EURO 7 IMPACT ASSESSMENT: THE OUTLOOK FOR AIR QUALITY COMPLIANCE IN THE EU AND THE ROLE OF THE ROAD TRANSPORT SECTOR

NITROGEN DIOXIDE SUPPLEMENT

An independent study undertaken on behalf of ACEA

AERISEUROPE
Air Quality Intelligence

Executive Summary

This report is part of a Euro 7 Impact Assessment[a] commissioned by ACEA[1] to quantify the impact on measured air quality in urban environments throughout the EU[2] between 2020 and 2035 from the implementation of currently mandated emission reduction measures[3] in all contributing sectors, including road transport.

The main study explored NO_2, PM2.5, PM10 and Ozone; the aim of this supplementary report is to focus on the effect of these measures on atmospheric concentrations of NO_2, including the impact on compliance with legislated EU Ambient Air Quality Limit Values (AQLV) and World Health Organisation (WHO) guideline values. In the case of NO_2, the current EU AQLV is set at an annual mean of $40\mu g/m^3$, the same as the current WHO guideline value.

Although the focus of the study is road transport, by including emissions from all source sectors the contribution from each sector can be evaluated to provide an overall EU air quality perspective. The additional impact on air quality from a series of scenarios that might additionally reduce road transport emissions (if these were the only regulatory measure) is also explored.

The emissions Base Case adopted for this study is consistent with the Thematic Strategy on Air Pollution Report #16 Current Legislation Baseline Scenario data from the GAINS[4] model for all sectors except road transport. Road transport emissions are derived from the SIBYL[5] baseline fleet and COPERT[6] emission tool. Specific elements of the Baseline fleet have been modified to more accurately reflect the anticipated real-world fleet composition predicted by ACEA.

The results indicate that the introduction of the full range of Euro7/VII[7] NO_X emission limit scenarios explored in this study result in very limited further reductions in road transport emissions beyond that achieved in the Euro 6d/VI Base Case. **Table 1** summarises the Base Case emission reductions from 2020 to 2030/35 and the range of additional reductions from all the scenarios explored in this study.

Table 1 - NO_X - Emission reductions delivered by the Base Case and the range of additional reductions delivered by the various Euro 7/VII scenarios

NO_X Emissions - Road Transport	**2030 (% reductions from 2020)**		**2035 (% reductions from 2020)**	
	Base Case	**Scenarios**	**Base Case**	**Scenarios**
Euro 7 Final Scenarios (diesel cars and vans)	66.7%	0.9 - 3.4%	79.0%	1.1 - 4.6%
Euro VII Scenarios (heavy duty vehicles)		0.1 - 1.6%		0.1 - 2.4%

The study also explores the benefits that result from the early replacement of Euro 3/III through to Euro 5/V vehicles with Euro 6/VI vehicles in the 2020/21 diesel passenger and heavy-duty vehicle parc.

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[1] The European Automobile Manufacturers' Association (ACEA) represents the 15 major Europe-based car, van, truck, and bus makers.

[2] For the purposes of this study, the 'EU' includes the EU 27 nations and the United Kingdom.

[3] Where it has not been possible to quantify the impact of a measure, for example the Medium Combustion Plant Directive, emissions have not been reduced.

[4] The Greenhouse gas - Air pollution Interactions and Synergies (GAINS) model, developed at the International Institute for Applied Systems Analysis (IIASA).

[5] SIBYL baseline: vehicle fleet and activity data projections for the member states of the of the EU.

[6] COPERT is the EU standard vehicle emissions calculator, developed and maintained by EMISIA SA for the EEA.

[7] Euro 7/VII refers to possible new standards beyond the current Euro 6/VI emission standard. The introduction of a range of potential Euro 7/VII standards are explored in this report.

In contrast to the very limited further reductions resulting from the introduction of a 'zero-exhaust' Euro 7/VII emission standard, early replacement (via an incentivised early scrappage scheme for example) would, on a vehicle for vehicle basis, result in some 6 to 25 times the emission reduction benefits for NO_X. Importantly, these benefits would also be realised much earlier. The full monetised benefits of such schemes will be more fully set forth in a planned follow-up report exploring the cost-benefits of a possible future Euro 7/VII.

The concentrations at urban monitoring stations across the EU have been modelled using the AQUIReS+ model, developed by Aeris Europe and used in previously published works on urban air quality.[b, c]

Regarding the impact on air quality, the results of this study indicate that currently mandated (Base Case) measures will achieve widespread compliance (~99% of stations) with the current NO_2 AQLV by 2025. Furthermore, all of the 'beyond the baseline road transport scenarios' explored in this study have negligible impact on the compliance picture.

If further reductions in concentration are to be realised, then the results indicate that the most effective strategy would be to target those sectors that are demonstrated to have the greatest scope for reduction, for example domestic and commercial combustion. Since the remaining areas of NO_2 non-compliance are limited to a small number of monitoring stations, achieving compliance in these instances would be more effectively realised by introducing local measures that target the specific contributors to non-compliance at these geographically limited areas. Many successful examples of targeted local measures exist, including low emission bus schemes and urban access restrictions by vehicle technology.[d,e] None of the modelling in this study suggests that any further European-wide measures are warranted to achieve compliance with the currently legislated AQLV.

The study also explores the impact of the outbreak of SARS-COV-2 (COVID-19) on air quality, with a particular focus on nine selected cities[8] and the 'Innsbruck Transit Corridor'. The modelled COVID scenarios were confined to a range of reduced road transport activities - ranging from a 25% to 75% reduction in activity.

In the case of urban NO_2, measurement station data in almost all cases indicates a more significant reduction in concentrations during the lockdown periods than the modelled responses. This is in-line with the important un-modelled, retained NO_X contribution from domestic and commercial combustion systems in cities. During lockdown, the emissions from these sources were also significantly reduced (by the move from office to working from home for example) but the effect of this was not included in the COVID scenarios explored in this study. In the case of the Innsbruck Transit Corridor, where heating emissions are not present, the NO_2 measurements are within the range of the modelled scenarios.

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[8] Berlin, Brussels, London, Madrid, Milan, Paris, Rome, Stuttgart, and Warsaw

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[a] (Aeris Europe, 2021) *Euro 7 Impact Assessment: The Outlook for Air Quality Compliance in the EU and the Role of the Road Transport Sector*

[b] (Aeris Europe, 2016) *Urban Air Quality Study, #11/16*

[c] (Concawe, 2018) *A comparison of real driving emissions from Euro 6 diesel passenger cars with zero emission vehicles and their impact on urban air quality compliance*

[d] https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/low-emission-bus-zones-evaluation-report

[e] https://www.polisnetwork.eu/news/baden-wurttemberg-the-lez-of-stuttgart-delivers-good-results/

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Revision: 1

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Introduction

Air Quality in European Cities continues to be an issue of policy and public concern at European, national and city level. Over the last five years, much attention has focussed on non-compliance with the current AQLV for ambient nitrogen dioxide (NO_2). There have been legal actions[1,2,3] in individual member states and EU infringement proceedings[4] against member states who have failed to comply with the AAQD in reducing NO_2 levels to within the current AQLV. The primary mechanism for reducing urban concentrations of NO_2 has been to target the emissions from road transport, with the recent focus on diesel vehicles.

The forthcoming revision of the AAQD is likely to reduce the permitted concentrations of specific pollutants. If enacted, this will intensify the current concerns over air quality and increase the focus on those emission sources that are contributors to non-compliance. This NO_2 focussed report includes details of the current and projected NO_2 emissions inventories identifying the main contributing sources and sectors as well as their potential for reductions.

With the above as background, the European Commission have started to prepare draft regulatory proposals for the next iteration of vehicle emission standards. To assist in the formulation of these Euro 7/VII proposals, the Commission have contracted members of CLOVE (Consortium for Ultra Low Vehicle Emissions) to conduct a series of studies.

The aim of this ACEA commissioned independent study is to put the contribution of road transport emissions into a Europe-wide context by examining the impact on urban air quality that currently mandated emission reduction measures from all contributing sectors will achieve. This is followed by an assessment of what a further tightening of Euro standards, including a hypothetical 'Euro 7/VII' can offer to the improvement of air quality compared to other available actions.

The AQUIReS+ model has been used to forecast the effect of emissions changes on atmospheric concentrations at urban monitoring stations across the EU from 2020 to 2035. This ensures the modelling is directly related to the individual measuring stations used to monitor compliance with the legislated limit values. In this regard, it is worth noting that these limit values, as set forth in the Ambient Air Quality Directive, are the result of a lengthy legislative process beginning with the 'Risk Assessment' step undertaken by the WHO and concluding with the 'Risk Management' step during the finalisation process of the Directive. As such, these limits represent the legislator's view of the appropriate level of managing the risk associated with human exposure to each pollutant in the context of a multi-risk world. Therefore, from an air quality perspective, compliance with limit values must be the priority for the protection of human health.

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[1] https://www.clientearth.org/latest/latest-updates/news/clientearth-wins-air-pollution-case-in-high-court/

[2] https://www.umweltbundesamt.de/en/press/pressinformation/air-quality-2020-only-a-few-cities-still-exceed

[3] https://www.umweltbundesamt.de/staedte-no2-grenzwertueberschreitungen

[4] https://ec.europa.eu/commission/presscorner/detail/en/IP_17_238

Methodology

For full details of the methodology and modifications to the vehicle fleets please see the main report: *Euro 7 Impact Assessment: The Outlook for Air Quality Compliance in the EU and the Role of the Road Transport Sector*[a].

What follows here is a summary of the important elements.

Emissions Base Case

The emissions Base Case used in this study is aligned with the January 2015 Thematic Strategy on Air Pollution Report #16 (TSAP16) Working Party for the Environment (WPE) Current Legislation Baseline Scenario.[b,c] This emissions data set was developed for the EU Air Policy Review process,[d] and was generated by IIASA's GAINS model.

The reference activity projections included in the national, sectoral emissions totals are based on the PRIMES 2013 reference activity projections, however they obviously exclude the effects of further measures that were legislated in response to the findings of the Clean Air Programme for Europe. Examples of these are, the Medium Combustion Plants Directive (MCPD) and the latest National Emissions Ceilings Directive (NECD).[e,f] As a result, the Base Case adopted for this study should be considered as somewhat under-estimating anticipated overall emissions reductions.

Road transport emissions in the Base Case are based on the 'SIBYL Baseline' fleet and activity dataset, produced by Emisia S.A. This dataset was chosen as it has been used by the CLOVE consortium in their work supporting the EU Commission review of future vehicle emission standards. The SIBYL Baseline includes vehicle fleet, activity, emissions, and energy consumption projections for the EU 27 member states and 6 additional countries, including the UK. In this study the SIBYL Baseline fleet data set of May 2020, as presented in the Emisia ERTE 2020 report[g] was used as the starting vehicle fleet.

