Transport Alliance for Clean Air

Briefing

Pathways to clean air in cities

Summary

The Transport Alliance for Clean Air (TACA) is a group of companies and associations from the transport and mobility space that share a common vision for clean air in the EU. We believe that the private sector should be at the forefront of action to tackle toxic air pollution, by helping authorities to strengthen controls over transport emissions and providing low- and zero-emission technologies, goods, and services.

Although improving, air pollution remains the biggest environmental threat to human health: a silent killer that causes more than 300,000 premature deaths a year in addition to causing various illnesses such as lung cancer, strokes, asthma, and is suspected to damage every organ in the human body. Concentrations of air pollution in Europe are still way above what is considered healthy by the World Health Organization (WHO). 89% of European city dwellers are still breathing dangerous levels of NO_2 , and 96% of them are breathing dangerous levels of $PM_{2.5}$.

With the EU's new Ambient Air Quality Directive (AAQD) entering into force, national governments will need to establish "air quality roadmaps" in order to set a pathway to comply with the new European air quality standards for pollutants, including Nitrogen Dioxide (NO_2) and fine particulate matter ($PM_{2.5}$). In anticipation of the preparation of these air quality roadmaps, the Transport Alliance for Clean Air commissioned a study to Air Quality Consultants (AQC) to assess what transport interventions would be required in cities in order for them to reach the new European air quality standards for NO_2 and $PM_{2.5}$ in 2030 (respectively 20µg/m³ and 10µg/m³), and the WHO recommended concentrations for these same pollutants in 2040 (respectively 10µg/m³ and 5µg/m³).

Results of the modelling show that both **the EU limit values and WHO guidelines for NO_2 can be met respectively in 2030 and 2040 under each of the three following scenarios:**

1. Upgrading the entire internal combustion engine (ICE) vehicle fleet (covering cars, vans and trucks) to the latest relevant Euro standards (Euro 6d petrol cars and vans, Euro 6d temp diesel cars and vans and Euro VI trucks)

2. Electrifying parts of the ICE fleet (ranging from 15% to 57% depending on the vehicle type and the compliance year), prioritising older and more polluting combustion vehicles (diesel cars, combustion vans and trucks)
3. Favouring alternative mobility modes such as active mobility, public transport, and electric light mobility (e-scooters, e-bikes and electric cargo bikes) individual motorised trips.

However, **in order to reach the EU $PM_{2.5}$ limit values in 2030 and WHO guidelines in 2040, more ambitious transport measures are required that combine the three pathways listed above, including a significant reduction of traffic levels** (ranging from 10% to 50%, depending on the city).

These results can be transposed into the following policy recommendations:

- **Low-emission zones (LEZs)** should be designed in order to:
    - **Phase out diesel vehicles, and only allow the circulation of Euro 5 petrol cars, Euro 6d vans and Euro VI trucks from 2030.**
    - **Only allow the circulation of electric vehicles** (cars, vans and buses), as well as **Euro VI trucks by 2040.**
- **Scrappage schemes need to be established where not already in place**, as an incentive to accelerate the transition from polluting cars (particularly diesel) to electric.
- **Limited traffic zones need to be rolled out in large cities all over Europe** in order to reduce car and traffic levels by 25 to 50% for cars and by 5 to 25% for vans depending on the cities and the years, targeting transit trips in priority.
- **Public transport and shared and active mobility need to replace 25 to 50% of car trips, 5 to 25% of van trips by 2030 and 2040 respectively.**
    - **Incentives are therefore needed for the uptake of these mobility modes** such as mobility credits where scrapping an old polluting car will result in temporary free public transport passes.
    - Complementarily, road space needs to be reallocated in favour of infrastructure dedicated to transport modes other than cars, such as active mobility and public transport

1. Introduction

1.1 Context and purpose

Although improving, air pollution remains the biggest environmental threat to human health:[1] a silent killer that causes more than 300,000 premature deaths a year[2] in addition to causing various illnesses such as lung cancer, strokes, asthma, and is suspected to damage every organ in the human body.[3] Transport is a major culprit and specific action is needed to tackle a sector which accounts for almost half of all toxic emissions of Nitrogen Oxides (NOx) in Europe, and 9% of $PM_{2.5}$ emissions.[4]

With the new Ambient Air Quality Directive (AAQD) entering into force,[5] Member States will need to establish "air quality roadmaps" (formerly called "air quality plans"), in order to set a pathway to comply with the new European air quality standards for pollutants including Nitrogen Dioxide (NO_2) and fine particulate matter ($PM_{2.5}$). These air quality standards, called limit values[6], will kick in in 2030. Local authorities and more particularly city administrations will be the primary entities responsible for implementing the measures of these air quality roadmaps.

The Transport Alliance for Clean Air (TACA) is a group of companies and associations from the transport and mobility space that share a common vision for clean air in the EU. We believe that the private sector should be at the forefront of action to tackle toxic pollution, by helping authorities to strengthen controls over transport emissions and providing low- and zero-emission technologies, goods, and services. We stand ready to support and help shape a European policy framework that is fit for purpose to support the EU's vision towards Zero Air Pollution by 2050.

In anticipation of the preparation of these air quality roadmaps, the Transport Alliance for Clean Air (TACA) commissioned a study to Air Quality Consultants limited (AQC) to assess what transport interventions would be required in cities in

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[1] World Health Organization. (2021). *WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. Link.

[2] European Environment Agency. (2021). *Health impacts of air pollution in Europe, 2021*. Link.

[3] The Guardian. (2021). Revealed: air pollution may be damaging 'every organ in the body'. Link.

[4] European Environment Agency. (2022). Sources and emissions of air pollutants in Europe. Link.

[5] Council of the European Union. (2024). Air quality: Council gives final green light to strengthen standards in the EU. Link.

[6] More precisely, these are pollution concentration limits, expressed in µg/m³ (micrograms per cubic metres).

order for them to reach the new European air quality standards for NO_2 and $PM_{2.5}$ in 2030 (respectively 20µg/m³ and 10µg/m³), and the WHO recommended concentrations for these same pollutants in 2040 (respectively 10µg/m³ and 5µg/m³).

Many policy options exist when it comes to reducing emissions and lowering concentrations of pollutants: some focus on renewing vehicle fleets, some on reducing motorised traffic, or some promoting public transport and active mobility. It is crucial to determine which of these policies and combinations are the most effective in reducing emissions, and this study tries to shed light on what needs to be done for each urban transport mode in order to reach the objectives previously stated.

The modelling has been done for five cities in total: Paris, Milan, Warsaw and two 'synthetic' cities representing a typical large Western European city, and a typical large Eastern European city.

The first three cities have been chosen because they are representative of different European regions (Westen, Eastern and Southern Europe), in addition to having good air quality data. Air quality data from several large western and eastern European cities have been compiled in order to build a typical western and a typical eastern European city from an air quality concentration perspective. The logic behind picking two synthetic cities was to be able to derive results and policy recommendations that would closely resemble and fit most cities from the corresponding European regions.

1.2 Methodology of the study

The study models the effects of different transport-related measures on air quality concentrations in the five cities mentioned above. The model used measurements from the worst-performing monitoring stations in respective cities, as these are the stations that will ultimately determine whether the air quality standards are complied with or not.

The contribution from road traffic to the pollution levels at these stations was calculated by comparing the measurements of these stations with those of nearby 'background' stations, i.e. stations that are not pollution hotspots and which are therefore more representative of the levels of air pollution of the entire city. The same approach has been used for calculating baseline air pollution levels due to traffic in the synthetic cities.

The intention of the 'typical' city data is to present a reasonable worst-case of the roadside measurements reported to the EEA. For the 'typical' city, local traffic-related pollution levels have been defined as the 75th centile of all calculated NO_2 & $PM_{2.5}$ concentrations from local roads in the geographic area they represent. These values have been combined with the mean measured background concentrations which represent the average background across all of the data. Combining the 75th centile of local traffic-related NO_2 & $PM_{2.5}$ concentrations with the average background concentrations provides a reasonable worst-case. The fleet composition in the 'typical' Western European city was defined as the average of that in Paris and Milan. The relative importance of each vehicle type was then averaged across urban total fleet data held for France, Spain, Italy and Belgium. These countries were used owing to data availability. For the 'typical' Eastern European city, the fleets were derived using the data for Warsaw.

Projections on the future size of vehicle fleets have been determined by combining country-specific baseline fleet compositions from 2018, which were then adjusted for the future based on fleet projections from Transport & Environment. More information is available in Air Quality Consultants' technical report on the study.

Emissions were calculated using an emissions model developed specifically for this project, employing COPERT (V5.7) hot emissions factors[7] along with the Tier 2 methodology outlined in the 2024 update to the 2023 EMEP/EEA Emission Inventory Guidebook[8] (from road abrasion, tyre wear and brake wear). Future background concentrations were extrapolated from recent measurement trends, with the assumption that improvements would not fall below the levels observed during the COVID-19 pandemic.

