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IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council

on ambient air quality and cleaner air for Europe (recast)

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1. INTRODUCTION

Following the publication of the results of the Fitness Check of the Ambient Air Quality Directives, in November 2019, the European Commission launched an exercise to address the issues identified as needing additional technical support documents and/or guidance documents (below referred to as '*technical guidance documents'*) to support the implementation of the Ambient Air Quality Directives.

[80]/[81] The focus of this exercise was on making air quality monitoring and modelling, and air quality plans, more effective and efficient and is complementary to any changes to be done to the legal provisions:

(1) *Improve and further specify air quality monitoring requirements*: additional precision on monitoring requirements would consolidate the representativeness of, and confidence in, monitored data, as well as provide increased comparability of air quality data across the EU. This would include streamlining, simplifying, and increasing precision and coherence of monitoring requirements, as well as providing further technical guidance documents as necessary, in relation to assessment regimes, micro- and macro-scale siting criteria of sampling points, data quality objectives for measurements and reference measurement methods, continuity of measurements in the same location, and provision of air quality data to the public.

(2) *Improve the use of complementary air quality assessment methods*: common rules on other air quality assessment methods to complement air quality monitoring (such as air quality modelling, indicative measurements, and objective estimation), would improve the representativeness, comparability, coverage and timelines of air quality assessments. The further use of these methods may also significantly reduce the costs of air quality assessment. More concretely, the European Commission explored an enhanced role of modelling in air quality assessment, further improving the quality of modelling, the use of complementary air quality assessment methods in informing air quality network design and the needs for further guidance on indicative measurements, objective estimation and low-cost sensors.

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[80] The European Green Deal (COM(2019) 640 final) announced as the framework of a zero pollution ambition for a toxic-free environment that the Commission would draw on the lessons learnt from the Fitness Check of the Ambient Air Quality Directives and strengthen the provisions for air quality monitoring, modelling, and plans.

[81] COM (2022), Strengthening of air quality monitoring, modelling and plans under the Ambient Air Quality Directives - final (accessed: 04.08.2022)

(3) *Improve effectiveness of air quality plans*: it is essential to consider ways to address the need for more precise requirements, complemented with technical guidance documents as appropriate, to ensure that air quality plans and their implementation by competent authorities result in air quality standards being respected in the shortest time possible. This may be achieved by looking at inter alia, minimum elements required for an effective air quality plan, the process of elaboration of air quality plans, the methods used to estimate the impact of measures (including their costs and benefits) and support for the implementation of air quality plans and assessing of their impacts and effectiveness.

2. METHODOLOGY

To identify, analyse and recommend the issues needing of additional guidance for strengthening air quality monitoring, modelling and plans, a set of 15 specific questions were defined which guided the whole exercise. The questions were grouped into four topic areas: monitoring, modelling, planning, and general aspects as follows:

[Q1 - (general) administrative burden] What scope is there to reduce the administrative burden and improve the efficiency of air quality assessments, thus addressing the instances with scope for simplification and burden reduction potential as identified in the Fitness Check? What specific changes are needed for this?

[Q2 - (general) air quality assessment regimes] In view of how Member States establish, review and update air quality zoning, applicable assessment regimes, as well as classification of zones, what scope is there to make this more transparent, especially in air quality zones with a limited number of monitoring stations?

[Q3 - (monitoring) micro- and macro-scale siting of sampling points] In view of how Member States ensure adequate monitoring in areas within zones and agglomerations where the highest concentrations occur, especially around, close to or downwind from key point sources, are there significant assessment gaps related to these and what can be done?

[Q4 - (monitoring) representativeness and continuity of monitoring] In view of how Member States ensure adequate monitoring to reliably assess average exposure indicators (for fine particulate matter), how can the representativeness of sampling points and continuity of monitoring be ensured for particulate matter and would aligned requirements improve the assessment of other air pollutants with exceedances?

[Q5 - (monitoring) monitoring other air pollutants] Are Member States monitoring the concentration levels of air pollutants not covered by the AAQ Directives? If so, how, where, against which data quality objectives – and what is the scope to harmonise this?

[Q6 - (monitoring / modelling) air quality assessment methods)] What role do complementary assessment methods (i.e. modelling, indicative measurements, objective estimation, satellite measurements and low-cost sensors) play in the air quality assessment regimes applied in different Member States? Is there a need for more guidance?

[Q7 - (modelling) enhanced role of air quality modelling] What role does modelling play in the air quality assessment regimes applied in different Member States? Is there a need for guidance and for further harmonisation?

[Q8 - (modelling) improving quality of air quality modelling] Where air quality modelling is used in air quality assessment regimes, which modelling quality objectives are applied? Is there a need for, and scope to specify these further? Is more comprehensive guidance on the use of modelling (for example on fitness-for purpose, on, on modelling data quality objectives) needed and, if so, what should such guidance cover?

[Q9 - (air quality plans) elements of air quality plans] In view of how do competent authorities in Member States fulfil the requirements for an air quality plan as per Annex XV of Directive 2008/50/EC, which elements are considered essential, less essential or missing to ensure an effective air quality plan?

[Q10 - (air quality plans) role of modelling to support air quality plans] Where air quality modelling is used to support plans which approaches are applied? Is there a need for more guidance on the use of such approaches? Is there a need for, and scope to specify quality objectives (or benchmarks) for these approaches?

[Q11 - (air quality plans) air quality plan development process and engagement] Who are the main actors and stakeholders during the process of setting up an air quality plan in different Member States, and to what extent have they control and enforcement powers to ensure implementation? What further requirements would be effective?

[Q12 - (air quality plans) ex-ante impact, costs and effectiveness of air quality plans] How do competent authorities in Member States estimate the improvements in air quality expected due to air quality plans? Is there scope for further requirements in relation to ex-ante impacts and cost estimates to increase effectiveness of air quality plans?

[Q13 - (air quality plans) ex-post assessments of impacts and costs of air quality plans] Do competent authorities in Member States monitor and evaluate the effects and costs of air quality plans during and after their implementation? Is there scope for further requirements in relation to ex-post assessment of impacts and costs to increase effectiveness of air quality plans?

[Q14 - (general) public access to air quality data] How do competent authorities in Member States communicate with the public on and involve them in air quality matters, and specifically: how do they provide access to air quality data? How is the public informed about long and short term health risks of air pollution? Is there need for good practice guidance?

Q15 - (general) External factors. How do competent authorities in Member States calculate external factors contributing to the worsening of air quality in their monitoring, modelling and planning activities? How do they facto these sources into air quality planning processes?

To analyse the above-mentioned topics and be able to propose solutions for strengthening air quality monitoring, modelling and plans, the following steps were taken divided in two phases with the following activities included:

Phase 1: Scoping, mapping and analysis

1. Identification of key issues related to implementation of the provisions for air quality monitoring, modelling and air quality plans that would benefit from a further technical guidance document: a total of 271 literature sources were reviewed, of which 84 were ranked of potential relevance to the task at hand.
2. Consultation with experts, practitioners and other stakeholders on how the provisions on air quality monitoring, modelling and air quality plans have been implemented, where they are subject to interpretation and how their implementation could be further improved. This included an expert consultation that received 107 responses representing 23 Member States, four interviews of those Member States that had not responded to the expert consultation and the organisation of focus groups to deepen on the understanding of the issues identified as well as receiving feedback on the first solutions proposed. Additional inputs to the evidence base were also considered, such as those coming from a workshop hosted by the Commission on 20 April 2021. The workshop engaged the members of the Ambient Air Quality Expert Group to specifically discuss air quality assessments and assessment regimes highlighting guidance needs, and improvement potential.[82]
3. Mapping and analysis of established practice across Member States for several specific issues related to the implementation of provisions for air quality monitoring, modelling, and air quality plans.

The stakeholder engagement activities of phase 1 concluded with the identification of 72 technical issues that stakeholders are currently facing when implementing the Ambient Air Quality Directives.

Phase 2: Assessing the impacts of technical suggestions and recommendations for future

1. To address these 72 technical issues, 42 *potential* technical solutions were formulated, which could subsequently take the form of elements for technical guidance documents. The technical solutions were elaborated considering their respective consequences, their relevance, effectiveness, efficiency and coherence, as well as estimates of how long it would take to implement the possible modifications and the likelihood of their success (including in the absence of legislative changes).
2. The impacts of the different technical suggestions (including costs and efficiency gains) to strengthen the monitoring, modelling and air quality plans' provisions were assessed, as well as a quantification of any reduction potential for the administrative burden. To undertake this, a logic framework was developed to compare the evidence gathered for

[82] The workshop was attended by 40 experts from 25 Member States and from DG ENV (6), JRC (2), EEA (3) and ETC (1), plus 4 invited external experts.

each of the *potential* technical solutions. The result allowed for a comparative assessment of the 42 *potential* technical solutions.

3. As the last step a thorough review of existing technical guidance documents was done to identify those that would need to be replaced or reviewed; and which new technical guidance documents would need to be elaborated to allow the implementation of the technical solutions. *Potential* technical solutions deemed to have a low likelihood of success without changes to existing provisions were not considered in this last step.

3. TECHNICAL GUIDANCE DOCUMENTS

Most of the currently available technical guidance documents require updates to bring them in line with the current practice and knowledge, and to allow implementation of the technical solutions; or require the full replacement by new technical guidance documents.

Eight core technical guidance documents are recommended for future development by the European Commission in close cooperation with experts from AQUILA (for monitoring related guidance), FAIRMODE (for modelling related guidance) and the members of the Ambient Air Quality Expert Group:

A. Technical guidance document on air quality assessment in air quality zones.

EU air quality legislation requires Member States to designate air quality zones and report their corresponding air quality data to the European Commission. The Commission's Implementing Decision 2011/850/EU stipulates in Article 6 the information on zones and agglomerations that need to be made available by the Member States. The available guidance on the Commission's Implementing Decision specifies how and when air quality zones are to be reported while the guidance on their definition and the methods to be used in their identification is provided in the *Guidance on the Assessment under EU Air Quality Directives.*[83]

The proposal is to develop a technical guidance document to replace the current and outdated *Guidance on the Assessment under EU Air Quality Directives*.

Such new technical guidance document should focus on air quality zones and methodologies used for their determination - identifying the additional requirements necessary for their application for different air quality management purposes. This technical guidance document could specify that the definition of air quality zones applies for all assessment purposes concerning monitoring, modelling, and air quality plans. It could also identify methods to be applied so that the zones can be used for all assessment purposes. Such technical guidance document could clarify whether air quality modelling and plans are needed for a whole air quality zone or only at hot spot areas within the air quality zone, thus addressing the technical issues identified.

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[83] COM (2022), Guidance on Assessment under the EU Air Quality Directives Final (accessed: 04.08.2022)

This new technical guidance on air quality assessment in air quality zones encompasses most guidance topics identified as necessary to support assessment purposes concerning monitoring, modelling, and air quality plans, which description follows.

B. Technical guidance document on exceedance and exposure indicators.

The document should provide a clear and transparent outline of how to derive and report the relevant exceedance and exposure situation indicators (ESI) and the type of input data to be used in the process to harmonise these indicators for different air quality zones, regions and at Member State level.

This proposed new technical guidance document may rely on a tiered approach that allows the combination of fixed measurements, modelling results and indicative measurements to calculate different exceedance and exposure situation indicators (see also *E. Technical guidance document on the tiered approach of assessment methods*), as well as on the by FAIRMODE suggested two-stage assessment and reporting process.

This new technical guidance document should therefore consider FAIRMODE activities in relation to the calculation of exceedance and exposure indicators and their benchmarking activities to identify best practices.

C. Technical guidance document on reference methods and data quality objectives for new pollutants.

This new technical guidance document would identify the methodologies recommended for the measurement of additional pollutants that may be included in a revised Ambient Air Quality Directive, specifying for each of the pollutants recommended reference methods, equivalence methods and methods to establish compliance with their given data quality objective. It would explain the purpose of monitoring the additional pollutants with respect to health, ecosystems and climate impacts and explain the link with the legal monitoring and reporting requirements.

This new technical guidance document would also update the currently available *Guidance report on demonstration of equivalence of ambient air monitoring methods (2010)*[84] by updating the reference methods of for the currently monitored pollutants, and addressing also the methods needed for the use of indicative measurements.

This new technical guidance document would provide examples on good practices to reduce the uncertainties related to variability and the representativeness of measurements and provide direct support to fulfilling legal monitoring and reporting requirements.

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[84] COM (2010), Guidance report on demonstration of equivalence of ambient air monitoring methods (accessed: 04.08.2022)

It would enable monitoring experts in Member States to undertake comparable measurements with specific data quality objectives in support for improved health, climate and ecosystem impact assessments. This would lead to a harmonisation of additional monitoring requirements and ensure a good standard of monitoring.

This new technical guidance document should consider other parallel activities ongoing such as AQUILA's position paper from Working Group 6 on additional pollutants and reference methods, the outcome of the support contract on "*Systematic assessment of monitoring of other air pollutants not covered under Directives 2004/107/EC and 2008/50/EC (with a focus on ultrafine particles, black carbon and ammonia)",* as well as various current activities undertaken by the European Monitoring and Evaluation programme (EMEP), the Global Atmosphere Watch Programme (GAW), the Aerosol, Clouds, and Trace Gases Research Institute (ACTRIS) and the European Committee for Standardisation (CEN).

D. Technical guidance document on use of indicative measurements/low-cost sensors.

This new technical guidance document would be designed for competent authorities involved in the setup of monitoring campaigns to complement the fixed monitoring network or validate model applications. The document would focus on the capabilities of various complementary assessment methods, including indicative measurements and objective estimation, and would clarify what method is fit for what purpose. An additional specific technical advice document should be developed for the use of modelling systems in the context of the Ambient Air Quality Directives. This technical guidance document would primarily focus on measurement techniques.

From a monitoring perspective there is special interest in indicative measurements as robust, reliable and rather low-cost complementary assessment method. Given the strong uptake of low-cost sensors by society as well as by academia and environmental experts there is also a need for additional guidance with respect to the deployment, characterisation of accuracy and the use of low-cost sensors, sensor networks as a whole and its integration in modelling applications.

Topics to include would be how to characterise and evaluate the accuracy of indicative measurements and low-cost sensors, how to setup, deploy and maintain an effective network of indicative measurements or low-cost sensors, and how to integrate sensor data in air quality models to improve overall quality of the assessment maps.

The proposed technical guidance document should consider current ongoing activities performed by the European Commission's Joint Research Centre as regards low cost sensors, FAIRMODE´s work under cross-cutting task (CT) 6 and AQUILA´s input to the revision process under Working Group 4 on indicative measurements and objective estimation.

E. Technical guidance document on the tiered approach of assessment methods.

In general, compliance checking under the Ambient Air Quality Directive is performed on the basis of data collected in the fixed monitoring networks. Fixed measurements are the basis of every monitoring network, installed following the requirements of the Ambient Air Quality Directives. However, the use of additional methods such as indicative measurements, modelling or objective estimation are used by competent authorities to complement fixed monitoring data. This allows for a better understanding of air quality, and may have different uses such as for the evaluation of the monitoring network in assessing air pollution or sampling point representativeness. These data may also be reported to the European Commission via the e-Reporting system for compliance purposes.

Such technical guidance document would clarify the tiered approach that is recommended for use for these assessment purposes. The tiered approach ranges from:

- Tier 1: the use of expert opinion;
- Tier 2: the use of proxy data or specific measurement campaign data;
- Tier 3: the application of fit-for-purpose modelling systems;
- Tier 4: the application of modelling systems complemented with additional measurement data to further improve the quality of the assessment results.

For each of the tiers a proper description of its complexity level and the added value would be described together with a related quality assurance/quality control (QA/QC) process.

For the elaboration of this technical guidance document the results of the European Commission's support contract '*SR5 Sensitivity and feasibility tests for a tiered approach - Assessing the spatial representativeness of air quality sampling points',* as well as FAIRMODE´s work under CT8 on monitoring design and AQUILA´s position paper for the revision under Working Group 3 should be considered.

F. Technical guidance document on the use of models.

This technical guidance document would clarify the purpose and the role of modelling for its various application domains under the Ambient Air Quality Directive such as for complementary assessment; estimation of exceedance situation indicators; estimation of spatial representativeness of monitoring stations; evaluation of monitoring network design, estimation of population exposure; short term forecasting; near real time mapping; source apportionment and assessment of natural and long range transport contributions or air quality planning.

This technical guidance document would cover topics such as how to apply modelling systems in the various contexts of the Ambient Air Quality Directive, an QA/QC Protocol with recommendations to guarantee overall quality of modelling applications, including the minimum number of stations for robust model validation, criteria to evaluate the overall fitness-for-purpose of modelling applications in the context of the Ambient Air Quality Directives, information on the appropriate spatial resolution of models for the various purposes, and information on the fitness-for-purpose of modelling tools for source apportionment.

For the elaboration of this document, the following activities and reports should be considered: FAIRMODE´s work under CT2 for recommendations for QA/QC Protocol, recommendations regarding modelling applications within the scope of the Ambient Air

Quality Directives report on *'Source apportionment to support air quality management practices'*,[85] and the *'Guidance Document on Modelling Quality Objectives and Benchmarking'*.[86]

It is to be noted as well that there is currently no consensus in the modelling community regarding the definition of fitness-for-purpose, the modelling setup for planning and validation of models in planning modus. This presents a challenge and may require intensified discussions in the modelling community to solve these issues as soon as possible.

G. Technical guidance document on preparing air quality plans.

This technical guidance document would be designed for competent authorities responsible for preparing and updating air quality plans either at a national or local level, or both. It would aim to provide information for a successful preparation of air quality plans to increase the effectiveness, efficiency and coherence of air quality plans and ultimately result in air quality standards being respected in the shortest time possible.

The topics addressed would be governance and coordination, policy linkages to ensure policy coherence, the process of plan development from the analysis of the exceedance situation, source apportionment, developing a long list of possible measures to improve air quality in consultation with stakeholders, screening to a short list of measures and assessing their impact to develop a preferred policy option to implement. This technical guidance document would assist competent authorities on technical aspects of assessment and elaborate the importance of consultation and communication during the preparation and implementation phase. The technical guidance document would also elaborate post implementation assessment of the realised impacts under a monitoring and evaluation phase.

This technical guidance document should consider the current work by FAIRMODE CT5 working group preparing a best practice guide for local and regional air quality management, and the '*Catalogue of Air Quality Measures*'[87] being hosted and managed by the European Commission's Joint Research Centre.

H. Technical guidance document on air quality management best practice (governance and communication).

This technical guidance document would target the problematics concerning governance levels and responsibilities, and communication to the public. The main topics addressed would be the responsibilities at various government levels regarding the implementation of the Ambient Air Quality Directives, how to effectively communicate between national and lower levels of government for an effective implementation, how to communicate to the

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85 Fairmode (2019), Source apportionment to support air quality management practices (accessed 01.06.2022)
86 Fairmode (2020), Guidance Document on Modelling Quality Objectives and Benchmarking (accessed 01.06.2022)
87 JRC (2022), Catalogue of Air Quality Measures (accessed 01.06.2022)

public on the most critical air quality information, how to engage the general public in air quality planning, how to share information among municipalities / regions within a country and with other Member States, and how to cooperate with health authorities.

4. CONCLUSIONS

To summarise, these eight core technical guidance documents described previously would replace the existing documents as follows:

- Guidance report on preliminary assessment under EC air quality directives (1998) - replaced by new technical guidance document under A.
- Guidance on Assessment under the EU Ambient Air Quality Directive - replaced by new technical guidance document under A, plus embedded linkages to technical guidance document under B, D, E, F, G and H.
- Necessity to prepare action plans to reduce the duration of exceedances of alert thresholds (Art 7(3), 96/62/EC) - Note by the CAFE-Working group on Implementation Nr. 2003/1 - replaced by new technical guidance document under G.

In addition to these eight core technical guidance document, several existing guidance are recommended for review:

- Guidance on the Commission Implementing Decision laying down rules for Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council as regards the reciprocal exchange of information and reporting on ambient air.
- Guidance on air quality assessment around point sources under the under the EU Air Quality Directive 2008/50/EC.
- Guidance report on demonstration of equivalence of ambient air monitoring methods (2010). This may also be included under the new suggested technical guidance document under B.
- Commission Staff Working Paper - Guidelines for the agreements on setting up common measuring stations for $PM_{2.5}$, SEC(2011) 77.
- Commission Staff Working Paper - Guidelines for determination of contributions from the re-suspension of particulates following winter sanding or salting of roads, SEC(2011) 207.
- Commission Staff Working Paper - Guidelines for demonstration and subtraction of exceedances attributable to natural, SEC(2011) 208 final.

ANNEX 8: EU CLEAN AIR POLICY

1. OVERVIEW

EU clean air policy rests on three main pillars.

The first pillar comprises air quality management as regulated by the Ambient Air Quality Directives (2008/50/EC and 2004/107/EC), which contain standards for the concentration levels of 12 air pollutants[88] in ambient air and the obligation for Member States to adopt effective air quality plans if limits are exceeded. As per the European Green Deal, the European Commission will propose a revised Ambient Air Quality Directive in 2022.

The second pillar consists of air pollution control through emission reduction obligations established in Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (the NEC Directive) for five air pollutants[89] that contribute to transboundary air pollution in particular. The NEC Directive establishes national emission reduction obligations for 2020 to 2029, and more ambitious ones from 2030 onward, and obliges Member States to adopt and regularly update National Air Pollution Control Programmes (NAPCPs).

The third pillar comprises emission standards for key sources of pollution, from vehicle and ship emissions to energy and industry, agricultural practices and consumer products. The European Green Deal has proposed making source policies more ambitious, including in the context of the "Fit for 55" package, the proposal for a revised Industrial Emissions Directive[90] and the upcoming one for a Euro 7 emission standard for road vehicles[91], as well as the Zero Pollution Action Plan.

2. AIR QUALITY MANAGEMENT

The Ambient Air Quality Directives regulate air quality management along four main strands.

First, the Directives define common methods and criteria to assess air quality in all Member States in a comparable and reliable manner: Member States must designate zones and agglomerations throughout their territory, classify them according to prescribed assessment

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88 These are: particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2, including NO_x), ozone (O_3), sulphur dioxide (SO_2), carbon monoxide (CO), benzene (C_6H_6), benzo(a)pyrene (BaP), lead (Pb), arsenic (As), cadmium (Cd), nickel (Ni).

89 These are: sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and fine particulate matter ($PM_{2.5}$)

90 COM (2022), Proposal for a Directive amending Directive 2010/75/EU (accessed 04.08.2022)

91 COM (2022), European vehicle emissions standards – Euro 7 for cars, vans, lorries and buses (accessed 04.08.2022)

thresholds, and provide air quality assessments underpinned by (fixed or indicative) measurement, modelling and/or objective estimation, or a combination of these.

