

Warsaw low-emission zone: The potential emissions benefits and impact on drivers

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Warsaw, Poland, is one of the most polluted cities in Europe and one of the main contributors to air pollution is the use of private cars. A previous TRUE report on the real-world emissions of the Warsaw fleet identified the creation of a low-emission zone (LEZ) as a potential policy that could effectively reduce traffic-related nitrogen oxides (NO_x) and particulate matter (PM) tailpipe emissions, which are detrimental to human health. In light of the recent announcement of Warsaw's intent to introduce a low-emission zone, this technical note proposes two potential LEZ designs for the city based on information about fleet emissions gathered during remote sensing testing. It presents the impacts of the initial steps of the two LEZs on both air pollutant emissions and vehicle drivers in Warsaw. While this technical note assesses only the effects of impending restrictions to highlight the immediate benefits and the minor costs on drivers of a well-designed LEZ, the evaluation of the further LEZ restrictions and the implications of an LEZ on greenhouse gas emissions will follow in a more comprehensive TRUE report.

LOW-EMISSION ZONE FOR PASSENGER CARS

A previous TRUE study revealed that diesel vehicles that are currently 14 years of age or older (certified to Euro 4 and below) showed real-world emissions significantly higher than the regulatory limits. These vehicles were responsible for around 40% of total NO_x emissions and 60% of total PM emissions from passenger cars in Warsaw, despite making up less than 15% of total passenger car activity. Therefore, the two LEZ options described below in Table 1 prioritize the phase-out of

older diesel vehicles that have disproportionate impact on Warsaw's air pollution. Option 1 implements each phase of restrictions every two years and Option 2 implements restrictions on a more accelerated schedule. Both LEZ options phase in from 2024, the year when the city of Warsaw plans on putting in place such policy, and progressively affect vehicles certified to newer emission standards with each phase.

Table 1. Low-emission zone implementation restrictions and implementation schedules for Option 1 and Option 2.

Passenger Car	Minimum standard		Implementation schedule	
	Diesel	Petrol	Option 1	Option 2
1	Euro 4	Euro 2	2024	2024
2	Euro 5	Euro 3	2026	2025
3	Euro 6	Euro 4	2028	2026
4	Euro 6d-TEMP	Euro 5	2030	2027
5	Euro 6d	Euro 6	2032	2028

EMISSION FACTORS FOR WARSAW'S PASSENGER CARS

Emission factors derived from the remote sensing measurements collected in 2020 in Warsaw, as shown in Table 2, are used to simulate the impacts of the LEZ on NO_x and PM emissions. As these values are based on measurements from one remote sensing testing campaign, they may not accurately represent the entire passenger car fleet of the city. However, they are reflective of the real-world emissions of the fleet under



Table 2. Distance-specific tailpipe NO_x and PM emission factors derived from the 2020 remote sensing measurements.

Fuel	Diesel		Gasoline		
	Standard	NO _x (mg/km)	PM (mg/km)	NO _x (mg/km)	PM (mg/km)
Euro 1		1113	95	1022	23
Euro 2		1152	61	873	15
Euro 3		1069	48	534	6.8
Euro 4		750	30	276	2.8
Euro 5		692	6.4	169	2.6
Euro 6		345	2.5	121	2.1
Euro 6d-TEMP		135	1.9	93	1.5
Euro 6d		92	1.9	93	1.5

urban driving conditions, which are often different from the emission levels vehicles are required to meet during type-approval. Passenger cars in Warsaw showed real-world emission levels higher than the levels of emissions derived from other TRUE European remote sensing campaigns. Elevated levels of NO_x emissions may be attributable to the old age and high mileage of the vehicles, which can cause deterioration of emission control systems. In 2020, the average age of in-use passenger cars in Poland was over 14 years old, while the European average was below 12 years.¹ There is also a significant presence of imported second-hand vehicles, which make up one third of the fleet and whose emissions are notably higher than domestic vehicles. Emission factors based on the remote sensing testing also capture the possible influence of liquid petroleum gas (LPG) conversions on emissions, a practice commonly performed on old gasoline vehicles.²

IMPACTS OF A LOW-EMISSION ZONE ON POLLUTANT EMISSIONS AND DRIVERS

The impacts of the two proposed LEZ schemes are assessed based on the passenger car fleet composition modeled for the respective years of the first two phases of LEZ restrictions, 2024-2026, and the emission factors given above, which are derived from the 2020

emissions measurements. By using the projected composition of passenger cars on the roads of Warsaw, the study ensures that vehicle fleet turnover is reflected in the assessment. The model used to predict future vehicle compositions is calibrated to the vehicle age distribution derived from the 2020 remote sensing measurements and Polish-specific rates of vehicle sales and retirement produced by the Roadmap model are applied.³ The fleet turnover also considers the growing uptake of electric vehicles in line with the recently agreed “Fit for 55” package proposal for the EU transport sector. Additionally, information obtained from the remote sensing measurements regarding the share and average age of used cars in Warsaw is used to more accurately project the fleet turnover.

