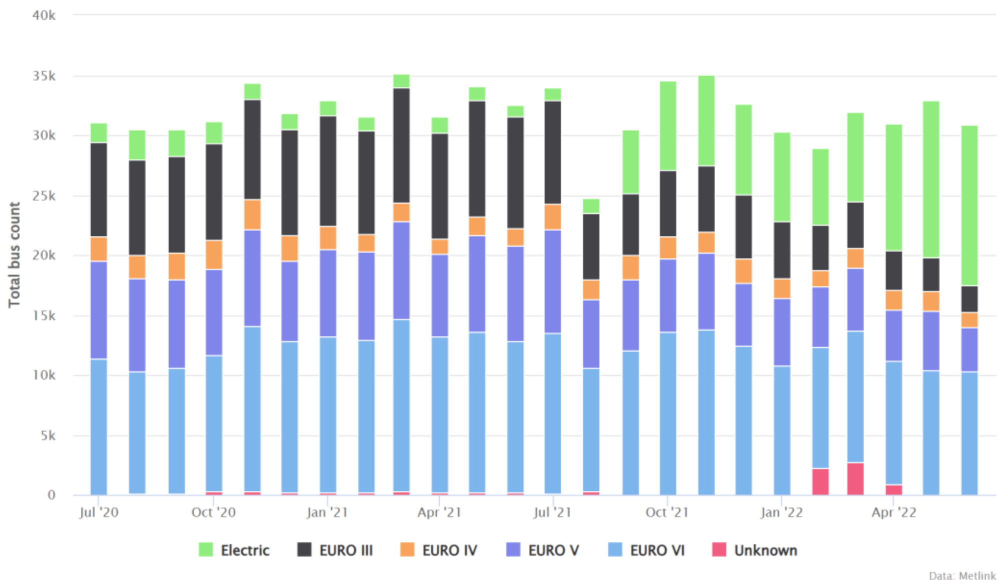

Figure 3.2: Number of buses by engine type operating on Manners Street between July 2020 and June 2022

The air quality analysis compared the percentage change in average black carbon levels on Manners Street to that measured at the urban motorway for the period October to June by 2020/21 and 2021/22 financial years. The 2020/21 period corresponded to 5% electric fleet on Manners Street and the 2021/22 period had monthly proportions of electrics, ranging from 17% to 43% (average 28%). This comparison period was selected to exclude the months of August and September that had fewer bus services operating due to COVID-19 impacts in 2021.

Figure 3.3 shows there was a 28% reduction in black carbon levels on Manners Street following the increase in proportion of electric and EURO VI buses. For the same period there was a 4% reduction in black carbon at the urban motorway control site.

