SEPA
Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

CLEANER AIR FOR SCOTLAND NATIONAL MODELLING FRAMEWORK

Low Emission Zone

Aberdeen Evidence Report Addendum

January 2022

Scope of Report

This report is an addendum to the SEPA report 'Low Emission Zone Aberdeen Evidence Report' submitted to Aberdeen City Council (ACC) in October 2021 to support Aberdeen City Council's (ACC) proposed Low Emission Zone (LEZ). This work represents the final stages air quality modelling work to examine the changes on emissions and concentrations associated with the implementation of the final LEZ boundary as agreed by ACC in December 2021. Predicted changes in Carbon Dioxide (CO_2) emissions are also presented.

The emissions and NO_2 concentration predictions reported previously in October 2021 were based on an earlier iteration of the LEZ boundary shown in Figure 1. This will be referred to as the 'Option 1 Boundary' below. This included the City Centre Masterplan (CCMP) Union Street Scheme, traffic management measures at the Milburn Street/South College Street junction and the exclusion of the East North Street and Commerce Street corridor following concerns regarding harbour access.

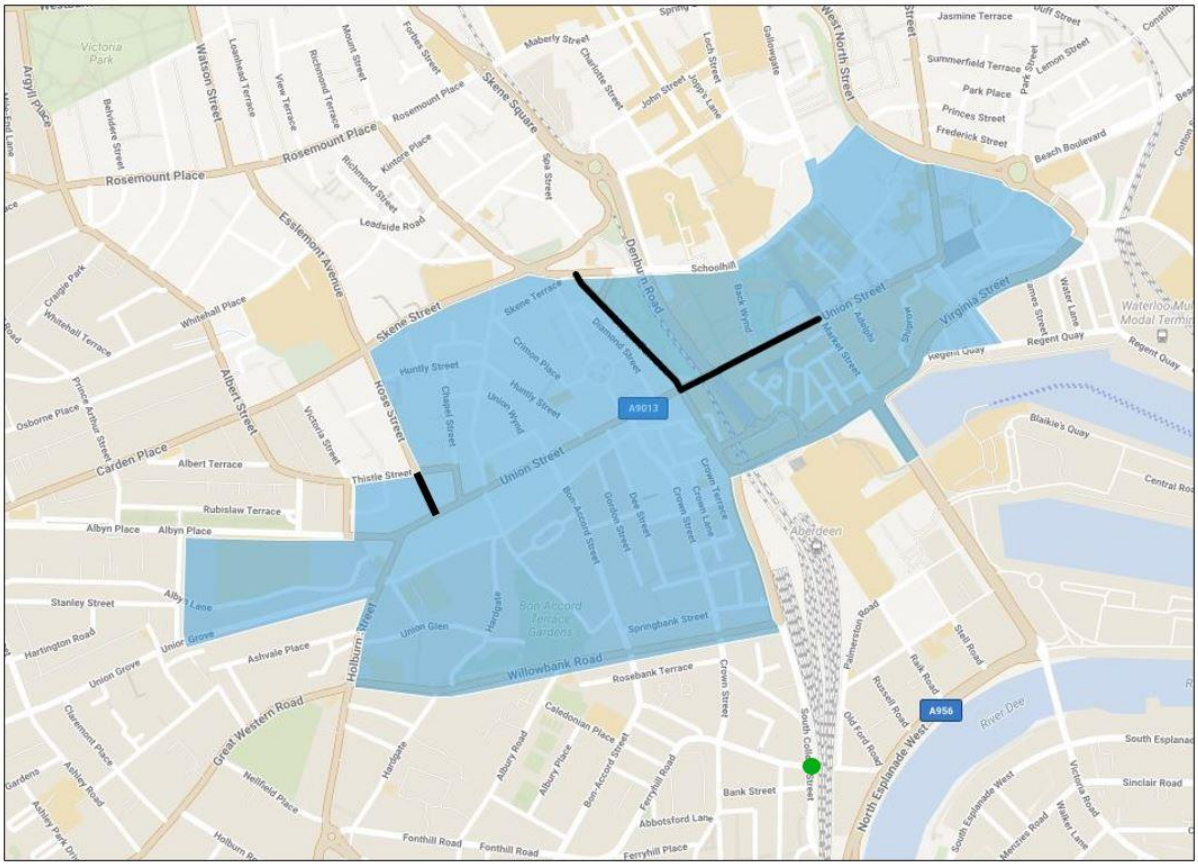

Figure 1: The Option 1 Boundary covering the area of Aberdeen City Centre with key elements of the City Centre Masterplan (CCMP) Union Street Scheme shown in black and the location of the Milburn Street junction improvements shown by the green marker. The extent of the LEZ is shown in blue.

The Final LEZ Boundary is shown in Figure 2 which was agreed following the consultation and objection period in November 2021. Due to concerns raised by the Trinity Centre and Q-Park regarding access to the shopping centre, the Wapping Street gyratory and Rennie's Wynd were excluded from the LEZ. Traffic model predictions suggested that the impact on traffic flows would be negligible in this area. Littlejohn Street was removed from the LEZ as there was some opposition to the inclusion of this street from residents. A small adjustment was made on Willowbank Road with the section between Holburn Street and Hardgate removed from the LEZ to allow all vehicles to access the Hardgate. Finally, the area of the LEZ enclosed by Union Grove, Albyn Grove and Albyn Place on the western boundary was removed to retain access to properties in this area. Due to the small number of vehicle movements affected by these additional changes it was concluded that impacts on traffic flows would be negligible resulting in no significant changes to predicted NO_2 concentrations in these areas.

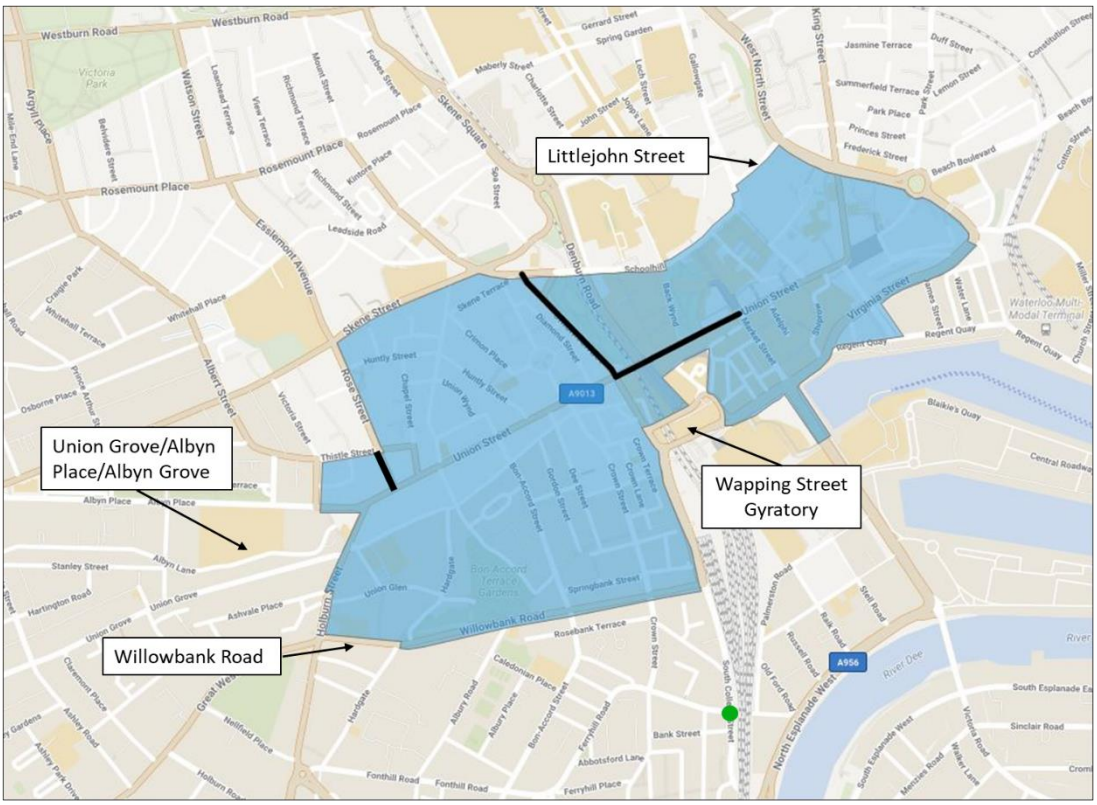

Figure 2: The Final LEZ Boundary with the Wapping Street gyratory, Littlejohn Street, Willowbank Road between the Hardgate and Holburn Street, and Union Grove/Albyn Lane area excluded. The CCMP Union Street Scheme is shown in black and the location of the Milburn Street junction improvements is shown by the green marker. The extent of the LEZ is shown in blue.