Second, the Directives establish objectives and standards for ambient air quality for 12 air pollutants to be attained by all Member States across their territories against timelines laid out in the Directives. These are: particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2, including NO_x), ozone (O_3), sulphur dioxide (SO_2), carbon monoxide (CO), benzene (C_6H_6), benzo(a)pyrene (BaP), lead (Pb), arsenic (As), cadmium (Cd), nickel (Ni) (see Table 8.1).[92]

Table A8.1 – EU air quality standards for different pollutants according to the Ambient Air Quality Directives

Pollutant	Concentration	Averaging period	Legal nature	Date entering into force	Permitted exceedances each year
Sulphur dioxide (SO_2)	350 µg/m³	1 hour	Limit value	1.1.2005	24
	125 µg/m³	24 hours	Limit value	1.1.2005	3
Particulate matte (PM_{10})	50 µg/m³	24 hours	Limit value	1.1.2005 **	35
	40 µg/m³	1 year	Limit value	1.1.2005 **	n/a
Fine particulate matter ($PM_{2.5}$)	25 µg/m³	1 year	Target value Limit value	1.1.2010 1.1.2015	n/a n/a
Nitrogen dioxide (NO_2)	200 µg/m³	1 hour	Limit value	1.1.2010 *	18
	40 µg/m³	1 year	Limit value	1.1.2010 *	n/a
Lead (Pb)	0.5 µg/m³	1 year	Limit value	1.1.2005 ***	n/a
Carbon monoxide (CO)	10 mg/m³	Max daily 8 hour mean	Limit value	1.1.2005	n/a
Ozone	120 µg/m³	Max daily 8 hour mean	Target value	1.1.2010	25 averaged over 3 years
Benzene	5 µg/m³	1 year	Limit value	1.1.2010 **	n/a
Arsenic (As)	6 ng/m³	1 year	Target value	31.12.2012	n/a
Cadmium (Cd)	5 ng/m³	1 year	Target value	31.12.2012	n/a
Nickel (Ni)	20 ng/m³	1 year	Target value	31.12.2012	n/a
Benzo(a)pyrene (BaP)	1 ng/m³	1 year	Target value	31.12.2012	n/a

**Under Directive 2008/50/EU, the Member States could apply for a postponement of a maximum of five years (i.e. maximum up to 2015) in specific zones; subject to an assessment by the Commission.*

***Under Directive 2008/50/EU, Member States were able to apply for an exemption to apply these limits until 11 June 2011 in specific zones; subject to assessment by the Commission.*

**** Or 1.1.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m3 limit value applied from 1.1.2005 to 31.12.2009.*

[92] In addition to limit values and target values, other types of air quality standards have been established in the form of critical levels, long-term objectives, alert thresholds and information thresholds, depending on the pollutant. The differences between these types of air quality standards are described in further detail below, see Table A8.1 and Box A8.1

Box A8.1 – A typology of EU Air Quality Standards

The Ambient Air Quality Directives deploy a number of different types of air quality standards for the different pollutants they cover. All these standards have been set on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, but their formats and purposes differ. These differences were motivated in part by different levels to which Member States were deemed to be able to address the respective air pollutants and their underlying emissions on their own territories.

Limit values are to be attained within a given period and not to be exceeded once attained – set for particulate matter, sulphur dioxide, nitrogen dioxide, benzene, carbon monoxide, and lead.

Target values are to be attained *where possible* over a given period by taking all necessary measures *not entailing disproportionate costs* – set for ozone, benzo(a)pyrene, arsenic, cadmium, nickel (also for fine particulate matter standards were initially established as target values before becoming limit values). One reason for setting target values rather than limit values can be to take account of specific formation mechanisms of the pollutant, for example in the case of ozone (also due to a strong role of transboundary sources and annual variations in meteorology for this air pollutant).

Critical Levels refer to concentrations above which direct adverse effects may occur on some receptors, such as trees, other plants or natural ecosystems but not on humans – set for sulphur oxides and for oxides of nitrogen.

Long-Term Objectives are set to be attained in the long term, save where not achievable through proportionate measures – set for ozone only.

Alert thresholds are levels beyond which there is a risk to human health from brief exposure for the population as a whole and at which immediate steps are to be taken by the Member States – set for sulphur dioxide, nitrogen dioxide, and ozone. And for ozone only, *information thresholds* set a level lower than the alert threshold beyond which there is a risk for particularly sensitive persons and for which immediate and appropriate information is necessary.

In addition, the *Average Exposure Indicator* provides an average level determined on the basis of measurements at urban background locations which reflects population exposure. It is used to calculate national exposure reduction targets (in percent) for each Member State.

Third, the Directives require Member States to monitor air quality in their territory. Member States need to report to the Commission, as well as to the general public, the results of air quality assessment on an annual basis, 'up-to-date' air quality measurements, as well as information on the plans and programmes they establish. It is the responsibility of Member States to approve the measurement systems required and ensure the accuracy of measurements.

Fourth, where the established standards for ambient air quality are not met, the Directives require Member States to prepare and implement air quality plans and measures (for the pollutants exceeding the standards). These air quality plans need to identify the main emission sources responsible for pollution, detail the factors responsible for exceedances, and spell out abatement measures adopted to reduce pollution. Abatement measures can include, for example: measures to reduce emissions from stationary sources (such as industrial installations or power plants, as well as medium and small size combustion sources, including those using biomass) or from mobile sources and vehicles (including through retrofitting with emission control equipment); measures to limit transport emissions through traffic planning or encouraging shifts towards less polluting modes (including congestion pricing or low emission zones); promoting the use of low emission fuels, or using economic and fiscal instruments to discourage activities that generate high emissions.

3. AIR POLLUTION CONTROL

Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants ("the NEC Directive") is one of the key legislative instruments to achieve the 2030 objectives put forward in the Zero Pollution Action Plan to reduce by more than 55% the health impacts (premature deaths) of air pollution and by 25% the ecosystems where air pollution threatens biodiversity in the EU[93]. The NEC Directive sets national emission reduction commitments for each EU Member State for the period 2020 to 2029, as well as more ambitious ones as of 2030, targeting five air pollutants that are responsible for significant negative impacts on human health and the environment: sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and fine particulate matter ($PM_{2.5}$).

Table A8.2 – 2030 national emission reduction commitments of the NEC Directive compared to 2005 levels (as per Annex II of the NEC Directive)

	SO_2	NO_x	NMVOC	NH_3	$PM_{2,5}$
Belgium	66%	59%	35%	13%	39%
Bulgaria	88%	58%	42%	12%	41%
Czech Republic	66%	64%	50%	22%	60%
Denmark	59%	68%	37%	24%	55%
Germany	58%	65%	28%	29%	43%
Estonia	68%	30%	28%	1%	41%
Greece	88 %	55 %	62 %	10 %	50 %
Spain	88%	62%	39%	16%	50%
France	77%	69%	52%	13%	57%
Croatia	83%	57%	48%	25%	55%
Ireland	85%	69%	32%	5%	41%
Italy	71%	65%	46%	16%	40%
Cyprus	93%	55%	50%	20%	70%
Latvia	46%	34%	38%	1%	43%
Lithuania	60%	51%	47%	10%	36%
Luxembourg	50%	83%	42%	22%	40%
Hungary	73%	66%	58%	32%	55%
Malta	95%	79%	27%	24%	50%

93 Predating the NEC Directive, the Clean Air Programme (COM (2013)918) had put forward a target to reduce the health impacts of air pollution by half by 2030 compared to 2005.

Table A8.2 – 2030 national emission reduction commitments of the NEC Directive compared to 2005 levels (as per Annex II of the NEC Directive)					
	SO_2	NO_x	NMVOC	NH_3	$PM_{2,5}$
Netherlands	53%	61%	15%	21%	45%
Austria	41%	69%	36%	12%	46%
Poland	70%	39%	26%	17%	58%
Portugal	83%	63%	38%	15%	53%
Romania	88%	60%	45%	25%	58%
Slovenia	92%	65%	53%	15%	60%
Slovakia	82%	50%	32%	30%	49%
Finland	34%	47%	48%	20%	34%
Sweden	22%	66%	36%	17%	19%
United Kingdom	88%	73%	39%	16%	46%
EU 27 + UK	**79%**	**63%**	**40%**	**19%**	**49%**

The NEC Directive entered into force on 31 December 2016, repealing Directive 2001/81/EC[94] on national emission ceilings for certain atmospheric pollutants, with effect from 1 July 2018. Under the NEC Directive, $PM_{2.5}$ was added to the pollutants for which mandatory reductions have been set, and the list of pollutants for which reporting is obligatory was expanded. The Directive also introduced a shift from emission ceilings, which prescribed a fixed maximum annual amount of emissions in kilo tonnes per pollutant, to emission reduction commitments, which set reduction obligations expressed as a percentage of the emissions of each pollutant in the baseline year 2005.

The emission reduction commitments for 2020 to 2029 under the NEC Directive correspond to the emission reduction commitments for 2020 and onwards taken by the EU and its Member States under the revised Gothenburg Protocol[95] to the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (LRTAP).[96] The Directive thereby transposes those international obligations, catering for the transboundary feature of air pollution. Pollution from all countries neighbouring the EU should be sought to be reduced in order to further increase synergies. Western Balkans countries (candidate and potential candidate for EU accession) are in the front line of this objective and the EU is working with them (in particular through capacity building) in order to reduce air pollution emitted in those countries. To track progress towards the reduction commitments under the Directive, Member States report annual emission inventories (as per Article 10(2) of the NEC Directive). These inventories, which report actual emissions with a two-year time lag, are used to check compliance with the emission reduction commitments.

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94 Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, OJ L 309, 27.11.2001, p. 22.

95 UNECE, 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Lang-range Transboundary Air Pollution (accessed: 10.06.2022)

96 UNECE (2022), The Convention and its achievements, 1979 Convention on Long-Range Transboundary Air Pollution (accessed: 10.06.2022)

The year 2022 is hence the first year for the Commission to check compliance against the emission reduction commitments for the year 2020-29 of the NEC Directive. Member States also have the obligation to report every two years their *projected* emissions (as per Article 10(2) of the NEC Directive), which are compared to reduction commitments for 2020-29 and 2030 onwards to assess whether the Member State is on track to reach them.

Member States also have to draw up, adopt and implement national air pollution control programmes (NAPCP),[97] as per Article 6(1) of the NEC Directive. These should show how they will meet their emission reduction commitments for 2020-2029, and how they will reach the more ambitious commitments by 2030 and beyond.[98] The NAPCP constitutes a central governance instrument that allows Member States to coordinate and agree their policies and measures (PaMs) to ensure national emission reduction commitments are met. Its preparation requires consultation and involvement of competent authorities at different levels and of several different sectors, such as environment, agriculture, energy, climate, transport, industry or finance. A particular emphasis is put on coherence with plans and programmes developed under other, related policy areas. Furthermore, the NAPCP is a tool to communicate a Member State's pollution control policies and to involve the public in the process of policy-making. The first NAPCPs were due by 1 April 2019. NAPCPs must be updated at least every four years and earlier if new data so requires.

Member States which do not project to achieve their emission reduction commitments with current policies have to report in their NAPCPs the additional policies and measures that they considered for adoption and those actually selected in order to fulfil their commitments.[99]

The first implementation report prepared by the Commission according to Article 11(1) of the NEC Directive presented the progress made in the implementation of the Directive, including its transposition and early assessment of the efforts made by Member States towards attaining national emission reduction commitments.[100] Subsequently, the Second Clean Air Outlook presented an analysis of the prospects for achieving the emission reduction commitments under the NEC Directive up to 2030, the related contribution to improving air quality, health and the environment, and of the costs and benefits of the needed measures and expected impacts. The third edition of the Clean Air Outlook is currently being prepared for publication towards the end of 2022 and will update the assessment of compliance prospects. The modelling work underlying the Outlook is developed in coherence with this impact assessment. The third Clean Air Outlook will be part of the Zero-Pollution Outlook and will also provide early inputs that will feed into the preparation of the review of the NEC Directive due by 2025.

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[97] The Commission has specified the format of the NAPCP, setting out mandatory and optional content, in Commission Implementing Decision (EU) 2018/1522 of 11 October 2018 laying down a common format for national air pollution control programmes under Directive (EU) 2016/2284 of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants.

[98] The Commission has also prepared guidance for the development of NAPCPs: OJ C 77, 1.3.2019, p. 1.

[99] This reporting had to be done via the (EEA PaM Tool) a web-tool developed by the EEA.

[100] COM/2020/266 final

4. LINKS TO OTHER POLICIES

The following table maps European Green Deal policies and priorities that are of relevance for the successful implementation of the Ambient Air Quality Directives and which in turn are likely to be influenced by increased ambition under the Ambient Air Quality Directives.

Table A8.2 – Mapping of European Green Deal policies and priorities relevant for the implementation of the Ambient Air Quality Directives and vice versa

Policy domains	Links to Ambient Air Quality Directives
Climate Ambition	
Fit for 55 legislative proposals to deliver the increased ambition level of 55% reduction of GHG emissions by 2030	Increased climate ambition will foster uptake of low- or zero emission technologies with co-benefits for air quality (such as non-combustible renewables, energy efficiency measures, electric mobility). Proposals on increased ambition include: • increased ambition of the EU emission trading system (**ETS**)[101]; • increased ambition of the EU's **Effort Sharing Regulation**[102]; • stricter **CO_2 emission performance standards for cars and vans**[103] requiring all newly registered cars and vans to be zero-emission from 2035. Stricter AQ standards bring co-benefits for climate in the form of reduction of black carbon (BC), a short-lived climate forcer (SLCF).
Clean, affordable and secure energy	
RePowerEU	RePowerEU proposes actions to rapidly reducing Europe's dependence on Russian fossil fuels by fast forwarding the clean transition and joining forces to achieve a more resilient energy system and a true Energy Union. Those actions include an overall reduction of the energy consumption, diversify energy imports, substituting fossil fuels and accelerating the transition to renewable energy in power generation, industry, buildings and transport and smart investments. Speeding up these actions can benefit air quality, too.
Increased ambition on renewables	Increased uptake of non-combustible renewable energy sources will reduce reliance on fossil fuels and hence emissions of air pollutants, improving air quality. Biomass burning, in inefficient and old installations, as part of renewable energy use emits air pollutants and thus negatively affects air quality. Initiatives promoting renewable energy sources include the 2021 proposal to revise the **Renewable Energy Directive** (RED II)[104], which puts forward more ambitious 2030 targets, as well as the 2022 Commission Communication on **RePower EU** with a lot of emphasis on frontloading

[101] COM (2021) 551 final
[102] COM (2021) 555 final
[103] COM (2021) 556 final
[104] COM (2021) 557 final

	investments in renewables, notably solar power and wind, and in heat pumps, all of which are beneficial also for air quality.
Increased ambition on energy efficiency	Increased ambition on energy efficiency and the introduction of a binding EU energy efficiency target through the proposal on a revised **Energy Efficiency Directive**[105] will decrease energy needs overall, including of fossil fuels and hence reduce emissions of air pollutants, improving air quality.
Renovation wave	Deeper and more widespread uptake of energy efficiency measures and of on-site generation from non-combustible renewable energy sources in building renovation, such as through the proposed recast **Energy Performance of Buildings Directive**[106], will help reduce the use of fossil fuels and biomass for heating[107] and hence reduce emission of air pollutants, improving air quality.
Digitalisation	
Accelerate the digital transformation	The European Environment Information and Observation Network (Eionet) hosted by the European Environment Agency gathers and displays data as a unique digital platform used by all Member States for their reporting of air quality data. The digital service offered on the platform facilitates online reporting and coordinating between National Focal Points (NFPs) in the countries and the European Commission.
Industrial strategy for a clean and circular economy	
Sustainable Products Initiative	By making products that consume less energy, by using them more efficiently and for longer, by relying on recycled materials instead of primary raw materials, and by spreading front-runner circular economic models, indirect co-benefits can be expected for air quality, notably through a reduction of fossil energy and the related emissions.
Sustainable and Smart Mobility	

[105] COM/2021/558 final
[106] COM/2021/802 final
[107] The definition in the proposed recast EPBD of a zero-emission building accommodates use of biomass for on-site energy generation, while biomass use leads to air pollutant emissions.

Sustainable and Smart Mobility Strategy and follow-up actions	Action supporting the move towards lower-emission and public transport will bring positive co-benefits for air quality. Some actions with particular relevance for air quality include: • Proposal for more stringent air pollutant emissions standards for combustion-engine vehicles (**Euro 7**)[108]: Euro standards reduce pollutant emissions from cars, vans, trucks and buses, improving air quality. The introduction of Euro 7 will bring further benefits in this regard. • Proposal for an **alternative fuels infrastructure** regulation[109]: a comprehensive network of recharging and refuelling infrastructure is needed to facilitate the increased uptake of renewable and low-carbon fuels, including e-mobility, which would bring important air quality co-benefits. • Proposals for **ReFuelEU Aviation** and **FuelEU Maritime** include measures that promote cleaner fuels, with a potential to reduce air pollutant emissions, and to improve air quality near ports by requiring the use of on-shore power supply or zero-emission energy at berth for specific ship types. In turn, the Ambient Air Quality Directives trigger increased action in urban areas to move to lower emission mobility, introduction of low-emission zones, increased uptake of public transport and active mobility to attain limit values.
Greening the Common Agricultural Policy / 'Farm to Fork' Strategy	
CAP national strategic plans	In December 2020, the Commission sent recommendations to all Member States for the drafting of the national CAP SPs[110]. Notably, Member States were recommended to ensure sufficient ambition level and to include and promote ammonia reduction measures as ecoschemes or investment interventions in their CAP SPs, thereby contributing to improved air quality and reduced concentrations of secondary particulate matter. The Commission reviews the final CAP SPs to assess whether these recommendations have been followed.
'Farm to Fork' Strategy	The strategy and its action plan support the move towards more sustainable farming practices and address improved nutrient management and excess use of pesticides and fertilisers. This will bring positive co-benefits for air quality, notably via reduced ammonia (an important precursor of $PM_{2.5}$) and nitrogen emissions from low-pollution manure management techniques. The Ambient Air Quality Directives improve understanding of and drive action to address rural background levels of pollutant concentrations which harm crop yields (in particular of SO_2, NO_X and O_3).
CAP GAEC 6 on stubble burning	Within the Common Agricultural Policy, the Good Agricultural and Environmental Conditions include as a cross-cutting conditionality the ban on open burning of arable stubble (except for plant health reasons), contributing to the reduction of particulate matter emissions and concentrations.
Preserving and protecting biodiversity	
Addressing biodiversity loss and degradation of ecosystems	Poor air quality negatively affects vegetation and ecosystems. The Ambient Air Quality Directives define critical levels for SO_2 and NO_X for the protection

[108] COM 2022), European vehicle emissions standards – Euro 7 for cars, vans, lorries and buses (accessed 04.08.2022)
[109] COM(2021) 559 final
[110] SWD C2020/846

	of vegetation and natural ecosystems and requires measurements to improve the protection of vegetation and natural ecosystems from high ozone concentrations. In turn, policies that improve ecosystem health, such as the proposed **Nature Restoration Law** can also deliver on clean air aspects.
Towards a zero-pollution ambition for a toxic free environment	
Zero Pollution Action Plan	Stricter air quality standards are a key deliverable under the ZPAP and a key tool to move closer to the EU's zero pollution ambition. The proposed revision of the **Industrial Emissions Directive**[111] is an important deliverable under the ZPAP. The IED prevents and reduces emission of pollutants to air and hence contributes to attaining air quality standards.
Chemicals Strategy	By promoting the transition towards safe and sustainable chemicals and moving towards cleaner chemical and material production processes can generate indirect benefits for air quality.
Ecodesign requirements	Requirements for heating appliances, in particular those for solid fuel heating, are important for curbing pollutant emissions and hence attaining air quality standards particularly in densely populated areas.
Indoor air quality	Indoor air quality benefits from improved ambient air quality through ventilation.
Mainstreaming sustainability in all EU policies	
Various source legislation	The success of EU clean air policy including the attainment of the Ambient Air Quality Directives' air quality standards relies on successful mainstreaming of clean air considerations into other policies, notably when it comes to key sources of air pollution such as energy generation, transport, industrial installations, domestic heating and agriculture.
EU funding – clean air expenditures tracking	While there is no clean air spending target, clean air tracking by the Commission is meant to monitor EU funding contributing to clean air in view of a better implementation of the clean air policies (incl. the Ambient Air Quality Directives) in Member States.
Socially just transition	Poor air quality disproportionally affects citizens of lower socio-economic status, as well as those with pre-existing conditions and children[112]. Consequently, these groups of society are expected to benefit most from stricter air quality standards.
The EU as a global leader	
International cooperation	Air quality in the EU partly depends on clean air action in third countries, and vice versa. International cooperation is therefore crucial and mutually beneficial, including e.g. though the UNECE Air Convention, WHO and United Nations Environment Programme (UNEP).
Maritime transport	Progress at international level towards stricter emissions limits on SO2 emissions, including through the introduction of emission control areas (ECAs), contribute to improving air quality notably in coastal regions.
Working together – a European Climate Pact	

[111] COM(2022) 156 final

[112] EEA (2018), EEA Report No 22/2018 (accessed: 09.06.2022)

Engagement with citizens / Citizen science	European citizens care strongly about air quality.[113] Air quality is an area where citizen science[114] complements official measurements performed in accordance with the Ambient Air Quality Directives, bringing EU policy objectives closer to citizens. The European Environment Agency's European Air Quality Index[115] allows users to gain insights into the air quality where they live, through a web-based application and a new Air quality index mobile app.
UNECE Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental matters (Aarhus Convention)	The EU is party to the Aarhus Convention since February 2005 and adopted several measures since to implement the provisions therein, *inter alia*: • Directive 2003/4/EC on public access to environmental information[116] • Directive 2003/35/EC providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment[117] • Regulation (EC) 1367/2006 on the application of the provisions of the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters to Union institutions and bodies[118] Safeguarding compliance with air quality objectives in the EU partly depends on European citizens having access to the right information, being able to participate in the decision-making process and, in case of non-compliance by Member States, having access to justice to enforce air quality objectives.

[113] COM (2019), Special Eurobarometer 497 (accessed: 09.06.2022) and COM (2021), Open Public Consultation on "Air quality – revision of EU rules" (accessed: 04.08.2022)

[114] e.g. CurieuzenAir (accessed: 09.06.2022)

[115] EEA (2022), European air quality index (accessed: 09.06.2022)

[116] OJ L 41, 14.2.2003, p.26.

[117] OJ L 156, 25.6.2003, p.17.

[118] OJ L 264, 25.9.2006, p.13.

ANNEX 9: FITNESS CHECK OF THE AMBIENT AIR QUALITY DIRECTIVES IN 2019

1. SCOPE AND METHODOLOGY

In November 2019, the European Commission completed and published its fitness check of the Ambient Air Quality Directives (Directives 2008/50/EC and 2004/107/EC).[119] The fitness check assessed whether the EU actions enshrined in these pieces of legislation have achieved their objectives without entailing disproportionate costs and continue to be justified.

The fitness check was guided by a roadmap[120] that outlined issues, looking in particular at the five evaluation criteria set out in the Better Regulation agenda. This translated into five overarching evaluation questions on the criteria of relevance, effectiveness, efficiency, coherence and EU added value. A sixth evaluation question specifically looked at the effectiveness and efficiency of air quality monitoring.

The fitness check draws on experience in, and data from, all Member States, focusing on the period from 2008 to 2018 as this is the period when both Directives were in force. The analysis covers all articles and provisions of the two Ambient Air Quality Directives, looking at the role they have played in meeting the objectives. The work was underpinned by the evidence collected in the study 'Supporting the fitness check of the EU Ambient Air Quality Directives (2008/50/EC, 2004/107/EC)'. 121 The support study helped gather information and data through different channels, including several means to solicit stakeholder views.

The fitness check allowed the public to participate effectively through a comprehensive stakeholder consultation including an open public consultation, a targeted questionnaire and two stakeholder workshops.