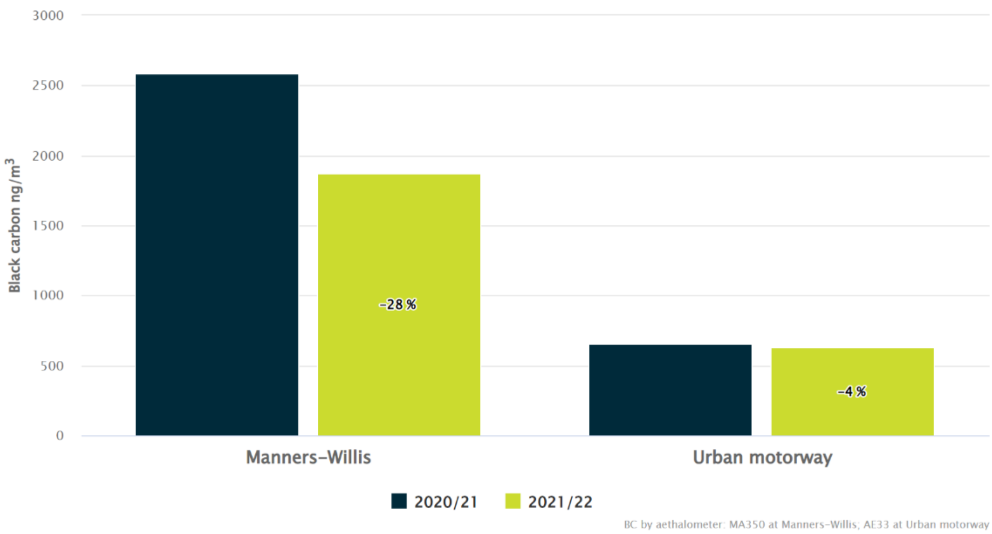

Figure 3.3: Average black carbon levels before and after the increase in proportion of electric buses on Manners Street. The before period was October 2020 to June 2021 and the after period was October 2021 to June 2022.

Although there was a small reduction in total bus counts in 2021/22 (2.8%) and vehicle traffic counts (3.7%)[11] at the urban motorway compared to 2020/21, this is not likely to be a significant factor in the black carbon reductions observed in Manners Street. Therefore, much of 2021/22 improvement in air quality on Manners Street was due to the higher proportion of lower emission buses rather than changes in vehicle numbers.

3.2.2 NO_2 air pollution

Air quality monitoring in the past 10 years has found a trend of reducing roadside NO_2 measured across the region (and nationwide), most likely due to improvements in the vehicle fleet and/or weather patterns more favourable for the dispersion of emissions[12]. Reduced road traffic during COVID-19 restrictions in 2020 and subsequent changes in travel patterns are also affecting NO_2 trends.

NO_2 has been monitored on Manners Street (close to Cuba Mall) using a passive diffusion tube since July 2016, ie, before the decommissioning of the trolley buses and the introduction of PTOM (mid 2018). COVID restrictions in March-April 2020 and August-September 2021 interrupted the sampling programme so that the tubes could not be exchanged during these months. In line with Waka Kotahi reporting for the national NO_2 tube monitoring network, a 2-month NO_2 average for the COVID disrupted periods was used in the data analysis.

[11] Inferred from Waka Kotahi NZTA terrace tunnel southbound counts (Site Ref: 01N11074)
[12] Waka Kotahi (NZTA) 2021.

Annual trends in NO_2 from the start of the monitoring programme (July 2016) to the latest available data point (June 2022) were assessed. The 12-month average for 1 July to 30 June (financial year) was calculated for both Manners-Cuba Street and the urban background control site (Figure 3.4).

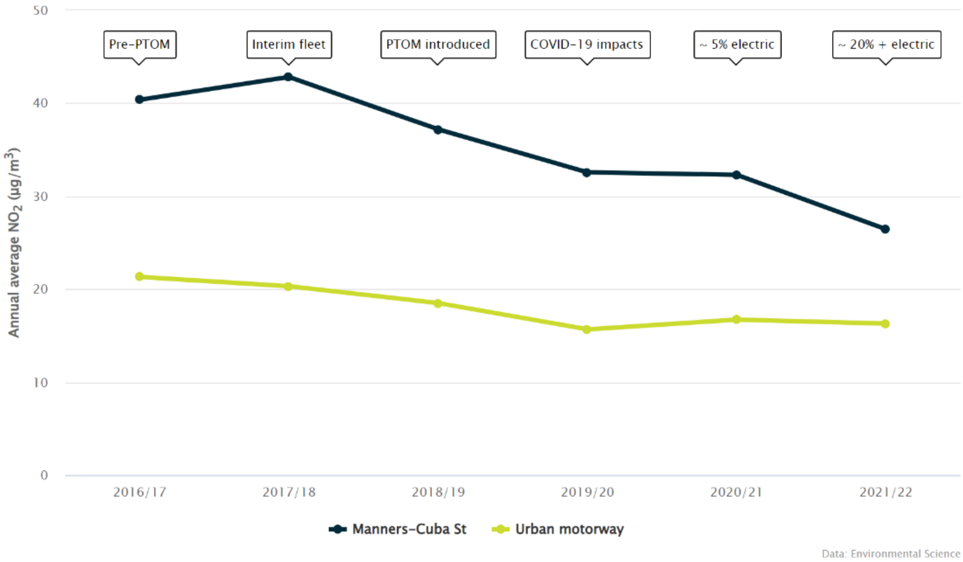

Figure 3.4: Nitrogen dioxide (NO_2) annual trends by financial year measured by passive diffusion tubes at the Manners-Cuba St and urban motorway monitoring sites from 2016/17 to 2021/22