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[7] 'Hot' emission factors refers to the emission of pollutants per km driven that are measured during the combustion process i.e. when the engine and exhaust components have reached their nominal operating temperature (as opposed to cold-start emissions. COPERT is the EU standard vehicle emissions calculator. It uses vehicle population, mileage, speed and other data in order to calculate emissions and energy consumption for a specific country or region.

[8] The guidebook, made by the UNECE in collaboration with the EEA, includes different methods for estimating emissions, which can vary based on the source of pollution.

Particulate Matter ($PM_{2.5}$) modelling and subsequent measures have been more challenging to define since this pollutant is mostly emitted as a result of energy consumption from buildings (58%), and by road transport to a much lesser extent (9%),[9] although it is slightly higher in cities (14% on average).[10] For comparison, 37% of NOx emissions come from road transport. This is even higher in cities: averaging at 47% on average and can even amount to 70% in cities like Milan or Athens.[11] Transport interventions have therefore less potential to reduce overall concentrations of $PM_{2.5}$. For example, the study found several instances where transport measures alone did not deliver sufficient $PM_{2.5}$ reductions needed to reach the air pollution concentration objectives.[12] In these cases, additional non-transport measures were assumed, which led to enough reductions of background levels of $PM_{2.5}$ for transport measures to be significant. More precisely these mostly addressed emissions from commercial and domestic heating for $PM_{2.5}$. These also also include more specific measures such as reduction of the use of commercial cooking, reduction of $PM_{2.5}$ emissions from non-road mobile machinery (NNRM), and reduction of agricultural ammonia emissions (ammonia chemically reacts in the air when emitted and forms secondary $PM_{2.5}$).

Four packages of transport measures - or pathways - were modelled for this study, each one with a slightly different focus and ambition level:

1. 'ICE Update' – focuses on upgrading the Internal Combustion Engine ('ICE') fleet to the latest Euro standards for both light- and heavy-duty vehicles. It does not rely on any additional uptake of EVs over that assumed in the future baseline scenarios and does not rely on traffic reduction measures or modal shift;
2. 'Accelerated EV' – this package focuses on upgrading parts of the ICE fleet to EVs. In most cases it does not rely on upgrading vehicles to alternative Euro standards (beyond that assumed in the future baseline) and does not rely on traffic reduction measures or modal shift;
3. 'Alternative Modes' – this package focuses on reducing trips made in passenger cars and vans. For passenger cars, trips are transferred to car

[9] European Environmental Agency (EEA). (2022). *Sources and emissions of air pollutants in Europe*. Link.
[10] Joint Research Centre (JRC). (2021). *Urban $PM_{2.5}$ Atlas.* Link.
[11] Joint Research Centre. (2019). Urban NO2 Atlas. Link.
[12] These instances were Milan for 2030 and 2040; Warsaw for 2040; Paris for 2030 and 2040; Eastern European city for 2030 and 2040; and Western European city for 2030 and 2040.

sharing, active and public transport, and to a set of vehicles collectively described as 'electric light mobility'.[13]

4. 'Going Further' – combines the measures from all of the above and shows how it would be possible to drive even larger air quality improvements and meet more challenging air quality standards. In many cases, the 'Going Further' package of measures can achieve larger improvements to concentrations with smaller changes to the existing vehicle fleet, since it draws from all available transport strategies.

A detailed explanation of the methodology and of the modelling containing all relevant data is included in Air Quality Consultants' technical report published alongside this briefing.

2. Results of the study

This next section will present the results of different transport measures on concentrations of NO_2 and $PM_{2.5}$ in selected cities and conclusions on what specific changes to transport systems must be made for these cities to comply with the new 2030 European air quality standards (20µg/m³ for NO_2, and 10µg/m³ for $PM_{2.5}$) and the WHO recommended levels by 2040 10µg/m³ for NO_2 and 5µg/m³ for $PM_{2.5}$. Policy recommendations for each city will also be derived from the scenarios modelled.

2.1 Paris

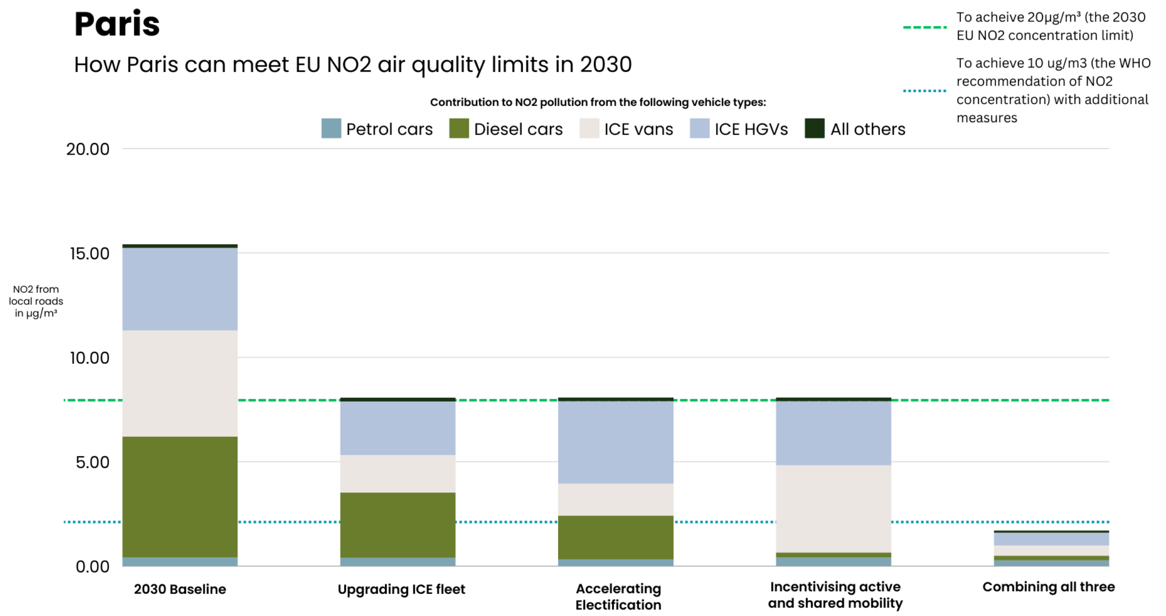
2.1.1 Results for 2030

Baseline projections for Greater Paris show that compliance with NO_2 European limit values in 2030 will necessitate reducing emissions from diesel cars, as well as internal combustion trucks and vans. $PM_{2.5}$ baseline projections for 2030 are quite positive, with projections projected to already be below the 10µg/m³ limit value.

[13] 'Electric light mobility' refers to any alternative to traditional cars and vans which has an electric motor (and is therefore distinct from 'active travel' although there can often be cross-overs). It includes, for example, electric bicycles, scooters, mopeds, cargo bikes, rickshaws and micro-cars.

Complying with the new European air quality standards for 2030 for NO_2 and $PM_{2.5}$ in Paris would be possible under every pathway modelled. Interestingly, the most ambitious pathway - 'Going Further' - would even already lead to compliance with the WHO recommended levels of NO_2 and $PM_{2.5}$ concentrations. The required measures to meet the EU limit values would mostly be to focus on pre-Euro 4 and 5 petrol and pre-Euro 6d temp diesel cars either by upgrading the entire fleet to Euro 6d, or electrifying and/or by electrifying 20% of the fleet. Replacing 24% of car trips with public transport, active and shared mobility would also work under the 'Alternative Modes' scenario. Similar options are also available for vans: upgrading all pre-Euro 4 petrol and pre-Euro 6 vehicles to Euro 6d, electrifying 41% of the fleet (i.e. all pre-Euro 5 petrol and Euro 5 diesel vans), or replacing 10% of the fleet with electric light mobility (e-cargo bikes). Finally, all trucks would need to be Euro VI under the 'ICE update' and 'Alternative Modes' scenarios, while no changes are needed in the 'Accelerated EV' scenario.

In order to comply with the 20μg/m³ NO_2 and 10μg/m³ $PM_{2.5}$ limit values in 2030, an update of the Greater Paris **low-emission zone (LEZ) needs to be made in order to restrict pre-Euro 4 or 5 petrol cars, pre Euro 6d temp diesel cars, all pre Euro 5 vans and pre Euro 6 diesel vans.** The newly established Limited Traffic Zone could be used to reduce motorised trips if the 'Alternative Modes' scenario is favoured**,** while the "Métropole Roule propre" scrappage scheme could be used to incentivise the uptake of EVs in the fleet for cars and vans. This will also help lower $PM_{2.5}$ concentrations, meaning that no additional measures would be needed for Paris to comply with the 10μg/m³ $PM_{2.5}$ limit value for 2030.