The findings of the fitness check are used to inform further reflections on whether the Ambient Air Quality Directives continue to provide the appropriate legislative framework to ensure protection from adverse impacts on, and risks to, human health and the environment.

2. EXECUTIVE SUMMARY OF THE FITNESS CHECK[122]

Clean air is essential to human health. It is also essential to sustaining the environment, and provides multiple economic and social benefits. The scientific evidence of harmful effects of air pollution is well-established, robust and points to a clear need for action.

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[119] SWD (2019) 427 final.
[120] COM (2019), Have your say on the fitness check of the EU Ambient Air Quality Directives (accessed: 04.08.2022)
[121] COWI et al. (2019). 'Supporting the fitness check of the EU Ambient Air Quality Directives (2008/50/EC, 2004/107/EC)' – hereafter referred to as 'Support study informing this Fitness Check'.
[122] SWD (2019) 428 final.

The current Ambient Air Quality Directives constitute the third generation of EU level air quality policies since the early 1980s, and have inherited many provisions, including many air quality standards from predecessor legislation. These policies have rendered some successes, as exemplified by the decrease of exceedances for most air pollutants over the past decade. However, the air quality challenge is far from being solved. Although the number of people exposed to air pollution decreased markedly during the past decade, persistent exceedances above EU air quality standards remain for several air pollutants, and especially for particulate matter, nitrogen dioxide, ozone and benzo(a)pyrene – with significant impacts on human health and the environment. In 2017, for example, 8% of the EU urban population was exposed to levels above the EU air quality standards for fine particulate matter ($PM_{2.5}$); but when measured against the more stringent recommendations by the World Health Organization this figure increased to around 77%.

With the Ambient Air Quality Directives, and in combination with the wider EU Clean Air Policy Framework, the European Union has the policy tools at hand to address this challenge. The fitness check, including the analysis of its underlying evidence and stakeholder views, concludes that the Ambient Air Quality Directives have been *partially effective* in improving air quality and achieving air quality standards. It also acknowledges that they have not been *fully* effective and not all its objectives have been met to date, and that the remaining gap to achieve agreed air quality standards is too wide in certain cases.

Clear EU air quality standards – Air quality standards have been set for a total of 12 air pollutants.[123] Their relevance and the underpinning scientific evidence on their harmful effects has been reconfirmed and reinforced. For other air pollutants, not covered by the Ambient Air Quality Directives, such as ultrafine particles or black carbon, the current scientific evidence on adverse health effects remains inconclusive and does not lend itself to setting standards. The air quality standards have been instrumental in driving concentrations downward and reducing exceedance levels. Nevertheless, two shortcomings remain: firstly, EU air quality standards are not fully aligned with well-established health recommendations (and they do not feature an explicit mechanism for adjusting air quality standards to the latest technical and scientific progress); while secondly, due to insufficiently effective air quality plans and lack of commitment to take appropriate measures by Member States, there have been and continue to be substantial delays in taking appropriate and effective measures to meet the air quality standards. Thus, while the number and magnitude of exceedances above air quality standards have decreased over the past decade, it is also clear that they have not been kept as short as possible to date.

A representative high-quality monitoring of air quality – Across the EU, Member States have established an air quality monitoring network with some 16 000 sampling points for specific pollutants (often grouped at more than 4 000 monitoring stations) based on common criteria defined by the Ambient Air Quality Directives. This extensive network can be considered a success in itself. Concerns have been raised that the criteria on monitoring offer

[123] Sulphur dioxide, nitrogen dioxide, particulate matter ($PM_{2.5}$, PM_{10}), ozone, benzene, lead, carbon monoxide, arsenic, cadmium, nickel, and benzo(a)pyrene.

too much leeway and present some ambiguity to competent authorities, resulting in instances where air quality monitoring does not live up to the criteria set by the Ambient Air Quality Directives. A key challenge here is to ascertain that air quality sampling points indeed provide information for where the highest concentrations of air pollutants occur. This, however, does not appear to amount to systemic shortcomings in the EU-wide monitoring network. Overall, the monitoring network by and large adheres to the provisions of the Ambient Air Quality Directives, and ensures that reliable and representative air quality data is available.

***Reliable, objective, comparable information on air quality* –** The provisions on reporting have prompted the establishment of improved and more efficient e-reporting systems to report both validated air quality data as well as up-to-date data. The air quality data reported by Member States is made available to the public by the European Environment Agency, including via an European Air Quality Index based on near-real time data. The Ambient Air Quality Directives have facilitated the availability and accessibility of objective and comparable air quality data and information across the EU. Further harmonisation of the way air quality information is presented, especially at Member State level, would be possible and provide further EU added value, and help ensure even higher comparability of air quality information across all geographical scales and all regions of the EU.

***Action to avoid, prevent, and reduce impact of poor air quality* –** The Ambient Air Quality Directives have been only partially, and therefore insufficiently, successful in meeting this objective. While action to reduce the impact of air quality has been taken, resulting in a reduced number and magnitude of exceedances, 20 Member States still report exceedances above EU limit values for at least one pollutant, and often for several. One reason for this is that improvements in air quality critically depend on action taken to address the sources of air pollution, and typically require action in the transport, energy (including domestic heating) and agricultural sectors or by industry. At national, regional and local level, this has not translated into sufficient level of commitment. At the EU level, synergies with climate, energy and transport policies have been strengthened over the past decade, and require coherent action at national, regional and local levels. Notwithstanding the important shortcoming of the remaining implementation gap to meet the air quality standards for all pollutants and throughout the EU, the clear requirement to take remedial action when and where exceedances are observed has been decisive in triggering improvement in air quality, yet often with delay.

***Conclusions* –** The Ambient Air Quality Directives have guided the establishment of a representative high-quality monitoring of air quality, set clear air quality standards, and facilitated the exchange of reliable, objective, comparable information on air quality, including to a wider public. They have been less successful in ensuring that sufficient action is taken by Member States to meet air quality standards and keep exceedances as short as possible. Nevertheless, the available evidence indicates the Ambient Air Quality Directives have contributed to a downward trend in air pollution and reduced the number and magnitude of exceedances. This partial delivery allows to conclude that the Ambient Air Quality Directives have been broadly fit for purpose – while at the same time pointing to scope for improvements to the existing framework such that good air quality be achieved across the EU. In particular, it emerges from the fitness check that additional guidance, or clearer requirements in the Ambient Air Quality Directives themselves, could help to make monitoring, modelling and the provisions for plans and measures more effective and efficient.

3. Some lessons learnt as highlighted by the fitness check

The fitness check showed that over the past decade, the Ambient Air Quality Directives have guided the establishment of a representative high-quality monitoring of air quality, set clear air quality standards, and facilitated the exchange of reliable, objective, comparable information on air quality, including to a wider public.

At the same time, the Ambient Air Quality Directives have been less successful in ensuring that sufficient action is taken to meet air quality standards and keep exceedances as short as possible. Having said that, the evidence shows that they significantly contributed to a downward trend in air pollution and reduced the number and magnitude of exceedances.

This *partial* success allows to conclude that the Ambient Air Quality Directives have been broadly fit for purpose, with clear shortcomings as regards achieving the overarching ambition to *fully* meet all air quality standards for all pollutants and throughout the European Union according to the timelines established in the Ambient Air Quality Directives at the time of adoption.

This points to scope for improvements to the existing framework for air quality management. In particular, it emerges from the fitness check that additional guidance, or clearer requirements in the Ambient Air Quality Directives themselves, could help to make monitoring, modelling and the provisions for plans and measures more effective and efficient.

Specifically, the fitness check identified several lessons learnt to be considered in the follow-up to the fitness check, including the below:

- air pollution continues to be a major health and environmental concern to the citizens of the EU, and surveys show it to be one of the two most important environmental issues (the other being climate change) – a relative majority of citizens share the view that the issue of air pollution can be best addressed at the EU level: this underlines the continued relevance of the Ambient Air Quality Directives;
- the EU air quality standards have been instrumental in driving a downward trend in exceedances and of exposure of population to exceedances – however, the current air quality standards are not as ambitious as established scientific advice suggests for several pollutants, especially fine particulate matter ($PM_{2.5}$); the WHO Air Quality Guidelines are currently being reviewed, and the Commission is following this closely;
- trends in exceedance levels for fine particulate matter ($PM_{2.5}$) indicate that limit values have been more effective in facilitating downward trends than other types of air quality standards, such as target values – especially where this has been done in conjunction with an exposure concentration obligation requirement and national emission reduction commitments as established under the NEC Directive;
- enforcement action by the European Commission and in particular also by civil society actors in front of national courts (under general right to access to justice provisions, as

there are no explicit provisions in the Ambient Air Quality Directives on this) has resulted in actionable rulings, shown that the legislation is enforceable, and proven to be important to accelerate downward trends for air pollution;

- the Ambient Air Quality Directives have given flexibility to competent national authorities to ensure air quality monitoring and air quality measures optimally fit local circumstances in line with the principle of subsidiarity – yet additional guidance or implementing acts could help to further harmonise approaches applied to monitoring, information provisions, and air quality plans and measures;
- for air quality data, not all data reported is equally useful and the successful establishment of an EU-wide e-reporting based on machine-readable formats now allows for further efficiency gains – and opens the way for further up-to-date reporting of air quality data and to make further use of air quality modelling (which is increasingly reported, but would benefit from further guidance).

4. PROVISIONS OF THE AMBIENT AIR QUALITY DIRECTIVES THAT HAVE BECOME REDUNDANT

There are a number of provisions of the Ambient Air Quality Directives that have become redundant over time. This is the case with the provisions that contain a temporal component, prescribing the starting or the ending date of an obligation. In the meantime, they either have been exhausted or have lost relevance:

- Article 22, in connection with Annex XV, section B, of Directive 2008/50/EC, related to the postponement of attainment deadlines by up to five years and the exemption from the obligation to apply certain limit values until June 2011.
- Article 32 of Directive 2008/50/EC, obliging the Commission to review in 2013 provisions related to PM2.5 and, as appropriate, other pollutants. This 2013 review has occurred.
- Article 8 of Directive 2004/107/EC requiring the Commission to report by the end of 2010 on the experience with the Directive. A corresponding analysis has been prepared as part of the air policy review initiated in 2011.[124]
- Several provisions of Directive 2008/50/EC refer to margins of tolerance (allowed exceedances of limit values expressed in percentages) that were applicable until a certain date (e.g. until 1 January 2010 for nitrogen dioxide).

Furthermore, it is worth noting that the preamble to Directive 2008/50/EC refers to the possible merger of the two Directives once sufficient experience is gained in the implementation of Directive 2004/107/EC.

[124] SEC(2011)342. ‘Implementation of EU Air Quality Policy and preparing for its comprehensive review’; see also underpinning analysis provided jointly by Environment Agency Austria, Ricardo-AEA, and TNO (2013) ‘Review of the Air Quality Directive and the 4th Daughter Directive’.

Annex 10: WHO Recommendations and EU Air Quality Standards

1. World Health Organization recommendations

EU Clean Air Policy bases itself on scientific evidence and sets appropriate objectives for ambient air quality taking into account relevant World Health Organization (WHO) standards, guidelines and programmes.

Since 1987,[172] the WHO has periodically issued health-based Air Quality Guidelines to assist governments and civil society in reducing human exposure to air pollution and its adverse effects. The overall objective of these Air Quality Guidelines is to offer quantitative health-based recommendations for air quality management, expressed as long- or short-term concentrations for several key air pollutants. Exceedance of the air quality guideline levels is associated with important risks to public health.

The WHO Air Quality Guidelines are not conceived as legally binding standards; however, they do provide an evidence-informed reference point that public authorities can use to inform legislation and policy. Furthermore, the WHO points out that, when translating their recommendations into policies, other features such as legal aspects, cost-benefit or cost-effectiveness, technological feasibility, infrastructural measures and socio-political considerations may also need to be examined. The WHO Air Quality Guidelines are to be seen as an input into a policy making process.

Previous versions of WHO Air Quality Guidelines were published in a 2000 edition,[173] and in a 2005 edition.[174] The 2000 edition provided recommendations on a wide range of air pollutants (including, but not limited to, all those referred to in the current versions of the Ambient Air Quality Directives), whereas the 2005 edition indicated more refined guidelines for the major health-damaging air pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

In September 2021, a revised edition of the WHO global Air Quality Guidelines was published[175]. This revision focused on particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide – see Table A10.1. For these air pollutants, the WHO offers evidence-informed recommendations in the form of guideline levels, including an indication of the shape of the concentration–response functions in relation to critical health outcomes, as well as interim targets to guide reduction efforts.

The revised WHO Air Quality Guidelines were formulated following a rigorous process involving several groups with defined roles and responsibilities. The steps in the development

[172] WHO (1987), Air quality guidelines for Europe
[173] WHO (2000), Air quality guidelines for Europe, 2nd edition
[174] WHO (2006), Air quality guidelines – global update 2005
[175] WHO (2021), WHO global Air Quality Guidelines

included a determination of which pollutants to focus on; systematic reviews[176] of the evidence and meta-analyses of quantitative effect estimates to inform updating of the guideline levels; assessments of the level of certainty of the bodies of evidence resulting from these systematic reviews; and the identification of guideline levels, that is, the lowest levels of exposure for which there is evidence of adverse health effects.

Table A10.1 - Recommended Air Quality Guidelines levels and interim targets – 2021 edition of the WHO Air Quality Guidelines (WHO, 2021)

Pollutant	Averaging time	Interim target				AQG level
		1	2	3	4	
$PM_{2.5}$, µg/m³	Annual	35	25	15	10	5
	24-hour[a]	75	50	37.5	25	15
PM_{10}, µg/m³	Annual	70	50	30	20	15
	24-hour[a]	150	100	75	50	45
O_3, µg/m³	Peak season[b]	100	70	–	–	60
	8-hour[a]	160	120	–	–	100
NO_2, µg/m³	Annual	40	30	20	–	10
	24-hour[a]	120	50	–	–	25
SO_2, µg/m³	24-hour[a]	125	50	–	–	40
CO, mg/m³	24-hour[a]	7	–	–	–	4

[a] 99th percentile (i.e. 3–4 exceedance days per year).
[b] Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration.

The 2021 edition of WHO Air Quality Guidelines stresses that levels recommended in previous WHO Air Quality Guidelines for pollutants and averaging times not covered in the most recent update remain valid. This includes the short averaging times for nitrogen dioxide, sulphur dioxide and carbon monoxide that were included in 2005 edition. See Table A10.2.

Table A10.2 - Recommended Air Quality Guidelines levels and interim targets – not evaluated in the 2021 edition, but that remain valid (WHO, 2021)

Pollutant	Averaging time	Air quality guidelines that remain valid
NO_2, µg/m³	1-hour	200
SO_2, µg/m³	10-minute	500
CO, mg/m³	8-hour	10
	1-hour	35
	15-minute	100

[176] The systematic reviews that informed the formulation of WHO Air Quality Guidelines levels and other related evidence discussed during the process are available in a special issue of Environment International published in 2021, entitled 'Update of the WHO global Air Quality Guidelines: systematic reviews'.

In addition, the 2021 edition also provided qualitative statements on good practices for the management of certain types of particulate matter (i.e., black carbon or elemental carbon, ultrafine particles, and particles originating from sand and dust storms for which the available information is insufficient to derive guideline levels but indicates risk – see Box A10.1 and Table A10.3).

Table A10.3 – Summary of good practice statements for black carbon or elemental carbon (BC/EC), ultrafine particles (UFP), and particles originating from sand and dust storms (SDS), as published in the 2021 edition of the WHO Air Quality Guidelines (WHO, 2021).

	Good practice statements
BC/EC	1. Make systematic measurements of black carbon and/or elemental carbon. Such measurements should not replace or reduce existing monitoring of those pollutants for which guidelines currently exist. 2. Undertake the production of emission inventories, exposure assessments and source apportionment for BC/EC. 3. Take measures to reduce BC/EC emissions from within the relevant jurisdiction and, where appropriate, develop standards (or targets) for ambient BC/EC concentrations.
UFP	1. Quantify ambient UFP in terms of PNC for a size range with a lower limit of ≤ 10 nm and no restriction on the upper limit. 2. Expand the common air quality monitoring strategy by integrating UFP monitoring into the existing air quality monitoring. Include size-segregated real-time PNC measurements at selected air monitoring stations in addition to and simultaneously with other airborne pollutants and characteristics of PM. 3. Distinguish between low and high PNC to guide decisions on the priorities of UFP source emission control. Low PNC can be considered < 1 000 particles/ cm³ (24-hour mean). High PNC can be considered > 10 000 particles/cm³ (24-hour mean) or 20 000 particles/cm³ (1-hour mean). 4. Utilize emerging science and technology to advance approaches to the assessment of exposure to UFP for their application in epidemiological studies and UFP management.
SDS	1. Maintain suitable air quality management and dust forecasting programmes. These should include early warning systems and short-term air pollution action plans to alert the population to stay indoors and take personal measures to minimize exposure and subsequent short-term health effects during SDS incidents with high levels of PM. 2. Maintain suitable air quality monitoring programmes and reporting procedures, including source apportionment activities to quantify and characterize PM composition and the percentage contribution of SDS to the overall ambient concentration of PM. This will enable local authorities to target local PM emissions from anthropogenic and natural sources for reduction. 3. Conduct epidemiological studies, including those addressing the long-term effects of SDS, and research activities aimed at better understanding the toxicity of the different types of PM. Such studies are especially recommended for areas where there is a lack of sufficient knowledge and information about the health risk due to frequent exposure to SDS. 4. Implement wind erosion control through the carefully planned expansion of green spaces that considers and is adjusted to the contextual ecosystem conditions. This calls for regional collaboration among countries in the regions affected by SDS to combat desertification and carefully manage green areas. 5. Clean the streets in those urban areas characterized by a relatively high population density and low rainfall to prevent resuspension by road traffic as a short-term measure after intense SDS episodes with high dust deposition rates.

PNC: particle number concentration.

Box A10.1 - Health impacts of ultrafine particles

There is increasing, though limited epidemiological evidence of adverse health impacts of ultrafine particles (smaller than 0.1 µm) in ambient air. Such particles have been found in several organs, and recent systematic literature reviews point to short-term association with cardiorespiratory health, including pulmonary and systemic inflammation, as well as the health of the central nervous system. For other adverse health outcomes, the evidence on health effects remains inconclusive or insufficient.

To establish a correlation with illnesses is difficult due to the limited availability of specific air quality monitoring data, expressed in terms of number of particles per cubic meter or as mass of ultrafine particles ($PM_{0.1}$), which does not allow to conduct targeted epidemiological studies. The risk linked to such particles is however potentially large, due to the evidence of several sources -- notably linked to transport-- emitting large numbers of extremely small particles whose mass is extremely limited while their specific surface area is high, as is their capacity to penetrate the circulatory and nervous systems is enhanced by their small size.

World Health Organization recommendations for ultrafine particles

The 2021 WHO Air Quality Guidelines notes that *"studies demonstrated short-term effects of exposure to [ultrafine particles], including mortality, emergency department visits, hospital admissions, respiratory symptoms, and effects on pulmonary/systemic inflammation, heart rate variability and blood pressure; and long-term effects on mortality (all-cause, cardiovascular, [ischemic heart disease] and pulmonary) and several types of morbidity."* However, for these studies *"various [ultrafine particles] size ranges and exposure metrics were used, preventing a thorough comparison of results across studies. Therefore, there was a consensus in the [WHO Guideline Development Group] that the body of epidemiological evidence was not yet sufficient to formulate an [Air Quality Guideline] level."*

"At the same time, however, there is a large body of evidence from exposure science that is sufficient to formulate good practice advice. The most significant process generating [ultrafine particles] is combustion and, therefore, the main sources of the [ultrafine particles] include vehicles and other forms of transportation (aviation and shipping), industrial and power plants, and residential heating."

To address concerns about the health and environmental effects of ultrafine particles, the 2021 WHO Air Quality Guidelines formulate four good practice statements (see Table A10.3).

Previous editions of the WHO Air Quality Guidelines, and in particular the 2000 edition of the WHO Air Quality Guidelines, provide additional information for additional air pollutants. The subsequent sections summarise current understanding of the health impacts of all twelve air pollutants covered by the Ambient Air Quality Directives, and includes reference to WHO recommendations and guideline levels as relevant.

2. EU AIR QUALITY STANDARDS AS SET BY THE AMBIENT AIR QUALITY DIRECTIVES

Tables A10.4 and A10.5 compare the current EU air quality standards with the WHO Air Quality Guidelines of 2021 (including interim targets) and of 2000 (for pollutants for which guideline values have not been modified since publication).

Table A10.4 – Comparison of EU air quality (AQ) standards with WHO Air Quality Guidelines levels and interim targets covered by the 2021 edition (WHO, 2021)

	EU AQ standard	WHO AQ guideline	WHO interim target 4	WHO interim target 3	WHO interim target 2	WHO interim target 1
$PM_{2.5}$ (annual) [µg/m³]	**25 / 20**	**5**	**10**	**15**	**25**	**30**
$PM_{2.5}$ (24-hour) [µg/m³]	-	(1%) **15**	(1%) **25**	(1%) **37.5**	(1%) **50**	(1%) **75**
PM_{10} (annual) [µg/m³]	**40**	**15**	**20**	**30**	**50**	**70**
PM_{10} (24-hour) [µg/m³]	(35 days) **50**	(1%) **45**	(1%) **50**	(1%) **50**	(1%) **100**	(1%) **150**
NO_2 (annual) [µg/m³]	**40**	**10**	-	**20**	**30**	**40**
NO_2 (24-hour) [µg/m³]	-	(1%) **25**	-	-	(1%) **50**	(1%) **120**
NO_2 (hourly) [µg/m³]	(18 hours) **200**	**200**	-	-	-	-
O_3 (peak-season) [µg/m³]	-	**60**	-	-	**70**	**100**
O_3 (8-hour mean) [µg/m³]	(25 days) **120**	(1%) **100**	-	-	(1%) **120**	(1%) **160**
SO_2 (annual) [µg/m³]	**20**	-	-	-	-	-
SO_2 (24-hour) [µg/m³]	(3 days) **125**	(1%) **40**	-	-	(1%) **50**	(1%) **125**
SO_2 (hourly) [µg/m³]	(24 hours) **350**	-	-	-	-	-
SO_2 (10 min) [µg/m³]	**-**	**500**	-	-	-	-
CO (daily) [mg/m³]	-	(1%) **4**	-	-	-	(1%) **7**
CO (8-hour) [mg/m³]	**10**	**10**	-	-	-	-

Note: For daily air quality standards reference is made in parentheses to allowed exceedances expressed as number of days or percentiles. For a full year of measurements, 1% translates into the standard not to be exceeded on more than 3 days.

Table A10.5 – Comparison of EU air quality (AQ) standards with WHO Air Quality Guidelines for pollutants covered by the 2000 edition (WHO, 2000)

	EU AQ standard	WHO AQ guideline	Excess lifetime risk	… of 1/10 000	… of 1/100 000	… of 1/1 000 000
Benzene (annual) [µg/m³]	**5**	**1.7**		**17**	**1.7**	**0.17**
Arsenic (annual) [ng/m³]	**6**	**6.6**		**66**	**6.6**	**0.66**
Nickel (annual) [ng/m³]	**20**	**25**		**250**	**25**	**2.5**
BaP (annual) [ng/m³]	**1**	**0.12**		**1.2**	**0.12**	**0.012**
Cadmium (annual) [ng/m³]	**5**	**5.0**				
Lead (annual) [µg/m³]	**0.5**	**0.5**				

As part of the fitness check of the Ambient Air Quality Directives published in 2019, the Commission compared current EU air quality standards and the standards in place in selected (non-EU) OECD countries. This showed alignment with the WHO recommendations in place at the time (i.e. the 2005 edition WHO Air Quality Guidelines) in some cases and large differences in other cases. For fine particulate matter, the EU air quality standards were above those set in selected OECD countries, while for most other pollutants EU levels are within the range established in OECD countries. Table A10.6 provides a comparison.