A review of the SIBYL fleet data showed a somewhat ambitious uptake of plug-in hybrid and battery electric vehicles in the passenger car (PC) fleet category beyond 2020. It also showed no penetration of Zero or Low Emission Vehicles (ZLEV) in any of the other fleet categories. In consultation with ACEA experts, an alternative view of new registration penetration rates for zero and low emission vehicles (ZLEV) was developed across all fleet categories. For cars and HDVs an additional 'high-penetration' sensitivity case was also developed. These reflect ACEA estimates of fleet electrification based on future CO_2 benchmarks (2025/2030)[h,i] and the expected impact of the Clean Vehicle Directive[j]. In view of the 'Green Deal', the already considered greenhouse gas reduction targets for 2030, and the CO_2 reviews in 2020/21, these fleet electrification penetration rates are likely to be underestimates.

COPERT version 5.3.26 was used in this study but with important modifications to Euro 6/VI diesel NO_X emission factors. These modifications were made following a back-calculation of emission factors from the SIBYL Baseline data and adjusted in consultation with ACEA and a review of measurement data.

The full results of these modifications and their rationale can be found in the main study.

Overview of Base Case emissions by Sector - NO_X

This focus study gives additional details of the NO_X emissions sources that are described in the main report.

Figure 1 shows the total EU NO_X emissions in the Base Case used in this study. Each source sector is shown separately so that the contribution of each sector to overall emissions can be clearly seen. Over the fifteen-year period, from 2005 to 2020, emissions from all major sectors have declined, however some sectors have experienced significantly greater reductions than others. Road-transport has seen the greatest reduction of all, with a 54% reduction from 2005 to the present day.

By 2030, and beyond, road transport is no longer forecast to be the primary contributing sector. Energy production and industrial combustion are 25% and 33% larger, respectively. This change in relative sectoral contribution is due to the significant improvement in vehicle emissions performance. In addition, unlike all the other major sectors, industrial combustion emissions are projected to increase from 2020, returning to pre-2010 levels by 2030.

Overall, the road transport contribution to total NOx emissions falls from 40% in 2005 to a projected 18% of the total by 2030.

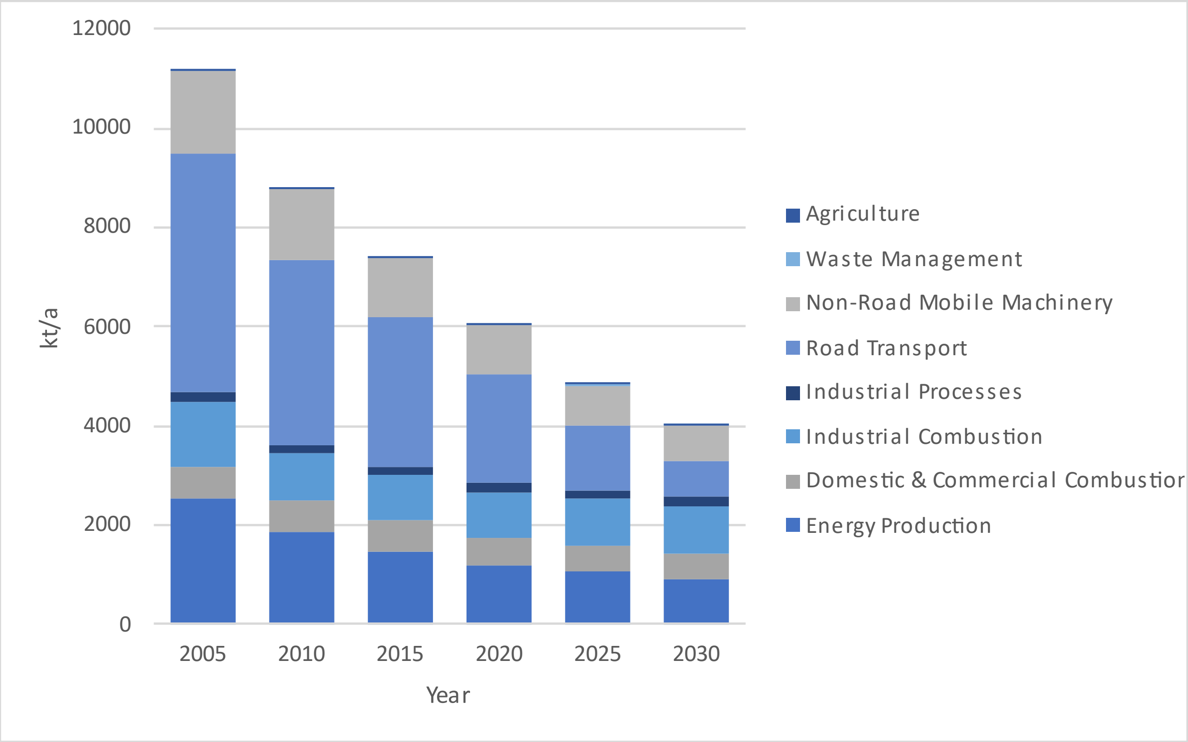

Figure 1 - EU - NO_X emissions Base Case. Excluding fuel extraction and solvent and product use as zero emissions. Source: GAINS IIASA/SIBYL ACEA fleet.

Detailed View of Emissions Reduction Potential by Sector - NO_X

The 2030 sectoral emissions breakdown is presented in **Figure 2** for the EU member states. This data is extracted from the GAINS database for non-road transport and combined with the road transport sector emissions as generated in the main study using the SIBYL ACEA adjusted fleet. The left-hand column shows the 2030 Base Case emissions, and the centre column shows the GAINS sectoral '*Maximum Technically Feasible Reduction'* case (MTFR) plus *Scenario 14* 2030 emissions.[5] The difference between the two is in the right-hand column which shows even the ambitious *Scenario 14* has a very small NO_X emissions reduction potential. It also shows the small potential for reductions of the road transport sector emissions compared to those available from other major sources across Europe.

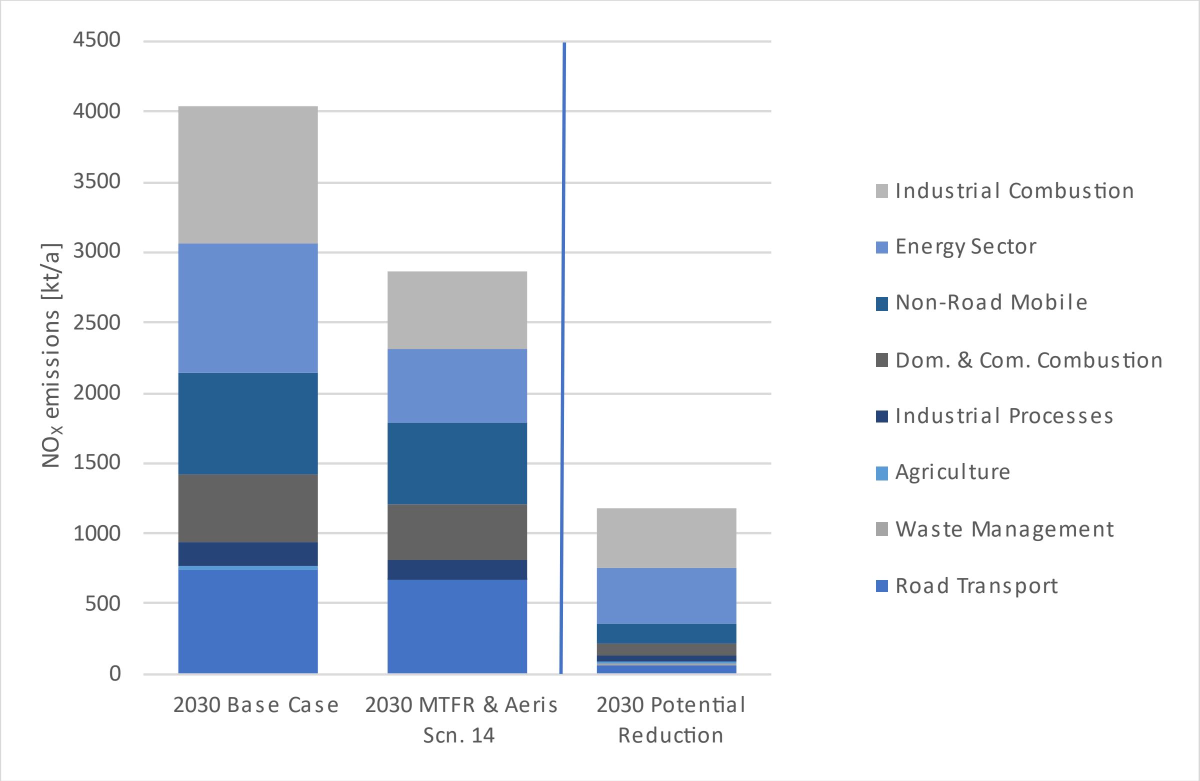

Figure 2 - Emissions of NO_X across the EU by sector. Source: GAINS IIASA/SIBYL ACEA fleet.

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[5] See pages 12-13 for detailed scenarios.

Scenarios

This study is primarily focussed on road transport emissions and their contribution in context with other emissions. The scenarios model the effect of hypothetical vehicle emission reductions as well as reductions from other sectors. These scenarios have been designed to show the relative contributions to potential air quality improvements from all key sectors.

Throughout these scenarios (and the report as a whole) shorthand terms are used to describe different components of the vehicle fleet, these terms and their meanings are listed in **Table 2.**

Table 2 - Glossary of vehicle classifications

Term	Description
PC	Passenger Car
PCD	Diesel Passenger Car
PCG	Gasoline Passenger Car
LCV N1-I	Light Commercial Vehicles with a TPMLM[6] < 1305kg
LCV N1-II	Light Commercial Vehicles with a TPMLM > 1305kg and < 1760kg
LCV N1-III	Light Commercial Vehicles with a TPMLM > 1760kg and < 3500kg
LCV N2	Light Commercial Vehicles with a TPMLM > 3500kg and < 12000kg
LDV	Light Duty Vehicles: An aggregation of LCV N1-II and LCV N1-III
HDV	Heavy Duty Vehicles (trucks) with a TPMLM > 12000kg
HCV	Heavy Commercial Vehicles: An aggregation of LCV N2, buses and commercial vehicles with a TPMLM >12000kg

The scenarios were primarily designed to determine the impact on air quality and compliance with air quality limit values over a wide range of emissions reductions from diesel vehicles and other non-transport sources.

Each scenario was developed jointly between ACEA and Aeris Europe, with input in the form of comments and requests received from the AGVES[7] stakeholder group. Each of the transport scenarios was designed with implementation dates of 2025 and 2027 to test the impact on air quality of alternative 'Euro 7/Euro VII' start dates. The non-transport scenarios were all designed with implementation from 2025 and a series of 'book-end zero-emission scenarios' were included as the 'highest possible impact' cases.

The scenarios and dates chosen in this study are for modelling purposes only. They do not represent any commitment to a level of technical feasibility, nor feasible timings which is highly dependent on any regulatory process.

The following descriptions explain the scenario rationale and detail the coefficients applied to the Baseline vehicle emission factors.

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[6] TPMLM - Technically Permissible Maximum Laden Mass

[7] Advisory Group on Vehicle Emission Standards

Passenger Car and Light Duty Vehicle Scenarios with NO_X impacts

Scenario 1 - Alignment of diesel emissions limits with gasoline limits

PC and LCV N1-I, II, III technology neutral alignment of diesel NO_X emission limits with gasoline emission limits. Coefficients of 0.75 for diesel passenger cars and 0.65 for diesel light duty vehicles were applied to newly registered vehicles from both 2025 and then 2027. These coefficients were calculated by dividing the gasoline Euro 6d emission factor mg/km by the diesel equivalent i.e., 60/80 for PCD and LCV N1-I and 75/115 for LCV N1-II and LCV N1-III.