Predicted changes in NO_2 concentration due to the LEZ

Running the traffic model output for the Final LEZ Boundary in the air quality model results in negligible changes to emissions and predicted roadside NO_2 concentrations compared to those reported previously. Figure 3 shows predicted NO_2 concentrations across the city for the Option 1 Boundary (A) and the Final LEZ Boundary (B). The number of predicted kerbside exceedances across the city remain unchanged at 17 and occur in the same locations with the maximum concentration of 43.9 μgm^{-3} at a kerbside point located at the Westburn Road/Berryden Road junction increasing slightly to 44.1 μgm^{-3}.

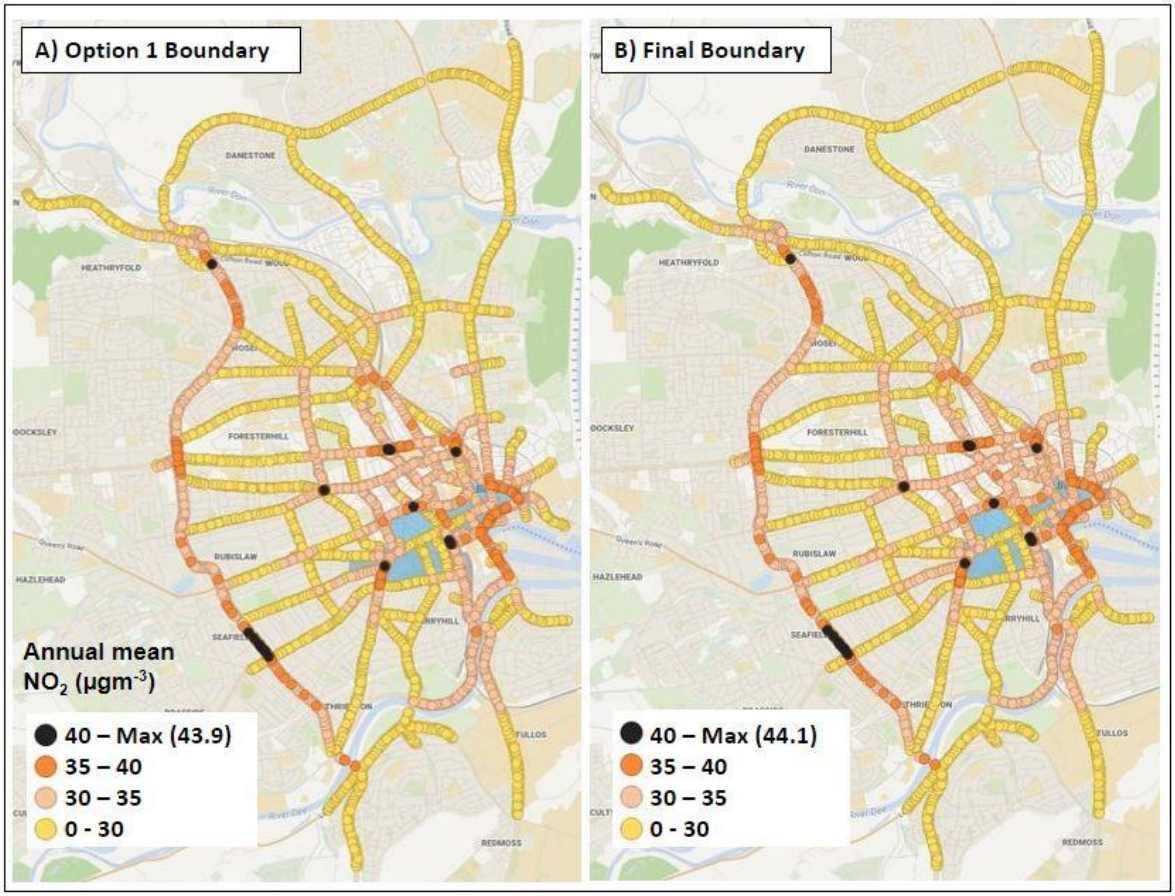

Figure 3: Predicted NO_2 concentrations at kerbside receptors across the city for the Option 1 Boundary (A) and Final LEZ Boundary (B).

Figure 4 shows predicted NO_2 concentrations for the Option 1 Boundary (A) and the Final LEZ Boundary (B) in the city centre. Due to the removal of the Wapping Street gyratory from the LEZ, the exceedances at the two kerbside points at the southern end of Bridge Street are no longer situated within the LEZ. For the Option 1 Boundary (A) modelled previously the predicted NO_2 concentrations at these two kerbside points were 40.1 μgm^{-3} and 40.7 μgm^{-3} respectively. For the Final Boundary (B) the predicted NO_2 concentrations at these two kerbside points increased slightly to 40.4 μgm^{-3} and 41.0 μgm^{-3} respectively. The number of

exceedances within the final LEZ boundary has reduced to the single remaining exceedance on Holburn Street.