Consistent with the principle established in Article 193 of the Treaty on the Functioning of the European Union, the Ambient Air Quality Directives do not prevent Member States from setting more stringent standards in national legislation – as is the case, for example, in Austria (for particulate matter (PM_{10}) and nitrogen dioxide), or Sweden (most notably for nitrogen dioxide).

Table A10.6 – Comparison of EU air quality standards with WHO Guidelines and standards applicable in other OECD countries (Based on SWD(2019) 427 final)

	EU AQ standard	2021 WHO AQ guideline	2005 WHO AQ guideline	Selected standards applicable in other OECD countries
$PM_{2.5}$ (annual) [µg/m³]	**25 / 20**	**5**	**10**	AU: **8**; CH: **10**; CA: **10**; US: **12;** JP: **15**; NO: **15**
$PM_{2.5}$ (24-hour) [µg/m³]	-	(1%) **15**	(1%) **25**	AU: **25**; CA: **28**; JP: (2%) **35**; US: (2%) **35**
PM_{10} (annual) [µg/m³]	**40**	**15**	**20**	CH: **20**; AU: **25**; NO: **25**
PM_{10} (24-hour) [µg/m³]	(35 days) **50**	(1%) **45**	(1%) **50**	NO: (30 days) **30;** AU: **50**; NZ: (1 day) **50**; CH: (3 days) **50**; US: (1 day) **150**
NO_2 (annual) [µg/m³]	**40**	**10**	40	CH: **30**; CA: **32**; NO: **40**; AU: **57**; US: **101**
NO_2 (hourly) [µg/m³]	(18 hours) **200**	**200**	**200**	CA: **115**; US: (2%) **191**; NZ: (9h) **200**; NO: (18h) **200**; AU: **230**;
O_3 (8-hour mean) [µg/m³]	(25 days) **120**	(1%) **100**	(1%) **100**	CA: **126**; US: **140**
SO_2 (24-hour) [µg/m³]	(3 days) **125**	(1%) **40**	(1%) **20**	CH: (1 day) **100**; JP: **107** NO: (3 days) **125**; AU: (1 day) **213**;
SO_2 (hourly) [µg/m³]	(24 hours) **350**	-	-	US: (1%) **200**; JP: **266**; NZ: (9h) **350**; NO: (24h) **350**; AU: (1 day) **532**

Note: For daily air quality standards reference is made in parentheses to allowed exceedances expressed as number of days or percentiles. For a full year of measurements, 1% translates into the standard not to be exceeded on more than 3 days.

Note: where standards applicable in selected other OECD countries have been established as 'ppb (parts per billion)', this has been converted to µg/m³ for this table.

AU (Australia): *Standards and Goal established under National Environment Protection (Ambient Air Quality) Measure, status of 25 February 2016, see https://www.legislation.gov.au/Details/F2016C00215*
CA (Canada): *Canadian Ambient Air Quality Standards (CAAQS) established under the Canadian Environmental Protection Act, see http://airquality-qualitedelair.ccme.ca/en/*
CH (Switzerland)*: ‚Luftreinhalte-Verordnung (vom 16 Dezember 1985, inklusive Änderung vom 11. April 2018)', see https://www.admin.ch/opc/de/classified-compilation/19850321/index.html*
JP (Japan)*: Environmental Quality Standards in Japan – Air Quality. http://www.env.go.jp/en/air/aq/aq.html*
NO (Norway): *'Grenseverdier for tiltak', as established in 'forskrift om begrensning av forurensning' see https://lovdata.no/dokument/SF/forskrift/2004-06-01-931 (see Del 3)*
NZ (New Zealand): *Ambient air quality standards for contaminants under Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (SR 2004/309), see http://www.legislation.govt.nz/regulation/public/2004/0309/latest/DLM287036.html*
US (United States of America): *National Ambient Air Quality Standards (NAAQS) set by the Environmental Protection Agency under the Clean Air Act, see https://www.epa.gov/criteria-air-pollutants/naaqs-table*

3. HEALTH IMPACTS OF AIR POLLUTANTS IN THE AMBIENT AIR QUALITY DIRECTIVES

This section provides an overview on the health effects of and WHO recommendations for the twelve pollutants covered by the Ambient Air Quality Directives. This is based on reviews of existing literature and meta-studies describing the health effects of the pollutants, focused on inhalative and outdoor air pollution exposure. Evidence from both toxicological and epidemiological studies is considered in developing health-based WHO recommendations.

As noted above, the WHO formulates Air Quality Guidelines, which are in form of a value and a corresponding qualitative description. These are recommendations, and not intended to be simply adopted as legally enforceable standards. Standards should include further factors such as the current exposure, the mixture of air pollutants, specific social, economic and cultural conditions, legal aspects, technological feasibility and the capability of air quality management. (WHO, 2021)

3.1 Fine Particulate Matter ($PM_{2.5}$) and Particulate Matter (PM_{10})

'Particulate matter in urban and non-urban environments is a complex mixture with components having diverse chemical and physical characteristics. Research on particulate matter and the interpretation of research findings on exposure and risk are complicated by this heterogeneity, and the possibility that the potential of particles to cause injury varies with size and other physical characteristics, chemical composition and source(s).

Different characteristics of particulate matter may be relevant to different health effects. Newer research findings continue to highlight this complexity and the dynamic nature of airborne particulate matter, as it is formed either primarily or secondarily and then continues to undergo chemical and physical transformation in the atmosphere.

Nonetheless, particles are still generally classified by their aerodynamic properties, because these determine transport and removal processes in the air and deposition sites and clearance pathways within the respiratory tract. The aerodynamic diameter is used as the summary indicator of particle size; the aerodynamic diameter corresponds to the size of a unit-density sphere with the same aerodynamic characteristics as the particle of interest. The differences in aerodynamic properties among particles are exploited by many particle sampling techniques.' (WHO, 2006)

World Health Organization recommendations for annual $PM_{2.5}$

The recommendation for an annual $PM_{2.5}$ in the 2021 edition of the WHO Air Quality Guidelines is 5 µg/m^3. The WHO also recommends maintaining the 2005 interim targets at 35 µg/m^3, 25 µg/m^3, and 15 µg/m^3, and introducing an interim target 4 at the level of 10 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

'If mortality in a population exposed to $PM_{2.5}$ at the WHO Air Quality Guidelines level is arbitrarily set to 100, then it will be 124, 116, 108 and 104, respectively, in populations exposed to $PM_{2.5}$ at interim target 1, 2, 3 and 4 levels. These projections are based on the linear hazard ratio of 1.08 per 10-µg/m^3 increase in $PM_{2.5}$ for all non-accidental mortality reported in the systematic review. At higher concentrations, the CRF may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

World Health Organization recommendations for short-term (24-hour) $PM_{2.5}$

The recommendation for a short-term (24-hour) $PM_{2.5}$ WHO Air Quality Guidelines level is 15 µg/m^3, defined as the 99th percentile (equivalent to 3-4 exceedance days per year) of the annual distribution of 24-hour average concentrations. The WHO also recommends maintaining the 2005 interim targets at 75 µg/m^3, 50 µg/m^3, and 37.5 µg/m^3, and introducing an interim target 4 at the level of 15 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

World Health Organization recommendations for annual PM_{10}

The recommendation for an annual PM_{10} WHO Air Quality Guidelines level is 15 µg/m^3 (WHO, 2021). *'This is based on an evaluation of the studies on the long-term effects of PM_{10} on mortality only, without taking into consideration that a large proportion of PM_{10} is made up of $PM_{2.5}$. As in most situations $PM_{2.5}$ is about 50-80% of PM_{10} by weight, the annual PM_{10}* Air Quality Guidelines *level of 15 µg/m^3 is less protective than the annual AQG level for $PM_{2.5}$. In all situations where both $PM_{2.5}$ and PM_{10} measurements are available, preference should be given to the $PM_{2.5}$ Air Quality Guidelines level.'* (WHO, 2021). Furthermore, the WHO recommends maintaining the 2005 interim targets at 70 µg/m^3, 50 µg/m^3, and 30 µg/m^3, and introducing an interim target 4 at the level of 20 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

'If mortality in a population exposed to PM_{10} at the Air Quality Guidelines level were arbitrarily set at 100, then it will be 122, 114, 106 and 102, respectively, in populations exposed to PM_{10} at the interim target 1, 2, 3 and 4 levels. These projections are based on the linear hazard ratio of 1.04 per 10-µg/m³ increase in PM_{10} for all non-accidental mortality reported in the systematic review. At higher concentrations, the concentration-response functions may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

World Health Organization recommendations for short-term (24-hour) PM_{10}

The recommendation for a short-term (24-hour) PM_{10} WHO Air Quality Guidelines level is 45 µg/m3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. Furthermore, the WHO recommends maintaining the 2005 interim targets at 150 µg/m^3, 100 µg/m^3, and 75 µg/m^3, and introducing an interim target 4 at the level of 50 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

3.2 Nitrogen Dioxide (NO_2)

'Many chemical species of nitrogen oxides exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide. Nitrogen dioxide is a reddish brown gas with a characteristic pungent odour. Nitric oxide spontaneously produces the dioxide when exposed to air. Nitrogen dioxide gas is a strong oxidant, and reacts with water to produce nitric acid and nitric oxide.

Nitrogen dioxide is an important atmospheric trace gas not only because of its health effects but also because: (a) it absorbs visible solar radiation and contributes to impaired atmospheric visibility; (b) it absorbs visible radiation and has a potentially direct role in global climate change; (c) it is, along with nitric oxide, a chief regulator of the oxidizing capacity of the free troposphere by controlling the build-up and fate of radical species, including hydroxyl radicals; and (d) it plays a critical role in determining ozone concentrations in the troposphere because the photolysis of nitrogen dioxide is the only key initiator of the photochemical formation of ozone, whether in polluted or in non-polluted atmospheres.

Nitrogen dioxide is subject to extensive further atmospheric transformations that lead to the formation of strong oxidants that participate in the conversion of nitrogen dioxide to nitric *acid and sulphur dioxide to sulphuric acid and subsequent conversions to their ammonium neutralization salts. Thus, through the photochemical reaction sequence initiated by solar-radiation-induced activation of nitrogen dioxide, the newly generated pollutants are an important source of organic, nitrate and sulphate particles currently measured as PM_{10} or $PM_{2.5}$. For these reasons, nitrogen dioxide is a key precursor of a range of secondary pollutants whose effects on human health are well-documented.'* (WHO, 2006)

World Health Organization recommendations annual NO_2

The recommendation is an annual nitrogen dioxide *WHO Air Quality Guidelines level of 10 µg/m^3. An interim target 1 of 40 µg/m^3, an interim target 2 of 30 µg/m^3 and an interim target 3 of* 20µg/*m^3 are proposed.* (WHO, 2021).

If all-cause mortality in a population exposed to nitrogen dioxide at the WHO Air Quality Guidelines level is arbitrarily set at 100, then it will be 106, 104 and 102, respectively, in populations exposed to nitrogen dioxide at the interim target 1, 2 and 3 levels. For respiratory mortality, the numbers would be 109, 106 and 103, respectively, at the interim target 1, 2 and 3 levels. These projections are based on the linear hazard ratio of 1.02 and 1.03 per 10-µg/m^3 increase in nitrogen dioxide for all non-accidental and respiratory mortality, respectively, as reported in the systematic review. At higher concentrations, the concentration-response functions may no longer be linear, which would change the numbers in this example. (WHO, 2021)

World Health Organization recommendations short-term (24-hour / 1 hour) NO_2

The recommendation is a short-term (24-hour) nitrogen dioxide *WHO Air Quality Guidelines level of 25 µg/m^3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. An interim target 1 of 120 µg/m^3 and an interim target 2 of 50 µg/m^3 are proposed. (WHO, 2021)*

Furthermore, the 2005 edition of the WHO Air Quality Guidelines included a recommendation for a 1-hour nitrogen dioxide concentration below 200 µg/m^3, which the 2021 edition confirms as being valid still.

3.3 Ozone (O_3)

Ozone (and other photochemical oxidants) are pollutants that are not directly emitted by primary sources, but are formed through a series of complex reactions in the atmosphere driven by the energy transferred to nitrogen dioxide (NO_2) molecules when they absorb light from solar radiation. Outside of polluted areas ozone is mainly formed by reactions of carbon monoxide and methane with nitrogen (US EPA, 2020a).

Such emissions result from anthropogenic sources (e.g., motor vehicles and power plants) and natural sources (e.g., vegetation and wildfires). In addition, ozone, which is created naturally in the stratosphere, mixes with tropospheric ozone near the tropopause, and, less frequently can mix nearer the earth's surface. Ozone is in a constant daily flux and because it is produced photochemically, levels are typically highest during sunny periods with reduced atmospheric dispersion (US EPA, 2020b). Ozone can be transported long distances by wind.

'The precursors that contribute most to the formation of oxidant species in polluted atmospheres are nitrogen dioxide and non-methane volatile organic compounds (VOCs),

especially unsaturated VOCs. Methane is much less reactive than the other VOCs but is present at much higher concentrations, having risen in concentration over the past 100 years owing to its increasing use as fuel, and is released from rice fields and farm animals. Photochemistry involving methane accounts for much of the rise in ozone over the oceans and remote land areas, from about 30 µg/m^3 to about 75 µg/m^3.' (WHO, 2006)

World Health Organization recommendations for peak season ozone

The recommendation for a peak season ozone '*WHO Air Quality Guidelines level is 60 µg/m^3 (the average of daily maximum 8-hour mean ozone concentrations). The peak season is defined as the six consecutive months of the year with the highest six-month running-average ozone concentration. In regions away from the equator, this period will typically be in the warm season within a single calendar year (northern hemisphere) or spanning two calendar years (southern hemisphere). Close to the equator, such clear seasonal patterns may not be obvious, but a running-average six-month peak season will usually be identifiable from existing monitoring or modelling data. An interim target 1 of 100 µg/m^3 and an interim target 2 of 70 µg/m^3 are proposed.'* (WHO, 2021)

'If mortality in a population exposed to ozone at the WHO Air Quality Guidelines level is arbitrarily set at 100, then it will be 104 and 101, respectively, in populations exposed to ozone at the interim target 1 and 2 levels. These projections are based on the linear HR of 1.01 per 10-µg/m^3 increase in ozone of all non-accidental mortality reported in the systematic review. For respiratory mortality, the numbers will be 108 and 102, respectively, at the interim target 1 and 2 levels, based on the linear hazard ratio of 1.02 of respiratory mortality reported in the systematic review. At higher concentrations, the concentration-response function may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

World Health Organization recommendations for short-term (8-hour) ozone

The recommendation for a short-term daily maximum 8-hour ozone *'WHO Air Quality Guidelines level of 100 µg/m^3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of daily maximum 8-hour average concentrations. An interim target 1 of 160 µg/m^3 is retained from Global update 2005. An interim target 2 of 120 µg/ m^3 is also proposed*' (WHO, 2021)

3.4 Benzene (C_6H_6)

Benzene is highly volatile, and exposure occurs mostly through inhalation. The main sources of benzene in outdoor air are road transport and energy use in industry, and in indoor air smoking, and to a lesser extent building materials (WHO, 2010).

The most relevant health effects of benzene are haematotoxicity, genotoxicity and carcinogenicity. Based on sufficient evidence of its carcinogenicity in humans, sufficient evidence of its carcinogenicity in experimental animals, and strong mechanistic evidence benzene is classified by International Agency for Research on Cancer (IARC) as a human carcinogen (IARC, 2019).

World Health Organization recommendations for annual benzene

In the WHO Guidelines for Indoor Air Quality a unit risk of leukaemia per 1 μg/m^3 air concentration of 6×10^{-6} is proposed. The concentrations of airborne benzene associated with an excess lifetime risk of 1/10 000, 1/100 000 and 1/1 000 000 are 17, 1.7 and 0.17 μg/m^3, respectively (WHO, 2010). Which means, when exposed to 1.7 μg/m^3 of benzene over a lifetime of 70 years, the risk of developing leukemia would be 1 in a 100 000.

In the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation noted that *"Ambient air exposure is widespread and relevant worldwide. Sources include biomass burning, the use of compressed petroleum gas and its presence in gasoline and high emissions in several countries including China, due to high concentrations of aromatic compounds in gasoline. (...) Experts agreed that all this body of new evidence should be re-evaluated."* (WHO, 2016).

3.5 Sulphur Dioxide (SO_2)

Sulphur dioxide is a colourless gas that is readily soluble in water. Sulphur dioxide has a strong odour. Anthropogenic sources are combustion of sulphur-containing fossil fuels for domestic heating, stationary power generation and motor vehicles (WHO, 2006). Natural sources are volcanoes.

In the air, it can be converted to sulphuric acid, sulphur trioxide and sulphates (ATSDR, 1999). Sulphur dioxide dissolves in water, where it forms sulphurous acid (WHO, 2006). However, inhalation is the only route of exposure to sulphur dioxide that is of interest with regards to its health effects (WHO, 2006).

Vulnerable groups are asthmatics, children and people exercising (heavy breathing leads sulphur dioxide to penetrate further into the respiratory tract).

World Health Organization recommendations short-term (24-hour) SO_2

The recommendation for a short-term (24-hour) sulphur dioxide *'WHO Air Quality Guideline level of 40 µg/m^3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. An interim target 1 of 125 µg/ m^3 and an interim target 2 of 50 µg/m^3 are proposed.'* (WHO, 2021).

'If mortality in a population exposed to sulphur dioxide for a day at the 24-hour WHO Air Quality Guideline level of 40 µg/m^3 is arbitrarily set at 100, then it will be 105 and 101, respectively, in populations exposed to sulphur dioxide at the interim target 1 and 2 levels. These projections are based on the linear hazard ratio of 1.0059 per 10-µg/ m^3 increase in sulphur dioxide of all non-accidental mortality reported in the systematic review. At higher concentrations, the concentration-response function may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

Based on controlled studies of exercising asthmatics experiencing changes in pulmonary function and respiratory symptoms, a guideline value of 500 µg/m^3 over an averaging period of ten minutes was set by the WHO in 2005 (WHO, 2006). The 24-hour guideline value is 20 µg/m^3 to provide according to the precautionary principle greater protection than those provided in the previous guidelines.

3.6 Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless and toxic gas, which is predominantly produced by incomplete combustion of carbon-containing materials (such as wood, petrol, coal, natural gas and kerosene). Examples are vehicle exhausts, fuel burning ovens, coal burning power plants, small gasoline engines, fires places, grills and gas heaters. (WHO, 2021).

Natural sources include volcanoes and forest fires. Further, vegetation can emit carbon monoxide directly in the atmosphere as a metabolic by-product. Carbon monoxide is also produced indirectly from the photochemical oxidation of methane and other volatile organic compounds in the atmosphere. Still, the biggest share of carbon monoxide emissions come from vehicle exhaust. (ATSDR, 2012a).

Carbon monoxide mixes freely with air in any proportion and moves with air via bulk transport (WHO, 2010). It is found indoors and outdoors. When it is released to the environment, it remains there for an average of about two months. Human exposure occurs through inhalation of outdoor and indoor air. Most vulnerable are people with ongoing cardiovascular and/or respiratory disease, as well as foetuses.

World Health Organization recommendations* short-*term (24-hour / 8-hour) CO

The recommendation is a short-term (24-hour) carbon monoxide *'WHO Air Quality Guideline level of 4 mg/m^3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. An interim target 1 of 7 mg/m^3 is proposed, as a point of reference to the existing 24-hour indoor WHO air quality guideline.'* (WHO, 2021)

'If the number of myocardial infarctions in a population exposed to carbon monoxide for a day at the WHO Air Quality Guideline level of 4 mg/m^3 is arbitrarily set at 100, the number will be 106 in populations exposed to carbon monoxide at the interim target 1 level. This projection is based on the linear hazard ratio of 1.019 per 1 mg/m^3 increase in carbon monoxide for hospital admissions due to myocardial infarction. At higher concentrations, the concentration-response function may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

Furthermore, the 2005 edition of the WHO Air Quality Guidelines included a recommendation for an 8-hour carbon monoxide concentration below 10 mg/m^3, a 1-hour carbon monoxide concentration below 35 mg/m^3, and ten min carbon monoxide concentration below 100 mg/m^3 which the 2021 edition confirms as being valid still.

3.7 Benzo(a)Pyrene (BaP)

Benzo[a]pyrene (BaP) is a five-ring polycyclic aromatic hydrocarbon (PAH) that results from incomplete combustion of organic matter at temperatures between 300°C and 600°C (e.g., coal, oil, fossil fuels, waste, tobacco smoke and wood). It is relatively insoluble in water and has low volatility. In air, BaP is predominantly adsorbed to particulates, but may also exist as a vapor at high temperatures (US EPA, 2017).

BaP can be found in coal tar, tobacco smoke and many foods, especially grilled meats. It is released to the environment via both natural sources (such as forest fires) and anthropogenic sources including stoves burning fossil fuels (especially wood and coal), motor vehicle exhaust, cigarettes and various industrial combustion processes (US EPA, 2017).

BaP is a suitable marker due to its stability and relatively constant contribution to the carcinogenic activity of particle-bound PAH (WHO, 2010b). BaP is measured as its total content and its compounds in the PM_{10} fraction (Directive 2004/107/EC). It is further specified: *"To assess the contribution of benzo(a)pyrene in ambient air, each Member State shall monitor other relevant polycyclic aromatic hydrocarbons at a limited number of measurement sites. These compounds shall include at least: benzo(a)anthracene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene. Monitoring sites for these polycyclic aromatic hydrocarbons shall be co-located with sampling sites for benzo(a)pyrene and shall be selected in such a way that geographical variation and long-term trends can be identified."*

The International Agency for Research on Cancer (IARC) concluded about the carcinogenicity of BaP in several assessments: *"There is sufficient evidence in experimental animals for the carcinogenicity of benzo[a]pyrene"* (IARC, 2010). *„Benzo[a]pyrene is carcinogenic to humans"* (IARC, 2012b).

World Health Organization recommendations for annual BaP

In the WHO Air Quality Guidelines from 2000 based on epidemiological data from studies in coke-oven workers, a unit risk for BaP as indicator air constituent for PAHs is estimated to be 8.7×10^{-5} per ng/m^3, which is the same as that established by WHO in 1987. The corresponding concentrations of BaP leading to an excess life time cancer risks of 1/10 000, 1/100 000 and 1/1 000 000 are 1.2, 0.12 and 0.012 ng/m^3, respectively (WHO, 2000). In some publications the unit risk of 8.7×10^{-5} per ng/m^3 is translated in a life time risk of 1/10 000, 1/100 000 and 1/1 000 000 for 1.0, 0.1 and 0.01 ng/m^3, respectively (WHO, 2013).

In 2013, a WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) concluded: "*Even in the absence of new evidence, the acceptability of the level of risk associated with the current target value should be reviewed and discussed. The current lifetime cumulative risk for benzo[a]pyrene causing cancer ($1x10^{-4}$) that is associated with the current guideline (1 ng/m^3) is somewhat high."* (WHO, 2013).