Scenario 2 - Reduced diesel emission limits: NO_X 25mg/km, PM2.5 2.5 mg/km

This scenario is a stakeholder-based request for a 'lower than Ricardo Scenario 3' (see below)[k] based on NO_X diesel emission factors of 25 mg/km and PM2.5 exhaust emission factors of 2.5mg/km. The corresponding NO_X emission coefficients were 0.31 for PCD and LCV N1-I and 0.22 for LCV N1-II and LCV N1-III. For PM2.5 exhaust a coefficient of 0.56 was applied to both the PCD and LDV elements of the fleet.

Scenario 3 - 'Ricardo' median EURO 7 diesel emission limits: NO_X 35mg/km, PM2.5 2.5mg/km

In an early stakeholder briefing, Ricardo presented a view of possible Euro 7/VII emission limits. This suggested a NO_X EF range of 30-40 mg/km and a PM2.5 EF of 2.5mg/km. Using the midpoint of the suggested NO_X EF resulted in coefficients for PC and LCV N1-I of 0.44 and (by interpolation) for LCV N1-II and LCV N1-III of 0.38. For PM2.5 exhaust a coefficient of 0.56 was applied to both fleet the PCD and LDV elements.

Scenario 7 - Diesel PC and LCV: NO_X 0, PM2.5 0

This scenario was run to give a hypothetical 'book-end' to possible emissions reductions. For diesel PC and LCV N1-I both NO_X and PM2.5 exhaust emission factor coefficient were set to zero.

Scenario 8 - Diesel LCV N1-II and LCV N1-III: NO_X 0, PM2.5 0

This scenario was run to give a hypothetical 'book-end' to possible emissions reductions. For diesel LCV N1-II and LCV N1-III both NO_X and PM2.5 exhaust emission factor coefficient were set to zero.

HDV and Bus Scenarios

Scenario 4 - Diesel LCV N2 and HDV aligning the WHTC with WHSC limits

This scenario tested the benefit of aligning the NO_X WHTC[8] limit with the stricter WHSC[9] limit. For both diesel LCV N2 and HDV the NO_X emissions coefficient was set to 0.87 (i.e., 400/460)

Scenario 5 - Low NO_X scenario (Diesel HCV) NO_X limit of 230 mg/kWh

Low NO_X scenario modelling a reduction in NO_X limit to 230 mg/kWh by applying a coefficient of 0.58 to diesel LCV N2 and HDV emissions.

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[8] World Harmonized Transient Cycle (WHTC)

[9] World Harmonized Stationary Cycle (WHSC)

Scenario 6 - Very-Low NO_X scenario (Diesel HCV) NO_X limit of 100 mg/kWh

A more ambitious low NO_X scenario modelling a reduction in NO_X limit to 100mg/kWh by applying a coefficient of 0.25 to diesel LCV N2 and HDV emissions.

Scenario 12 - Ultra-Low NO_X scenario (Diesel HCV) NO_X limit of 30 mg/kWh

Stakeholder request for an ultra-low NO_X scenario modelling a reduction in NO_X limit to 30mg/kWh by applying a coefficient of 0.075 to diesel LCV N2 and HDV emissions.

Combined Scenarios

Scenario 13 = Scenario 1 + Scenario 4

Scenarios 1 and 4 emissions applied together in one scenario.

Scenario 14 = Scenario 3 + Scenario 5 (Introduction of combined Euro 7/VII)

Scenarios 3 and 5 emissions applied together in one scenario.

Other Scenarios

Scenario 9 - Zero Emissions from Domestic & Commercial Combustion

A hypothetical ‘book end’ scenario to test the impact on air quality if residential and commercial emissions of both NO_X and PM2.5 were reduced to zero from 2025.

Scenario Emission Changes

Table 3 shows that, for the period to 2030, significant emissions reductions are forecast for NO_X as a result of existing measures and the impact that meeting future fleet CO_2 targets will have on technology choices. For NO_X, there are further reductions in emissions to 2035, although at a reduced rate (**Figure 1**).

Table 3 - NO_X - Emission reductions delivered by the Base Case and the range of additional reductions delivered by the various Euro 7/VII scenarios

NO_X Emissions - Road Transport	**2030 (% reductions from 2020)**		**2035 (% reductions from 2020)**	
	Base Case	**Scenarios**	**Base Case**	**Scenarios**
Euro 7 Final Scenarios (diesel cars and vans)	66.7%	0.9 - 3.4%	79.0%	1.1 - 4.6%
Euro VII Scenarios (heavy duty vehicles)		0.1 - 1.6%		0.1 - 2.4%

For $NO_{X,}$ the significant emissions reductions delivered by the Base Case are in sharp contrast with the emissions reductions delivered by the scenarios. Even the most ambitious NO_X scenario only delivers an additional 4.6% reduction beyond the 79% reduction delivered in the Base Case.

Early Replacement of Existing Vehicles

As part of this study, early scrappage scenarios were considered for both diesel passenger cars and heavy-duty vehicles. Several approaches were tested to simulate older vehicle replacement strategies and alternative uptake rates for vehicles meeting the current Euro 6d/VI standards.

At a fundamental level, the benefit of targeted scrappage compared to the introduction of a hypothetical Euro 7/VII was tested through a comparison of emission factors. To do this, the difference in older technology emission factors relative to the Euro 6d/VI emission factors as implemented in the COPERT and SIBYL versions used for this report[10], were examined.

The calculation made the ambitious 'best possible case' assumption that the Euro 7/VII standard would have zero emissions, hence the calculated ratio used was:

(Emission Factor Replaced - Emission Factor of Euro 6d/VI) / (Emission Factor of Euro 6d/VI)

The result of this calculation is a number which is the multiple of the zero-emissions case reduction. By using this emission factor test, the results are independent of activity levels.

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[10] As noted in the section in the main report, the most recent COPERT release (v5.4.36) made significant improvements to Euro 6 emission factors.

On this basis it was found that:

1. The range of Diesel Passenger Car (medium) NO_X emissions reductions from replacing a Euro 5 to Euro 3 vehicle with a Euro 6d vehicle is 6 to 8 times that of replacing a Euro 6d vehicle with a zero-tailpipe emission vehicle.
2. The range of HDV NO_X emissions reductions (averaged across weight classes) from replacing a Euro V to Euro III vehicle with a Euro VI vehicle is 10 to 25 times that of replacing a Euro VI vehicle with a zero-tailpipe emission vehicle.

Notably, through successful implementation of a targeted scrappage scheme, these significant reductions would be realised well before even the most ambitious Euro7/VII regulation could be implemented. Full details of the benefits of scrappage schemes will be explored at both EU and member state levels in a forthcoming publication on cost benefits.

SARS-COV-2 (COVID-19)

The outbreak of SARS-COV-2 across the world in early 2020 resulted in a substantial change in emissions across the EU. National and regional lockdowns, international travel restrictions, enforced home-working and a myriad of other behavioural changes provided a unique opportunity to study how changing emissions affected air quality. In this study, these changes have been handled in two ways, described below:

1) For the emissions Base Case, emission changes due to the pandemic have deliberately been excluded, so in effect the Base Case represents a world where the pandemic did not happen. This allows for trends over time to be more effectively and easily observed. It also prevents a significant, but temporary event from impacting predicted future air quality trends.

2) A series of SARS-COV-2 sensitivity scenarios have been formulated to reflect how different countries responded to the outbreak (**Table 4**). These are not intended to be exhaustive but are meant to provide an insight into how behavioural changes in road transport activity, affect urban air quality. No other emissions changes were explored in this context, so any changes in emissions related to domestic or commercial combustion systems, for example, have not been considered.

Table 4 - SARS-COV-2 sensitivity scenarios

Cov-Scn-1a	Passenger Car and LCV Activity (vehicle kilometres) Reduced by 25%
Cov-Scn-1b	Passenger Car and LCV Activity (vehicle kilometres) Reduced by 50%
Cov-Scn-1c	Passenger Car and LCV Activity (vehicle kilometres) Reduced by 75%
Cov-Scn-2a	Total Road Transport Activity (vehicle kilometres) Reduced by 25%
Cov-Scn-2b	Total Road Transport Activity (vehicle kilometres) Reduced by 50%
Cov-Scn-2c	Total Road Transport Activity (vehicle kilometres) Reduced by 75%

EU Air Quality Limit Values

The current ambient air quality limit values as defined in the Ambient Air Quality Directive (AAQD) are referred to throughout this study and are summarised for nitrogen dioxide in **Table 5.** The * indicates the statistically more significant limit, or the metric that will usually be exceeded first.

Table 5 - EU Ambient Air Quality Limit Values

Pollutant	Frequency	Value (µg/m^3)	Allowed Exceedances
Nitrogen Dioxide (NO_2)	Hourly Exceedance	200	18
Nitrogen Dioxide (NO_2)	Annual Mean *[l]	40	0

WHO Guideline Values

The World Health Organisation (WHO) have published a series of guideline values for ambient air quality[m] that in the case of NO_2 are the same as those in the AAQD. The most recent guidelines at the time of writing are those published in 2005 and summarised in **Table 6**.

Table 6 - WHO Guideline Values

Pollutant	Frequency	Value (µg/m^3)
Nitrogen Dioxide (NO_2)	Hourly Exceedance	200
Nitrogen Dioxide (NO_2)	Annual Mean	40

Air Quality Model - AQUIReS+

AQUIReS+ is Aeris Europe's air quality forecasting model. Designed to predict the concentration of the main pollutants covered by the AAQD, and compliance with air quality limit values at individual monitoring stations in the European Air Quality monitoring station network. The AQUIReS+ model has been used in several published works on European air quality[n,o] and is well suited to support the aims of this study.

Further details related to AQUIReS+, modelling errors and input data can be found in the main report.

Compliance Banding

Within AQUIReS+ the RMS modelling error is calculated for each station individually; it is therefore possible to assign a station specific band of uncertainty with respect to compliance with a given limit value. In this study, the predicted status of each station has been grouped into one of the four categories defined in **Table 7.**

Table 7 - Station compliance categories

Abbreviation	Name	Description
C	Compliant	Modelled concentration is below the limit or guideline value by at least the RMS error of that station.
PC	Probably Compliant	Modelled concentration is below the limit or guideline value by less than the RMS error of that station.
PNC	Probably Non-Compliant	Modelled concentration is above the limit or guideline value by less than the RMS error of that station.
NC	Non-Compliant	Modelled concentration is above the limit or guideline value by at least the RMS error of that station.

The two categories 'Probably Compliant' and 'Probably Non-Compliant' may be grouped together into a single category of 'Uncertain Compliance'.