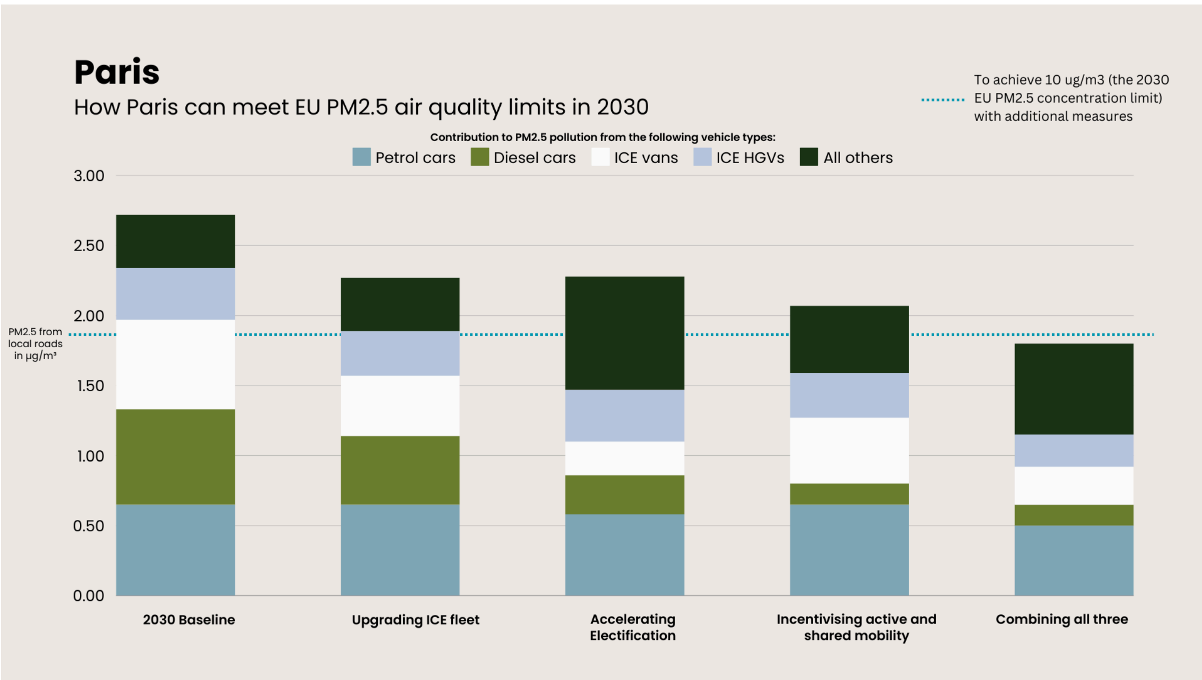


Figure 1: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2030 in Paris in the Baseline Scenario and with Four Alternative Packages of Interventions*[14]

[14] The scale on the left shows the pollutant concentration coming from transport only and not the overall concentration level based on the calculation explained in the methodology section

2.1.2 Results for 2040

Baseline projections for 2040 tell a different story than for 2030: for both NO_2 and $PM_{2.5}$, levels of concentrations are projected to be well above WHO recommended levels of respectively 10µg/m³ and 5µg/m³.

Still, every pathway modelled would allow Paris to comply with WHO recommended level of NO_2 concentration of 10µg/m³, with the "Going Further" pathway leading to even lower concentrations. To comply with WHO guidelines for NO_2, focusing on the remaining ICE fleet will be necessary either by upgrading the entire ICE cars and vans fleets to Euro 6d and Euro VI for ICE trucks, electrifying parts of the fleets (15% of cars, 16% for vans, 20% for trucks) or replacing some trips with light electric mobility and active / public transport (32% for cars and 25% for vans).

However, reaching WHO recommendations for $PM_{2.5}$ is only possible under the "Going Further" scenario, also assuming additional non transport-related measures. This is due to the limited effect of transport interventions on $PM_{2.5}$ concentrations as explained in section 1.2. The measures needed to achieve these concentrations mainly consist in phasing out petrol and diesel cars. To achieve the $PM_{2.5}$ objective, replacing 45% of car trips with active travel and public transport (30%), car sharing (10%) and electric light mobility (5%) would also be required. All van trips would need to be reduced by 25% and replaced by electric light mobility such as cargo bikes, while a third of the remaining vans on the road should be EVs, the rest shouldn't be older than Euro 6d.

A zero-emission zone (ZEZ) would therefore be needed in Greater Paris by 2040, only allowing EVs to circulate, combined with a limited traffic zone (LTZ) that should limit car trips to 55% of the current levels. In parallel, more **space should be allocated to active travel (walking and cycling), and car sharing schemes would need to be ramped up as well as incentives to use public transport**, in order to provide sufficient alternative transport options to inhabitants. Finally, the scrappage scheme "Métropole Roule Propre" should be maintained in order to offer access to either alternative mobility modes such as public transport and (electric) bikes, or to an electric vehicle for a reduced price in exchange of an old vehicle.

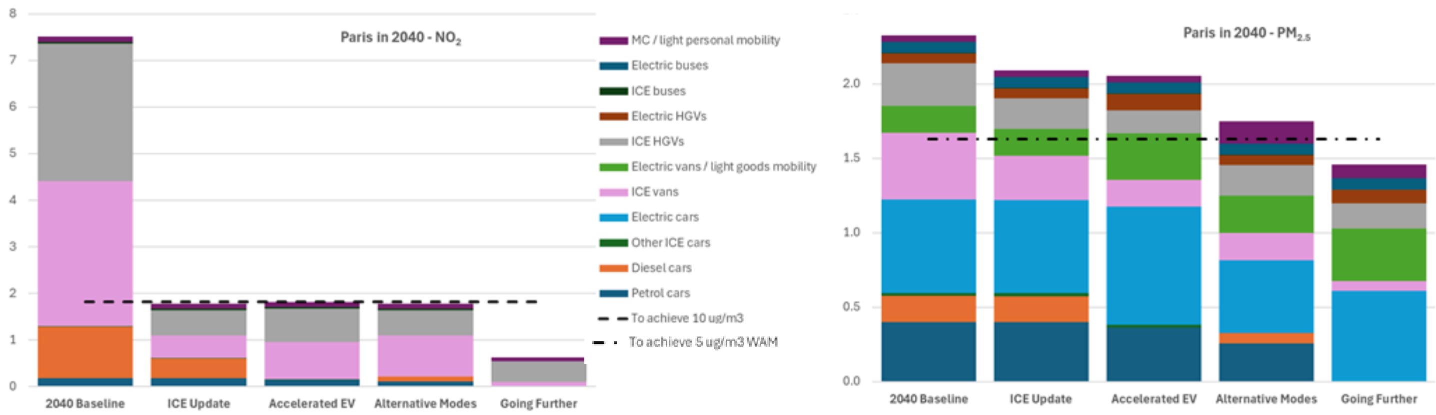


Figure 2: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2040 in Paris in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.2 Milan

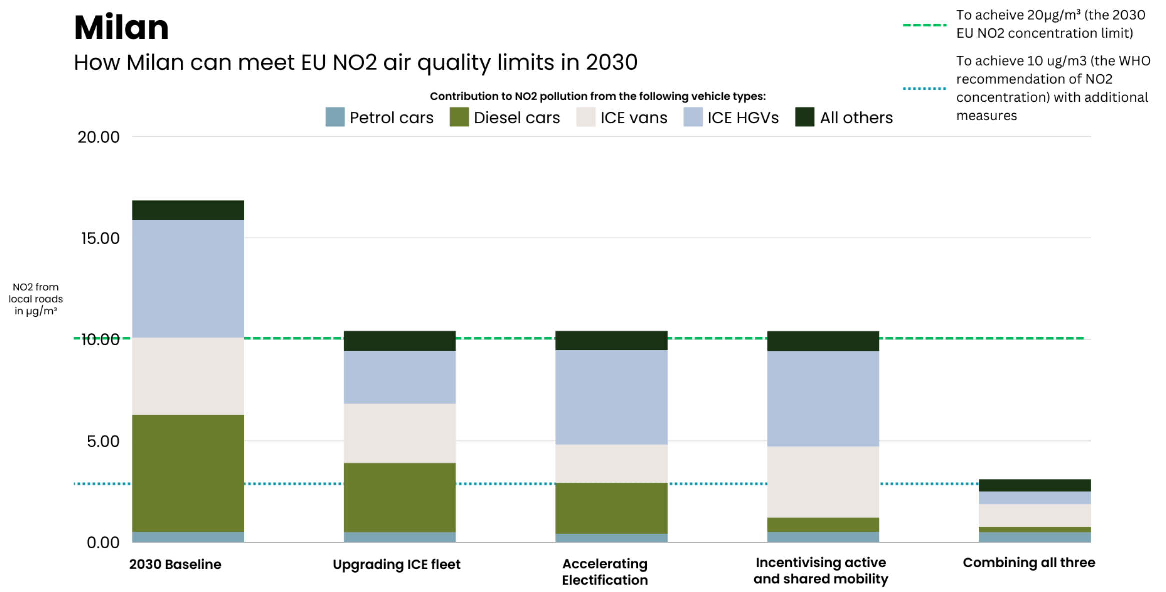
2.2.1 Results for 2030

Baseline projections for NO_2 and $PM_{2.5}$ concentrations in Milan tell a similar story as for Paris, with diesel cars as well as internal combustion vans and trucks being major contributors to NO_2 concentrations. Background levels are also crucial for $PM_{2.5}$, to a slightly lesser extent than for Paris.