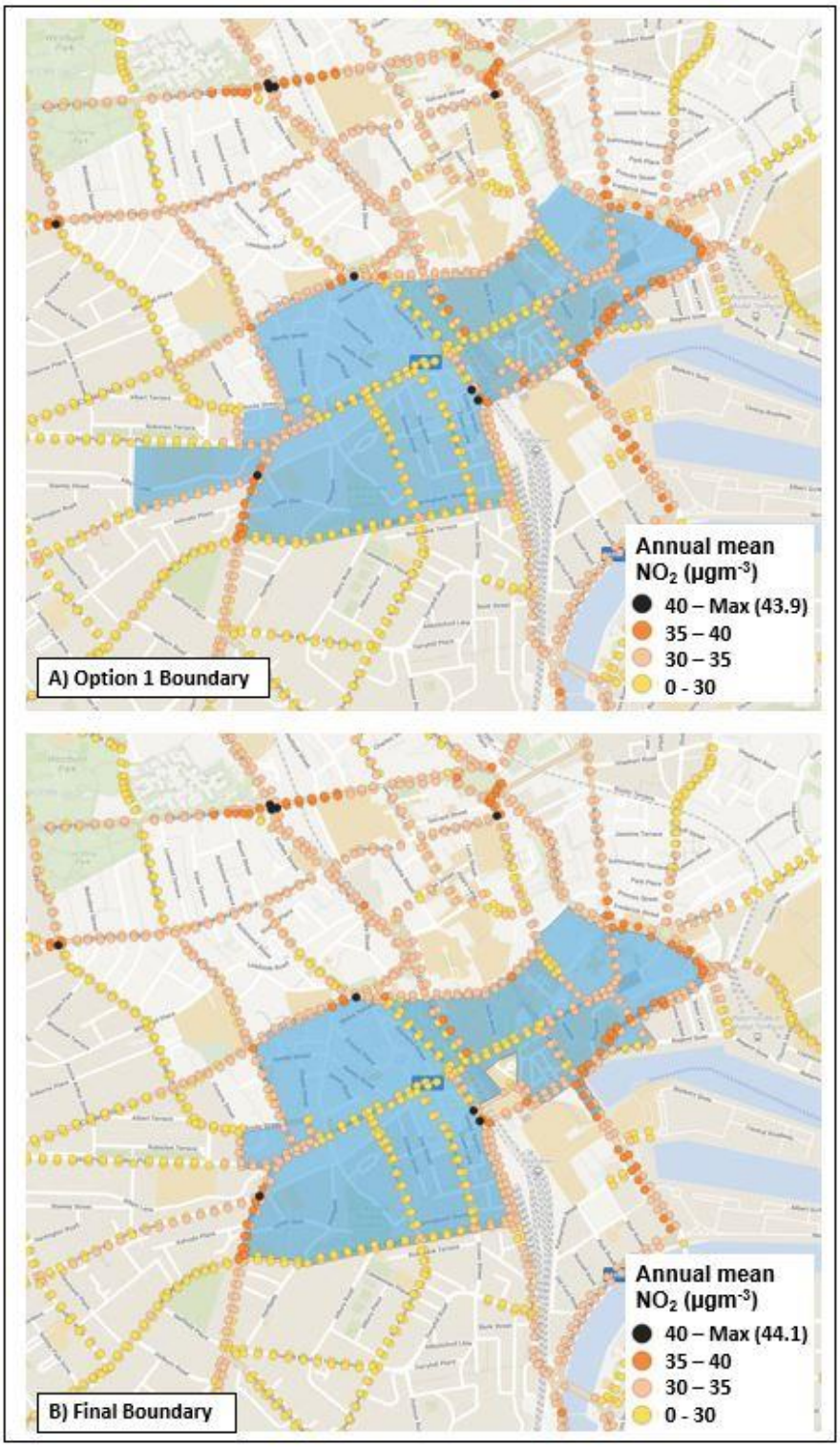

Figure 4: Predicted NO_2 concentrations at kerbside receptors in the city centre area for the Option 1 Boundary (A) and Final LEZ Boundary (B).

Façade and Sensitive Receptor Modelling

Detailed modelling was carried out to predict concentrations at building façades in areas where there were particular concerns about air quality predictions. In the modelling carried out for the Option 1 Boundary consideration was given to sensitive receptors in the central AQMA, Caroline Place and Kittybrewster areas due to isolated NO_2 exceedances at kerbside locations in these areas. Additional sensitive receptor locations were included in the modelling carried out for the Final LEZ Boundary at the Gallowgate/Spring Garden, Skene Street/Rosemount Viaduct and Beechgrove Terrace/Westfield Road junctions (Figure 5). This shows that a new exceedance was predicted at a façade receptor adjacent to the Skene Street/Rosemount Viaduct junction.

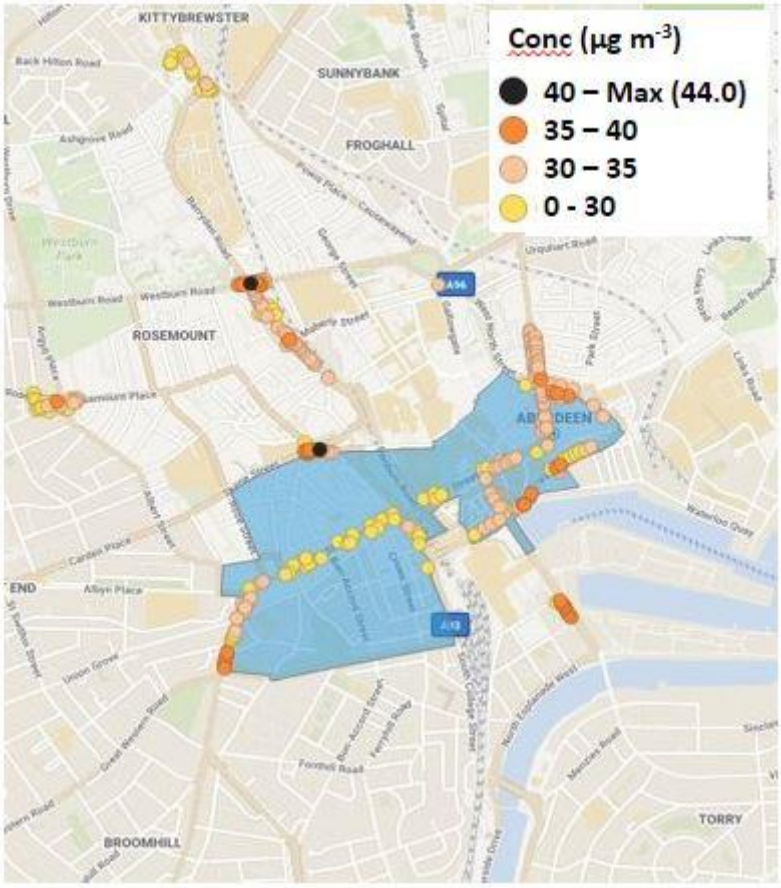

Figure 5: Predicted NO_2 concentrations at building façades for the Final LEZ Boundary scenario.

The single new exceedance of 40.6 µgm^{-3} at the Skene Street/Rosemount Viaduct junction (Figure 6) suggests that the risk of exceedances in the vicinity of this junction will be low following the implementation of the LEZ. The predicted exceedance of 43.7 µgm^{-3} at the façade receptor at the junction of Caroline Place and Hutcheon Street reported previously increased slightly to 44.0 µgm^{-3} in the Final LEZ Boundary scenario.

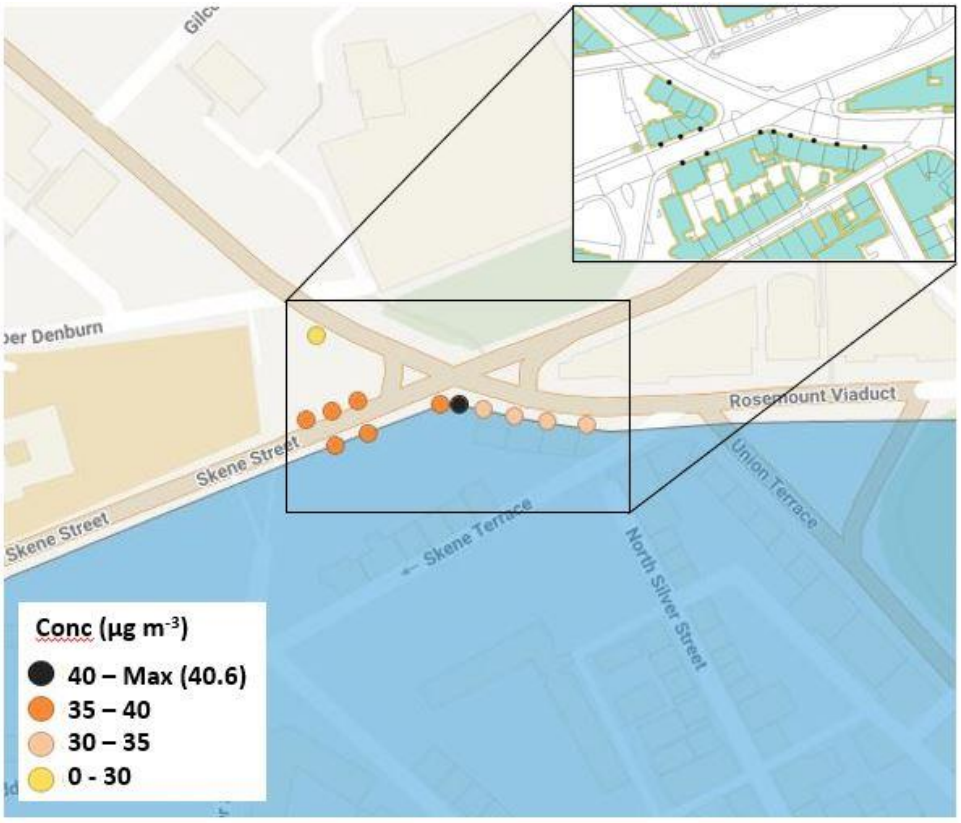

Figure 6: Predicted NO_2 concentrations at building façades at the Skene Street/Rosemount Viaduct junction.