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[a] (Aeris Europe, 2021) *Euro 7 Impact Assessment: The Outlook for Air Quality Compliance in the EU and the Role of the Road Transport Sector*

[b] (IIASA, 2015a) *Adjusted historic emission data, projections, and optimized emission reduction targets for 2030 – A comparison with COM data 2013. Part A: Results for EU-28.*

[c] (IIASA, 2015b) *Adjusted historic emission data, projections, and optimized emission reduction targets for 2030 – A comparison with COM data 2013. Part B: Results for Member States.*

[d] (European Commission, 2011) *Review of EU Air Quality Policy - Commission Staff Working Document (SEC(2011)342)*

[e] (Directive (EU) 2016/2284, 2016) *The European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC*

[f] (Directive (EU) 2015/2193, 2015) *European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants*

[g] (Papadimitriou & Mellios, 2020) *European Road Transport & Emissions Trends Report*

[h] (Regulation (EU) 2019/631, 2019) *Setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011*

[i] (Regulation (EU) 2019/1242, 2019) *Setting CO2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC*

[j] (Directive (EU) 2019/1161, 2019) *Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles*

[k] (Ricardo, 2020) *Euro 7 / VII - New Emissions Limits, The Challenges and Solutions. Slide 9 - Diesel* NO_X *emission factor range of 30-40 mg/km and a PM2.5 emission factor of 2.5mg/km*

[l] (de Leeuw & Ruyssenaars, 2011) *Evaluation of current limit and target values as set in the EU Air Quality Directive - ETC/ACM Technical Paper*

[m] (WHO, 2005) *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide*

[n] (Aeris Europe, 2016) *Urban Air Quality Study, #11/16*

[o] (Concawe, 2018) *A comparison of real driving emissions from Euro 6 diesel passenger cars with zero emission vehicles and their impact on urban air quality compliance*

Results - Nitrogen Dioxide

Base Case

In the Base Case, almost universal compliance with the currently legislated annual mean limit value for NO_2 is predicted by 2025 from currently mandated measures. This is a conservative view as discussed earlier in the report since the NO_x emissions reductions in some non-transport sectors in the Base Case used in this study are likely to be understated.[1]

Across the EU, approximately 99% of urban monitoring stations (1,638 out of 1,661) are predicted to be compliant or probably compliant by 2025. The overall number of stations and their related compliance states are shown in **Figure 3.** As the annual mean limit value for NO_2 is statistically stricter, i.e., it is harder to achieve than the hourly exceedances limit, the annual mean is examined here.[a]

	2020	2025	2030	2035
Non-Compliant	55	13	4	4
Probably Non-Compliant	28	10	4	2
Probably Compliant	44	21	11	6
Compliant	1534	1617	1642	1649

Figure 3 - EU, NO_2 predicted station compliance with 40µg/m^3 annual mean: 2020 - 2035 Base Case.

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[1] See Base Case methodology section for explanation.

Air Quality Response to Key Scenarios

To simplify discussion of the impact of additional emission abatement, the results of the scenario with the greatest emission reduction (scenario 9) is in shown in **Table 8** and compared to the road transport scenarios with the greatest emission reductions.

Table 8 - NO_2 - Non-compliant station summary under key scenarios in the EU (total of 1661 stations)

	2020	2025	2030	2035
Base Case	**83** (5%)	**23** (1.4%)	**8** (0.5%)	**6** (0.4%)
Introduction of Combined Euro 7/VII (2025) ***Scenario 14***	**83** (5%)	**23** (1.4%)	**6** (0.4%)	**5** (0.3%)
Diesel PC and LCV - NO_X: 0, PM2.5: 0 (2025) ***Scenario 7***	**83** (5%)	**23** (1.4%)	**6** (0.4%)	**5** (0.3%)
Zero Emissions from Domestic & Commercial Combustion (2025) ***Scenario 9***	**83** (5%)	**12** (0.7%)	**5** (0.3%)	**3** (0.2%)

The modelling indicates that, from an NO_2 compliance perspective, the results from the two road transport scenarios in **Table 8** show the same minimal further improvement beyond that achieved in the Base Case. Already mandated measures will achieve above 99% compliance by 2030, and from then onwards, even in the extreme non-transport scenario of eliminating all NO_X emissions from domestic and commercial combustion, there is little further impact on compliance. The latter non-transport scenario shows an improvement over the Base Case in 2025 because it was modelled as an instant measure whilst the transport scenarios are dependent on fleet evolution. In all cases, only a handful of stations are non-compliant by 2030, and most of these remain stubbornly non-compliant regardless of the measures taken nationally. This indicates that action on specific local sources, identified by a thorough source attribution analysis, rather than further national or European wide measures, should be pursued.

Taking Germany as an example, we see the minimal compliance impact of the scenarios beyond the base case. (**Table 9**)

Table 9 – Germany, NO_2 non-compliant stations (total of 285 stations)

	2020	2025	2030	2035
Base Case	**24** (8%)	**5** (2%)	**2** (1%)	**2** (1%)
Introduction of Combined Euro 7/VII (2025) ***Scenario 14***	**24** (8%)	**5** (2%)	**2** (1%)	**1** (0.4%)
Diesel PC and LCV - NO_X: 0, PM2.5: 0 (2025) ***Scenario 7***	**24** (8%)	**5** (2%)	**2** (1%)	**1** (0.4%)
Zero Emissions from Domestic & Commercial Combustion (2025) ***Scenario 9***	**24** (8%)	**2** (1%)	**1** (0.4%)	**0**

City Focus - NO_2

Although all the urban monitoring stations in the EU were included in the scope of this study, nine cities were selected for closer examination: Berlin, Brussels, London, Madrid, Milan, Paris, Rome, Stuttgart, and Warsaw. Notably each of these cities is in a Member State which has ongoing infringement proceedings against them for failure to comply with the AAQD with respect to the NO_2 AQLV.

The following tables (**Table 10** through to **Table 18**) show the detailed city by city compliance results for the Base Case and key scenarios 14, 7 and 9 as listed in **Table 9**. They are formatted with the results at 5-year intervals, with the predicted annual mean concentrations in µg/m^3. In order to aid legibility for compliance status, the font colours are selected to be “green” for compliant, “orange” for uncertain compliance and “red” for non-compliant.

The tables confirm the findings of the main report in that there are already a very large number of compliant stations across the EU in 2020. By 2025, there are only 9 stations non-compliant across three of the 9 cities studied, London, Paris, and Stuttgart. This also confirms the findings in the main report that any further actions on vehicle standards will have a negligible impact on air quality, typically improving annual average NO_2 values by only 1µg/m^3 in urban areas. There are other sectors where actions to reduce NO_X emissions would be more effective, such as the domestic and commercial combustion sector, where the range of NO_2 reductions would be in the range 3-5µg/m^3.

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[a] (de Leeuw & Ruyssenaars, 2011) *Evaluation of current limit and target values as set in the EU Air Quality Directive - ETC/ACM Technical Paper*

Table 10 - Berlin - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		**Base Case**				**Introduction of Combined Euro 7/VII (2025)** ***Scenario 14***			**Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025)** ***Scenario 7***			**Zero Emissions from Domestic & Commercial Combustion (2025)** ***Scenario 9***		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	41	35	30	29	34	30	28	31	27	26	34	30	29
TRAFFIC	URBAN	39	29	24	23	29	23	21	25	14	9	29	24	22
TRAFFIC	URBAN	38	31	27	26	31	27	26	28	24	23	31	27	26
TRAFFIC	URBAN	38	26	19	17	26	18	16	20	14	12	26	19	17
TRAFFIC	URBAN	35	26	20	19	26	19	18	22	16	15	26	19	18
TRAFFIC	URBAN	32	25	21	20	25	21	20	22	18	17	25	21	20
BACKGROUND	URBAN	23	20	18	17	20	17	16	18	15	14	20	17	16
BACKGROUND	URBAN	21	18	15	15	18	15	14	16	14	13	18	15	14
BACKGROUND	URBAN	21	17	15	14	17	14	14	15	12	11	17	14	14
BACKGROUND	URBAN	21	17	14	14	17	14	13	15	12	12	17	14	13
BACKGROUND	URBAN	13	8	7	6	8	6	6	7	6	5	8	6	6
BACKGROUND	SUBURBAN	11	9	8	8	9	8	7	9	7	6	9	8	7

Table 11 - Brussels - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		**Base Case**				**Introduction of Combined Euro 7/VII (2025)** ***Scenario 14***			**Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025)** ***Scenario 7***			**Zero Emissions from Domestic & Commercial Combustion (2025)** ***Scenario 9***		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	SUBURBAN	30	20	15	13	20	14	13	20	14	13	15	10	8
TRAFFIC	SUBURBAN	30	25	23	22	25	23	22	25	23	22	23	21	20
TRAFFIC	URBAN	27	20	16	15	20	16	14	20	16	14	16	12	11
BACKGROUND	URBAN	22	16	13	12	16	13	11	16	13	11	13	10	9
TRAFFIC	URBAN	20	11	8	7	11	7	6	11	7	6	8	5	4
BACKGROUND	SUBURBAN	17	12	10	9	12	9	9	12	9	9	10	7	7
BACKGROUND	SUBURBAN	13	8	6	5	8	6	5	8	6	5	6	4	3
TRAFFIC	URBAN	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 12 - London – Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		**Base Case**				**Introduction of Combined Euro 7/VII (2025)** ***Scenario 14***			**Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025)** ***Scenario 7***			**Zero Emissions from Domestic & Commercial Combustion (2025)** ***Scenario 9***		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	69	52	39	36	52	38	35	52	38	35	47	35	31
TRAFFIC	URBAN	49	36	27	24	36	26	23	36	26	23	32	23	21
BACKGROUND	URBAN	43	35	29	27	35	28	26	35	28	26	32	26	25
TRAFFIC	URBAN	43	33	26	24	33	26	23	33	25	23	30	23	21
TRAFFIC	URBAN	40	32	27	25	32	26	24	32	26	24	30	24	23
TRAFFIC	URBAN	37	32	28	27	32	28	26	32	27	26	30	26	25
BACKGROUND	URBAN	36	28	22	20	28	21	19	28	21	19	25	19	18
BACKGROUND	URBAN	32	24	18	17	24	18	16	24	18	16	21	16	14
BACKGROUND	URBAN	28	22	18	17	22	18	17	22	18	17	21	17	16
BACKGROUND	URBAN	21	17	14	13	17	14	12	17	14	12	16	12	10
BACKGROUND	SUBURBAN	20	15	12	11	15	11	10	15	11	10	14	10	9
BACKGROUND	SUBURBAN	16	12	9	8	12	9	8	12	8	8	11	8	7
BACKGROUND	URBAN	16	8	3	2	8	2	1	8	2	1	6	1	0