The city of Milan would comply with the NO_2 limit value by 2030 under every modelled scenario, mainly by either upgrading the entire ICE fleet to latest Euro standards, electrifying or replacing with public transport pre-Euro 4 (or 5 depending on the scenario) diesel and pre-Euro 5 petrol cars, pre-Euro 4-5 (depending on the preferred scenario) vans. Pre Euro VI trucks should also be upgraded or electrified.

Reaching the $PM_{2.5}$ 2030 limit value would be more challenging, as it could only be done under the 'Going Further' scenario, also assuming additional non-transport measures that would help reduce background $PM_{2.5}$ concentrations**.** For cars, that means phasing out pre-Euro 4 petrol cars and pre-Euro 6d temp diesel. There would also need to be a 23% reduction of car trips, replacing 5% with electric light mobility (e-scooters, e-bikes), car sharing (5% too), and the remaining 13% with active travel. 15% of the van fleet would need to be replaced with electric light mobility, and another 15% would need to be electrified. Remaining vans should be Euro 6d standard. The truck fleet would also require some changes, starting by upgrading 50% of the fleet to Euro VI, and 25% to EVs. The bus fleet would need to be 100% electric, and all pre Euro 3 L category vehicles (motorcycles, mopeds, etc) would need to be upgraded to Euro 3 minimum.

Since the 'Going Further' scenario is the only one allowing for compliance with both limit values in 2030, its requirements are translated into the following policy recommendations: **Milan's LEZ would need to restrict pre-Euro 4 petrol cars, pre-Euro 6d temp diesel cars, non-electric vans, pre-Euro VI trucks, and pre-Euro 3 L vehicles.** An **upgrade of the Milan ZTL** (zona a traffico limitato or limited traffic zone) would need to be made in order to **reduce car trips by a quarter and van trips by 15% compared** to the projected baseline levels. Complementary to that, a scrappage scheme offering reduced prices for either using public transport or buying electric vehicles would be needed in order to reduce the overall number of trips.



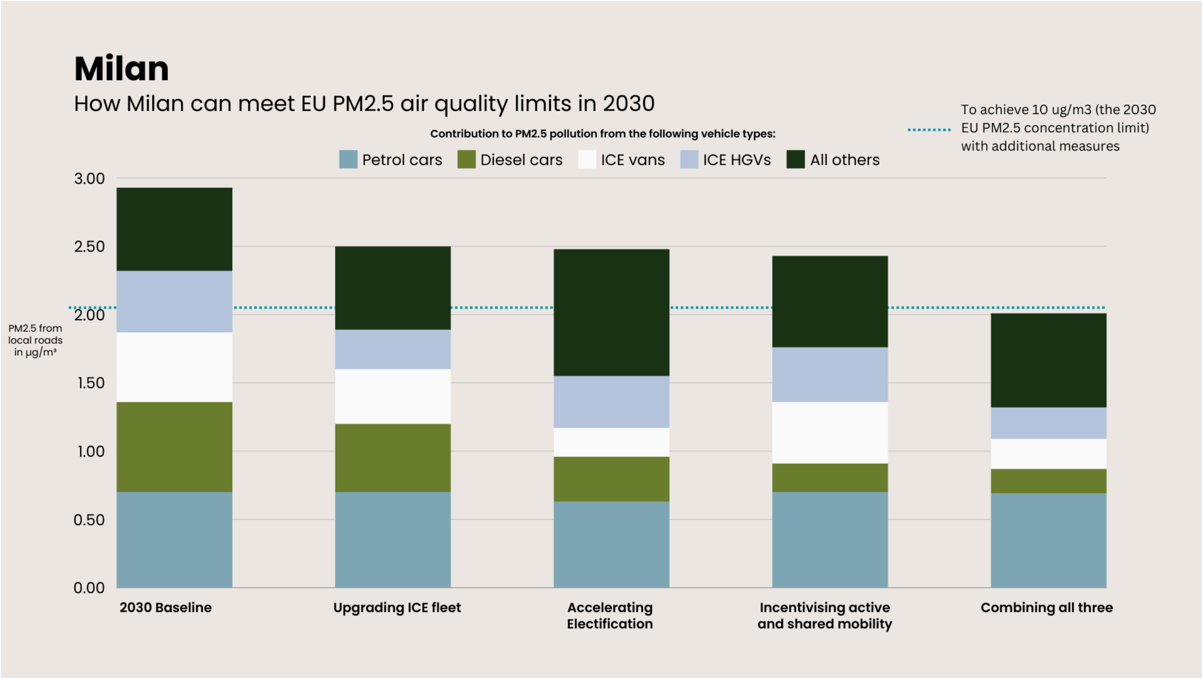


Figure 3: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2030 in Milan in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.2.2 Results for 2040

All modelled scenarios would lead Milan to comply with WHO recommendation for NO_2. This means that, as long as emissions from ICE trucks and vans, and diesel cars are addressed, the city administration is free to either focus on electrifying or replacing diesel cars and ICE vans with active and shared transport. More precisely, the 'ICE update' scenario would require an upgrade of the entire ICE fleet to the latest Euro standards. The 'Accelerated EV' scenario would require all pre-Euro 6d diesel cars, all pre-Euro 6 vans and all pre-Euro IV trucks to be electrified. Finally, the 'Alternative modes' scenario focuses on reducing motorised trips (-32% for cars, -20% for vans) and upgrading all pre-Euro V and 20% of Euro V trucks.

In 2040, $PM_{2.5}$ background levels in Milan are projected to be around 10µg/m³. Since the WHO recommended concentration level for $PM_{2.5}$ is 5µg/m³, it seems unlikely that it will be reached solely based on those projections. However, the projections used in the study are likely to be overestimates, meaning that further reductions of background levels of $PM_{2.5}$ are expected by 2040, which could therefore make the WHO recommendations reachable.

In practice, this means that important efforts are needed in the city of Milan to hope to reach the WHO recommendations on $PM_{2.5}$ concentrations, which is why the 'Going Further' scenario has been favoured here.

Cars and buses will need to be fully electric by 2040, with 50% of car trips being replaced by active and shared transport (23%), electric light mobility (12%) and car sharing (12%). All vans older than Euro 6d will also need to be removed, 25% of traffic being replaced by electric light mobility such as cargo bikes. The share of electric trucks will need to be doubled compared to the fleet projections used for the study, and the remainder of the fleet should only be composed of Euro VI trucks. Finally all L category vehicles should be Euro 3.

The required policy measures to adopt would therefore be a **ZEZ for cars and buses, and a strict LEZ for vans and trucks (Euro 6d and Euro VI** respectively). The **ZTL would have to cut car traffic levels by 50%** (further de-incentivising car use via circulation plans or congestion charges coupled with incentives for other mobility modes with additional measures such as scrappage schemes and mobility credits would be needed), and van trips by 25%.

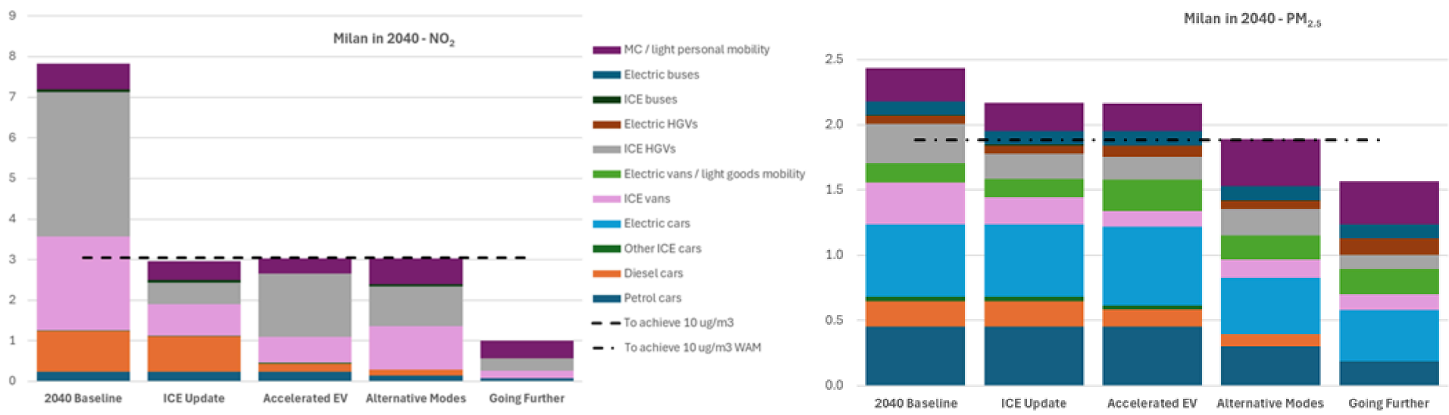


Figure 4: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2040 in Milan in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.3 Warsaw

2.3.1 Results for 2030

Warsaw's projected concentration levels of NO_2 and $PM_{2.5}$ in 2030 are different from the first two cities presented as they are projected to be much higher, mostly due to the foreseen increase of traffic levels and the older vehicle fleet. Moreover, internal combustion trucks and vans are the two biggest contributors to NO_2 concentrations, followed by diesel cars, whereas diesel cars had a bigger role for Milan and Paris. Interestingly, $PM_{2.5}$ background levels are expected to be lower in Warsaw than in Milan and Paris, probably due to the efforts already made to reduce heating $PM_{2.5}$ emissions.