Consideration of Carbon Dioxide changes within an LEZ scheme

The main objective of a Low Emission Zone (LEZ) is to improve air quality to meet current statutory air quality standards and objectives. Access to the LEZ is restricted on the basis of the vehicle Euro classification, which is designed to control emissions of Nitrogen Oxides (NO_x), Total Hydrocarbons, Non-methyl Hydrocarbons, Carbon Monoxide and Particulate Matter (PM) See EU Commission Regulation.

Carbon Dioxide (CO_2) emissions are not currently controlled by the Euro classification, although CO_2 emissions will be included in the upcoming Euro 7 standards which are expected to come into force in 2025. The Transport (Scotland) Act (2019) includes a statutory obligation to consider the contributions made towards greenhouse gas emissions.

CO_2 emissions are linked to the quantity of fuel burnt by a vehicle and therefore reductions in emissions are mostly linked to improved fuel efficiency. No vehicles currently include CO_2 emission abatement, and therefore no significant changes in CO_2 emissions are expected following implementation of an LEZ.

Lower CO_2 emissions could be achieved by reducing the number of vehicle journeys made by petrol/diesel vehicles and increasing the proportion of journeys made using alternative technologies (e.g. electric and hydrogen vehicles) and active travel. This move to zero carbon emissions could be achieved by actions set out in CAFS2 or the introduction of zero emission zones.

Euro class emissions standards are outlined in Tables 1, 2 and 3. CO_2 is not included in this framework.

Table 1: Car Emission Standards (NO_x and PM) for different Euro Classes.

g/km	Diesel Car		Petrol Car	
	NO_x	PM	NO_x	PM
Euro 1	-	0.14	-	-
Euro 2	-	0.08	-	-
Euro 3	0.5	0.05	0.15	-
Euro 4	0.25	0.025	0.08	0.005
Euro 5 (incl 5a and 5b)	0.18	0.0045	0.06	0.005 (5a) 0.0045 (5b)
Euro 6 (incl 6b, 6c, 6d-TEMP and 6d)	0.08	0.0045	0.06	0.0045

Table 2: LGV Emission Standards (NO_x and PM) for different Euro Classes.

g/km	<1305kg		1305-1760kg		1760-3500kg	
	NO_x	PM	NO_x	PM	NO_x	PM
Euro 1	-	0.14	-	0.19	-	0.25
Euro 2	-	0.08	-	0.12	-	0.17
Euro 3	0.5	0.05	0.65	0.07	0.78	0.10
Euro 4	0.25	0.025	0.33	0.04	0.39	0.06
Euro 5 (incl 5a and 5b)	0.18	0.0045	0.235	0.005 (5a) 0.0045 (5b)	0.28	0.005 (5a) 0.0045 (5b)
Euro 6 (incl 6b, 6c, 6d-TEMP and 6d)	0.08	0.0045	0.105	0.0045	0.125	0.0045

Table 3: Bus and HGV Emission Standards (NO_x and PM) for different Euro Classes. Note that Bus and HGV emissions standards are defined as g/kWh).

	Vehicle Type	NO_x (g/kWh)	PM (g/kWh)
Euro I	All	8	0.36
Euro II	All	7	0.15
Euro III	EEV	2	0.02
	Non EEV	5	0.1
Euro IV	All	3.5	0.02
Euro V	All	2	0.02
Euro VI	All	0.4	0.01
Note: EEV is Environmentally Enhanced Vehicle			

The Emissions Factor Toolkit (EfT) is published by Defra and the Devolved Administrations so that emission factors can be calculated for different vehicle speeds. These have been extracted from EfT v10.1 for vehicles travelling at an average speed of 20km/h, to show the effect of the Euro classification on emissions of NO_x and CO_2.

Figure 7 confirms that between Euro classes 5 and 6d there is a reduction in NO_x emissions from diesel cars of around 70%, compared with a reduction in CO_2 emissions of 8%. From petrol cars there is a small increase in NO_x emissions between Euro classes 5 and 6d of 13%, compared with an 8% reduction of CO_2. From diesel LGVs there is a reduction in NO_x emissions of around 90% between Euro classes 5 and 6, whereas CO_2 emissions remain unchanged.

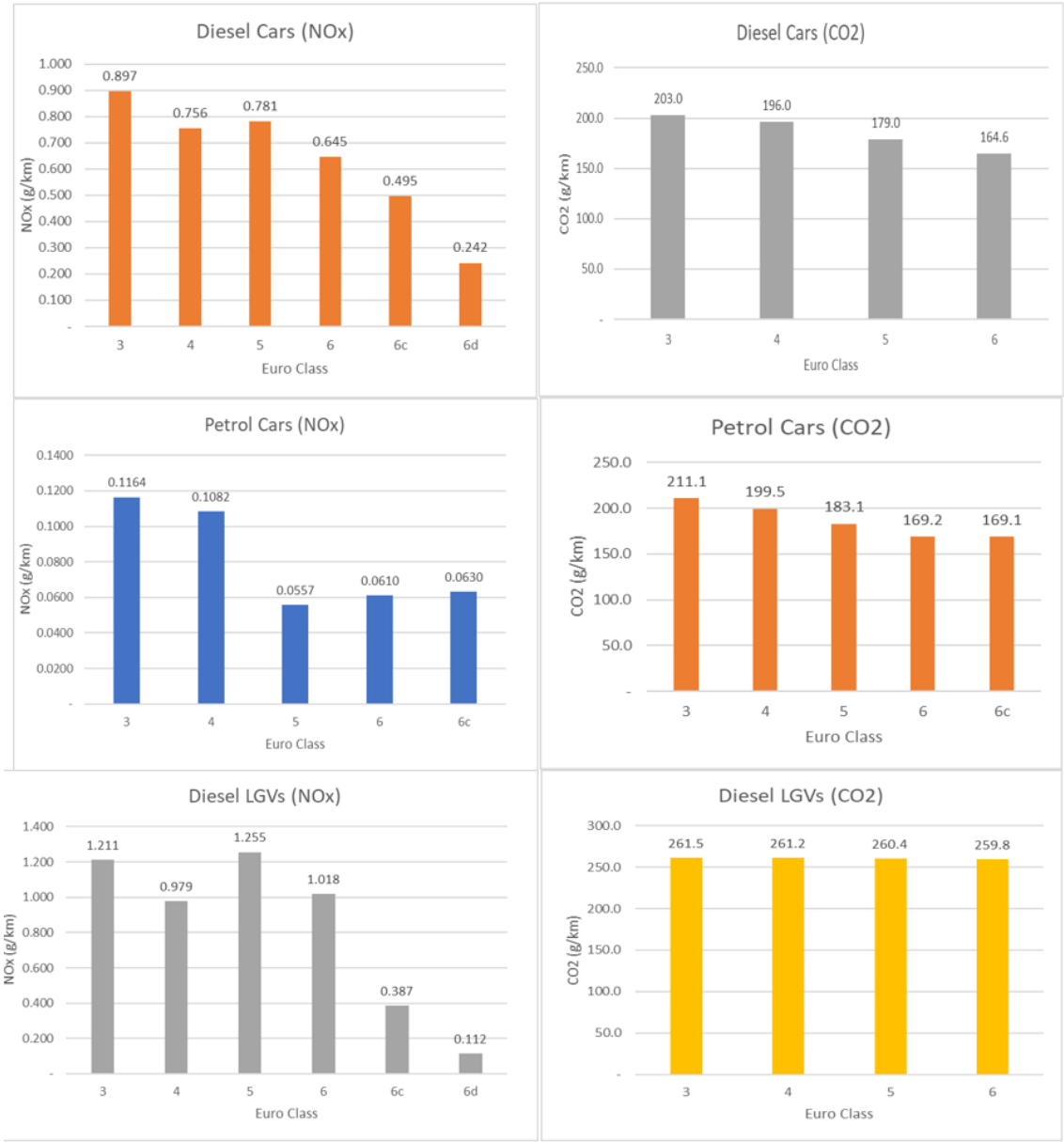

Figure 7: NO_x and CO_2 emission factors for Cars and LGV's.