Table 13 - Madrid - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		Base Case				Introduction of Combined Euro 7/VII (2025) *Scenario 14*			Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025) *Scenario 7*			Zero Emissions from Domestic & Commercial Combustion (2025) *Scenario 9*		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	48	40	35	32	40	34	32	40	34	32	38	33	30
TRAFFIC	URBAN	46	39	34	32	38	34	31	38	33	31	36	32	30
TRAFFIC	URBAN	38	32	28	26	32	28	26	32	28	26	30	26	25
TRAFFIC	URBAN	38	31	27	25	31	27	25	31	27	24	29	25	23
TRAFFIC	URBAN	38	31	27	25	31	27	25	31	27	25	30	26	24
BACKGROUND	URBAN	38	31	27	25	31	27	25	31	27	25	29	25	23
TRAFFIC	URBAN	37	34	31	30	34	31	30	34	31	30	32	30	29
BACKGROUND	URBAN	37	33	31	30	33	31	29	33	30	29	32	30	28
BACKGROUND	URBAN	36	31	27	26	31	27	25	31	27	25	29	26	24
TRAFFIC	URBAN	36	28	24	22	28	23	21	28	23	21	26	22	19
TRAFFIC	URBAN	34	29	26	24	29	26	24	29	26	24	28	25	23
TRAFFIC	URBAN	34	29	25	24	29	25	23	29	25	23	27	24	22
BACKGROUND	URBAN	33	28	24	23	28	24	22	28	24	22	26	23	21
BACKGROUND	URBAN	33	27	24	23	27	24	22	27	24	22	26	23	21
BACKGROUND	URBAN	32	26	22	20	26	21	19	26	21	19	24	20	18
BACKGROUND	URBAN	31	27	24	22	27	24	22	27	24	22	25	23	21
BACKGROUND	URBAN	30	25	22	21	25	22	20	25	22	20	24	21	19
BACKGROUND	URBAN	29	25	22	21	25	22	21	25	22	20	24	21	20
BACKGROUND	URBAN	29	22	19	17	22	18	17	22	18	17	20	18	16
BACKGROUND	URBAN	27	22	19	17	22	18	17	22	18	16	20	17	15
BACKGROUND	URBAN	25	20	17	16	20	17	15	20	17	15	19	16	14
BACKGROUND	SUBURBAN	20	16	14	13	16	14	13	16	14	13	15	13	12
BACKGROUND	SUBURBAN	19	15	13	12	15	13	11	15	13	11	14	12	11
BACKGROUND	SUBURBAN	15	13	12	12	13	12	11	13	12	11	13	12	11

Table 14 - Milan - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		**Base Case**				**Introduction of Combined Euro 7/VII (2025)** ***Scenario 14***			**Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025)** ***Scenario 7***			**Zero Emissions from Domestic & Commercial Combustion (2025)** ***Scenario 9***		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	56	44	36	33	44	36	33	43	36	32	39	31	21
TRAFFIC	URBAN	47	38	32	27	38	32	25	38	32	25	34	23	15
TRAFFIC	URBAN	43	36	33	32	36	33	31	36	33	31	34	31	29
TRAFFIC	URBAN	38	31	27	25	31	26	24	31	26	24	28	24	22
BACKGROUND	URBAN	31	27	26	25	27	25	25	27	25	24	26	24	24

Table 15 - Paris - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		Base Case				Introduction of Combined Euro 7/VII (2025) *Scenario 14*			Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025) *Scenario 7*			Zero Emissions from Domestic & Commercial Combustion (2025) *Scenario 9*		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	73	62	54	51	62	54	50	62	54	50	57	50	46
TRAFFIC	URBAN	63	49	40	36	49	39	35	49	39	35	43	35	30
TRAFFIC	URBAN	59	47	40	37	47	39	36	47	39	36	42	36	32
TRAFFIC	URBAN	58	44	35	31	44	34	30	44	34	30	38	29	25
TRAFFIC	URBAN	51	43	38	36	43	38	35	43	38	35	40	35	33
TRAFFIC	URBAN	51	43	38	36	43	38	35	43	38	35	40	35	33
TRAFFIC	URBAN	46	35	28	25	35	28	24	35	28	24	30	24	21
TRAFFIC	URBAN	45	34	27	24	34	27	24	34	27	24	30	23	20
TRAFFIC	URBAN	42	30	21	17	29	21	16	29	21	16	24	16	12
TRAFFIC	URBAN	42	38	35	29	38	35	27	38	35	27	36	27	19
BACKGROUND	URBAN	33	28	25	23	28	24	23	28	24	23	26	23	21
BACKGROUND	URBAN	33	28	25	24	28	25	23	28	25	23	26	23	22
BACKGROUND	URBAN	32	28	25	24	28	25	23	28	25	23	26	23	22
BACKGROUND	URBAN	32	26	23	21	26	23	21	26	23	21	24	21	19
BACKGROUND	URBAN	31	26	23	22	26	23	21	26	23	21	24	21	20
BACKGROUND	URBAN	30	24	19	17	24	19	17	24	19	17	21	16	14
BACKGROUND	URBAN	30	25	22	21	25	22	20	25	22	20	23	20	19
BACKGROUND	URBAN	28	25	23	22	25	23	22	25	23	22	24	22	21
BACKGROUND	URBAN	28	24	21	20	24	21	20	24	21	20	22	20	19
BACKGROUND	URBAN	28	23	20	19	23	20	19	23	20	19	21	19	17
BACKGROUND	URBAN	28	23	20	19	23	20	18	23	20	18	21	18	17
BACKGROUND	URBAN	27	24	22	21	24	22	21	24	22	21	23	21	19
BACKGROUND	URBAN	27	22	19	18	22	19	18	22	19	18	20	18	16
BACKGROUND	URBAN	27	22	19	18	22	19	18	22	19	18	20	18	17
BACKGROUND	URBAN	25	21	18	17	21	18	17	21	18	17	19	17	15

Table 16 - Rome - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		Base Case				Introduction of Combined Euro 7/VII (2025) *Scenario 14*			Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025) *Scenario 7*			Zero Emissions from Domestic & Commercial Combustion (2025) *Scenario 9*		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	50	39	33	30	39	32	29	39	32	29	34	28	26
TRAFFIC	URBAN	48	37	31	29	37	31	28	37	31	28	33	27	25
TRAFFIC	URBAN	45	27	20	17	27	19	16	27	19	16	22	15	12
TRAFFIC	URBAN	40	27	22	20	27	22	20	27	22	19	23	19	17
BACKGROUND	URBAN	37	28	23	21	28	23	20	28	22	20	25	20	17
BACKGROUND	URBAN	35	23	16	12	23	15	12	23	15	11	18	11	8
BACKGROUND	URBAN	32	24	19	17	23	18	16	23	18	16	20	16	13
BACKGROUND	URBAN	32	22	17	15	22	16	14	22	16	14	19	13	11
BACKGROUND	URBAN	29	22	18	17	22	18	16	22	18	16	20	16	14
BACKGROUND	URBAN	29	20	14	12	20	14	12	20	14	11	16	11	9
BACKGROUND	SUBURBAN	18	15	13	12	15	12	12	15	12	11	13	11	10

Table 17 - Stuttgart - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		Base Case				Introduction of Combined Euro 7/VII (2025) *Scenario 14*			Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025) *Scenario 7*			Zero Emissions from Domestic & Commercial Combustion (2025) *Scenario 9*		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	67	54	48	46	54	47	45	54	46	44	48	42	33
TRAFFIC	URBAN	61	49	42	40	49	41	39	48	41	39	43	36	28
TRAFFIC	URBAN	39	25	16	14	24	16	13	24	15	13	18	10	8
BACKGROUND	URBAN	24	19	16	16	19	16	15	19	16	15	17	14	14

Table 18 - Warsaw - Forecast Annual Mean NO_2 concentrations at each measuring station in the AQUIRES+ model.

Station		Base Case				Introduction of Combined Euro 7/VII (2025) *Scenario 14*			Diesel PC and LCV - NOX: 0, PM2.5: 0 (2025) *Scenario 7*			Zero Emissions from Domestic & Commercial Combustion (2025) *Scenario 9*		
Type	**Area**	**2020**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
TRAFFIC	URBAN	45	33	27	26	33	27	25	33	27	25	26	21	14
TRAFFIC	URBAN	38	30	26	25	30	26	24	30	26	24	25	21	19
BACKGROUND	URBAN	22	16	14	13	16	13	13	16	13	13	13	11	9
BACKGROUND	URBAN	20	15	12	12	15	12	11	15	12	11	12	9	8

Locally Targeted Measures and Compliance with NO_2 Targets

The nine selected cities in this report, are all in Member States which are subject to infringement proceedings by the European Commission. The urgency of required action to achieve compliance has seen the implementation of several successful Low Emission Zone (LEZ) projects, as well as significant improvements to captive fleets such as buses and taxis. As a result of these successful schemes, several cities are experiencing improvements in air quality beyond that of the modelled Base Case. In addition, as stated in the main report, this study has a conservative view of emissions reductions as the Base Case does not include reductions from the Medium Combustion Plant Directive or the recent NECD commitments.

This more focussed supplementary report confirms the conclusions in the main study that "hotspots" of pollution in urban areas are best addressed by local measures. This can be seen in **Figure 4** below, where the comparison between measured data and the forecast from AQUIRES+ shows a marked fall in the chosen station in Stuttgart, where action to improve air quality has been taken on more than one front, including banning pre-Euro 5 diesel passenger cars from January 2019. The impact of these measures can be seen in 2019 which is from pre-COVID 19 reductions in traffic activity.

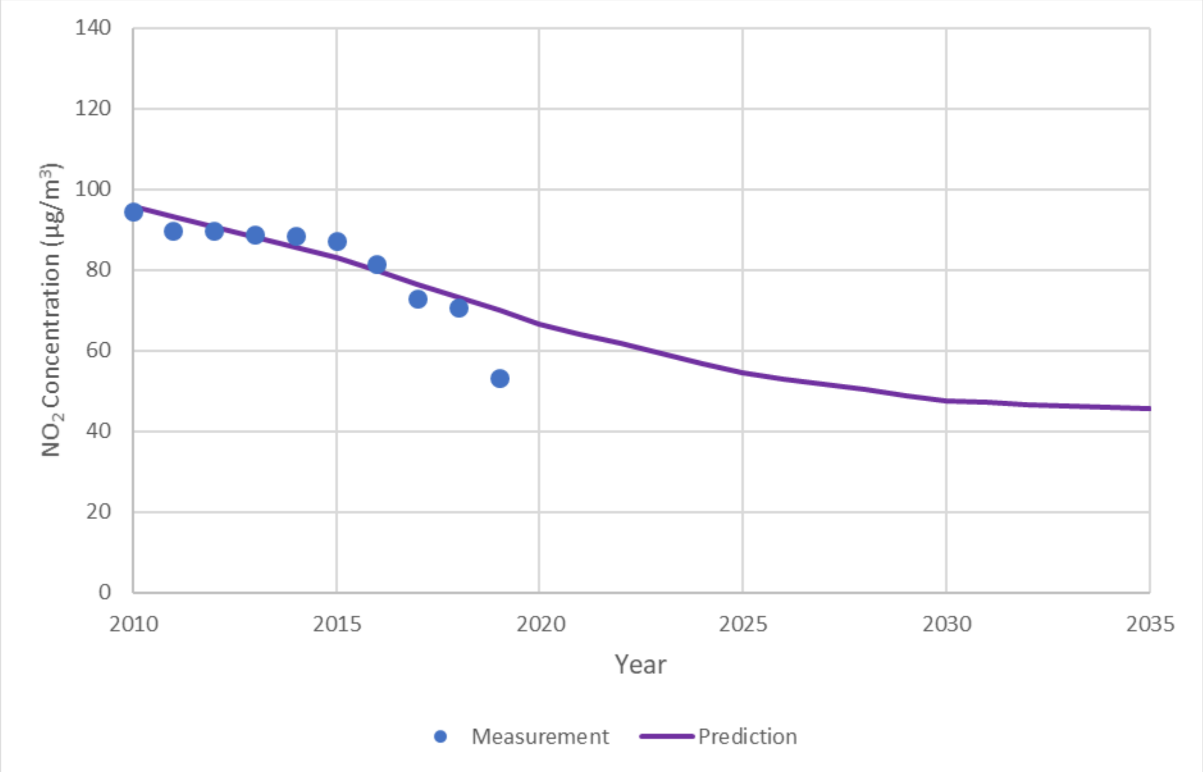

Figure 4 - Measured vs predicted NO_2 at the Am Neckartor measuring station in Stuttgart over 25 years.