All modelled scenarios, if applied, would allow the city of Warsaw to comply with the 2030 limit value for NO_2 , with most efforts focusing on reducing emission from ICE trucks, ICE vans, and diesel cars for all four scenarios by either upgrading the entire ICE fleet to the latest Euro standards, electrifying pre-Euro 5 cars, pre-Euro 6 vans and pre-Euro VI trucks to EVs, or replacing a share of the fleet of the first two with electric light mobility (or active/shared transport in the case of cars).

However, the $PM_{2.5}$ limit value would be more challenging in 2030, and require following the most ambitious pathway of 'Going Further'. As a result, pre-Euro 5 petrol cars and pre-Euro 6d temp diesel cars would need to be phased out, and car trips would need to be reduced by 43% with 10% by electric light mobility, 20%

with car sharing and 13% by active travel and public transport. Van trips would need to be reduced by 9% and replaced with electric light mobility, and the rest of the fleet would need to be upgraded to Euro 6d (except for 9% of the fleet that would need to be electrified). The truck fleet would also need to be upgraded to Euro VI.

The Warsaw LEZ would therefore need an upgrade to cover the entire city and only allow Euro 5 petrol cars and Euro 6d temp diesel cars. Vans below Euro 6d and trucks below Euro VI should not be able to circulate either. A **limited traffic zone should also be introduced** in order to reduce traffic levels of cars by 43% and van trips by 9%. Complementarily, **car sharing and shared micromobility schemes should be introduced** in order for inhabitants to have access to suitable alternatives. Finally, setting up a scrappage scheme would be necessary in order to incentivise the transition away from polluting cars to either alternative modes such as public transport and active/electric light mobility or electric vehicles.

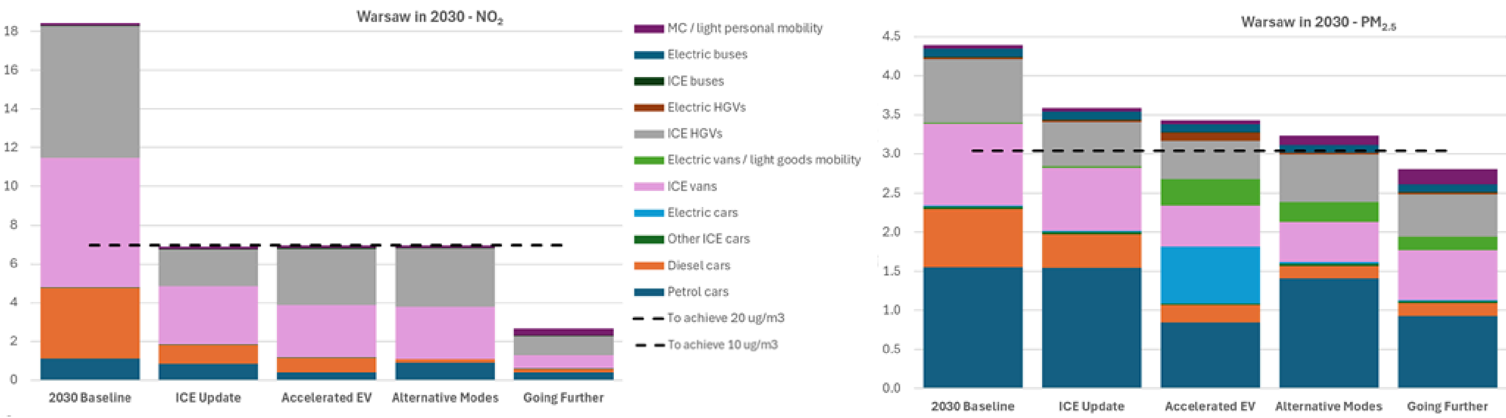


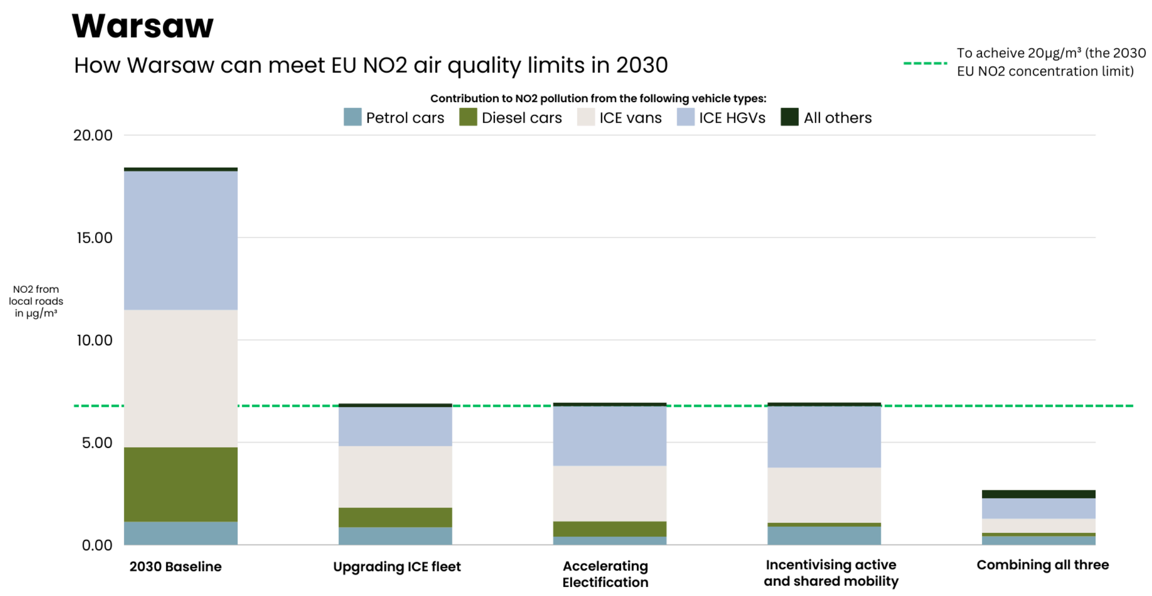
Figure 5: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2030 in Warsaw in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.3.2. Results for 2040

Reducing NO_2 concentration in Warsaw to WHO recommended levels will be more challenging than in some other cities for a few reasons. Firstly, traffic levels have been assumed to rise slightly in Warsaw until 2040, unlike the other cities modelled in the study. This assumption derives from T&E's scenarios on evolution of car traffic levels that forecast a rise of Polish traffic levels, as opposed to what has been assumed for Italian and French traffic levels. In addition, the car fleet in Poland is also older than the French and Italian ones, which lead to higher emissions overall, hence the slightly more important NO_2 concentration levels. Still, both the 'Accelerated EV' and 'Going Further' scenarios would lead to compliance with the 10µg/m³ concentration level of NO_2 recommended by the WHO. Under these scenarios, diesel cars would need to be almost completely phased out, with emissions from ICE vans and ICE trucks greatly reduced through electrification of 15%, 22% or 37% of the fleet depending on the preferred scenario.

Similarly to what has been modelled for 2030, reaching the 2040 target for $PM_{2.5}$ will only be possible under the most ambitious 'Going Further' scenario. Petrol cars are expected to be significant contributors to $PM_{2.5}$ emissions, as well as ICE vans to a slightly lesser extent. Reducing $PM_{2.5}$ concentration to 5µg/m³ would therefore require reducing car trips in the city by 50%, replacing 12% with electric light mobility, 15% with car sharing and 23% with active and shared mobility. Diesel cars would need to be completely phased out, and pre-Euro 6d cars.
Vans traffic levels would need to be slightly reduced (5%) and replaced with electric light mobility. 15% of the fleet needs to be electrified and the rest should have Euro 6d standard. Similarly, 10% of the truck fleet should be electrified, with the rest of the fleet complying with Euro VI standard. Buses would need to be fully electrified too.