Figure 8 shows comparable data for heavy duty vehicles. For buses, rigid HGVs and articulated HGVs there is a reduction in NO_x emissions between Euro classes 5 and 6 of between 85-90%. CO_2 emissions remain unchanged.

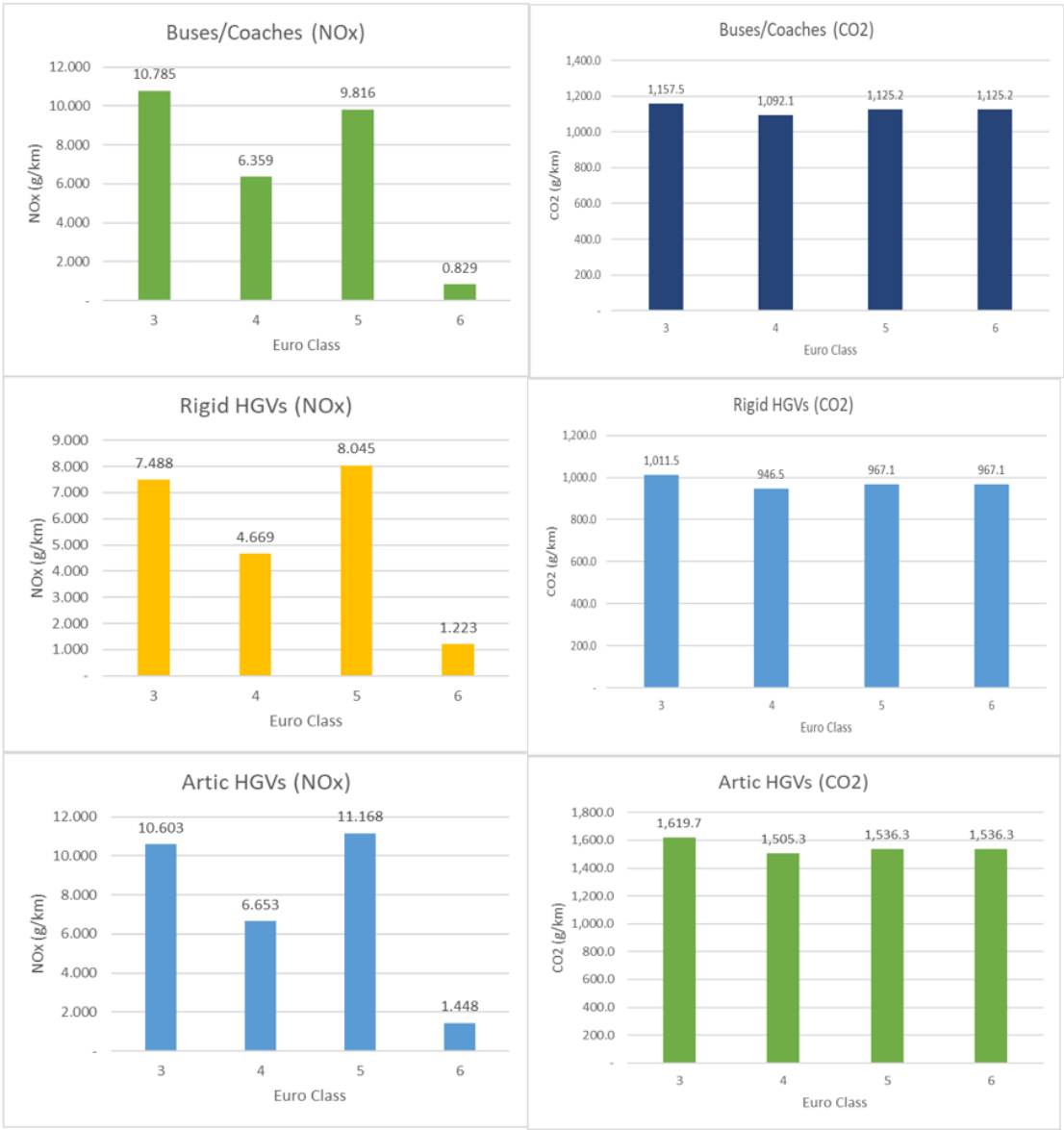

Figure 8: NO_x and CO_2 emission factors for Buses and HGV's.

CO_2 Emissions for Aberdeen

The methodology used to calculate CO_2 emissions is consistent with that used to calculate emissions of NO_x and PM_{10} in previous LEZ analyses and the National Modelling Framework (NMF). The traffic model was run for 3 scenarios:

- 2019 Base Case
- 2024 Reference Case (Base Case + Traffic Growth + Increase in fleet compliance)
- 2024 LEZ Case (Reference Case + Combined LEZ and CCMP measures)

All buses are assumed to be compliant in the Reference and LEZ scenarios. Emissions of CO_2 have been calculated for the roads included in the modelled network highlighted by the kerbside points in Figure 3 and so doesn't consider CO_2 emissions from every road across the city. Emission calculations were made in EMIT using emission factors from NAEI (2014). Emission factors from EfT are not currently available in EMIT.

The Reference Case traffic model included a 6 to 8% uplift in traffic levels over and above those in the Base model. This prediction in traffic growth over 5 years is considered to be a 'high growth' scenario in the context of Aberdeen City Centre (SYSTRA, 2021). Figure 9 shows total citywide CO_2 emissions for the 2019 Base, 2024 Reference and Final LEZ Boundary scenarios. The increase in CO_2 emissions due to the traffic growth is included in the Reference and Final LEZ Boundary (Reference + LEZ) scenarios. Figure 10 shows the percentage change between the Base and Reference scenarios (A), Reference and LEZ scenarios (B), and Base and LEZ scenarios (C).

Total CO_2 emissions are predicted to increase from 83,484 tonnes in the Base scenario to 86,924 tonnes in the Reference scenario, an increase of 3,440 tonnes, or 4.1% (Figure 10 A). A small portion of the higher CO_2 emissions resulting from the traffic growth will have been offset by the improvements in fleet compliance levels between 2019 and 2024, and introduction of additional hydrogen fuel cell vehicles on some of the main bus routes. Following the implementation of the LEZ CO_2 emissions increase from 86,924 tonnes in the Reference scenario to 88,890 tonnes in the LEZ scenario, an increase of 1966 tonnes, or 2.3% (Figure 10 B). Compared to the Base scenario, total CO_2 emissions are predicted to increase from 83,484 tonnes per year to 88,890 tonnes per year in the LEZ scenario, an increase of 5,406 tonnes, or 6.5% (Figure 10 C).