In the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation, a re-evaluation of the evidence taking BaP as a reference compound was suggested, because "*on the basis of availability of new evidence since 2010 regarding non-cancer health endpoints (i.e. cardiovascular, neurodevelopment effects, lower birth weight etc.) and conclusions from ongoing health risk assessments that have included non-cancer health effects from benzo[a]pyrene and reference concentration values for inhaled PAHs* (….) *experts concluded that the new health evidence should be re-evaluated."* (WHO, 2016).

3.8 Lead (Pb)

Lead exists in different forms, elemental, inorganic and organic lead, each with own chemical and toxicological properties. Lead is a natural occurring metal, however anthropogenic activities lead to an accumulation due to its persistency. Key anthropogenic sources are energy use in industries, industrial processes and road transport. Smoking is another source, while natural sources include volcanic activities, geochemical weathering and sea spray emissions.

For non-smokers, the largest contribution to the daily intake of lead is from ingestion of food, drinking water, dirt and dust (WHO 2019c). Exposure by inhalation is mainly due to burning materials containing lead, e.g., smelting, recycling, stripping leaded paint, leaded petrol (HBM4EU, 2020). Dust and soil may contain high levels of lead concentrations and is thereby an important source of children´s exposure. Children are particular vulnerable to the neurotoxic effects of lead and even relatively low levels of exposure can cause serious and in some cases irreversible neurological damage (WHO 2019c). Furthermore, pregnant women and their unborn children are most susceptible to the adverse effects of lead. Blood lead level is the best available indicator of current and recent environmental exposure: most biological effects relate to blood lead levels (WHO, 2000).

The International Agency for Research on Cancer (IARC) concludes *"that inorganic lead compounds are probably carcinogenic to humans"* while *"organic lead compounds are not classified as to their carcinogenicity to humans"* (IARC, 2006).

World Health Organization recommendations for annual lead

The air lead guideline value from the WHO from 2000 is based on concentrations of lead in blood using a conversion factor from air lead (1 μg/m^3) to blood lead (50 μg/L) which includes a direct contribution of about 19 μg/L in children and 16 μg/L in adults. It was noted that cognitive impairment has been shown in children at blood lead levels of 100–150 μg/L and proposed a critical level of 100 μg/l. To assure that at least 98% of children have blood lead levels of less than 100 μg/l, the median should not exceed 54 μg/l. Further, a baseline value of the (dietary) contribution to lead in blood of 20 μg/l in uncontaminated areas was assumed. Aiming at a lead level in air that would not increase blood lead to a level above 50 μg/l, lead in air should contribute no more than 30 μg/l. The guideline value was therefore set at 0.5 μg/m^3 lead in ambient air (see WHO, 2000, and WHO, 2013).

In 2013, a WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) concluded: "*Yes, there is definitely new evidence on the health effects of air emissions of lead that would have an impact on the current limit value. This evidence shows that effects on the central nervous system in children and on the cardiovascular system in adults occur at, or below, the present standards in the WHO air quality guidelines and EU"* (WHO, 2013).

Subsequently, in the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation *"There was a general expert consensus with the conclusions of the REVIHAAP Project in that the current WHO AQGs for lead need to be re-evaluated. (...) Experts pointed out the need to coordinate with other activities on lead that might be conducted by WHO."* (WHO, 2016).

3.9 Arsenic (As)

Arsenic has chemical and physical properties intermediate between a metal and a non-metal. It is emitted to the atmosphere from both natural and anthropogenic sources. Approximately one-third of the global atmospheric flux of arsenic is estimated to be from natural sources (IARC, 2012a), especially volcanic activity, followed by low-temperature volatilization, exudates from vegetation and windblown dusts. Anthropogenic emissions arise from mining and smelting of base metals, fuel combustion (e.g., waste and low-grade brown coal) and the use of arsenic-based pesticide (IARC, 2012a). Arsenic released from power plants and other combustion processes is usually attached to very small particles, and may stay in the air for many days and travel long distances. Ultimately, most arsenic ends up in the soil, sediment or water.

The primary route of arsenic exposure for the general population is via ingestion of contaminated food or water; inhalation of arsenic from ambient air is generally a minor exposure route for the general population. Arsenic compounds have long residence times in the atmosphere and are enriched in the fine particle mode about or below 1 μm and, consequently, can penetrate deeply into the respiratory system (EC, 2001).

From an epidemiological (population studies) perspective, the International Agency for Research on Cancer (IARC) concludes: "*There is sufficient evidence in humans for the carcinogenicity of mixed exposure to inorganic arsenic compounds (...). Inorganic arsenic compounds (...) cause cancer of the lung, urinary bladder, and skin. Also, a positive association has been observed between exposure to arsenic and inorganic arsenic compounds and cancer of the kidney, liver, and prostate. (...) Arsenic and inorganic arsenic compounds are carcinogenic to humans"* (IARC, 2012a).

Furthermore based on available toxicology (animal and cell-studies), IARC concludes: "*In view of the overall findings in animals, there is sufficient evidence in experimental animals for the carcinogenicity of inorganic arsenic compounds*" (IARC, 2012a).

World Health Organization recommendations for annual arsenic

In the WHO Air Quality Guidelines 2000 a unit risk for lung cancer per 1 μg/m^3 air concentration of 1.5×10^{-3} is proposed. The concentrations of airborne arsenic associated with an excess life time risk of 1/10 000, 1/100 000 and 1/1 000 000 are 66 ng/m^3, 6.6 ng/m^3 or 0.66 ng/m^3, respectively (WHO, 2000).

In 2013, a WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) concluded: "*Yes, there is some new evidence on the cancer risk of air emissions of arsenic, but it is contradictory in terms of the direction of risk. This new evidence is insufficient to have an impact on the current EU target value"* (WHO, 2013)

Subsequently, in the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation *"experts agreed with the conclusions of the REVIHAAP project, in that the new evidence available for arsenic might not lead to a substantial change to the unit risk currently recommended in the WHO AQGs. In addition, exposure through diet (food, water) is more relevant than air. However, non-carcinogenic effects should be looked at (...)."*(WHO, 2016).

3.10 Cadmium (Cd)

Cadmium is a silver-white solid metal. Particulate cadmium is emitted in the atmosphere from both natural and anthropogenic sources. The main anthropogenic sources are metal production and fossil fuel combustion, waste incineration and cement production. Cadmium particles in air can travel long distances before falling to the ground or water.

The main human exposure sources of cadmium are diet (higher uptake at low iron stores in the human body) and smoking (WHO, 2013). Inhalation is a minor part of total exposure (less than 10%), but ambient air levels are important for cadmium deposition in soil and, thereby, dietary intake. The average amount of cadmium ingested in European countries is 10-20 μg/day. The most well-known health effects of cadmium are kidney and lung damage and toxic effects on bone tissue (osteomalacia and osteoporosis) (WHO, 2013). Population groups at risk include elderly people, those suffering from diabetes and smokers. In addition, women may be at increased risk because, at the same level of exposure, they absorb more cadmium than men (WHO, 2007).

From an epidemiological (population studies) perspective, the International Agency for Research on Cancer (IARC) concludes: *"There is sufficient evidence in humans for the carcinogenicity of cadmium and cadmium compounds. Cadmium and cadmium compounds cause cancer of the lung. Also, positive associations have been observed between exposure to cadmium and cadmium compounds and cancer of the kidney and of the prostate. Cadmium and cadmium compounds are carcinogenic to humans."* (IARC, 2012a)

Furthermore based on available toxicology (animal and cell-studies), IARC concludes*: "There is sufficient evidence in experimental animals for the carcinogenicity of cadmium compounds. There is limited evidence in experimental animals for the carcinogenicity of cadmium metal"* (IARC, 2012a).

World Health Organization recommendations for annual cadmium

For the WHO Air Quality Guidelines 2000, the data behind the derivation of a unit risk of lung cancer was considered to be too complicated. The concomitant exposure with arsenic is seen as an important bias. It was noted that average kidney cadmium levels in Europe are very close to the critical level for renal effects. A further increase in dietary intake of cadmium, due to accumulation of cadmium in agricultural soils, must be prevented. Therefore, a guideline value of 5 ng/m3 was set for cadmium in air (WHO, 2000, 2013).

New evidence and new evaluations of data were published since the WHO Air Quality Guidelines 2000. A WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) noted that as the current EU air quality standard is already fully aligned with WHO recommendation, the latter do not point to a need for stricter levels. However, to prevent the increasing cadmium levels in agricultural soil by the air deposition and the thereby adverse health effects, more stringent standards would be needed (WHO, 2013).

Subsequently, in the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation *"experts agreed with the conclusions of the REVIHAAP project, in that present levels of cadmium in air are too high to obtain a cadmium balance in soils (suggesting that the cadmium dietary intake of the population will not decrease). In addition, strong evidence is available on new health effects due to cadmium exposure in the general population especially on bone, but also on hormone-related cancer, cardiovascular disease, and fetal growth."* (WHO, 2016).

3.11 Nickel (Ni)

Nickel is a hard silvery-white natural element, which is ubiquitous and naturally present in the environment, even if atmospheric nickel concentrations are higher in urban and industrial air than in rural areas. Anthropogenic sources of nickel and it species are industries that make or use nickel, nickel alloys, or nickel compounds. It is also released into the atmosphere by oil- and coal-burning power plants, and trash incinerators. In the air, nickel attaches to small particles of dust that settle to the ground or are taken out of the air in rain or snow; this usually takes many days.

The main routes of exposure are ingestion, dermal contact and to a lesser extend inhalation. Allergic skin reactions are the most common health effects of nickel, affecting about 2% of the male and 11% of the female population. Nickel content in consumer products and possibly in food and water are critical for the dermatological effect. The respiratory tract is also a target organ for allergic manifestations of occupational nickel exposure. There is no evidence that airborne nickel causes allergic reactions in the general population, although this reaction is well documented in the working environment. The key criterion for assessing the risk of airborne nickel exposure is its carcinogenic potential (WHO, 2000).

From an epidemiological (population studies) perspective, and on the basis of the underlying concept that all nickel compounds can generate nickel ions that are transported to critical sites in target cells, the International Agency for Research on Cancer (IARC) has classified nickel compounds as carcinogenic to humans, and metallic nickel as possibly carcinogenic to humans. Other than for lung cancer and nasal sinus cancer, there is currently no consistency in the epidemiological data to suggest that nickel compounds cause cancer at other sites (IARC, 2012a).

Furthermore based on available toxicology (animal and cell-studies), IARC concludes: "*There is sufficient evidence in experimental animals for the carcinogenicity of nickel monoxides, nickel hydroxides, nickel sulfides (including nickel subsulfide), nickel acetate, and nickel metal. There is limited evidence in experimental animals for the carcinogenicity of nickelocene, nickel carbonyl, nickel sulfate, nickel chloride, nickel arsenides, nickel antimonide, nickel selenides, nickel sulfarsenide, and nickel telluride. There is inadequate evidence in experimental animals for the carcinogenicity of nickel titanate, nickel trioxide, and amorphous nickel sulfide. In view of the overall findings in animals, there is sufficient evidence in experimental animals for the carcinogenicity of nickel compounds and nickel metal*." (IARC, 2012a)

World Health Organization recommendations for nickel

The WHO propose in the Air Quality Guidelines from 2000 on the basis of a risk estimated in industrial populations, an incremental risk of 3.8×10^{-4} per µg/m^3. The concentrations corresponding to an excess lifetime risk of 1/10 000, 1/100 000 and 1/1 000 000 are about 250, 25 and 2.5 ng/m^3, respectively (WHO, 2000). The carcinogenic effect of nickel is well researched, still different unit risks are recommended by different international organisations as well as limit values. Most of them are around the EU target value of 20 ng/m^3.

A WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) noted *"there is some updated occupational epidemiology on nickel refinery workers since the review by the WHO Working Groupon Air Quality Guidelines for 2000. The impression is, however that this new data will not change the previous unit risk estimate substantially. Data on the effect of ambient nickel levels on cardiovascular risk are yet too limited to permit their use in WHO air quality guideline standards."* (WHO, 2013)

The expert pollutant advice of the WHO Air Quality Guidelines consultation noted: *"The levels in ambient air are generally low (except for some hot spots). […] More recently, potential associations of nickel exposure through air and cardiovascular disease and inflammation have been described, but experts agreed with the REVIHAAP project conclusion that more epidemiological and experimental studies are needed in this regard."* (WHO, 2016)

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ANNEX 11: AIR QUALITY IN EUROPE IN 2020

1. INTRODUCTION

Air pollution is the single largest environmental health risk in Europe, causing cardiovascular and respiratory diseases that lead to the loss of healthy years of life and, in the most serious cases, to premature deaths. This annex presents the status of concentrations of pollutants in ambient air in 2020, in relation to both EU air quality standards and 2021 WHO Air Quality Guidelines. Exceedances of EU air quality standards are common across the EU, with concentrations well above the latest WHO recommendations. Nevertheless, in 2020, lockdown measures adopted to minimise the spread of COVID-19 had a temporary impact on emissions of air pollution from road transport and led to improved air quality.

Air pollution also damages vegetation and ecosystems. It leads to several important environmental impacts, which affect vegetation and fauna directly, as well as the quality of water and soil and the ecosystem services they support.

Sources and acknowledgement

This annex was prepared by the European Environment Agency (EEA). The EEA compiles information on air quality at station level reported by its member and cooperating countries, as well as Andorra. Hence, the analysis covers the 27 EU Member States, and third countries. The analysis of the air quality situation in Europe in 2020 is based on:

- European Environment Agency briefing "Europe's air quality status 2022" and
- Eionet Report 2022/2 "Status report of air quality in Europe for year 2020" produced by the European Topic Centre on Human Health and the Environment.

Information on population exposure to air pollution is based on the EEA indicator on the exceedance of air quality standards in Europe. Information on the health impacts of air pollution is based on the European Environment Agency briefing on the "Health impacts of air pollution in Europe, 2021" and refers to 2019. Data for 2020 calculations will be available later in 2022. Information on environmental impacts of ozone is based on European Environment Agency indicator on the exposure of Europe's ecosystems to ozone and the EMEP Status report 1/2021 and refers to 2019, since 2020 calculations will only be available later in 2022.

2. OVERVIEW OF MONITORING STATIONS IN THE EU

Data included in this report was reported to the European Environment Agency by 24 March 2022. Air quality data is reported to the European Environment Agency for a total of 39 European countries, namely for all 27 EU Member States, as well as for Albania, Andorra, Bosnia and Herzegovina, Iceland, Kosovo, Liechtenstein, Montenegro, North Macedonia, Norway, Serbia, Switzerland and Turkey.

The number of stations that reported data for each pollutant by country for the 27 EU Member States is provided in Table A11.1.

Table A11.1 Number of stations reporting data for each air pollutant by country

Country	PM_{10}	$PM_{2.5}$	O_3	NO_2	BaP	SO_2	CO	C_6H_6	As	Cd	Pb	Ni
Belgium	65	70	40	121	23	25	20	20	22	22	23	22
Bulgaria	40	6	20	22	15	27	16	18	7	12	11	7
Czechia	148	91	64	96	53	57	21	31	58	59	59	59
Denmark	7	9	8	14	2	4	6	3	3	3	3	3
Germany	380	230	265	619	111	111	85	108	98	98	98	98
Estonia	7	7	9	9	5	9	7	4	5	5	5	5
Ireland	37	31	17	22	5	10	3	1	5	5	5	5
Greece	23	11	16	21	0	8	6	5	0	1	0	0
Spain	450	240	410	494	70	389	176	80	91	91	94	91
France	358	172	304	379	47	95	16	28	52	52	55	53
Croatia	11	10	12	12	3	7	4	3	2	2	2	2
Italy	540	293	339	603	161	223	204	226	140	140	135	133
Cyprus	3	4	3	3	1	3	3	1	2	2	2	2
Latvia	6	5	7	8	5	6	1	5	5	5	5	5
Lithuania	14	7	12	17	5	14	9	1	5	5	5	5
Luxembourg	6	4	5	8	2	3	3	1	2	2	2	2
Hungary	23	11	18	22	16	23	21	12	16	16	16	16
Malta	3	4	4	4	1	3	2	2	3	3	3	3
Netherlands	66	46	45	71	3	14	6	9	0	0	0	0
Austria	123	57	102	143	34	65	27	18	12	13	12	12
Poland	242	123	101	142	157	102	68	61	72	71	73	71
Portugal	40	16	39	44	0	17	13	2	0	0	0	0
Romania	23	5	28	32	3	19	21	49	23	34	32	34
Slovenia	18	4	5	8	5	4	2	2	5	5	5	5
Slovakia	34	33	16	26	15	16	14	12	5	5	5	5
Finland	38	18	17	36	6	15	0	2	5	5	2	5
Sweden	56	32	27	91	3	24	5	2	4	4	4	4
EU-27	**2.761**	**1.539**	**1.933**	**3.067**	**751**	**1.293**	**759**	**706**	**642**	**660**	**656**	**647**
Total [177]	3.102	1.711	2.128	3.334	767	1.574	903	718	661	680	675	666

For most of the pollutants, data is only included in this assessment from those sampling points stations that fulfil the criterion of reporting more than 75% of valid data for the full year. While the Ambient Air Quality Directives set the objective of a minimum data capture of 90% for monitoring stations for compliance purposes, for assessment purposes a coverage of 75% allows more stations to be included without a significant increase in uncertainty.

[177] For all 39 countries that report air quality data to the European Environment Agency.

For random fixed measurements of particulate matter (PM), toxic metals (arsenic, cadmium, nickel and lead) and Benzo(a)pyrene (BaP), the required amount of valid data for the analysis is 14%, following the objectives for indicative measurements. For benzene, it is 50%. Stations not fulfilling the minimum data coverage are listed in the Annual Air Quality statistics table.[178]

3. CONCENTRATION LEVELS FOR KEY AIR POLLUTANTS IN THE EU

3.1 Fine particulate matter ($PM_{2.5}$) and particulate matter (PM_{10})

In terms of data coverage, $PM_{2.5}$ data with a general minimum coverage of 75%, and of 14% for fixed random stations, of valid data were received from 1 711 stations for the calculation of annual mean concentrations and from 1 711 stations in relation to the short-term WHO Air Quality Guidelines.

a) $PM_{2.5}$ annual mean concentration

The $PM_{2.5}$ concentrations were higher than the EU annual limit value (25 µg/m^3) in three EU Member States and three other reporting countries (Figure A11.1). These concentrations above the limit value were registered in 2% of all the reporting stations and occurred primarily (90% of cases) in urban (69%) or suburban (21%) areas.

The WHO Air Quality Guidelines for $PM_{2.5}$ annual mean (5 µg/m^3) was exceeded at 92% of the stations, located in 32 of the 33 countries reporting $PM_{2.5}$ data.

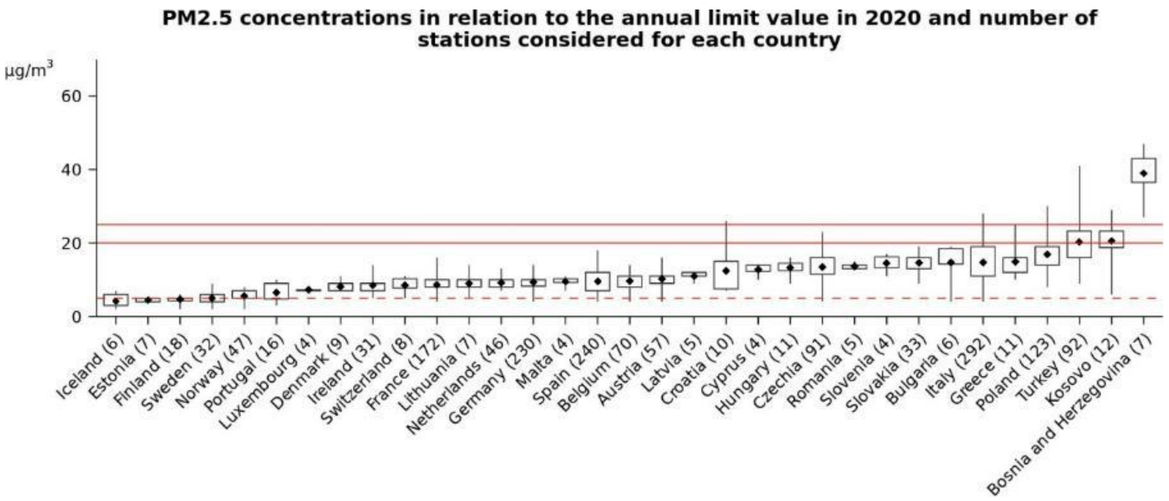


Figure A11.1 - $PM_{2.5}$ concentrations in relation to the annual limit value in 2020 by country. [179]

[178] EEA (2022), Annual AQ statistics portal (accessed: 09.06.2022)
[179] Note: The graph is based on annual mean concentration values. For each country, the number of stations considered (in brackets) and the lowest, highest and average values (in µg/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the lower percentile; at 25% of the stations, concentrations are above the upper percentile. The annual limit value and the indicative annual limit value set by EU legislation are marked by the upper continuous horizontal lines at 25 and 20, respectively. The WHO Air Quality Guidelines is marked by the lower dashed horizontal line.