Policy recommendations deriving from this scenario would require the **city of Warsaw to have a low-emission zone only allowing recent petrol cars to circulate (i.e. diesel cars should be phased out)**. It would also need to limit circulation to only **Euro 6d standard for vans, Euro VI standard for trucks**, and **electric buses**. Furthermore, a **limited traffic zone would need to be set up,** complemented with **a scrappage scheme in the form of mobility credits** where giving back an old car will result in reduced prices to use **alternatives such as car sharing, shared electric mobility and public transport. Adequate space and safe infrastructure for walking and cycling** are also needed.



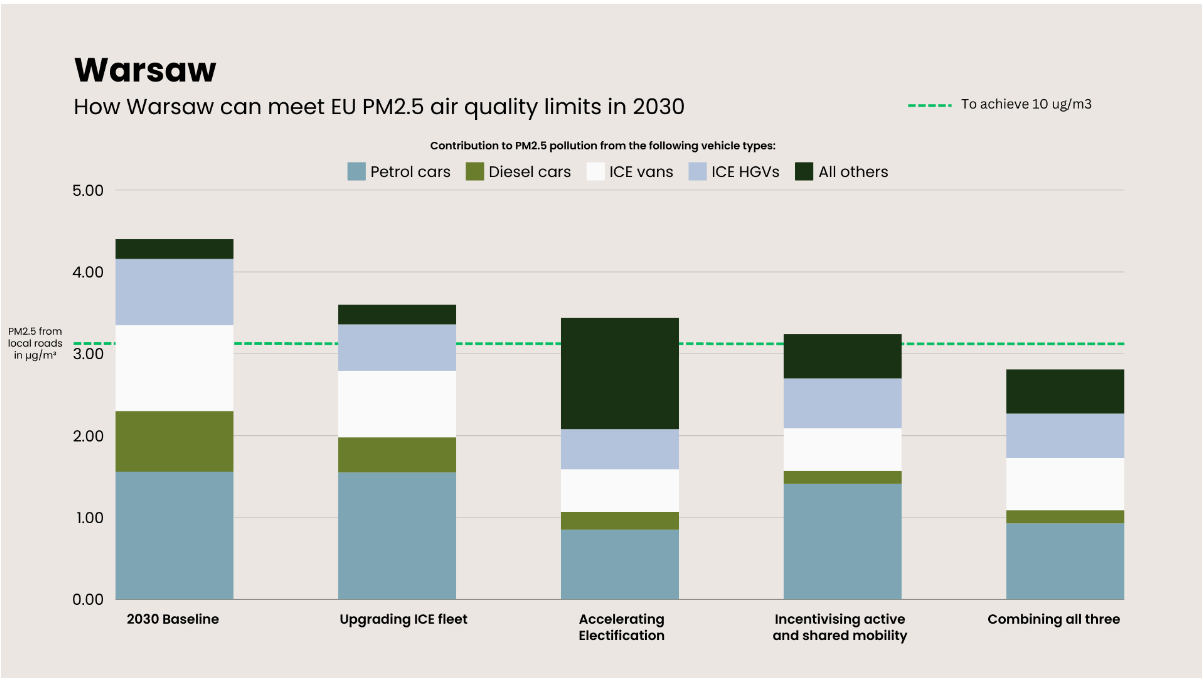


Figure 6: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2040 in Warsaw in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.4 Typical large western European city

2.4.1 Results for 2030

For a typical large Western European city, reaching the 2030 limit values for both NO_2 and $PM_{2.5}$ will be fairly easy, as baseline scenarios show that background concentration will decrease enough by then for compliance to be achieved without additional transport interventions.

The WHO recommended concentration levels for NO_2 could already be attained in 2030 in this typical large Western European city under all the modelled scenarios with additional non-transport measures. Opting for the 'Going Further' scenario would allow compliance with WHO recommended levels of NO_2 without additional non-transport measures, and would even allow compliance with the $PM_{2.5}$ WHO recommended limits with additional non-transport measures. Here too, targeting diesel cars alongside ICE vans and trucks is the most effective option in all scenarios. 15% to 41% of the fleets (starting with pre-Euro 6/VI vehicles) should either be electrified or replaced with electric light mobility and active/shared transport.

Complying with the WHO recommended levels of $PM_{2.5}$ concentrations by 2030 already would bring significant health benefits[15], but would only be possible under the 'Going Further' scenario. According to this scenario, a typical large western European city would need to reduce car trips by 42%, with 15% to be replaced with electric light mobility (e-scooters, e-bikes, e-mopeds), 7% with car sharing and 20% with active travel and public transport. A 20% increase of EVs in the fleet would also be needed. 25% of diesel van fleets would need to be replaced by electric light mobility (mainly electric cargo-bikes and quadricycles) another 25% by EVs, and the remainder of the fleet should comply with Euro 6d standard. The truck fleet would need to undergo similar upgrades, with 15% of the fleet needing to be electrified and the rest of the fleet needing to comply with Euro VI standards.

Large western European cities should therefore **introduce low-emission zones with a Euro 6d standard on petrol cars, a Euro 6d limit on ICE vans, and a Euro VI limit on trucks.** They should also **phase out diesel cars. Incentives for EVs to replace ICE vehicles (for cars, vans, and trucks)** should also be put in place.

[15] Failure to align with the WHO recommendations by 2030 is estimated to amount to 114,000 additional premature deaths a year across all European cities

More precisely, these could take the form of **scrappage schemes for cars and vans** which would provide targeted financial support to replace polluting cars with active and public transport and, where necessary, cleaner vehicles. These could also take the form of offering reduced parking fees for EVs more generally. Alternatives to private motorised vehicles need to be **incentivised, ranging from car sharing schemes to shared electric light mobility and increased space for active mobility.**

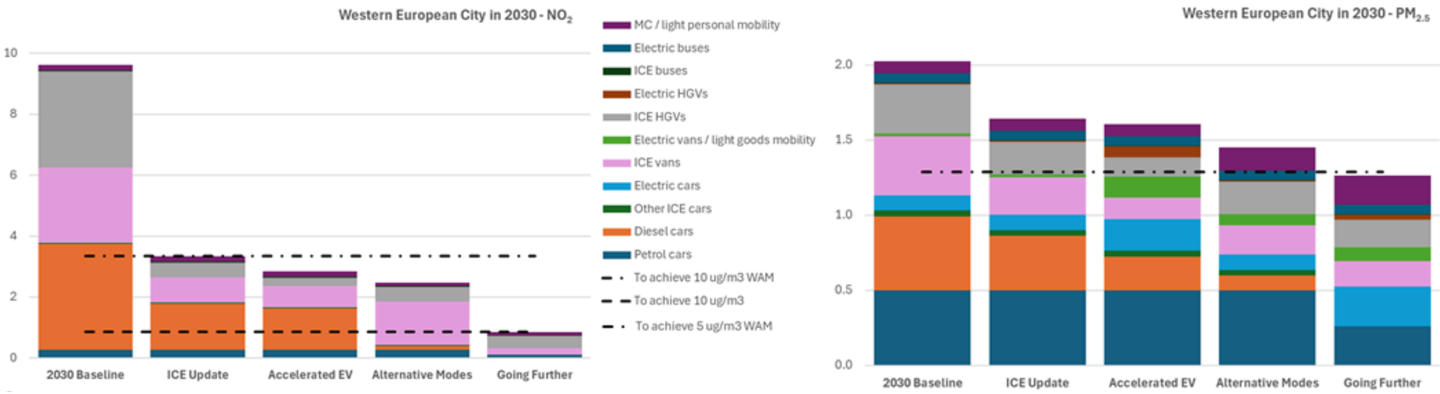


Figure 7: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2030 in the Western European City in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.4.2 Results for 2040

Similar to the results for 2030, all scenarios would lead a typical large western European city to comply with the NO_2 target for 2040, and would even lead to further reductions. However, the $PM_{2.5}$ target of 5µg/m³ would only be attainable under the 'Going Further' scenario, also assuming additional non-transport interventions.

More precisely, all diesel and pre-Euro 6d petrol cars would need to be phased out under this scenario. A 50% reduction of car trips would need to occur, with 25% being replaced by active travel and public transport, 18% with car sharing, and 7% with electric light mobility. The van fleets would need to be upgraded, mainly by electrifying 25% of them, replacing 25% of fleets with electric light mobility and having a Euro 6d standard on the remaining ones. Half of the truck fleets would need to be electrified, and the other half would need to be upgraded to Euro VI.

Finally, all pre Euro 3 L vehicles would need to be upgraded to Euro 3 minimum, and buses would need to be fully electrified.