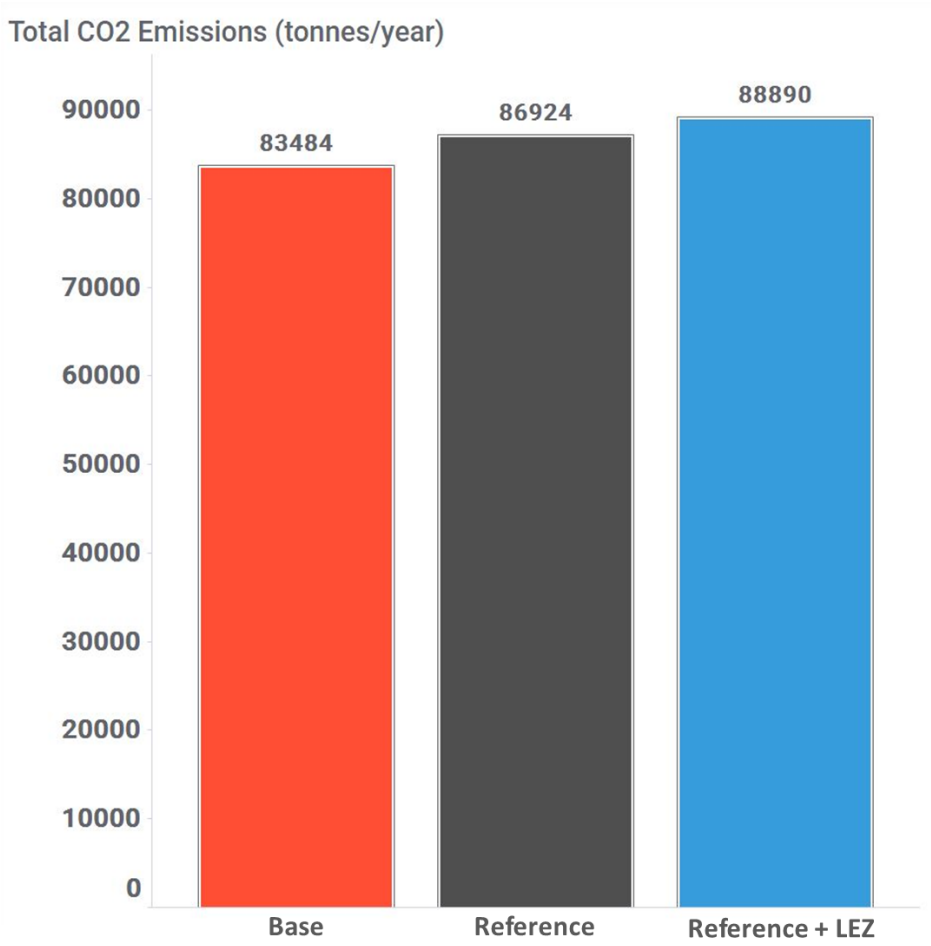

Figure 9: Total citywide CO_2 emissions (tonnes per year) for the Base, Reference and Final LEZ Boundary (Reference + LEZ) scenarios.

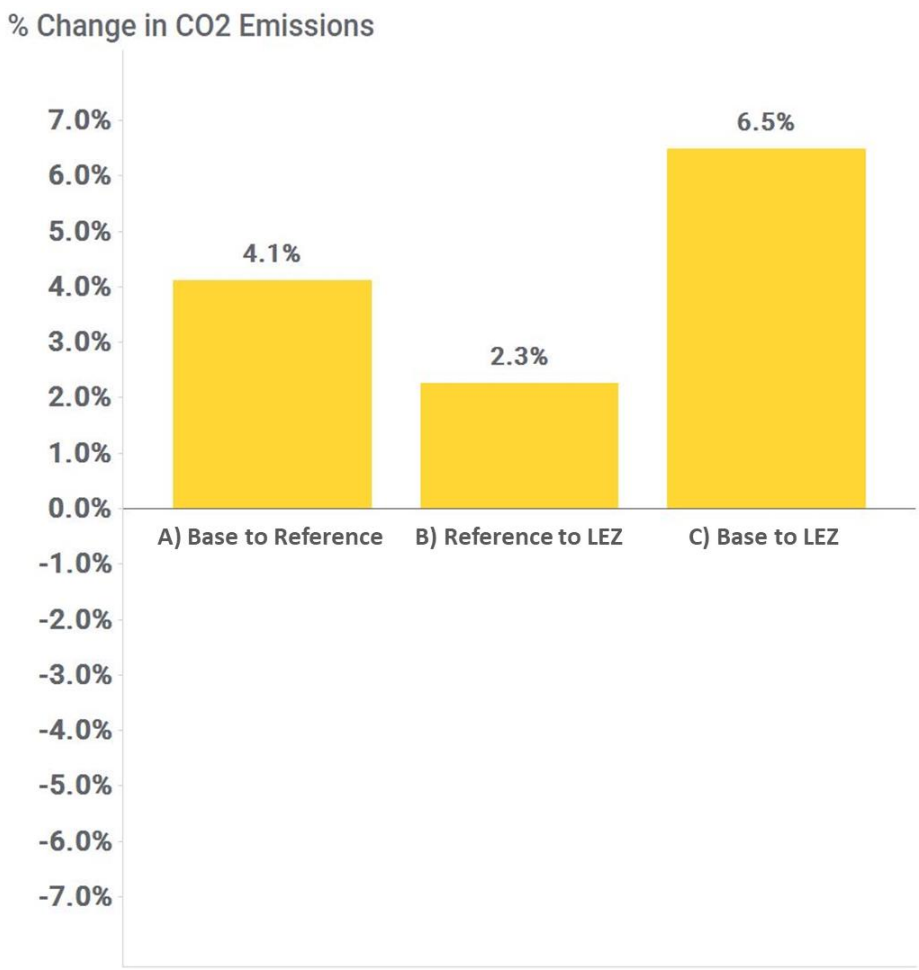

Figure 10: Change (%) in CO_2 emissions between the Base and Reference scenarios (A), Reference and LEZ scenarios (B), and Base and LEZ scenarios assuming no traffic growth (C).

Total CO_2 emissions for the Base, Reference and Final LEZ Boundary scenarios for the roads inside, and outside the LEZ are presented in Figure 11. Figure 12 shows the percentage change between the Base and Reference scenarios (A), Reference and LEZ scenarios (B), and Base and LEZ scenarios (C) for roads inside and outside the LEZ.

Inside the LEZ the uplift in traffic levels between the Base and Reference scenarios is reflected in the change in CO_2 emissions from 5,665 tonnes in the Base scenario to 6,140 tonnes in the Reference scenario, an increase of 475 tonnes, or 8.4% (Figure 12 A). The absolute changes in CO_2 emissions (tonnes) within the LEZ boundary are smaller than those outside the boundary but are a bigger proportion of the total CO_2 within the boundary and so correspond to larger percentage changes. There is a notable decrease from 6140 tonnes of CO_2 in the Reference scenario to 5,141 tonnes in the LEZ scenario, a reduction of 999 tonnes, or 16.3% (Figure 12 B). This will be due in part to the removal of petrol and diesel cars from the city centre area due to the restrictions on Union Street. Due to the increase in CO_2 emissions in the reference scenario resulting from the traffic growth the net reduction in CO_2 emissions

between the Base scenario and Final LEZ Boundary scenario is less at 524 tonnes, or 9.3% (Figure 12 C).

The reductions of CO_2 emissions between the Reference and LEZ scenarios, and the Base and LEZ scenarios inside the LEZ described above correspond to larger increases in CO_2 emissions between these scenarios outside the LEZ. Increases in CO_2 emissions of 2,965 tonnes or 3.7% (Figure 12 B) between the Reference and LEZ scenarios, and 5,930 tonnes or 7.6% (Figure 12 C) between the Base and LEZ Scenarios occur outside the LEZ. The larger increases in emissions outside the LEZ are due to the extra distance travelled by displaced traffic. Outputs from the traffic model showed that traffic displaced by the LEZ and restrictions on Union Street resulted in a 1.8% increase in the total distance travelled by all vehicles in the model with a reduction in mean speed of 10% (SYSTRA, 2021).