The introduction of PTOM on 15 July 2018 resulted in many fewer buses on Manners Street as well as a lower proportion of the higher NOx emitting EURO III buses. Since September 2021, the proportion of electric buses travelling on Manners Street has progressively increased from a baseline of around 5% to 17% (September 2021) and continued to increase to around 22% (October 2021 to March 2022), to 34% in April 2022 and 43% in June 2022 (Figure 3.2).

It appears that NO_2 levels on Manners Street have been reducing at a greater rate relative to the urban motorway monitoring site, indicating that air quality is improving on Manners Street due to the cleaner emissions profile of the local bus fleet cohort that now travels on Manners Street. Between 2020/21 and 2021/22 there was an 18% reduction in NO_2 on Manners Street compared to a 2% reduction at the urban motorway site. The reduction in NO_2 in 2021/22 corresponded to 48,053 fewer EURO III bus movements and an additional 70,704 electric bus movements compared to 2020/21.

New Zealand does not have an annual air quality standard or guideline for annual average NO_2. It is noted that the latest World Health Organization guidelines[13] (released in late 2021) have reduced the limit for annual average NO_2 from 40 µg/m^3 to 10 µg/m^3 – a 75% reduction. Therefore, declining NO_2 levels in Wellington CBD continue as the bus fleet is modernised and electrified, will lead to healthier air.

13 World Health Organization. 2021. https://apps.who.int/iris/handle/10665/352615

Appendix 1: Bus emissions tool inputs

A description of the development of the tool is provided by Vallyon, et al. 2021[14].

Base data sources for the model are:

- Mobile Plan (before 11/10/2019)
- Operator Reports (before 11/10/2019)
- PTBIS Service Utilisation (from 11/10/2019)

The tool is designed to report emissions from June 2018 (the start of PTOM). However, outputs before and after 11/10/2019 may not be exactly equivalent as they are from different sources.

The tool uses individual bus trip data (distance travelled, average speed, contractual weight) and COPERT[15] base emission factors for harmful pollutants and diesel fuel consumption.

Emissions are calculated for each bus trip based on:

- COPERT emission factors based on engine technology (EURO standard) (2km speed bands)
- COPERT emission factor for fuel consumption (to calculate diesel consumption)
- CO_2-e emissions factor for diesel consumption = 2.69 kg per litre of diesel (MfE, 2022[16])
- Upstream CO_2-e emissions from power used for electric buses are calculated as 1 kwh per km (AT) with a factor of 110 g CO_2-e per kwh for electricity purchased from grid (including transmission losses) as per 2019 (MfE, 2022[17])
- Contractual bus size
- Average speed on a trip

These base emission factors are adjusted based on Emission Impossible Ltd mass adjustment formula using:

- Vehicle tare weight
- Average passenger loaded weight (assumed average adult weight of 80kg and average student 61kg)

To account for fuel used during bus repositioning whilst not in-service, 15% is added to the calculated emissions total.

Metlink recently commissioned Emission Impossible Ltd. to revise the base emission factors and include additional adjustment factors for consistency with VEPM 7.0 and future updates, including:

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[14] Vallyon, C. et al. 2021. The new transport emissions toolset. Transportation 2021 Conference, 9-12 May, Hilton Auckland
[15] The EU standard vehicle emissions calculator https://www.emisia.com/utilities/copert/
[16] Table 4. https://environment.govt.nz/publications/measuring-emissions-a-guide-for-organisations-2022-detailed-guide/
[17] Table 9. https://environment.govt.nz/publications/measuring-emissions-a-guide-for-organisations-2022-detailed-guide/

- Gradient correction factors
- Correction factors for improved fuel properties
- Degradation factors (to account for the expected increase in emissions as vehicles age.
- Inclusion of brake and tire wear emission factors (to account for non-exhaust emissions of PM that arise from all vehicles, including electric).