The policies needed to enact these changes would be similar to the ones listed for 2030 with **low-emission zones phasing out diesel cars, introducing a Euro 6d standard on petrol cars, a Euro 6d limit on ICE vans, a Euro VI limit on trucks and a Euro 3 standard for L vehicles.** Under this scenario, incentives for electrification would be needed too, mainly via **scrappage schemes for cars and vans or reduced parking fees for EVs.** Complementary to that, a limited traffic zone for ICE trucks could be established, alongside the ramp up of **alternatives to private motorised vehicles such as car sharing and electric light mobility sharing schemes**, and **increased space for active mobility.**

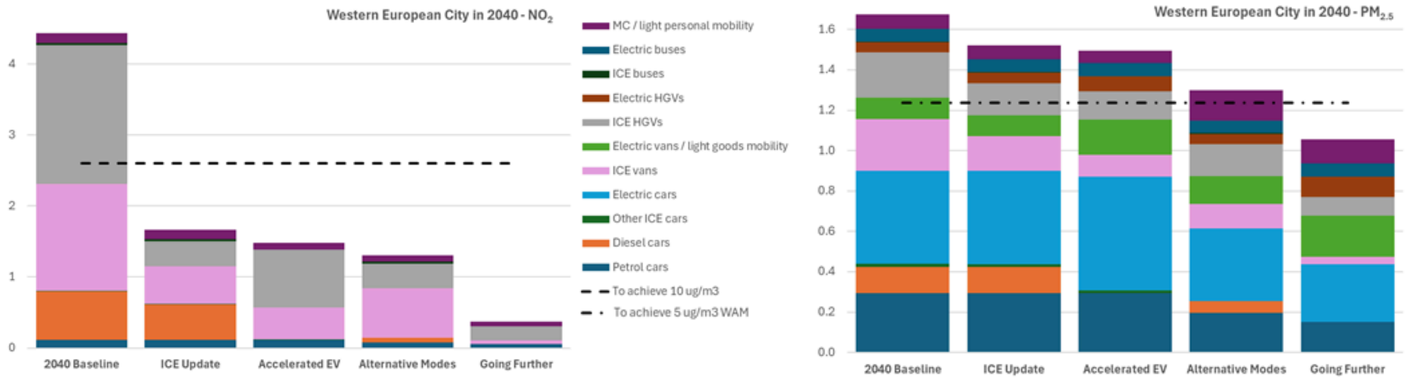


Figure 8: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2040 in the Western European City in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.5 Typical large eastern European city

2.5.1 Results for 2030

The air pollutant concentration projections for the typical large eastern European city are less optimistic than for the typical large western European city. While the 2030 NO_2 limit value of 20μg/m³ is largely reached under every scenario, with the 'Going Further' one even leading to compliance with the WHO recommendation of

10μg/m³, the situation for $PM_{2.5}$ is different. The 10μg/m³ limit value can only be reached with the most ambitious scenario ‘Going Further’ coupled with additional non-transport measures. This is due to high levels of background concentration of $PM_{2.5}$, which limits the impact of transport interventions.

ICE vans and trucks are the biggest contributors to NO_2 emissions, followed by diesel cars. All scenarios target these types of vehicles either through electrification of the fleets (prioritising pre-Euro 6d/VI vehicles) or replacing trips from those same vehicles with alternatives modes such as electric light mobility or active and shared transport in the case of cars.

As the ‘Going Further’ scenario is the only one leading to compliance with the 2030 limit values of $PM_{2.5}$, it will serve as a basis for our recommendations. This scenario would require phasing out pre Euro 6d temps diesel cars, as well as Euro 5 petrol cars. More precisely, a 43% reduction of all car trips would be needed, with 10% by electric light mobility, 20% with car sharing and 13% by active travel and public transport.
Van trips would need to be reduced by 9% and replaced with electric light mobility, and the rest of the fleet would need to be upgraded to Euro 6d (except for 9% of the fleet that would need to be electrified). The truck fleet would also need to be upgraded to Euro VI.

Similarly to Warsaw, this typical large eastern European city would need to introduce **a low-emission zone that covers the entire city and only allows Euro 5 petrol cars and Euro 6d temp diesel cars. Vans below Euro 6d and trucks below Euro VI should not be able to circulate either**. A **limited traffic zone should be introduced** in order to reduce traffic levels of cars by 43%, (here too, further de-incentivising car use via circulation plans or congestion charges coupled with incentives for other mobility modes with additional measures such as scrappage schemes and mobility credits would be needed) and van trips by 9%. Complementarily, **car sharing and shared micromobility schemes should be introduced** in order for inhabitants to have access to suitable alternatives. Scrappage schemes in the form of mobility credits would also be needed in order to make those alternatives more accessible financially.

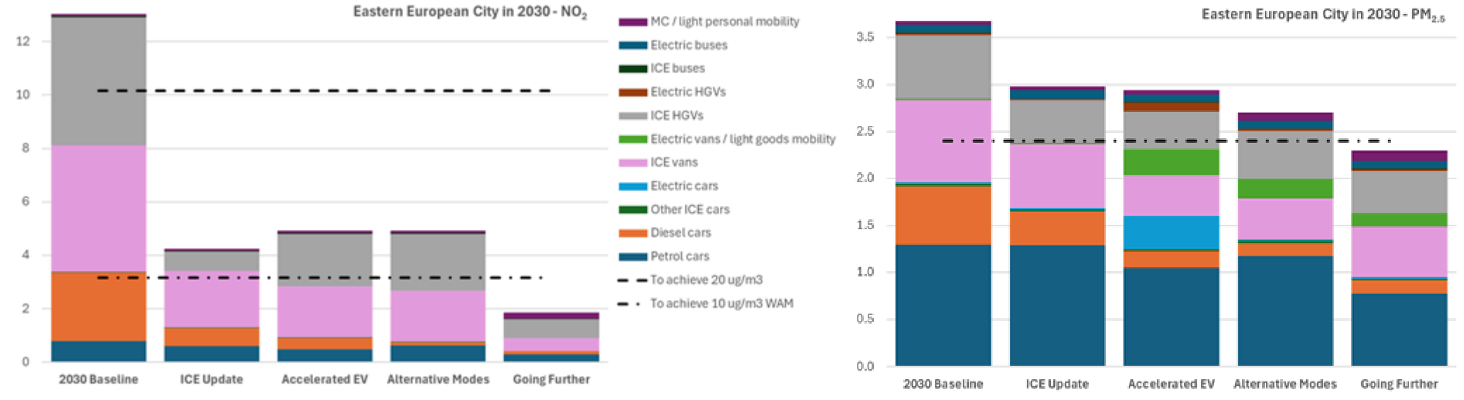


Figure 9: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2030 in the Eastern European City in the Baseline Scenario and with Four Alternative Packages of Interventions*

2.5.2 Results for 2040

This typical large eastern European city will be able to meet WHO recommendations for NO_2 concentrations under every scenario modelled, with the 'Accelerated EV' and 'Going Further' scenarios leading to concentration levels even below 10µg/m³. More precisely, all scenarios require to phase out Euro 6d temp diesel and Euro 6 petrol cars and vans, and Euro VI trucks. Since all scenarios would allow compliance, these vehicles could be replaced either by EVs, or alternative modes in the case of cars and vans such as electric light mobility and/or active / public transport (for cars only).

However, meeting the $PM_{2.5}$ concentration levels recommended by the WHO will be much challenging since projected background levels of $PM_{2.5}$ alone will overshoot the 5µg/m³ concentration level. It is worth bearing in mind that the assumptions used are likely to overestimate these concentration levels, which means that further reductions of background levels of $PM_{2.5}$ are to be expected by 2040, thus making the WHO recommendation achievable.
'Going further' in 2040 here would mean phasing out diesel cars, and only allow petrol cars with a Euro 6d to circulate in the city, as well as EVs. This scenario would also require reducing car trips by 40% with half of them being replaced by active travel and public transport, and the other half being replaced by electric light mobility and car sharing equally. A Euro 6d limit for vans circulating in the city would be needed, with 15% of the fleet needing to be electrified and 5% being

replaced by electric light mobility. A Euro VI limit would need to be introduced to the trucks fleet, and 10% of this fleet would need to be electrified. Finally, buses would need to be fully electrified.