Both LEZ Option 1 and Option 2 impose uniform restrictions in the first implementation phase in 2024: a ban on diesel vehicles certified to below Euro 4 and gasoline vehicles certified to below Euro 2. As most of the oldest vehicles in the 2020 Warsaw fleet are expected to retire by 2024, the first phase of restrictions would affect vehicles that account for only 3% of the passenger car stock in 2024. The emissions impacts, however, would be substantial. Our assessment, illustrated in Figure 1, shows that the vehicles restricted under the first phase of the LEZ would be responsible for 11% of the total NO_x emissions and 23% of the total PM emissions from the passenger car fleet. This step would be particularly significant for PM, as affected diesel vehicles contribute disproportionately to these emissions.

1 European Automobile Manufacturers’ Association, “Average age of the EU vehicle fleet, by country”, April 2, 2022, <https://www.acea.auto/figure/average-age-of-eu-vehicle-fleet-by-country/>.

2 Samar Automotive Market Research Institute, “Cars with LPG - condition of the park at the end of 2019,” July 10, 2020, https://www.samar.pl/_/3/3.a/108876/3.sc/11/Auta-z-LPG---stan-parku-na-koniec-2019-roku.html?locale=pl_PL.

3 The documentation of the Roadmap model v1.9 can be found at <https://theicct.github.io/roadmap-doc/versions/v1.9/#projected-sales>.

Impact of the first phase of LEZ restrictions in 2024 (for both LEZ Option 1 & 2)

Affected
 Not affected

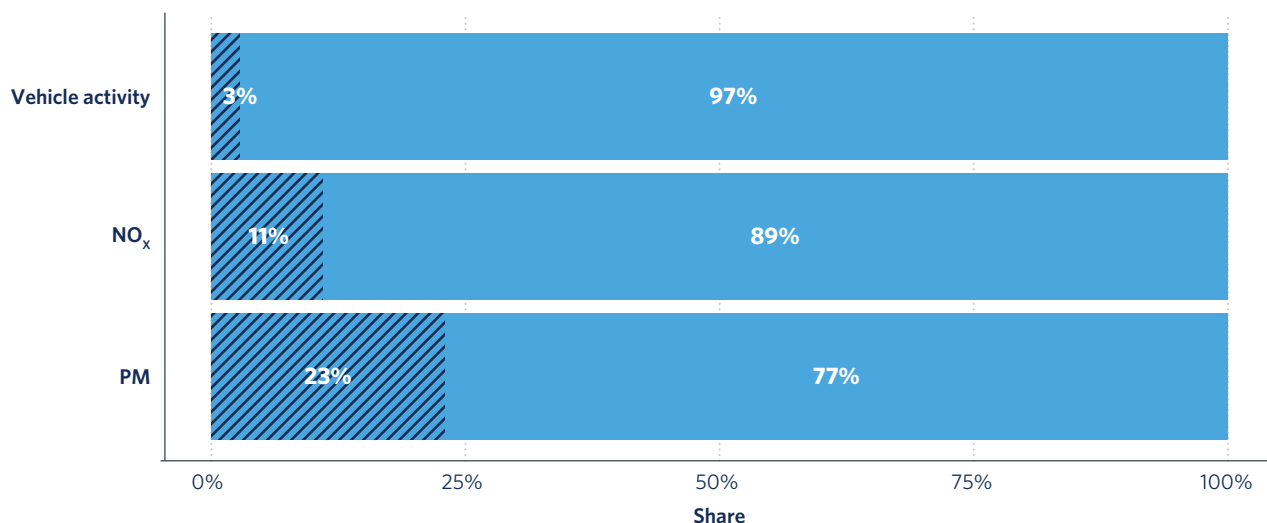


Figure 1. Impact of the first phase of the proposed low-emission zones. The first phase of the both Option 1 and Option 2 low-emission zones would limit the use of diesel vehicles certified to up to Euro 4 and petrol vehicles certified to up to Euro 2 in the zone from 2024. In 2024, these vehicle groups would account for only 3% of the total passenger car activity but 11% of the total tailpipe NO_x emissions and 23% of the total tailpipe PM emissions from passenger cars.

In the second phase, both LEZ options expand the restrictions to include diesel vehicles certified to Euro 4 and gasoline vehicles certified to Euro 2 but diverge in their implementation schedules (Table 1). The second phase of the LEZ is especially important as it would remove all diesel vehicles, which are not equipped with diesel particulate filters and are thus the highest emitters of PM from the zone. In 2026, Option 1 would impact 7% of the passenger cars that would otherwise enter the zone without LEZ restrictions. This share of cars would be responsible for 28% of NO_x and 55% of PM emissions from the passenger car fleet expected in 2026.⁴ The emission benefits of LEZ Option 2 are more immediate and significant with the implementation of the second phase in 2025. Compared to the scenario with no LEZ, this phase of Option 2 LEZ would affect 9% of passenger cars that would be responsible for 30% of NO_x emissions and 57% of PM emissions in 2025. Although the total emission benefits vary by the ways in which drivers react to the restrictions, such as by switching to zero-emission alternatives or replacing their cars with another diesel vehicle, it is evident Option 2 would bring about a greater impact on emissions within the LEZ at a more accelerated pace.