Figure A11.2 shows the maps of measured $PM_{2.5}$ annual mean concentrations from 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

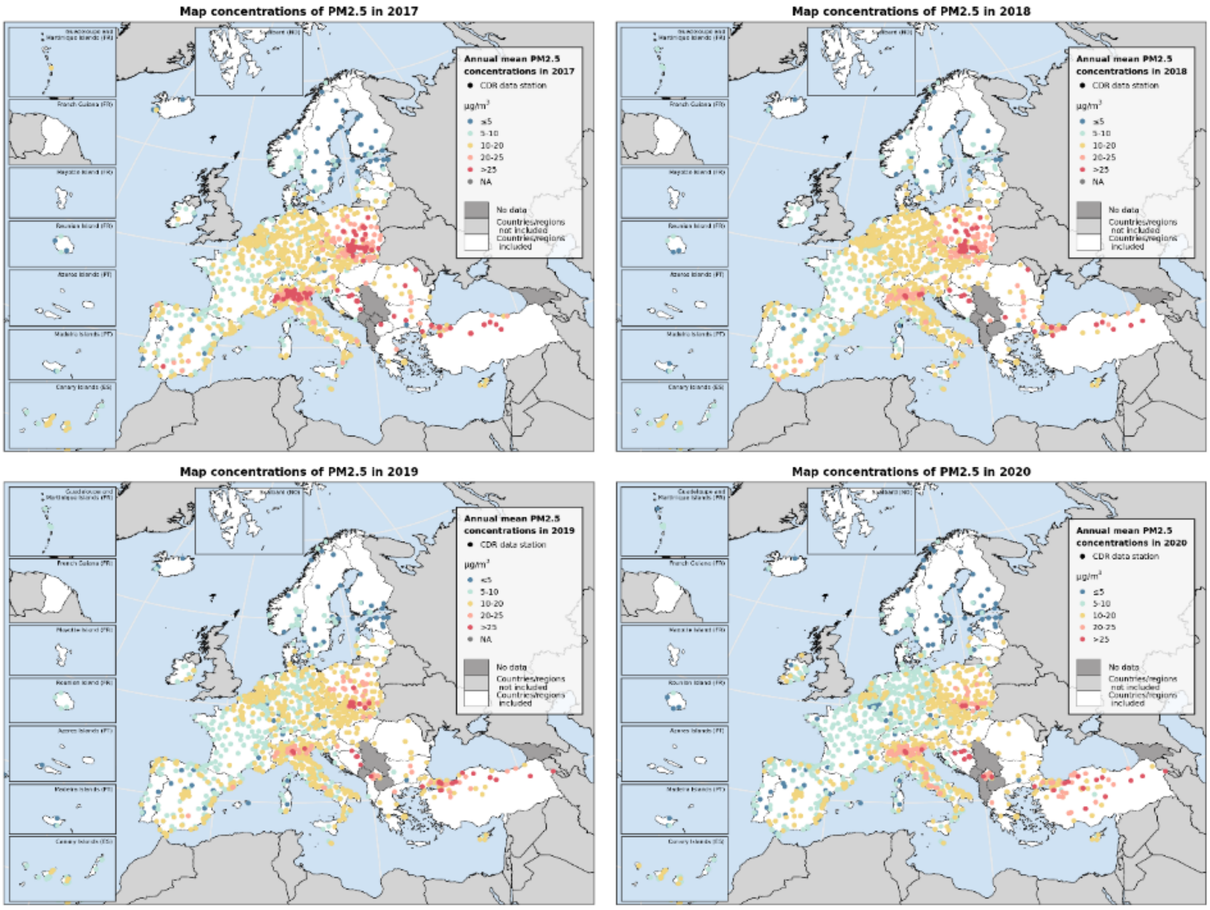


Figure A11.2 - $PM_{2.5}$ annual mean concentrations for 2017-2020

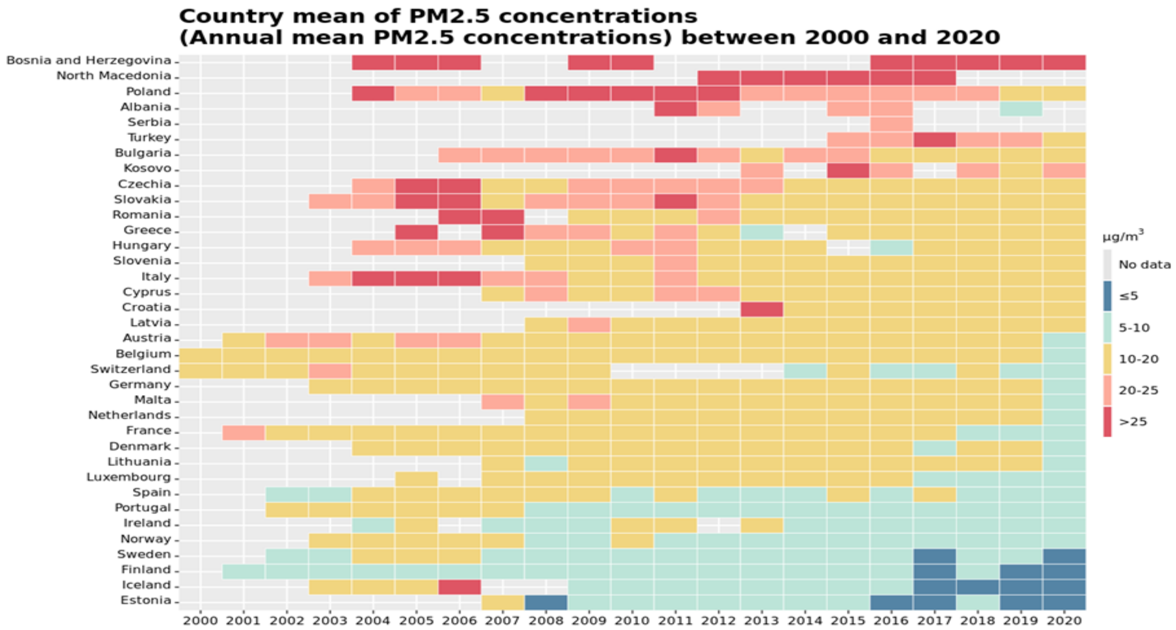
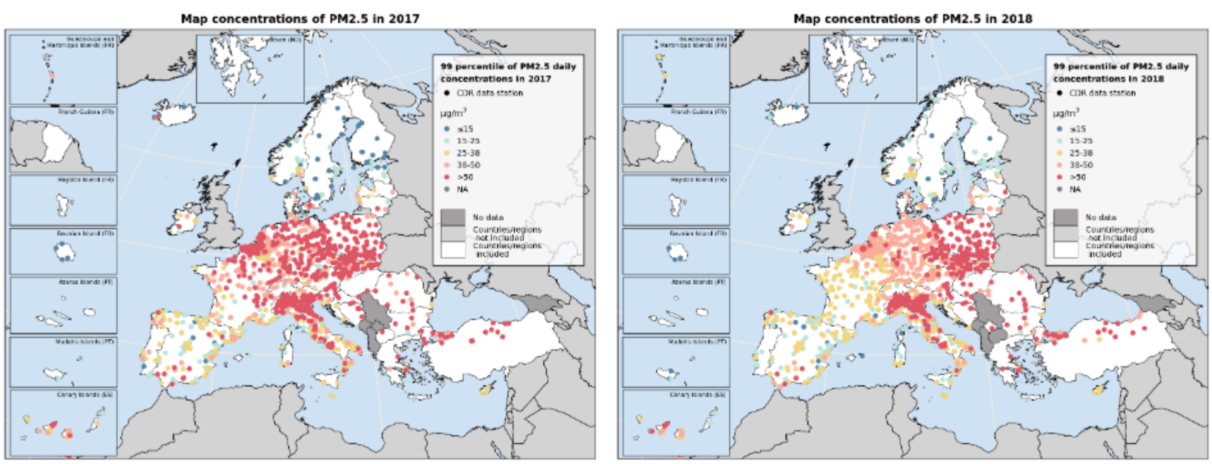


Figure A11.3 - Annual mean $PM_{2.5}$ concentrations between 2000 and 2020 by country

Heatmaps with the evolution from 2000 of the mean $PM_{2.5}$ annual mean concentrations at country level are shown in Figure A11.3. In this way, the evolution along years of the average measured concentration levels can be seen for each country. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

b) $PM_{2.5}$ daily mean concentration

Although the EU has not set any short-term standard for $PM_{2.5}$, the WHO defined in 2021 a daily air quality level of 15 µg/m^3, expressed as 99th percentile. It was exceeded at 95% (1 616 stations) of all stations in the reporting countries. Figure A11.4 shows the maps of measured $PM_{2.5}$ annual mean concentrations from 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.



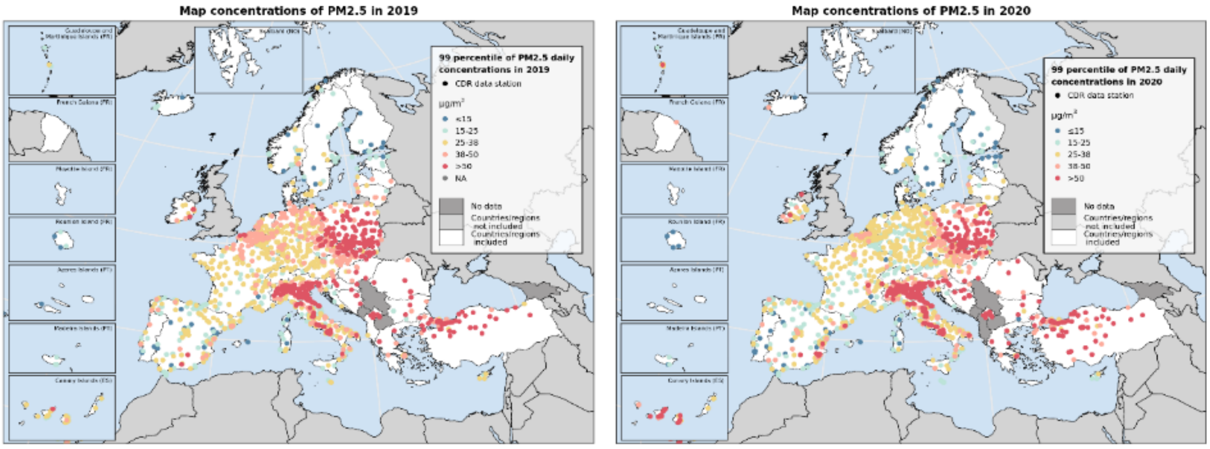


Figure A11.4 - $PM_{2.5}$ annual mean concentrations for 2017-2020

c) PM_{10} annual mean concentration

In terms of data coverage, the European Environment Agency received PM_{10} data for 2020, with sufficient valid measurements (a general minimum coverage of 75% and of 14% for fixed random measurements) from 3 101 stations for the calculation of annual mean concentrations and from 3 092 stations in relation to the daily limit value. Concentrations above the PM_{10} annual limit value (40 µg/m^3) were monitored in 5% (149 stations) of all the reporting stations, located in six countries in EU Member States, and four other reporting countries.

The stricter value of the WHO Air Quality Guidelines for PM_{10} annual mean (15 µg/m^3) was exceeded at 68% (2 118) of the stations in all the reporting countries, except in Iceland (Figure A11.5).

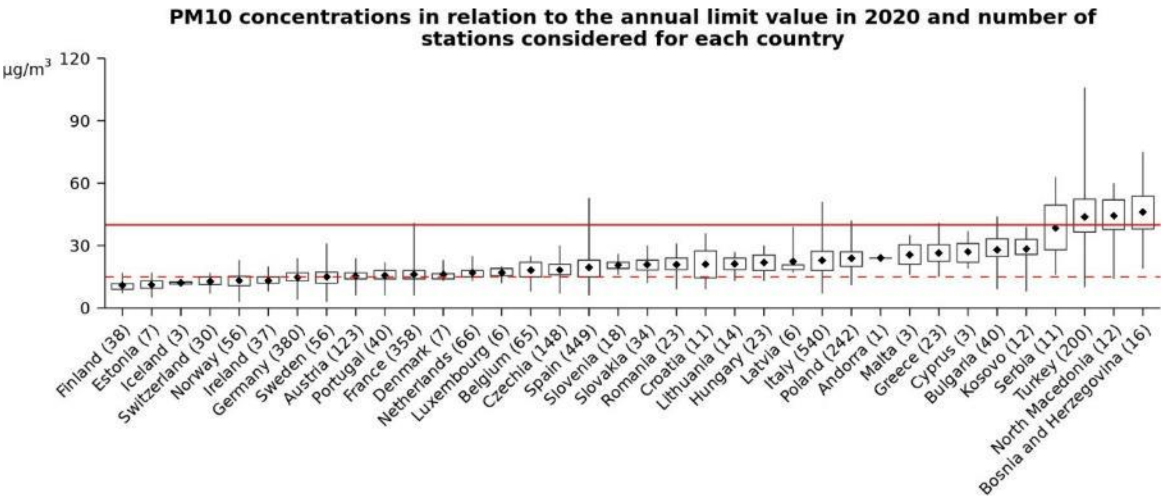


Figure A11.5 - PM_{10} concentrations in relation to the EU annual limit value[180]

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[180] Note: The graph is based on annual mean concentration values. For each country, the number of stations considered (in brackets) and the lowest, highest and average values (in µg/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the

Figure A11.6 shows the maps of PM_{10} annual mean concentrations at station level from 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

Figure A11.7 presents heatmaps of evolution of the mean annual mean PM_{10} concentrations from 2000 to 2020 at country level. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

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lower percentile; at 25% of the stations, concentrations are above the upper percentile. The annual limit value set by EU legislation is marked by the upper continuous horizontal line. The WHO Air Quality Guidelines is marked by the lower dashed horizontal line.

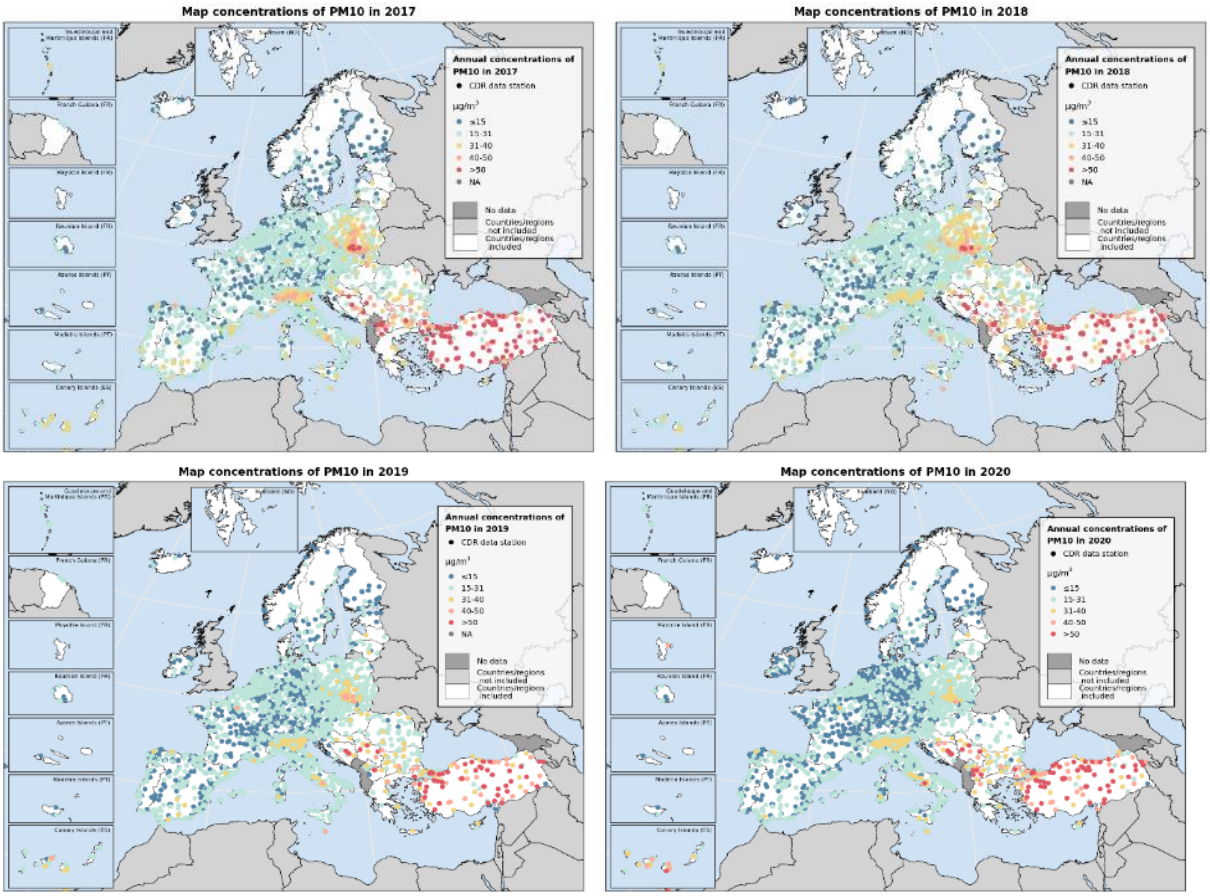

Figure A11.6 - PM_{10} annual mean concentrations for 2017 to 2020

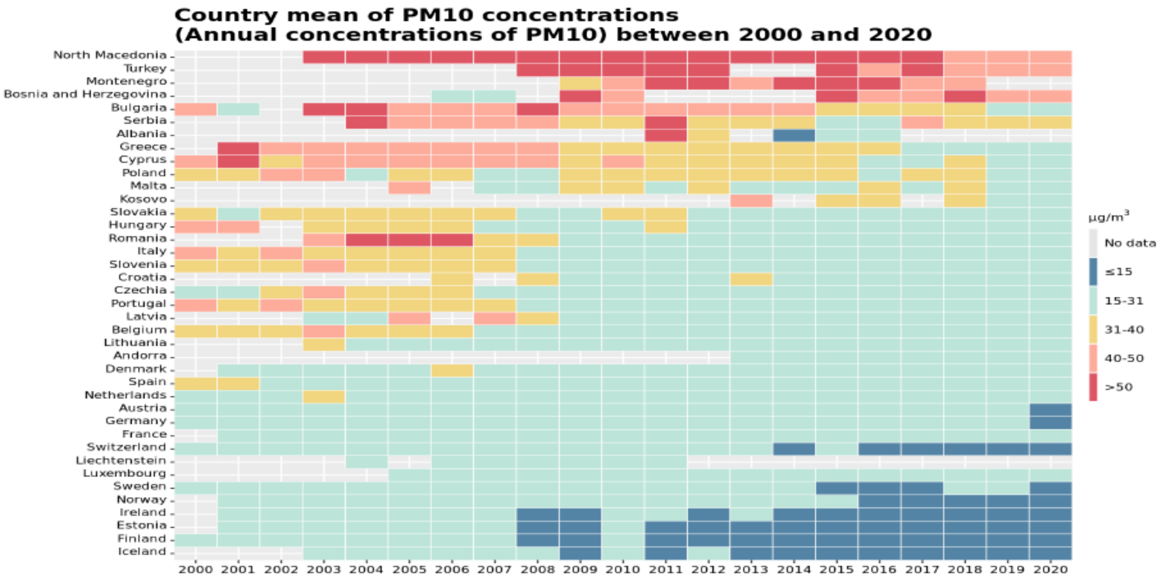

Figure A11.7 - Heatmaps presenting the evolution of the annual mean PM_{10} concentrations at country level from 2000 to 2020 *d) PM_{10} daily mean concentration*

15 EU Member States and five other reporting countries reported PM_{10} concentrations above the EU daily limit value of 50 µg/m^3 (Figure A11.8). This was the case for 16% (482) of reporting stations. In total, 95% of those stations were either urban (84%) or suburban (11%). The stricter WHO Air Quality Guidelines for PM_{10} daily mean (45 µg/m^3) was exceeded at 61% (1 894) of the stations in all the reporting countries.

Figure A11.8 shows the maps of the 90.4 percentile of PM_{10} daily mean concentrations (equivalent to the PM_{10} daily limit value) 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

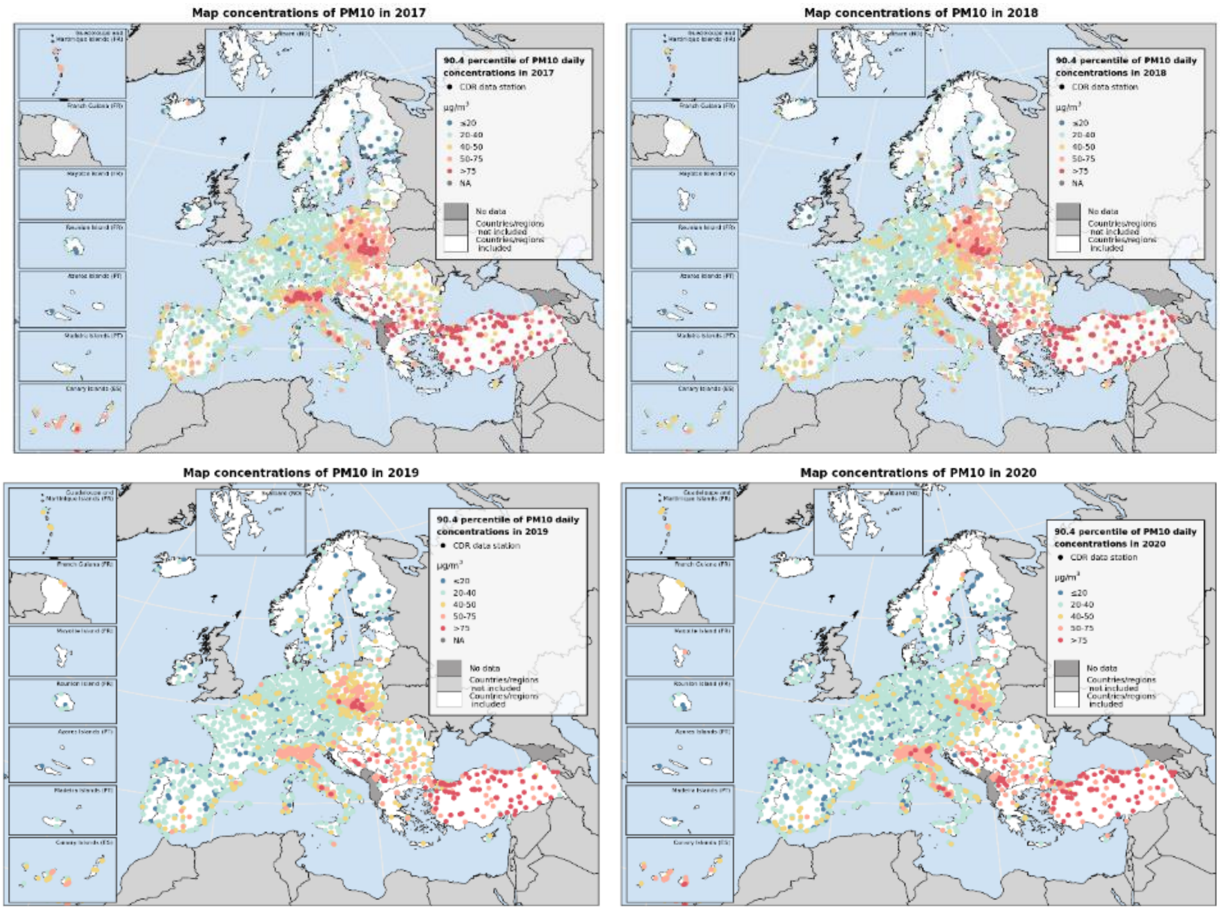

Figure A11.8 - PM_{10} daily mean concentrations for 2017 to 2020

3.2 Nitrogen dioxide (NO_2)

Reporting countries submitted NO_2 data from 3 333 stations for the annual limit value, 3 019 stations for the hourly limit value, and 3 329 stations for the daily WHO Air Quality Guidelines level.

a) NO_2 annual mean concentration

Seven EU Member States and one other reporting country recorded concentrations above the annual limit value (40 µg/m^3), with exceedances reported by 2% of all the stations measuring NO_2. In contrast, 73% of stations, located in the EU Member States and nine other reporting countries reported concentrations above the WHO Air Quality Guidelines level of 10 µg/m^3. Figure A11.9 presents the measured annual mean NO_2 concentrations at country level. 69% of all values above the annual limit value were observed at traffic stations. Furthermore, 100% of the stations with concentrations above the annual limit value were located in urban or suburban areas.

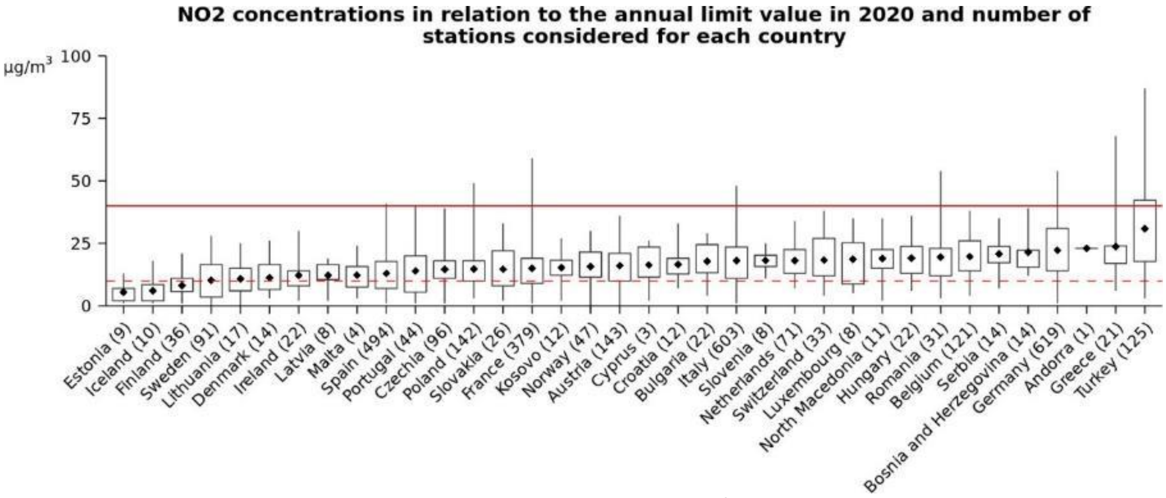

Figure A11.9 – 2020 annual mean NO_2 concentrations by country[181]

Figure A11.10 presents maps of NO_2 annual mean concentrations for the last four years.