These requirements would require the introduction of a **low-emission zone only allowing Euro 6d petrol cars and EVs. This LEZ would also need to have a Euro 6 standard for vans, a Euro VI standard for trucks, and would need to be a ZEZ for buses,** only allowing electric ones to circulate. In parallel, **scrappage schemes for cars and vans** would need to be introduced as a way to encourage the electrification of the fleet. Since scrappage schemes are hardly applicable to trucks due to their high cost, a limited traffic zone for ICE trucks seems more fit for purpose. Finally, **alternatives to private motorised vehicles such as car sharing and electric light mobility sharing schemes**, would need to be made available, as well as an **increase of space for active mobility.**

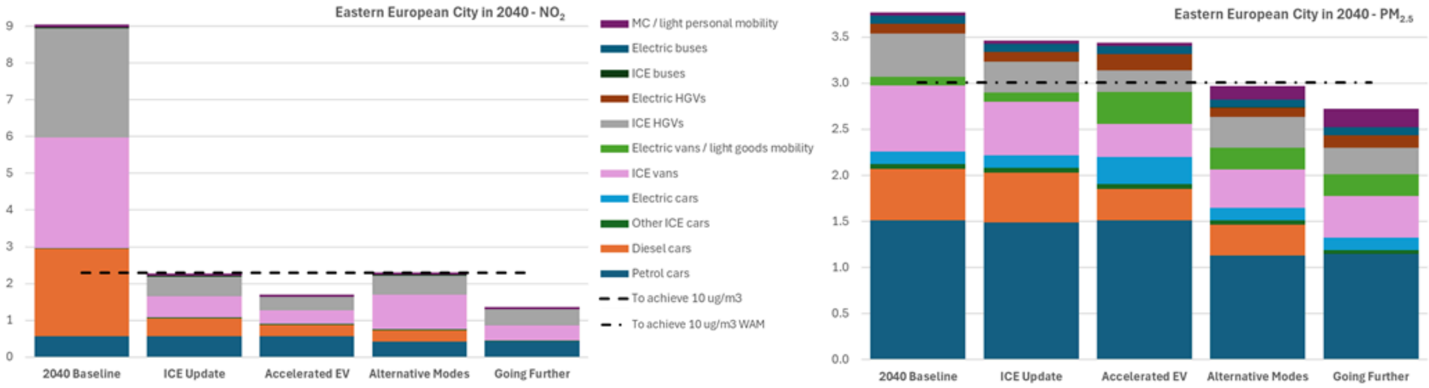


Figure 10: *NO_2 and $PM_{2.5}$ Concentrations from Local Roads in 2040 in the Western European city in the Baseline Scenario and with Four Alternative Packages of Interventions*

3. Policy recommendations

The previous section has shown that while each city has different baseline levels of air pollution and sizes of the vehicle fleets, specific policy measures to get to the targeted objectives will need to be tailored according to local context. Table 1 at the end of this section summarises the different transport measures that would need to be taken in 2030 and 2040 in each city in order to comply with the objectives.

However, there are some one-size-fits-all measures that cities can adopt as a priority in order to reduce traffic emissions from diesel cars, ICE vans and ICE trucks, as they are the most emitting vehicles from the fleets in all cities. The uptake of electric mobility is key to reducing NO_2 emissions and therefore NO_2 concentrations in every city. Some broad policy recommendations that will help all cities to deliver reductions of air pollution concentrations have been derived from these observations. They should be slightly more ambitious than what the study results suggest because the compliance rate for what is needed is rarely 100%. As a result, more ambitious measures are recommended here, which should serve as a safety net in the likely case compliance is not total.

- Low-emission zones (LEZs) should be designed in order to:
  - Phase out diesel vehicles, and only allow the circulation of Euro 5 petrol cars, Euro 6d vans and Euro VI trucks from 2030
  - Only allow the circulation of electric cars, vans and buses, as well as Euro VI trucks by 2040
- Scrappage schemes need to be established where not already in place, as an incentive to accelerate the transition from polluting cars (particularly diesel) to electric.

Complementary to these recommendations is the improvement of air pollution monitoring via the use of reliable technology in conjunction with regulatory-grade instruments. For this reason, the European Commission should promote the adoption of CEN/TS 17660:2022[16] as an EU Standard across Member States. This would ensure consistency with the data quality objectives for Indicative Measurements outlined in the Air Quality Directive 2008/50/EC. Standardizing CEN/TS 17660:2022 would facilitate the deployment of Class 1 air quality sensor systems in low emission zones and other projects, thereby enhancing regulation enforcement and improving data reliability for impact assessment.

Changing mobility habits, mainly by transitioning away from individual motorised trips whenever possible, will be crucial in reaching $PM_{2.5}$ European limit values in 2030 and WHO recommendations in 2040. Consequently, alternative mobility modes need to be made more accessible, more convenient, safer and cheaper in order not to penalise city dwellers.

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[16] Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air (Endorsed by Asociación Española de Normalización in February of 2022.). Link.

- Limited traffic zones need to be rolled out in large cities all over Europe in order to reduce car and traffic levels by 25 to 50% for cars and by 5 to 25% for vans depending on the cities and the years, targeting transit trips in priority. These zones would need to be complemented by additional measures aiming to cut traffic such as circulation plans, parking management measures or congestion charges.
- Public transport as well as active and shared mobility need to replace 25 to 50% of car trips, 5 to 25% of van trips by 2030 and 2040 respectively. Service quality, frequency and coverage need to be improved, complemented by incentives leading to the uptake of these mobility modes:
    - Space needs to be reallocated from cars to active travel (walking and cycling), and light electric mobility (e-scooters and e-(cargo) bikes mainly).
    - More specifically, implementing the EU Declaration on Cycling[17] is an important step towards cleaner air in Europe by making cycling safer, more inclusive and more affordable, and by generating more insightful and reliable data on the development of cycling infrastructure.
    - Scrappage schemes should offer mobility credits to city inhabitants wanting to scrap or retrofit their older vehicles and use cleaner modes of transport or vehicles. For example, this could take the form of temporary free public transport passes when giving back an old polluting car.

[17] European Commission. (2024). *European Declaration on Cycling.* Link.

Table 1: Overview of measures to achieve EU 2030 limit values for NO_2 and $PM_{2.5}$[18] and WHO recommended air quality guidelines[19]

City	Paris	Milan	Warsaw	Western European City	Eastern European City
2030 policy measures	Low-emission zone banning: • Pre Euro 5 petrol cars and vans, • Pre Euro 6 diesel cars and vans	Low-emission zone banning: • Pre Euro 4 petrol and pre Euro 6d temp diesel cars: • Pre Euro 6d vans • Pre Euro VI trucks • Pre Euro 3 L vehicles Limited traffic zone upgrade: • Reducing car trips by 25% • Reducing van trips by 15%	Low-emission banning: • Pre Euro 5 petrol and Euro 6d temp diesel cars • Pre Euro 6 vans • Pre Euro VI trucks Limited traffic zone reducing: • Car trips by 43% • Van trips by 9% Introduction of car sharing and shared micromobility vehicle fleets	Low-emission zone banning: • Pre Euro 6d petrol and banning diesel cars • Pre Euro 6d vans • Pre Euro VI trucks Incentives to fleet electrification: • Scrappage schemes resulting in mobility credits for cars and vans Incentives for alternative mobility modes such as: • Car sharing schemes • Shared electric light mobility • Increased space for active mobility	Low-emission zone banning: • Pre Euro 5 petrol and Euro 6d temp diesel cars • Pre Euro 6d vans • Pre Euro VI trucks A limited traffic zone reducing: • Car trips by 43% • Van trips by 9% Incentives to fleet electrification: • Scrappage schemes resulting in mobility credits for cars and vans Incentives for alternative mobility modes such as: • Car sharing schemes • Shared electric light mobility • Increased space for active mobility
2040 policy measures	Zero-emission zone for: • Cars, vans and buses Limited traffic zone reducing: • Car trips by 45% • Van trips by 25%	Zero-emission zone for: • Cars and buses Low-emission zone banning: • Pre-Euro 6d vans • Pre-Euro VI Limited traffic zone reducing: • Car trips by 50% • Van trips by 25% Incentives for: • Public transport • Electric light mobility • Car sharing	Low-emission zone banning: • Pre Euro 6 petrol cars • Pre Euro 6d vans • Pre Euro 6 trucks • Only electric buses should be allowed Limited traffic zone reducing: • Cars trips by 50% • Van trips by 5% Incentives for: • 23% of car trips replaced by active mobility and public transport	Low-emission zone banning: • Pre Euro 6d petrol cars and banning diesel cars • Pre Euro 6d vans • Pre Euro VI trucks • Pre Euro 3 L vehicles • E-buses only Limited traffic zones reducing: • Car trips by 50% • Van trips by 25% Incentives to fleet electrification: • Scrappage schemes resulting in mobility credits for cars and vans Incentives for alternative mobility modes such as: • Car sharing schemes • Shared electric light mobility • Increased space for active mobility	Low-emission zone banning: • Pre Euro 6d petrol cars and diesel cars • Pre Euro 6d vans • Pre Euro VI trucks • Pre Euro 3 L vehicles • Non-EV buses Limited traffic zones reducing: • Car trips by 50% • Van trips by 25% Incentives to fleet electrification: • Scrappage schemes resulting in mobility credits for cars and vans Incentives for alternative mobility modes such as: • Car sharing schemes, • Shared electric light mobility • Increased space for active mobility

[18] European Commission. (2024). Directive 2024/2881. Link.

[19] World Health Organization. (2021). *WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. Link.