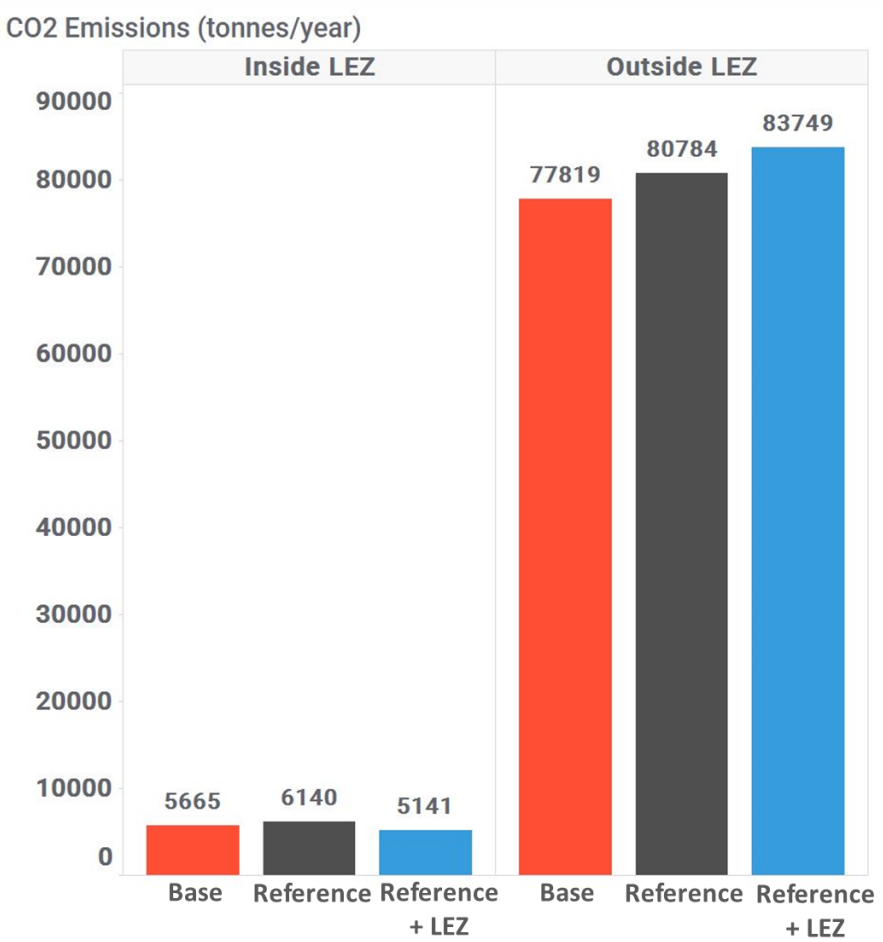

Figure 11: Total CO_2 emissions (tonnes per year) for the Base, Reference and Final LEZ Boundary (Reference + LEZ) scenarios on roads inside and outside the LEZ.

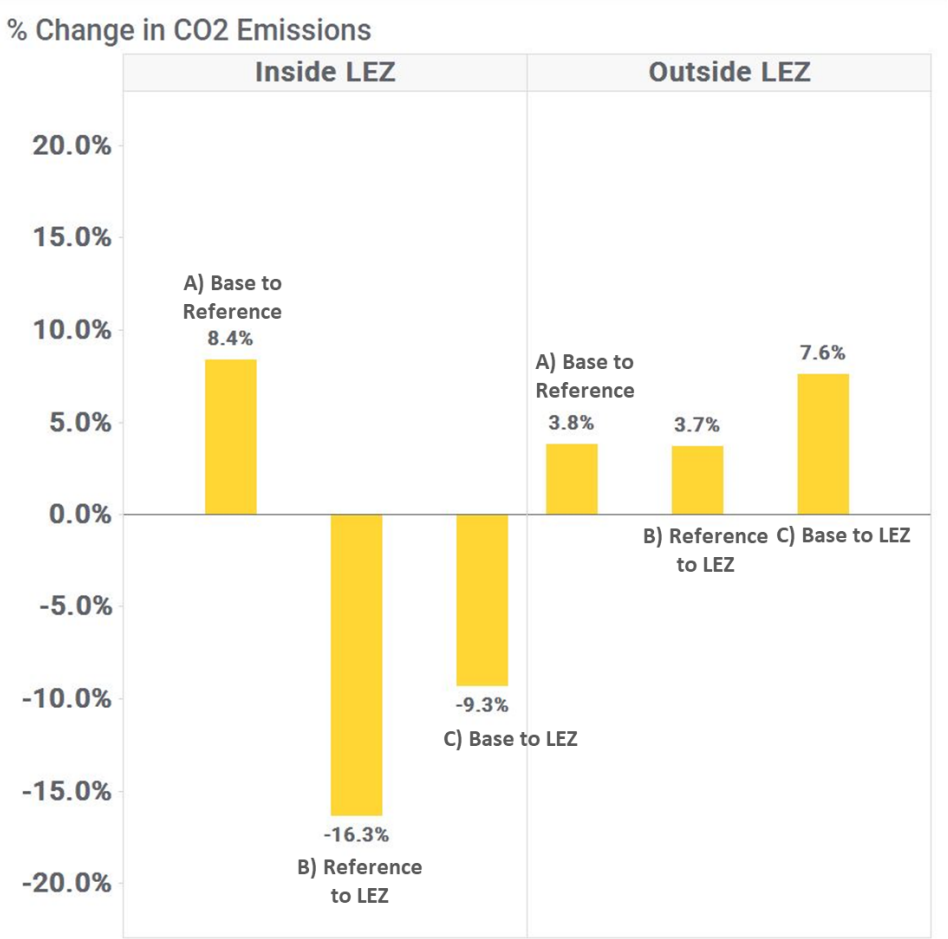

Figure 12: Change (%) in CO_2 emissions between the Base and Reference scenarios (A), Reference and LEZ scenarios (B), and Base and LEZ scenarios assuming no traffic growth (C).

Particulate (PM_{10}) emissions

The predicted changes in PM_{10} emission rates between the Reference and Option 1 Boundary scenarios were reported previously. Additional emissions analysis has now been carried out for the 2019 Base and Final LEZ Boundary scenarios. It should be noted that the PM_{10} emissions shown represent tailpipe emissions and do not include other particulate emission sources such as road wear, tyre wear, brake wear and resuspension of particulates. It is estimated that PM_{10} tailpipe emissions make up approximately 27% of total emissions (UK Air Quality Expert Group, 2019), though large uncertainties exist.

Figure 13 shows total citywide PM_{10} emissions (tonnes per year) for the Base, Reference and Final LEZ Boundary scenarios. Total PM_{10} emissions show a large decrease of 40% from 2.6 tonnes to 1.6 tonnes per year between the Base and Reference scenarios due to general fleet

improvements and fully compliant bus fleet in 2024. There is a negligible change in emissions between the Reference and Final LEZ Boundary scenarios. PM_{10} emissions of 1.48 tonnes per year were calculated previously for the Option 1 Boundary and these have increased slightly to 1.51 for the Final LEZ Boundary below.

Figure 14 shows total PM_{10} emissions (tonnes per year) for the three scenarios inside and outside the LEZ boundary. Inside the LEZ there is a significant reduction in PM_{10} emissions of 47% from 0.19 tonnes to 0.10 tonnes per year between the Base and Reference scenarios. This is due to the fleet improvements and change to a fully compliant bus fleet. There is a further reduction of 50% from 0.10 tonnes to 0.05 tonnes following the implementation of the LEZ and reduction in traffic levels due to the Union Street restrictions. Outside the LEZ boundary there are similar changes in PM_{10} emissions between the three scenarios as described for the citywide emissions in Figure 13.