Heatmaps resenting the evolution of NO_2 annual mean concentrations from 2000 to 2020 at country level are shown in Figure A11.11. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

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[181] Note: The graph is based on the annual mean concentration values. For each country, the number of stations considered (in brackets) and the lowest, highest and average values (in µg/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the lower percentile; at 25% of the stations, concentrations are above the upper percentile. The limit value set by EU legislation is marked by the horizontal line. The WHO Air Quality Guidelines level is marked by the lower dashed horizontal line.

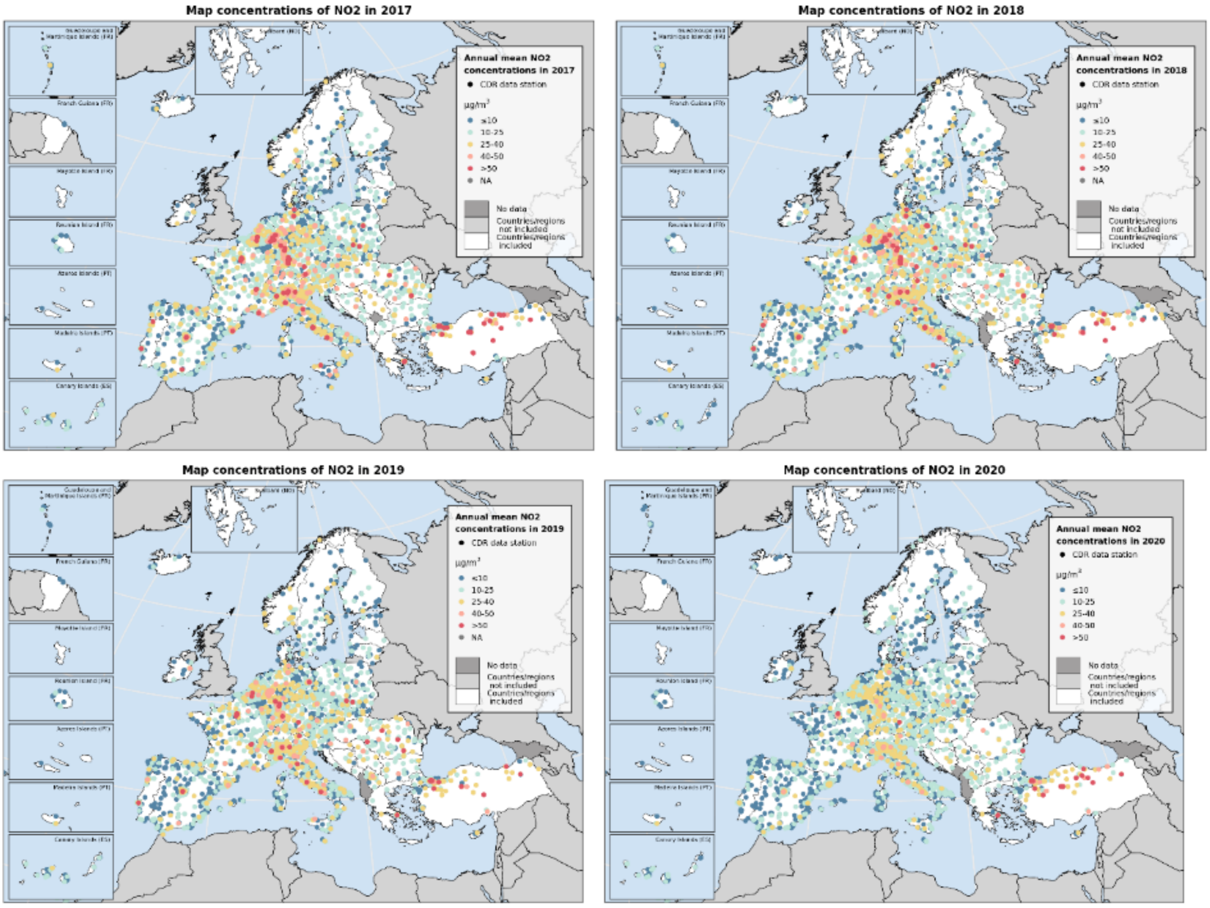


Figure A11.10 - NO_2 annual mean concentrations for 2017 to 2020

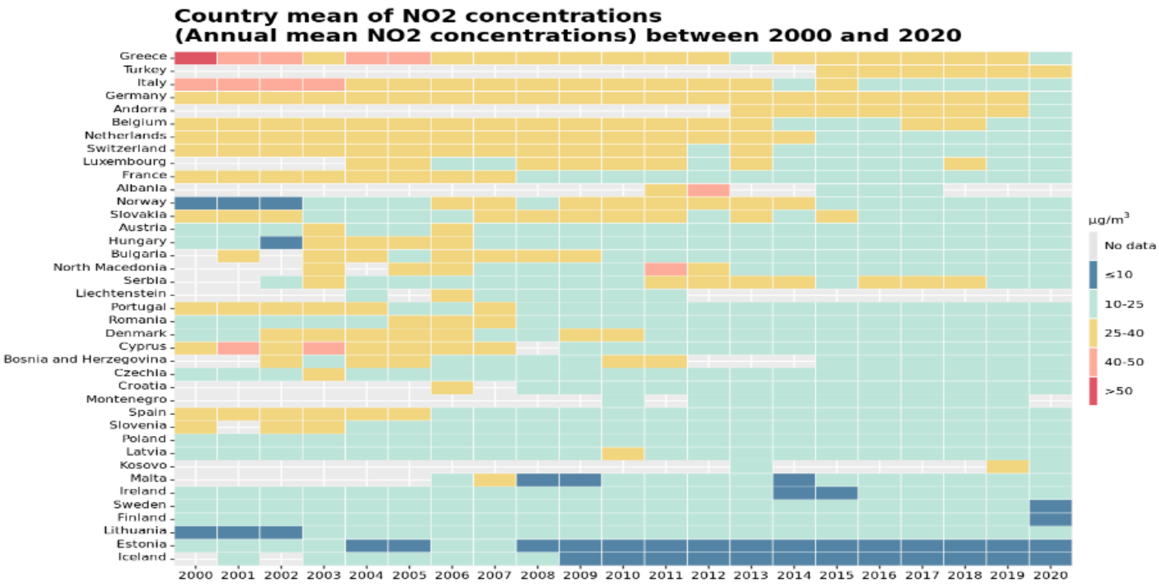


Figure A11.11 - Heatmaps showing the evolution of NO_2 annual mean concentrations from 2000 to 2020 at country level

b) *NO_2 daily and hourly mean concentration*

Concentrations above the daily NO_2 WHO Air Quality Guidelines level (25 µg/m^3) were registered in 78% (2 581 stations) of all the reporting stations in all EU Member States, as well as in nine other reporting countries (Figure A11.12).

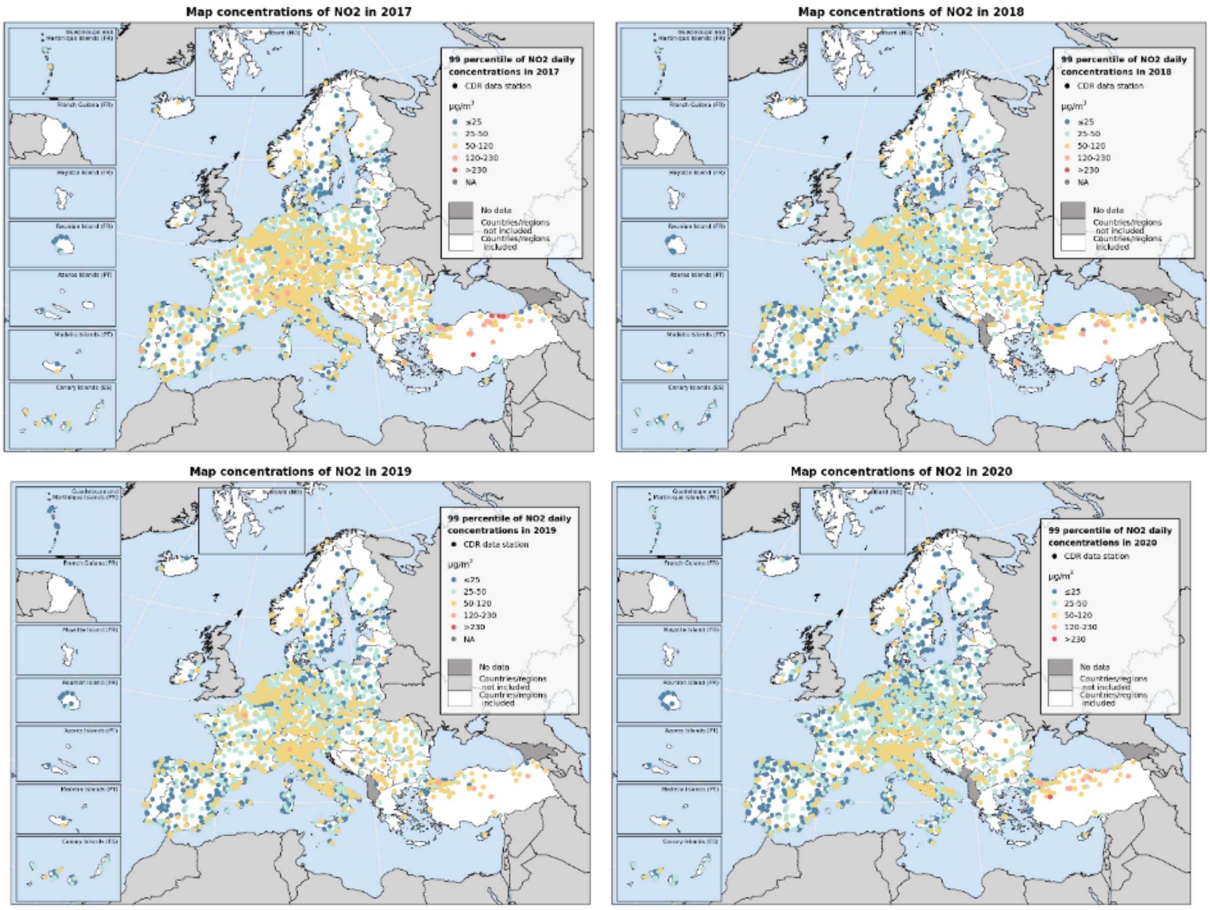


Figure A11.12 - NO_2 daily mean concentrations for 2017 to 2020

Concentrations above the hourly limit value (200 µg/m^3) were observed in only in Turkey, at 0.3% (ten stations) of all reporting stations, mostly at urban traffic stations.

3.3 Tropospheric ozone (O_3)

Data for O_3 were reported from 2 124 stations for the calculation of EU standards and from 2 008 stations for the long-term WHO Air Quality Guidelines.

a) O_3 peak season concentration

The long-term (peak season) WHO Air Quality Guidelines level (60 µg/m^3) was exceeded in 97% (1 950) of all stations located in 26 EU Member States and eight other reporting countries.

Figure A.1113 shows the maps of the peak season O_3 concentrations (equivalent to the long-term WHO Air Quality Guidelines level) from 2017 to 2020. In this way, significant changes in the spatial distribution of the values above the thresholds can be observed.

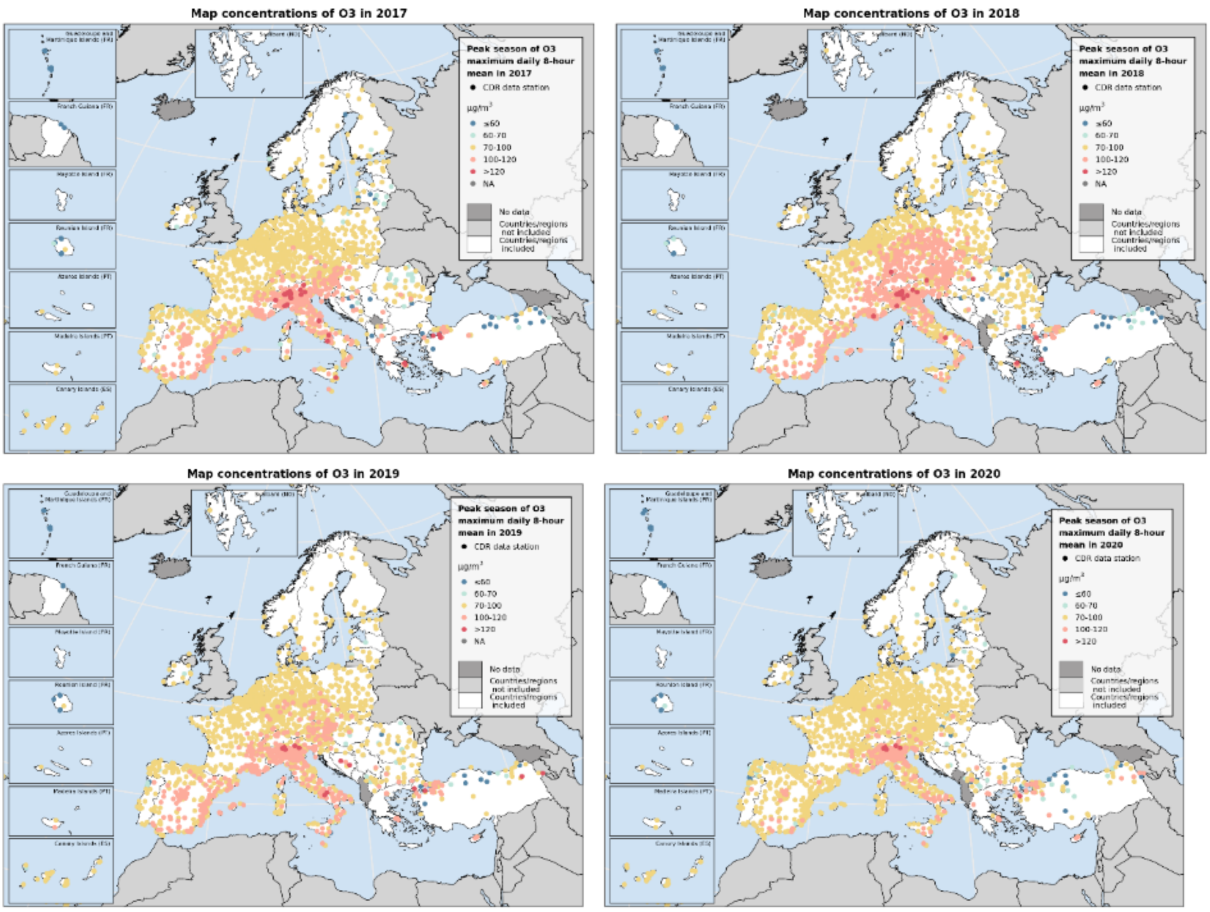


Figure A11.13 - peak season O_3 maximum daily 8-hour mean concentration for 2017 to 2020

Heatmaps presenting the evolution of the mean peak season O_3 concentrations from 2013 to 2020 at country level are shown in Figure A11.14. In this way, the evolution for year to year of the average measured concentration levels can be seen for each country. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

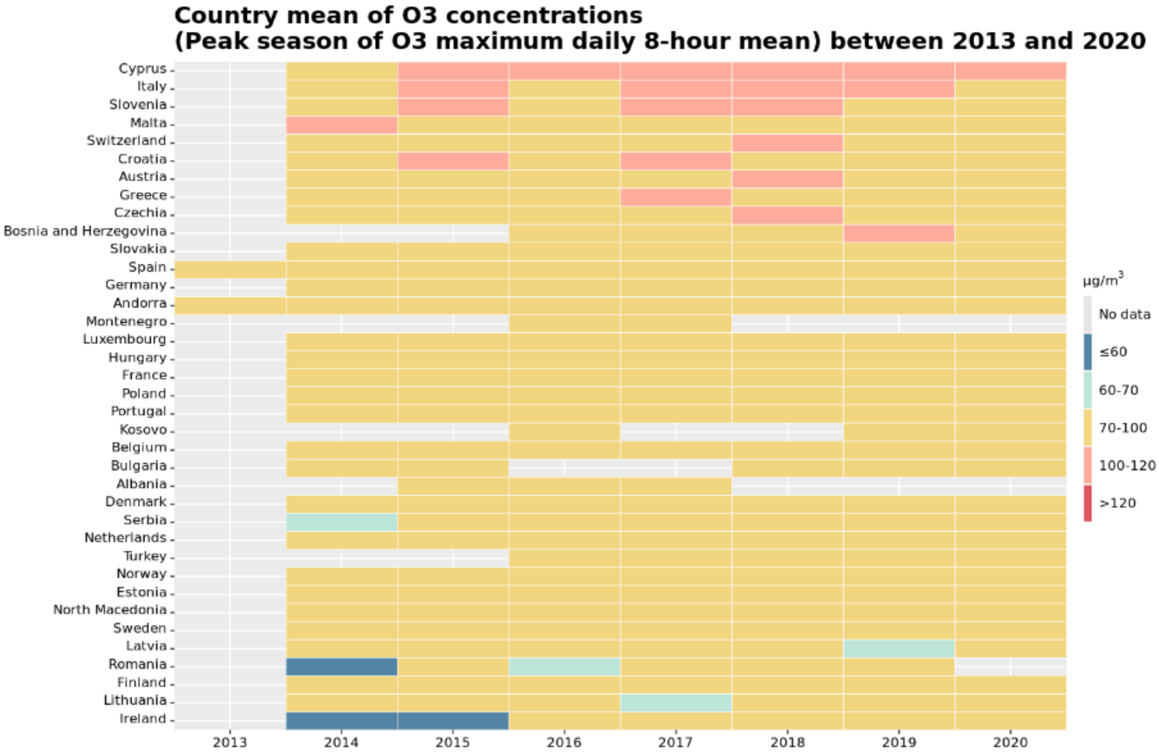


Figure 11.14 - Heatmaps presenting the evolution of the mean peak season O_3 concentrations from 2013 to 2020

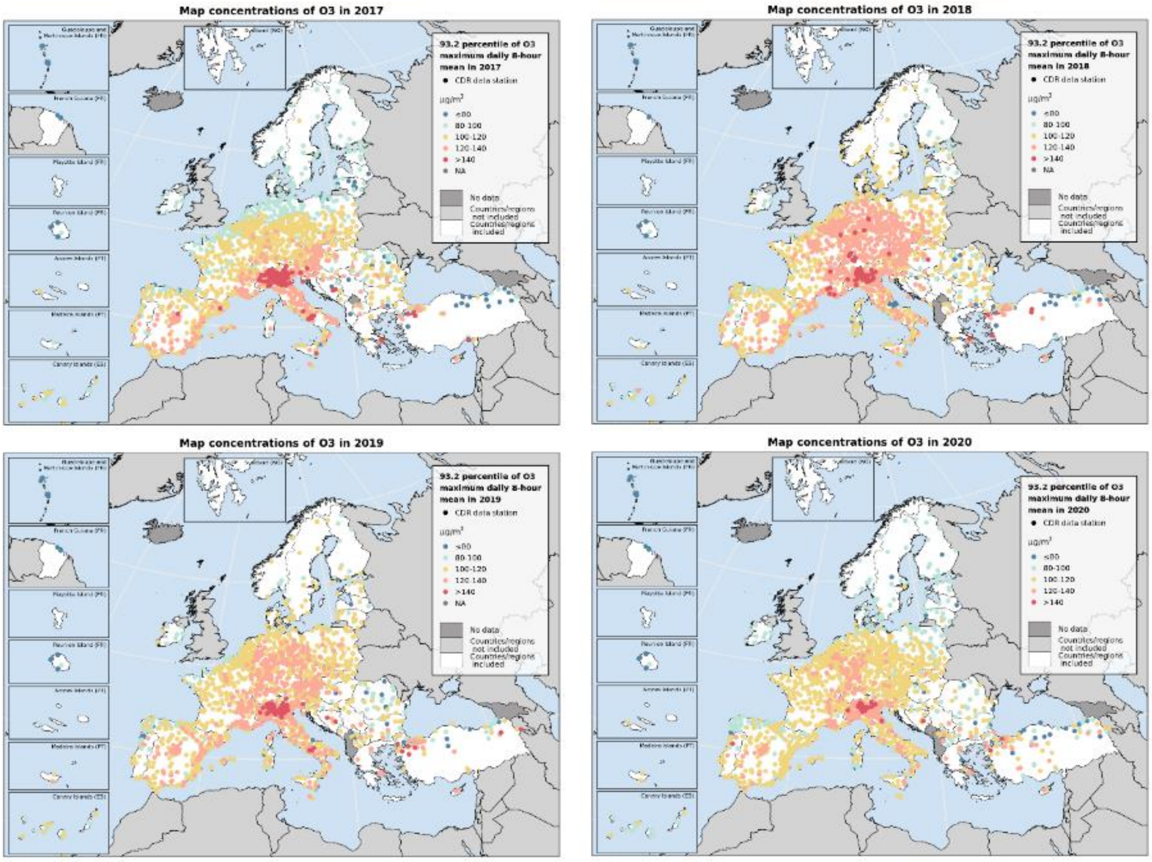
b) O_3 8-hour mean concentration

15 EU Member States and six other reporting countries registered concentrations above the O_3 target value (120 µg/m^3) more than 25 times. In total, 14% of all stations reporting O_3 showed concentrations above the target value for the protection of human health. In addition, only 19% (410) of all stations fulfilled the long-term objective (120 µg/m^3). 87% of the stations with values above the long-term objective were background stations.

Figure 11.15 shows the maps of the 93.2 percentile of the O_3 maximum daily 8-hour mean concentrations (O_3 target value) for the last four years. In this way, any significant change in the spatial distribution of values above thresholds can be observed.

200 (9%) of all stations measured values below the short-term WHO Air Quality Guidelines value for O_3 (100 µg/m^3). Only 27 of 539 rural background stations measured values below the short-term WHO Air Quality Guidelines value.

Figure 11.15 - O_3 maximum daily 8-hour mean concentrations by country for 2017 to 2020



3.4 Sulphur dioxide (SO_2)

The reporting countries reported measurements of SO_2 from 1 537 stations for the hourly limit value and 1 567 stations for the daily limit value.

a) SO_2 daily and hourly concentration

23 stations registered concentrations above the daily limit of 125 µg/m^3 for SO_2. In contrast, 7% (105) of all stations, located in 16 reporting countries, measured SO_2 concentrations above the WHO Air Quality Guidelines of 40 µg/m^3 for daily mean concentrations. Figure A11.16 shows the maps of the observed SO_2 daily mean concentrations from 2017 to 2020, allowing changes in the spatial distribution of values above the thresholds to be observed.

19 stations registered concentrations above the hourly limit value (350 µg/m^3).