The Federal Environment Agency in Germany (UBA) has commented on the recent improvements in Germany as follows: "*Measured concentrations of nitrogen dioxide (NO_2) in 2020 exceeded the annual mean limit of 40 µg/m³ of air at only about 3 to 4 percent of measuring stations located near road traffic, compared to 21 percent in 2019. Nitrogen dioxide pollution overall continues to decline throughout Germany. These are the results of a preliminary evaluation of measurement data collected* *by the federal states and the German Environment Agency (1 February 2021) at some 400 measuring stations."*[1]

In addition to the Low Emission Zone (LEZ) already in place in London for some years, an Ultra-Low Emission Zone (ULEZ) was recently introduced in central London. The administration in London have introduced a range of other measures including low emission bus fleets, introduction of low emission taxis along with vehicle exclusions encouraged by technology specific pricing policies.

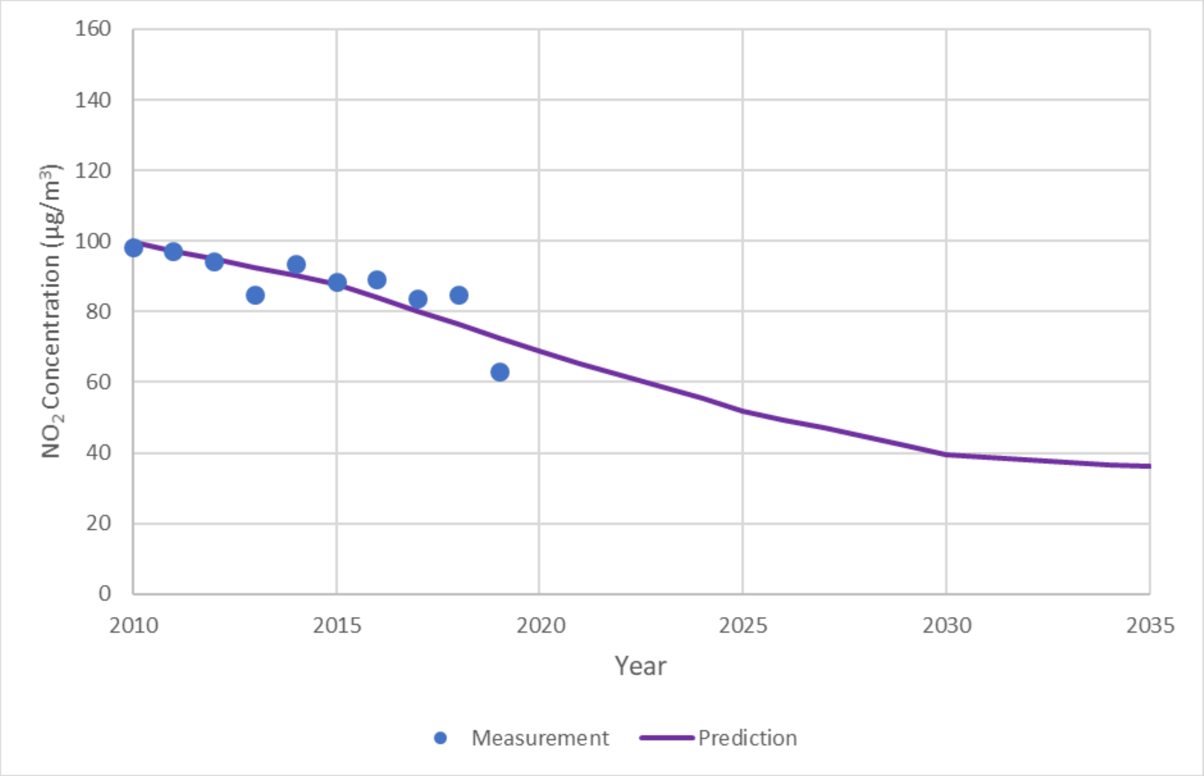

Figure 5 - Measured vs Predicted NO$_2$ at the Marylebone Road measuring station in London over 25 years.

Figure 5 shows an urban traffic station in the recently introduced ULEZ with both measured and predicted measurements of NO$_2$ over the past 25 years. It demonstrates the 2019 downward departure from the trend in NO$_2$ levels and highlights again the effectiveness of local measures in tackling the diminishingly small number of "hotspots" of non-compliance in urban areas.

The above examples of Stuttgart and London demonstrate the impact of Low Emission Zones which include requirements for fleet renewal. Given that all the nine selected cities have Low Emission Zone projects underway and at various levels of development, it is likely that the results presented above are conservative, over-estimating non-compliance. Importantly, in the context of the infringement proceedings, these examples demonstrate that targeted fleet renewal will play a significant part in minimising any periods of non-compliance.

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[1] https://www.umweltbundesamt.de/en/press/pressinformation/air-quality-2020-only-a-few-cities-still-exceed

The Innsbruck Transit Corridor

The A12 (E45) from Innsbruck to Wörgl in Austria is a heavily trafficked, high-altitude road, along which are sited a series of air quality monitoring stations recording nitrogen dioxide concentrations (**Figure 6**). Of the nine stations along this route, including those in urban environments, only a single station is currently non-compliant, and this is predicted to achieve compliance by 2022 in the Base Case (**Table 19**). The location of the non-compliant station (AT72821) is shown inset in **Figure 6**, at the exit of a slip-road from the Vomp services. This station is only a few metres from the roadside and exposed to vehicles undergoing heavy acceleration, it is also only a short distance from an urban area, so is subject to road traffic, commercial and domestic emissions of NO_X.

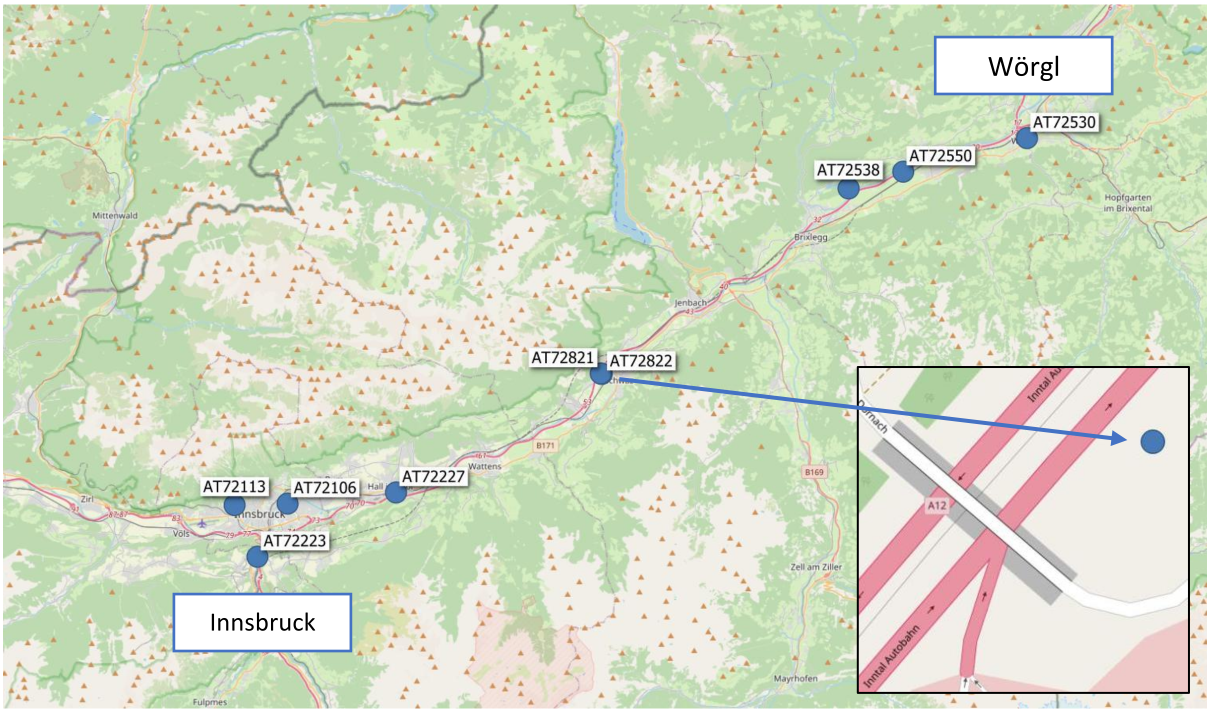

Figure 6 - Innsbruck Traffic Corridor - NO_2 stations

Table 19 - Innsbruck Transit Corridor, predicted NO_2 µg/m$^{3.}$

	2020	2025	2030	2035
AT72106	29	26	24	24
AT72113	17	14	13	13
AT72223	28	20	17	16
AT72227	28	22	20	19
AT72530	22	18	16	15
AT72538	16	12	10	10
AT72550	34	24	20	18
AT72821	**44**	**34**	**29**	**28**
AT72822	28	22	19	18

The modelled concentrations at the nine stations located along or near the transit corridor from 2020 to 2035 under Base Case emissions are shown in **Table 19**. This shows that by 2020 all but one station (AT72821) is predicted to be compliant. Since this modelling work was undertaken, the actual measurement data for the whole of 2020 has become available. This reveals that the actual annual mean, based on measurements, was 36 µg/m^3 (i.e., compliant).

Figure 7 shows the modelled versus measured NO_2 concentrations at this station for the period 2010 to 2020. This shows the good agreement between modelled and measured concentrations from 2010 to 2019. During this period, the very significant impact on NO_2 concentrations from the penetration of new vehicles meeting the latest Euro standards is evident. In 2020, Europe was significantly impacted by responses to the COVID crisis, this appears to be evident from the significant downward departure from the trend in annual mean for 2020 given that the predicted concentrations were consistent with Base Case activity levels prior to this. The reduction of some 8µg/m^3 is consistent with the responses at this station for the simulated reduced activity COVID-scenarios, for example, the COVID 2b scenario (50% Reduction in all road traffic activity) predicts a 9 µg/m^3 reduction at this station.