These updates will ensure consistency with the Waka Kotahi model and help streamline regular updates of the Metlink bus emissions model as new national and international emissions factors, that more closely match real-world performance, are released. The next step is to migrate the bus emissions tool with updated emission and adjustment factors into netBI (cloud data platform and analytics for public transport).

Appendix 2: Air quality monitoring

Manners-Cuba St monitoring tube

NO_2 monitoring by passive diffusion tube

NO_2 is a 'secondary pollutant' formed when exhaust emissions of NO are oxidised rapidly by ozone in outdoor air to produce NO_2. A proportion of NO_2 is directly emitted from exhaust emissions. Once formed, NO_2 can revert back to NO in the presence of strong sunlight. Collectively NO and NO_2 are known as NOx.

NO_2 has been monitored using passive diffusion tubes at four sites in the CBD since July 2016 (including Manners Street/Cuba Mall) and at Manners Street bus stop 5006 since August 2020. Passive diffusion tubes are a relatively inexpensive method that does not require a power source and provide useful information on long-term trends. The tubes are exchanged monthly using same method and sample exchange schedule as Waka Kotahi (NZTA). For further information see: https: //www.nzta.govt.nz/resources/air-quality-monitoring/

To see results for other NO_2 passive diffusion sites around the region see the latest annual air quality data report at https://www.gw.govt.nz/environment/air-quality/

Black carbon monitoring by aethalometer

Black carbon or soot is a light-absorbing, carbon-containing constituent of $PM_{2.5}$ ie, particles that are smaller than 2.5 µm and are readily inhaled and penetrate deeply into the lungs. Black carbon is formed by the incomplete combustion of fossil fuels, biofuels and biomass (eg, wood burning).

Roadside and tunnel monitoring in Auckland[18] confirmed that 90% of black carbon arises from diesel-fuelled vehicles and found that $PM_{2.5}$ from diesel vehicles constituted 60-90% of black carbon, depending on location. Exhaust emissions from EURO VI buses with high-efficiency diesel particulate filters have substantially lower black carbon emissions than those with older EURO emissions control technology systems[19]. Therefore, black carbon is used as an indicator of diesel particle air pollution.

Black carbon is measured on Manners Street (bus stop 5006) and at the Wellington central air monitoring site next to the urban motorway. Black carbon has been monitored at the bus stop 5006 since July 2020, following a successful pilot study in late 2019 to early 2020[20].

These two sites are used, as black carbon levels are higher in the winter months as the air is typically colder and more stable, leading to poorer dispersion of emissions. Black carbon levels can also be higher during winter if there are emissions from home heating from burning of wood or coal.

[18] Davy, PK, & Trompetter, WJ. 2018. *Black carbon in New Zealand*. GNS Science, Lower Hutt.
[19] The World Bank. 2014. Reducing black carbon emissions from diesel vehicles: impacts, control strategies, and cost-benefit analysis. https://openknowledge.worldbank.org/handle/10986/17785
[20] https://www.gw.govt.nz/document/19824/

A MicroAeth (MA350, Aethlabs) was used to measure black carbon on Manners Street. This instrument is compact and designed to be mounted on a fence line or street pole for black carbon monitoring in areas where it is not possible to deploy an air quality station. A Magee Scientific Aethalometer (AE33, Magee Scientific) was used to measure black carbon at the Wellington Central air monitoring station. This instrument measures black carbon at seven optical wavelengths. For more information see report: Pilot Study: using air quality to track changes on bus fleet emissions on the Golden Mile, Wellington City[21].

Manners-Willis St (Bus Stop 5006)

Urban motorway (Wellington central air monitoring station

[21] https://www.gw.govt.nz/document/19824/

Wellington City CBD air monitoring site locations