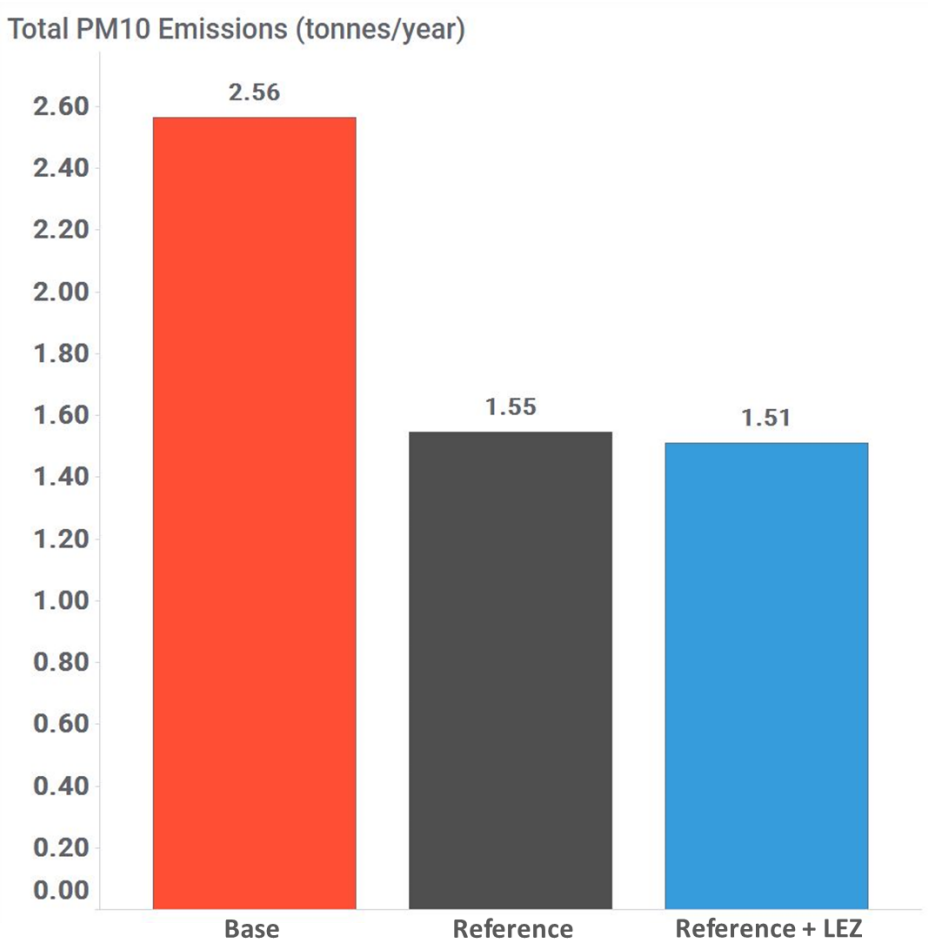

Figure 13: Total PM_{10} emissions (tonnes per year) for the Base, Reference and Final LEZ Boundary (Reference + LEZ) scenarios.

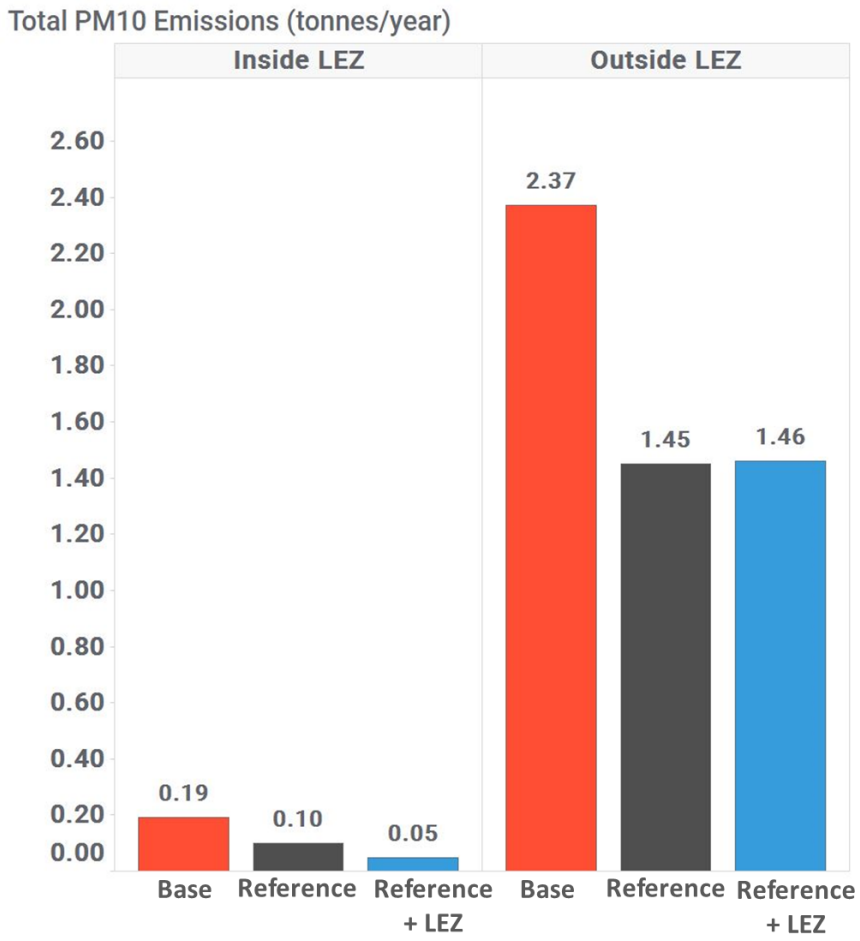

Figure 14: Total PM_{10} emissions (tonnes per year) for the Base, Reference and Final LEZ Boundary (Reference + LEZ) scenarios on roads inside and outside the LEZ.

Summary of CO_2 and PM_{10} Emissions

We present the initial findings following the use of the Aberdeen NMF model to compare emissions of CO_2 before and after implementation of the LEZ. As can be seen there are marked reductions in CO_2 emissions inside the LEZ. This is due to the combined effect of the LEZ and CCMP measures reducing the number of vehicle journeys made by petrol and diesel vehicles through the city centre.

These gains in CO_2 emission reduction inside the LEZ boundary are offset by larger increases in emissions outside the boundary. Previous work carried out by SYSTRA highlighted that non-compliant traffic displaced by the LEZ and compliant traffic displaced by the restrictions on Union Street resulted in a 1.8% increase on average in the total distance travelled by all vehicles in the model between the Reference and Final LEZ scenarios. The displaced traffic finds alternative and longer routes around the periphery of the LEZ to the west and along Anderson Drive to avoid the LEZ and the city centre area completely. This results in the burning of more fuel and the small increase in CO_2 emissions of 1966 tonnes, or 2.3% across

the city (Figure 10) following the implementation of the LEZ. No significant reductions in CO_2 emissions are expected unless the number of vehicle journeys are reduced or the proportion of journeys made using alternative technologies and active travel are increased more widely across the city.

There were no exceedances of the annual or 24 hour mean PM_{10} objectives in 2019 (ACC, 2020). As discussed in the SEPA (2021) report reductions in PM_{10} tailpipe emissions are predicted on many roads across the city with a smaller number of roads where emissions are predicted to increase locally. Where there are increases in emissions these are small in absolute terms and exceedances of the current PM_{10} objectives are not expected following implementation of the LEZ.

References

ACC, 2020. *2020 Air Quality Annual Progress Report (APR) for Aberdeen City Council, June 2020.*

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UK Air Quality Expert Group, 2019. *Non-Exhaust Emissions from Road Traffic.*