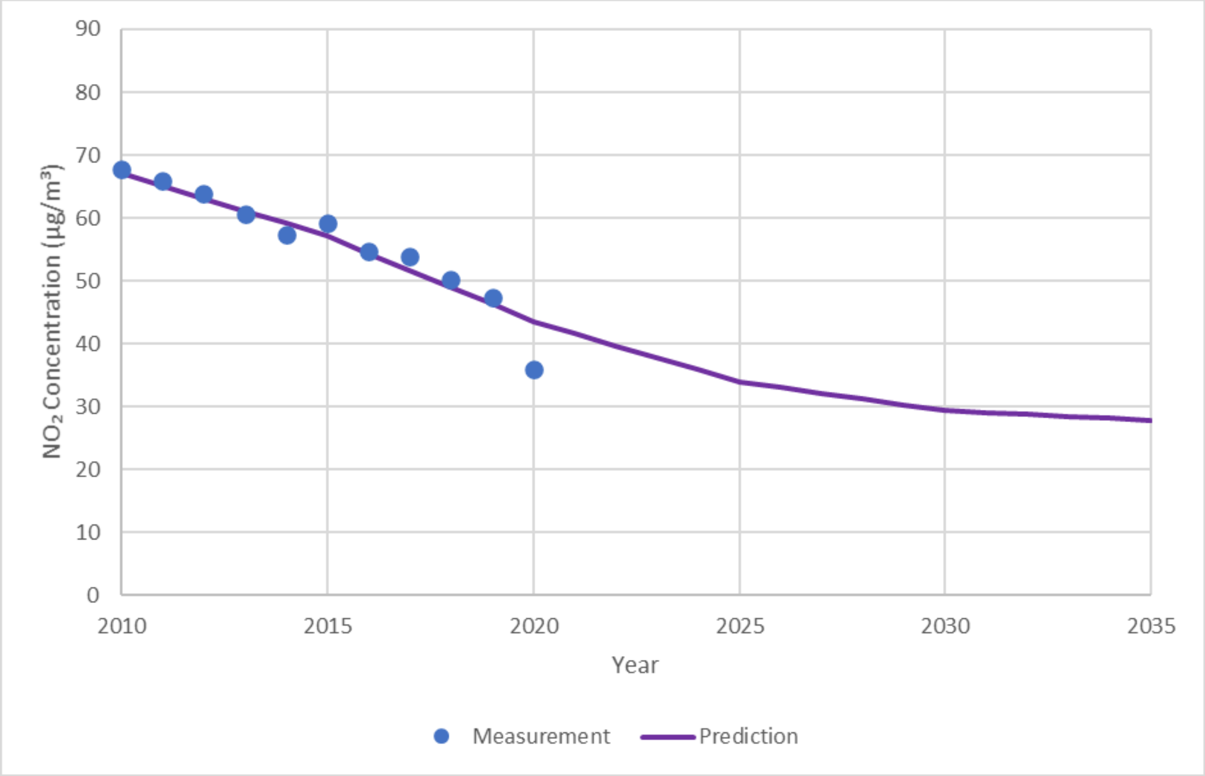

Figure 7 - Modelled versus measured annual mean NO_2 at station AT72821.

Air Quality Responses to Key Scenarios

To explore the impact of additional abatement measures on concentrations at this location, the results of modelling the scenario with the greatest NO_X reduction (Scenario 9) and the road-transport scenarios with the largest NO_X emission reductions are shown in **Table 20**. As expected, there are no changes in 2025 (the year of introduction) in either of the scenarios that impact road transport emissions. By 2030 small changes (a single microgram) are predicted at some of the stations along this route, a consequence of the small change in emissions that these measures are able to induce and the already low emissions from the Base Case reductions. In common with the cities explored in this study, reducing NO_X emissions from the nearby domestic and commercial combustion sources, in this case the roadside services and urban areas, is predicted to have a larger impact on emissions with a further reduction in NO_2 of up to 4µg/m^3 predicted at some stations.

Table 20 - Innsbruck Transit Corridor - NO_2 Concentrations (µg/m^3) - Selected scenarios from 2025

	Diesel PC and LCV NO_X: 0, PM2.5: 0 (2025) *Scenario 7*			**Introduction of Euro 7/VII (2025) *Scenario 14***			**Domestic & Commercial Combustion - NO_X: 0 (2025) *Scenario 9***		
	2025	**2030**	**2035**	**2025**	**2030**	**2035**	**2025**	**2030**	**2035**
AT72106	26	24	24	26	24	23	24	23	22
AT72113	14	13	13	14	13	13	13	12	12
AT72223	20	17	16	20	17	15	17	14	13
AT72227	22	20	19	22	19	18	20	17	16
AT72530	18	16	15	18	16	15	16	14	13
AT72538	12	10	10	12	10	9	10	8	7
AT72550	24	20	18	24	20	18	20	16	15
AT72821	**34**	**29**	**28**	**34**	**29**	**28**	**29**	**25**	**24**
AT72822	22	19	18	22	19	18	19	17	14

Results - SARS-COV-2 (COVID-19)

The outbreak of SARS-COV-2 across Europe in early 2020 resulted in a substantial change in emissions in urban areas across the EU. National and regional lockdowns, international travel restrictions, enforced home-working and a number of other behavioural changes provided a unique opportunity to study how changing emissions affected air quality.

As part of this study, a series of SARS-COV-2 'reduced activity' sensitivity scenarios were designed to provide an insight into how behavioural changes, particularly reductions in road transport activity, might impact urban air quality.

As only annual mean concentrations are directly modelled in AQUIRES+, the assumption made in each 'COVID scenario' was that the lockdown period was sustained over the whole of 2020. This enabled the difference between the annual mean concentration in the Base Case and in each COVID scenario to be determined. This delta concentration was then compared to the observed difference in monthly mean concentration during each lockdown month in 2020 versus the same monthly mean in the previous five years. For each pollutant, a typical urban traffic and background station were chosen.

The six COVID related road transport scenarios modelled are summarised in **Table 21**.

Table 21 - SARS-COV-2 sensitivity scenarios

Cov-Scn-1a	Passenger Car and LCV NO_X, PM2.5 and VOC Emissions Reduced by 25%
Cov-Scn-1b	Passenger Car and LCV NO_X, PM2.5 and VOC Emissions Reduced by 50%
Cov-Scn-1c	Passenger Car and LCV NO_X, PM2.5 and VOC Emissions Reduced by 75%
Cov-Scn-2a	Total Road Transport NO_X, PM2.5 and VOC Emissions Reduced by 25%
Cov-Scn-2b	Total Road Transport NO_X, PM2.5 and VOC Emissions Reduced by 50%
Cov-Scn-2c	Total Road Transport NO_X, PM2.5 and VOC Emissions Reduced by 75%

While the air quality impact of all these scenarios in each of the nine cities included in the scope of this study were modelled, here the results are given for a single representative city, in this case, Madrid.

NO_2 Results for COVID scenarios

Figure 8 shows NO_2 concentrations at an urban traffic station in Madrid from 2015 to 2020. The solid grey line shows the measured monthly mean concentrations and highlights large seasonal variations. The winter months exhibit significantly higher monthly means compared to the warmer months. This is consistent with increased domestic and commercial combustion in the winter period and higher traffic activity compared to the warmer, quieter summer months.

The winter period of 2019/2020 shows much less of a peak than previous years, the reason for this is unclear since no formal 'lockdown' measures in Spain were announced until March of 2020[a]. However, this significant reduction versus the previous 'winter peak' is not seen in the urban background station discussed below. This may indicate a change in traffic patterns at this road-side station during this period.

The previous five years of monthly measurements indicate that April typically has some of the lowest NO_2 concentrations at this station; some 5-6µg/m^3 below the annual mean in 2018 and 2019. This increases to 27 µg/m^3 below the annual mean in 2020, a very significant decrease that coincides with the lockdown in Spain.[b]

The drop in concentration in April compared to previous years is greater than any of the changes induced by the modelled COVID scenarios. This indicates that decreased road transport activity during the lockdown is unlikely to be solely responsible for observed reductions in NO_2 concentrations. The residual monthly concentration during the lockdown (both measured and modelled) serves to highlight that non-traffic sources are an important contribution to NO_2 concentrations in cities.

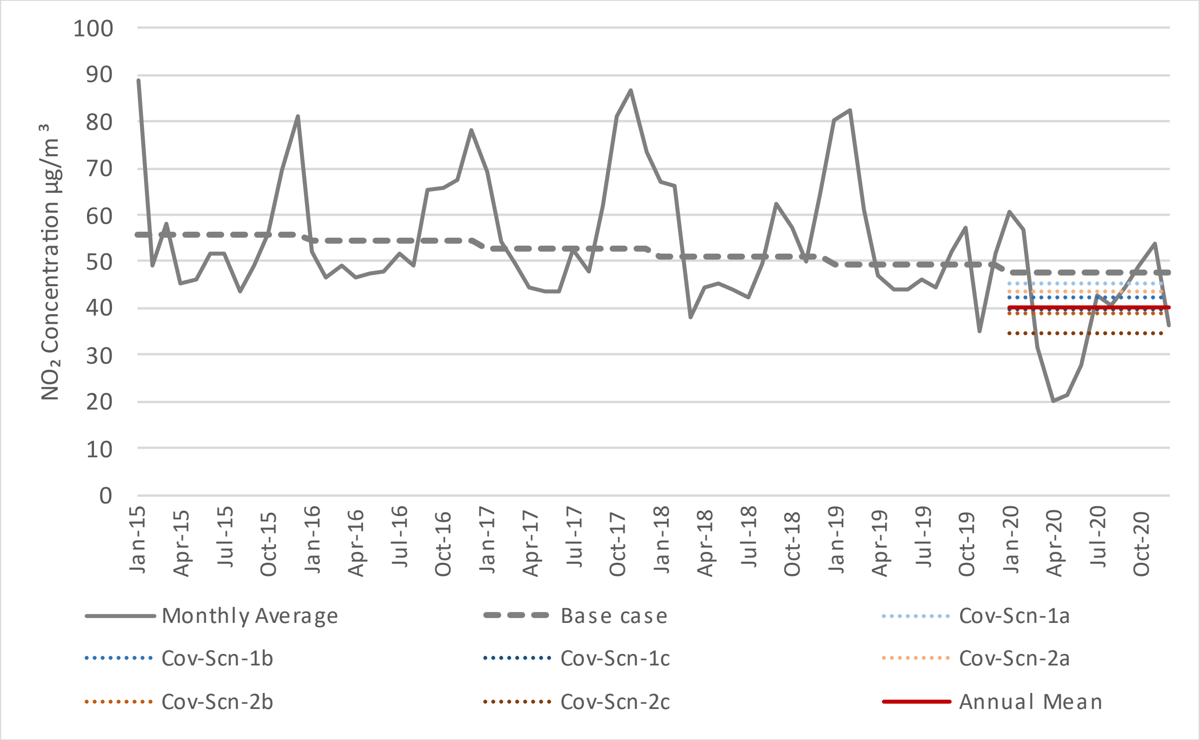

Figure 8 - ES1943A - Urban Traffic Station in Madrid - NO_2 - 2020

Figure 9 shows NO_2 concentrations at another station in Madrid, this time monitoring urban background concentrations. At this station, April is again a month that exhibits lower than average NO_2 concentrations.

As a background station, the impact of emissions from road transport are less dominant, however there is still a significant decrease in observed monthly concentration during the lockdown period in April compared to observations in previous years. Again, the most extreme (75% reduction in traffic activity) modelled scenario shows less reduction in concentration when compared to the observed change indicating that the lockdown impacted not just traffic sources in Madrid.