POLICY RECOMMENDATIONS

- An LEZ which restricts the oldest, high-emitting vehicle groups first would have immediate benefits while minimizing the impacts on drivers. In 2020 in Warsaw, diesel cars of over 15 years were responsible for nearly 20% of the total passenger car NO_x emissions and 40% of the PM emissions, while making up only 6% of the fleet activities.
- There is a significant advantage in phasing out diesel vehicles certified to below Euro 5 which are not equipped with diesel particulate filters. The second phase of the proposed LEZ would remove vehicles from the zone that contribute disproportionately to PM emissions.
- An LEZ that expands restrictions at a faster pace can achieve greater, more immediate emission benefits. The expansion of the area designated for an LEZ could further yield greater emission reductions.

⁴ The result does not consider the implementation of the first phase and therefore includes vehicles that would've been restricted with the first phase of the LEZ. However, these vehicles accounts for less than 1% of the total passenger car fleet in 2026 due to the assumed vehicle retirement.

Impact of the second phase of LEZ restrictions

 Affected
  Not affected

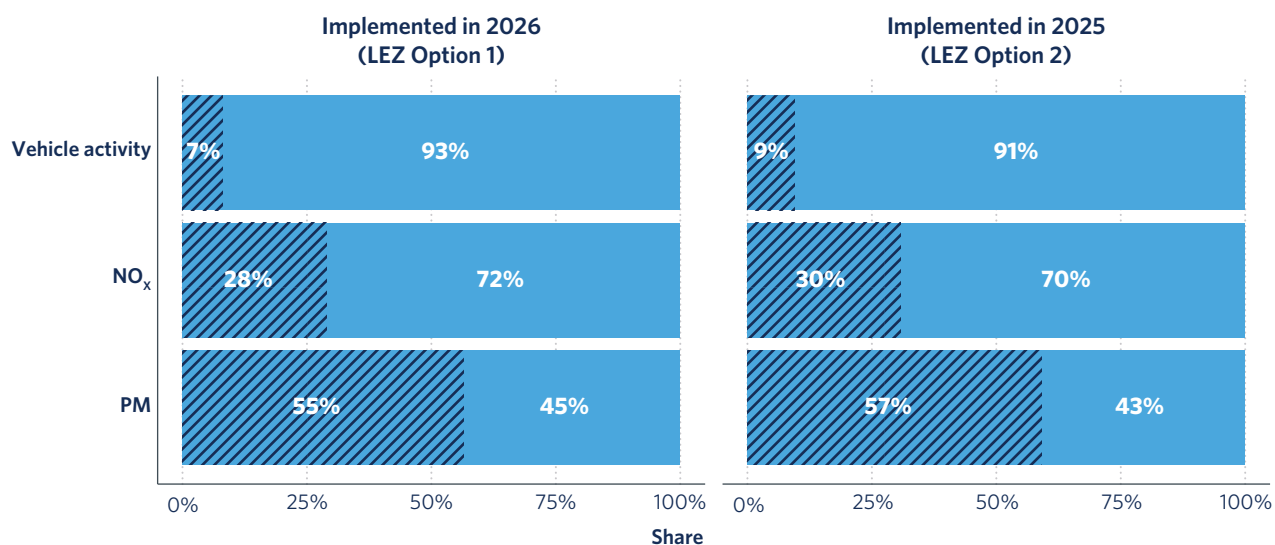


Figure 2. Impact of the second phase of the proposed low-emission zones, which would expand the restrictions to include diesel vehicles certified to Euro 5 and petrol vehicles certified to Euro 3. When compared with the scenario with no LEZ in respective years, the second phase would affect 7% of passenger car activity that are responsible for 28% of NO_x and 55% of PM emissions in 2026 for LEZ Option 1. LEZ Option 2 would impact only a slightly higher share of vehicle activity in 2025, but would have accelerated benefits, getting rid of vehicles responsible for 30% of NO_x emissions and 57% of PM emissions in the zone in 2025.

FURTHER READING

Evaluation of real-world vehicle emissions in Warsaw
<https://www.trueinitiative.org/data/publications/evaluation-of-real-world-vehicle-emissions-in-warsaw>

Recommendations for a clean transportation zone in Warsaw
<https://www.trueinitiative.org/media/792222/1-true-warsaw-factsheet-en.pdf>



TO FIND OUT MORE

For details on the TRUE remote sensing database, contact **Yoann Bernard**, y.bernard@theicct.org.
 For more information on TRUE, visit www.trueinitiative.org.