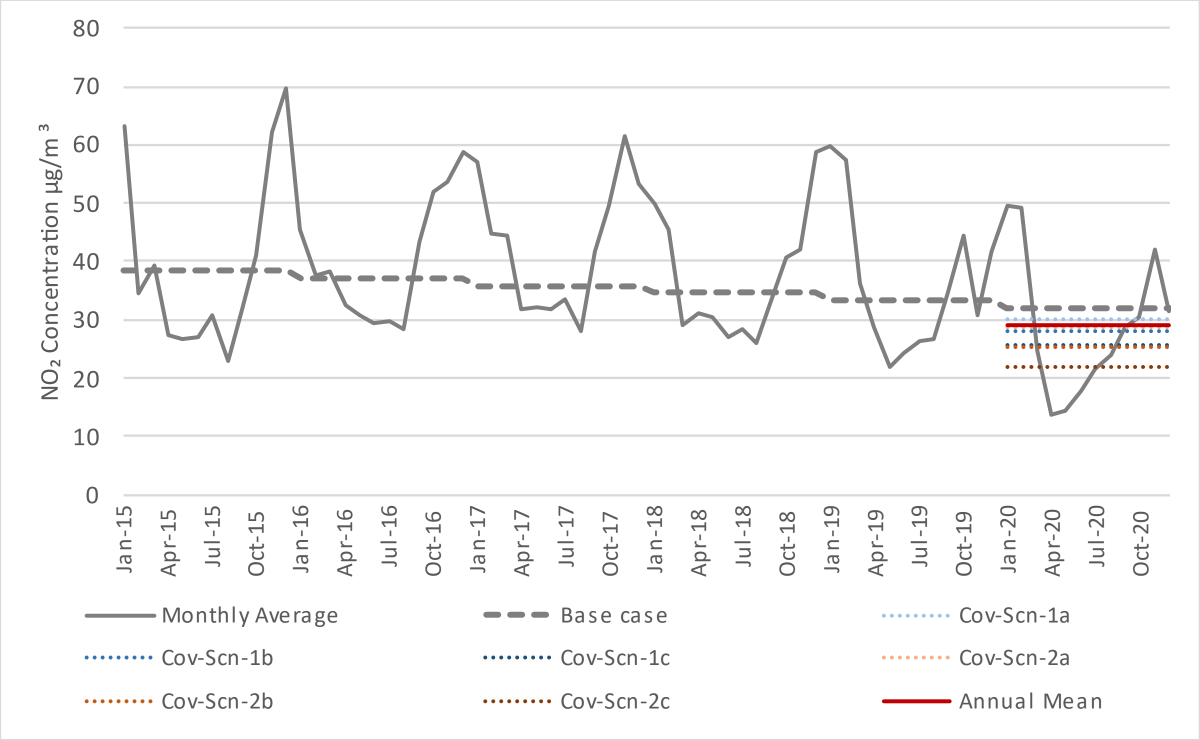

Figure 9 - ES1532A - Urban Background Station in Madrid - NO_2 - 2020

Conclusions

NO_X Emissions

NO_X emissions from road transport do not reduce significantly beyond the Baseline for any of the Euro 7/VII scenarios explored in this study. For example, the introduction of the full range of 'Euro 7/VII' emission limits for diesel passenger cars and vans results in 'beyond the Baseline' reductions in EU NO_X emissions (versus the 2020 Baseline) of only 0.9 - 3.4% by 2030 and only 1.1 - 4.6% by 2035. Similarly, the introduction of the full range of Euro 7/VII emission limits for HDVs results in reductions in EU NO_X emissions of only 0.1 - 1.6% by 2030 and only 0.1 - 2.4% by 2035. In comparison, the reductions in Base Case emissions by 2030 are 67% and by 2035, 79% from 2020 Base Case levels. Furthermore, any change in vehicle emission limits has a minimal impact compared to natural fleet renewal with the latest Euro 6/ VI new vehicles.

The study also explored the NO_X emission reduction benefits from early replacement of Euro 3/III through to Euro 5/V in the 2020/21 diesel passenger and HDV vehicle parc with Euro 6/VI vehicles. In contrast to the very limited further NO_X emission reductions resulting from the introduction of a Euro 7/VII standard, early vehicle replacement (via an incentivised early scrappage scheme for example) on a vehicle for vehicle basis would result in some 6 to 25 times the emission reduction benefits for NO_X compared to the introduction of a zero exhaust emission Euro 7/VII vehicle. Importantly, these benefits would also be realised much earlier, essentially impacting emissions as soon as implemented.

NO_2 Compliance

By 2025 there is a high degree of compliance (99%) at urban monitoring stations in the EU from Base Case emissions with no additional reductions. All of the 'beyond the baseline road transport scenarios' explored in this study have negligible further impact on the Base Case NO_2 compliance picture. This is also the case in the each of the nine selected cities and the Innsbruck Transit Corridor. In contrast, for urban areas and the nine selected cities, further action on domestic and commercial combustion systems is found to have a more significant impact. The importance of emissions from these non-transport combustion sources is further highlighted by the COVID scenario findings. The study has also highlighted the success which can be achieved by addressing urban "hotspots" of non-compliance with targeted local measures.

The Impact on NO_2 from COVID Related Activity Reduction

In the case of NO_2, the city measurement station data, in almost all cases, indicates a more significant reduction in concentrations during the lockdown periods than the modelled responses. This is consistent with the important additional NO_X contribution from commercial combustion systems in cities. During periods of lockdown, the emissions from these sources were also significantly reduced (e.g., from the move from offices to working from home) but this reduction was not included in the COVID scenarios explored in this study, hence the larger, measured response.

In the case of the Innsbruck Transit Corridor, the NO_2 measurements are within the range of the modelled scenarios. This serves to confirm that in urban areas, non-transport sources of NO_X are significant contributors to NO_2 levels.

Implications for Future Euro Standards

Overall, the findings of this study clearly demonstrate that all potential Euro 7/VII scenarios considered in this study show only marginal benefits compared to the Base Case.

This is further reinforced by the findings from the 'early replacement of pre-Euro 6/VI vehicles with Euro 6/VI vehicles' comparisons. These clearly demonstrate that for diesel, on a 'vehicle for vehicle' basis the NO_X emission reduction benefits from such an accelerated replacement scheme are some 6 to 25 times greater than the emission reduction benefit of a 'zero exhaust' Euro 7/VI standard. Importantly, these large early replacement benefits would begin to be realised as soon as a scheme is introduced and therefore much earlier than the small benefits of even the most ambitious future emissions standard which would take several years in legislating and implementing if it were indeed possible.

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[a] (Blas, et al., 2020) *Sánche decreta el estado de alarma durante 15 días*

[b] (José, 2020) *Paralizada toda actividad no esencial en España*

References

Aeris Europe, 2016. *Urban Air Quality Study, #11/16,* www.concawe.eu: Concawe.

Aeris Europe, 2021. *Euro 7 Impact Assessment: The Outlook for Air Quality Compliance in the EU and the Role of the Road Transport Sector,* s.l.: ACEA.

Blas, E. Cué, C., Pérez, C. & García de, E., 2020. *Sánche decreta el estado de alarma durante 15 días.* [Online]
Available at: https://elpais.com/espana/2020-03-13/el-gobierno-debate-decretar-el-estado-de-alarma.html

Buijsman, E. et al., 2005. *Particulate Matter: a closer look. MNP report no. 500037011,* Bilthoven: Netherlands Environmental Assessment Agency (MNP).

Concawe, 2018. *A comparison of real driving emissions from Euro 6 diesel passenger cars with zero emission vehicles and their impact on urban air quality compliance,* Brussels: Concawe.

De Leeuw, F. & Horálek, J., 2009. *Assessment of the health impacts of exposure to PM2.5 at a European level. ETC/ACC Technical Paper 2009/1.,* Bilthoven, The Netherlands: The European Topic Centre on Air and Climate Change (ETC/ACC).

de Leeuw, F. & Ruyssenaars, P., 2011. *Evaluation of current limit and target values as set in the EU Air Quality Directive - ETC/ACM Technical Paper,* Bilthoven: The European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM).

Directive (EU) 2008/50/EC, 2008. *Directive 2008/50/EC Of The European Parliament And Of The Council on ambient air quality and cleaner air for Europe,* COD 2005/0183: European Parliament, Council of the European Union.

Directive (EU) 2015/2193, 2015. *European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants,* Brussels: European Parliament, Council of the European Union.

Directive (EU) 2016/2284, 2016. *The European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC,* Brussels: European Parliament, Council of the European Union.

Directive (EU) 2019/1161, 2019. *Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles,* Brussels: European Parliament.

EEA, 2014 (b). *AirBase - The European air quality database.* [Online]
Available at: https://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-8
[Accessed 08 2017].

EEA, 2017. *Air Quality e-Reporting (AQ e-Reporting).* [Online]
Available at: https://www.eea.europa.eu/data-and-maps/data/aqereporting-2
[Accessed 01 2018].

European Commission, 2011. *Review of EU Air Quality Policy - Commission Staff Working Document (SEC(2011)342),* Brussels: European Commission.

IIASA, 2015a. *Adjusted historic emission data, projections, and optimized emission reduction targets for 2030 – A comparison with COM data 2013. Part A: Results for EU-28.,* Laxenburg: International Institute for Appied Systems Analysis.

IIASA, 2015b. *Adjusted historic emission data, projections, and optimized emission reduction targets for 2030 – A comparison with COM data 2013. Part B: Results for Member States.,* Laxenburg: International Institute for Applied Systems Analysis.

José, M., 2020. *Paralizada toda actividad no esencial en España.* [Online]
Available at: https://elpais.com/espana/2020-03-28/el-gobierno-amplia-el-confinamiento-los-trabajadores-de-actividades-no-esenciales-deberan-quedarse-en-casa.html

Lee, J. D. et al., 2020. UK surface NO2 levels dropped by 42% during the COVID-19 lockdown: impact on surface O3.

Papadimitriou, Y. & Mellios, G., 2020. *European Road Transport & Emissions Trends Report,* s.l.: Emisia.

Regulation (EU) 2019/1242, 2019. *Setting CO2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC,* s.l.: The European Parliament And The Council Of The European Union.

Regulation (EU) 2019/631, 2019. *Setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011,* s.l.: The European Parliament And The Council Of The European Union.

Ricardo, 2020. *Euro 7 / VII - New Emissions Limits, The Challenges and Solutions. Slide 9 - Diesel NOX emission factor range of 30-40 mg/km and a PM2.5 emission factor of 2.5mg/km.* s.l.:s.n.

Shi, Z. & Song, C., 2021. Abrupt but smaller than expected changes in surface air quality attributable to COVID-19 lockdowns. *Science Advances.*

Stedman, J. et al., 2007. A consistent method for modeling PM10 and PM2.5 concentrations across the United Kingdom in 2004 for air quality assessment. *Atmospheric Environment 41,* pp. 161-172.

Timmers, V. R. & Achten, P. A., 2016. Non-exhaust PM emissions from electric vehicles. *Atmospheric Environment,* Volume 134, pp. 10-17.

WHO, 2005. *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide,* Geneva: World Health Organisation.