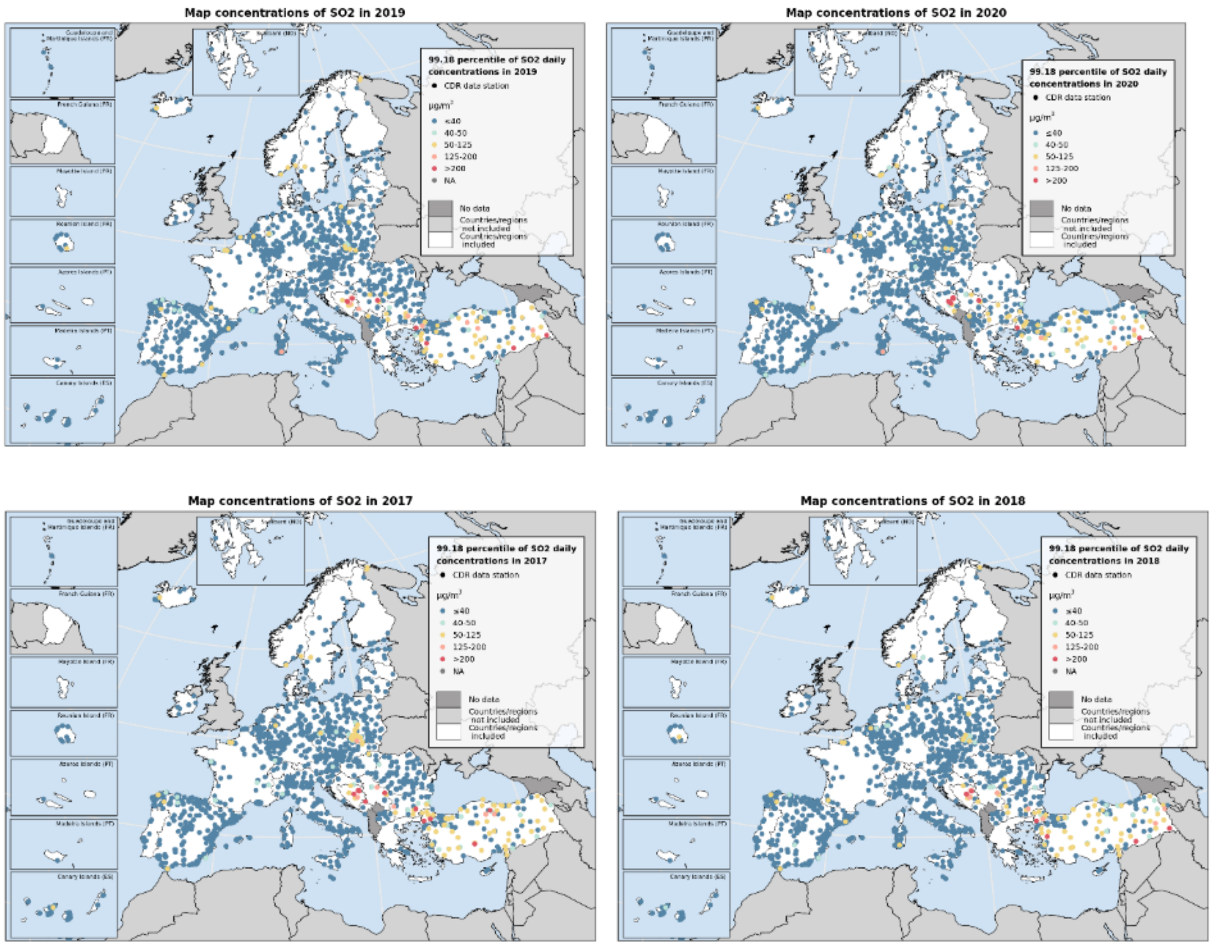


Figure A11.16 - SO_2 daily mean concentrations for 2017 to 2020

3.5 **Carbon monoxide (CO)**

Reporting countries measured CO data from 892 stations for the daily limit value and from 897 stations for the daily WHO Air Quality Guidelines.

a) CO 8-hour mean concentration

Only two stations (Figure A11.17) registered concentrations above the CO limit daily value (10 mg/m^3) and the WHO Air Quality Guidelines value for the maximum daily 8-hour mean, located outside EU Member States, in North Macedonia and Serbia.

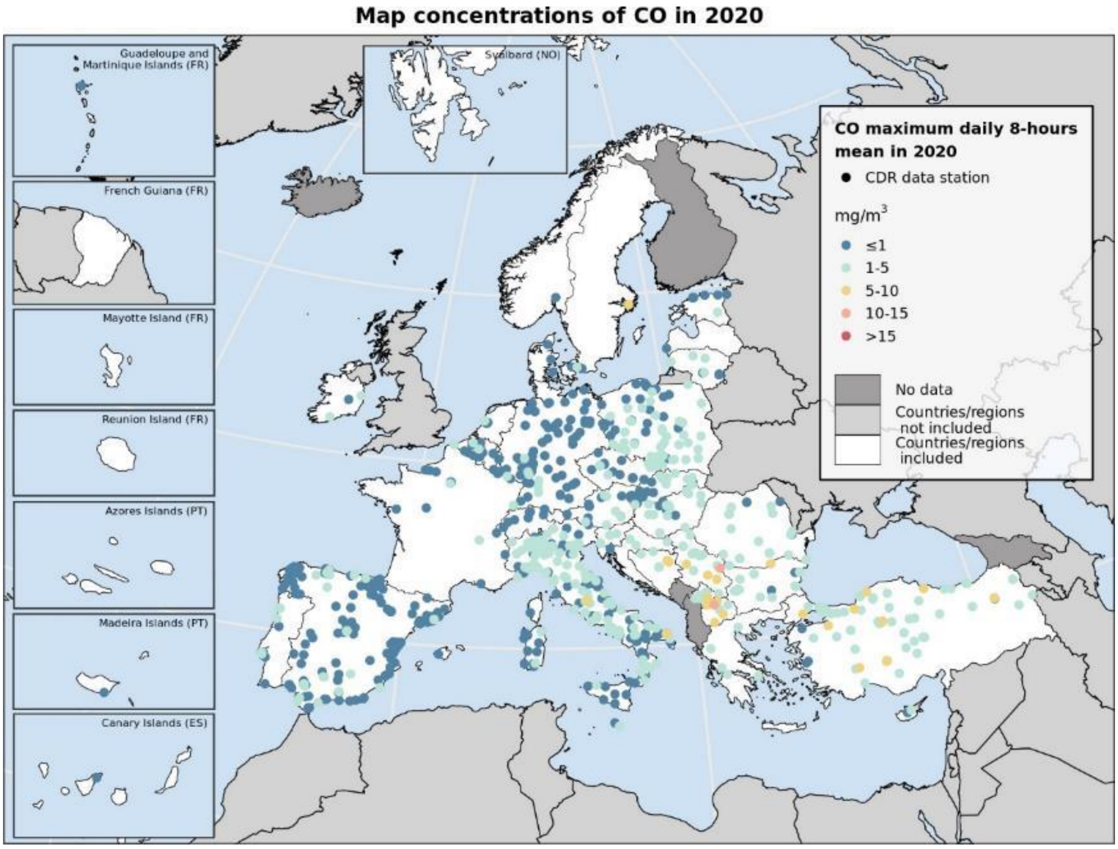


Figure A11.17 – CO maximum daily 8-hour mean in 2020

Concentrations above the daily WHO Air Quality Guidelines were measured at three stations, located in non EU Member States, namely: in Bosnia and Herzegovina (one), Kosovo (one) and North Macedonia (one).

Figure A11.18 shows the maps of the 99 percentile of CO daily mean concentrations (equivalent to the WHO Air Quality Guidelines for CO daily mean level) for the last four years. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

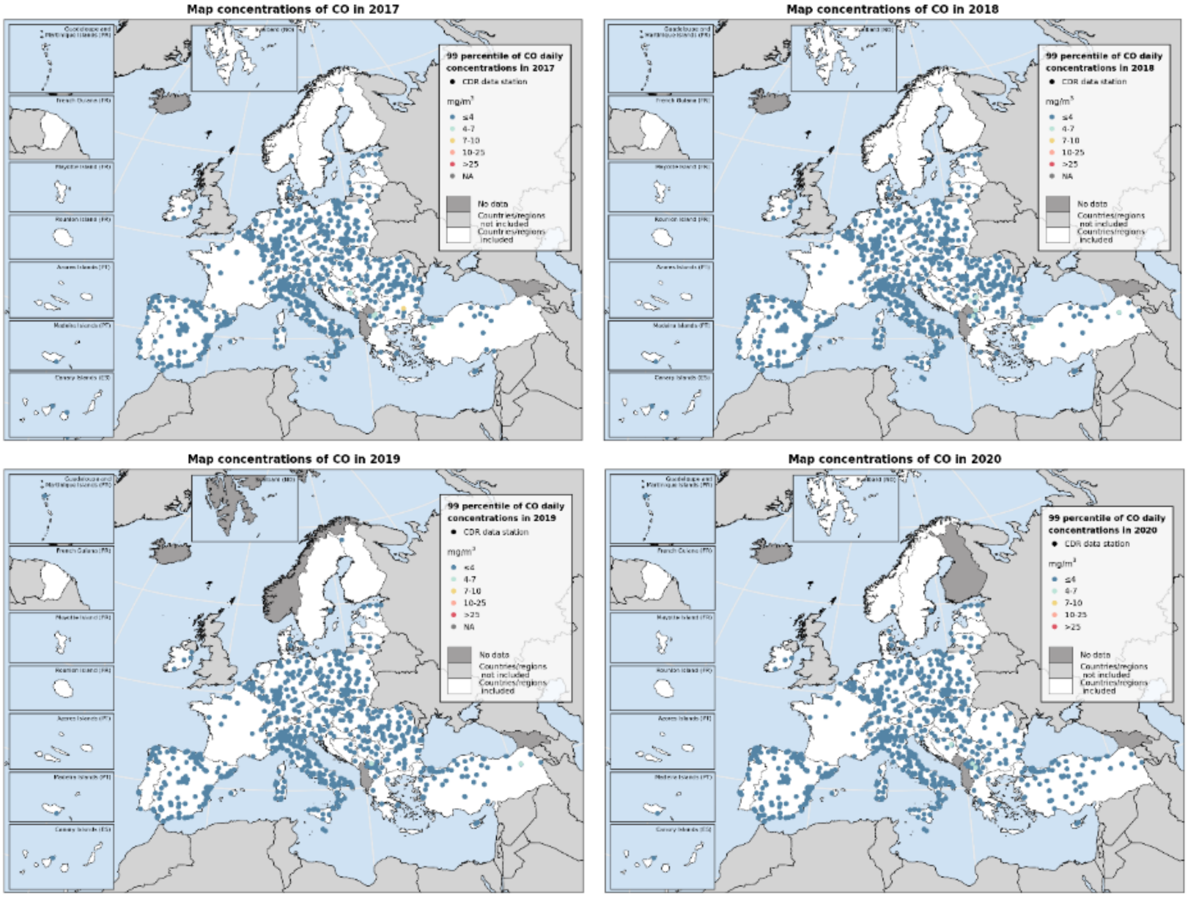


Figure A11.18 - CO daily mean concentrations for 2017 to 2020

3.6 Benzo(a)pyrene (BaP)

A total of 767 stations reported BaP data with sufficient data coverage.

a) BaP annual mean concentration

11 countries, all of which were EU Member States, registered values above 1.0 ng/m^3. Value above 1.0 ng/m^3 were measured at 27% of the reported BaP measurement stations, mainly at urban (79% of all stations with values above 1.0 ng/m^3) and suburban (15%) stations.

Regarding the WHO Air Quality Guidelines, all reporting countries, except for Cyprus, Malta and Sweden, had at least one station reporting concentrations above 0.12 ng/m^3. Only 20% of stations had annual concentrations below the reference level (Figure A11.19).

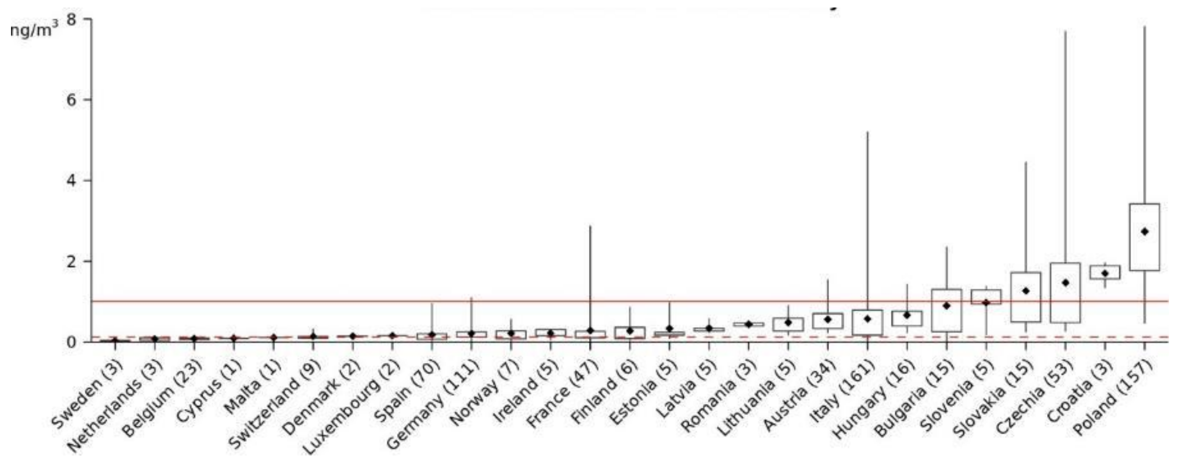


Figure A11.19 – 2020 BaP concentrations in relation to the annual limit value and WHO Air Quality Guidelines[182]

Figure A11.20 presents maps of the observed BaP annual mean concentrations from 2017 to 2020, allowing changes in the spatial distribution of the values above thresholds to be observed.

[182] Note: The graph is based on the annual mean concentration values. For each country, the number of stations considered (in brackets), and the lowest, highest and average values (in ng/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the lower percentile; at 25% of the stations, concentrations are above the upper percentile. The upper horizontal line marks the concentration of 1.0 ng/m³. The lower horizontal line marks the estimated air quality RL. The highest value in the boxplot, Poland (18.4 ng/m³), has not been included in the graph for representation purposes.

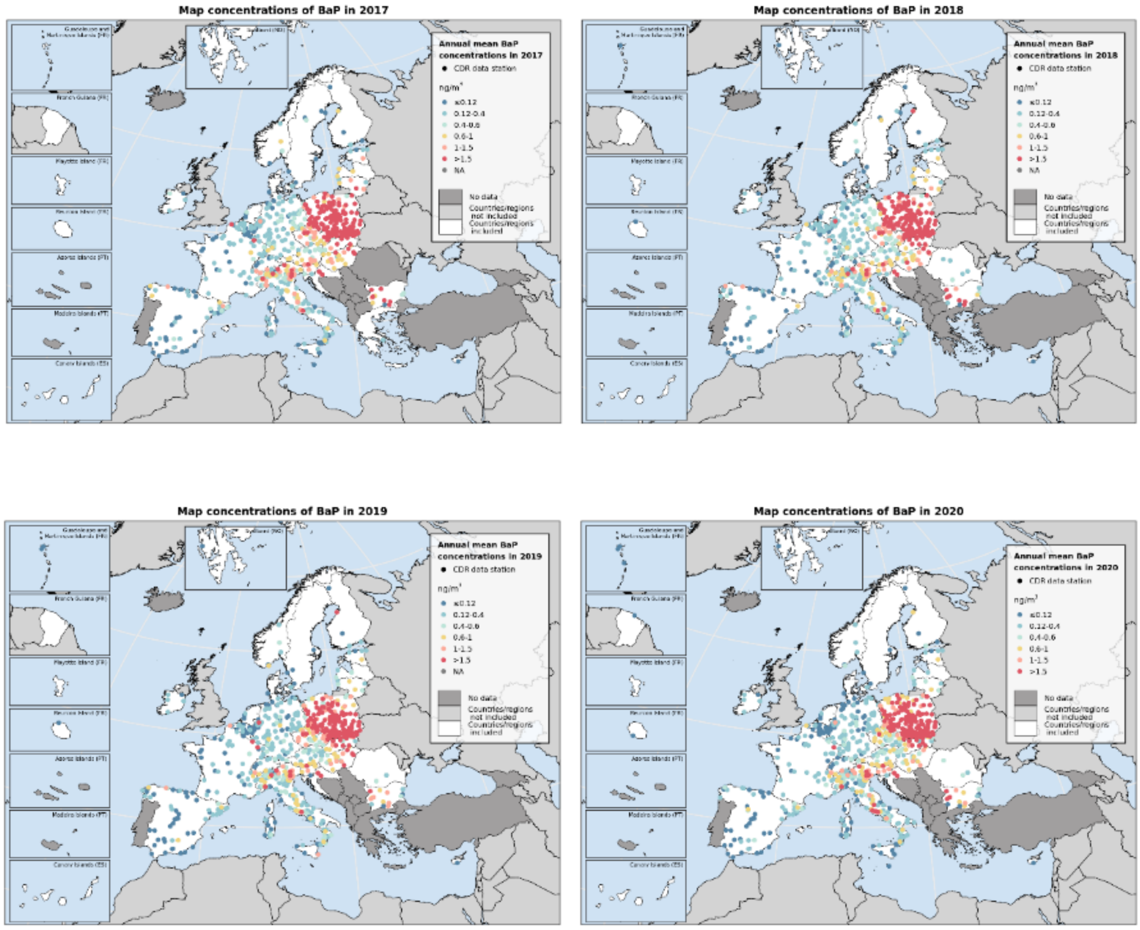


Figure A11.20 – Annual mean BaP concentrations for 2017 to 2020

3.7 Benzene (C_6H_6)

C_6H_6 measurements were reported from a total of 718 stations.

a) C_6H_6 annual mean concentration

As shown in Figure A11.21, concentrations above the limit value for C_6H_6 (5 µg/m^3) were not observed at any stations.

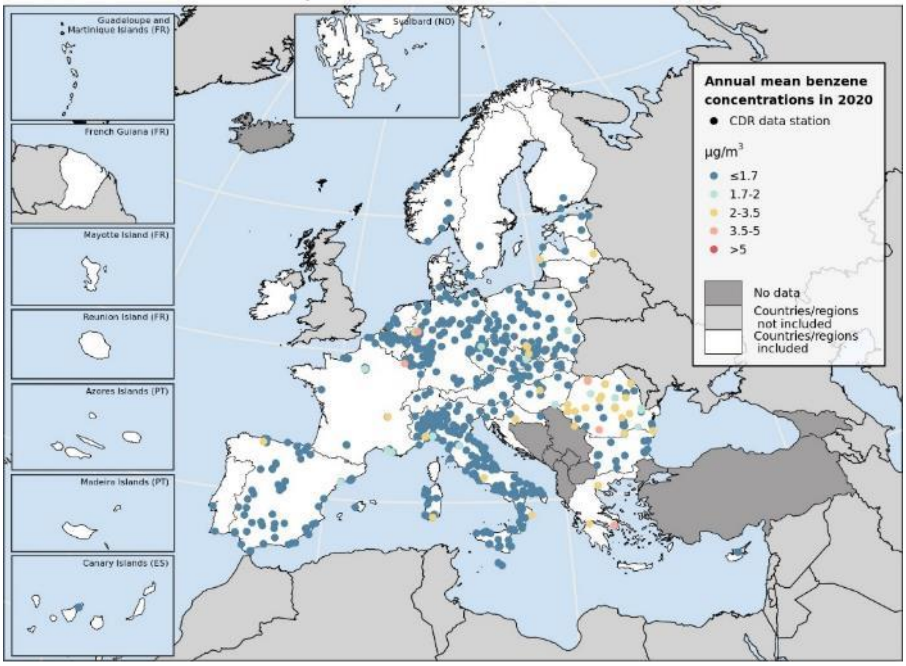


Figure A11.21 – Annual mean C_6H_6 concentrations in 2020

3.8 Lead (Pb)

Lead (Pb) data were reported from 675 stations.

a) Pb annual mean concentration

As shown in Figure A11.22, no stations reported Pb concentrations above the 0.5 µg/m^3 limit value.

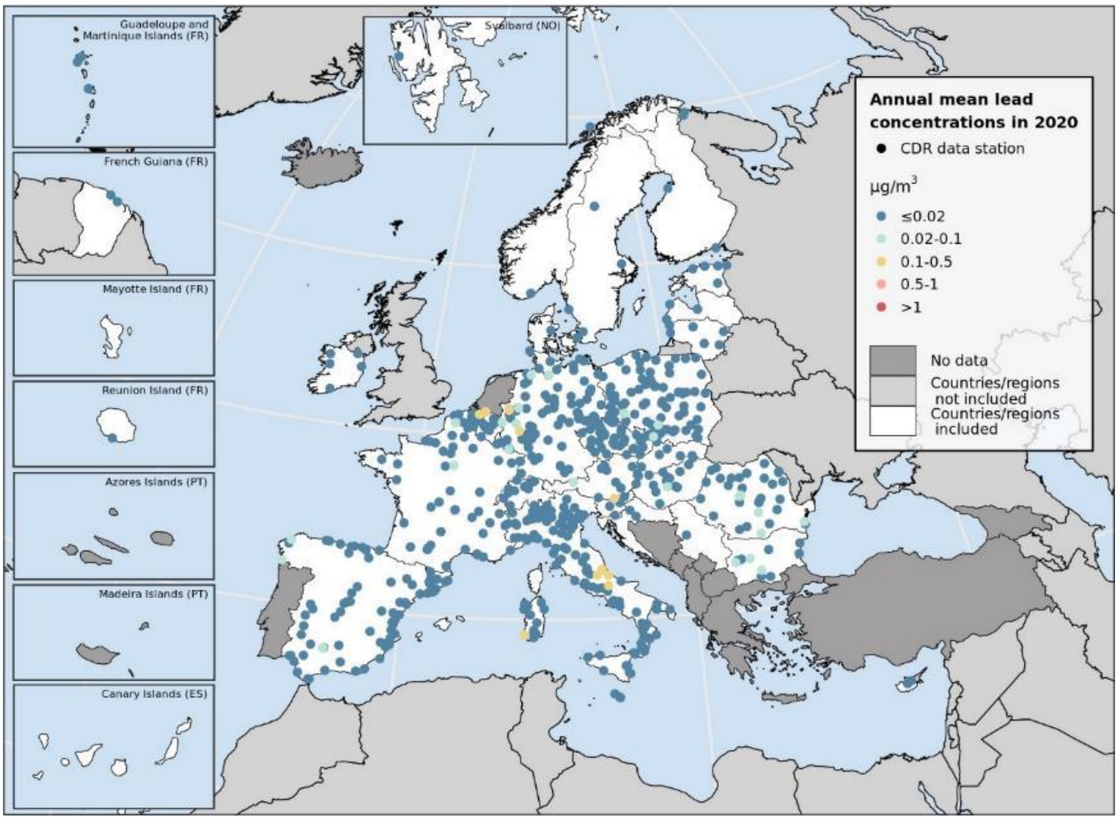


Figure A11.22 – Annual mean Pd concentrations in 2020

3.9 Arsenic (As)

Data for Arsenic (As) were reported from 661 stations.

a) *As annual mean concentration*

Seven stations measured concentrations above the target value of 6 ng/m^3. As shown in Figure A11.23, stations reporting concentrations above the target value were located in Belgium (three), Finland (two) and Poland (two). Four of these stations were industrial stations.

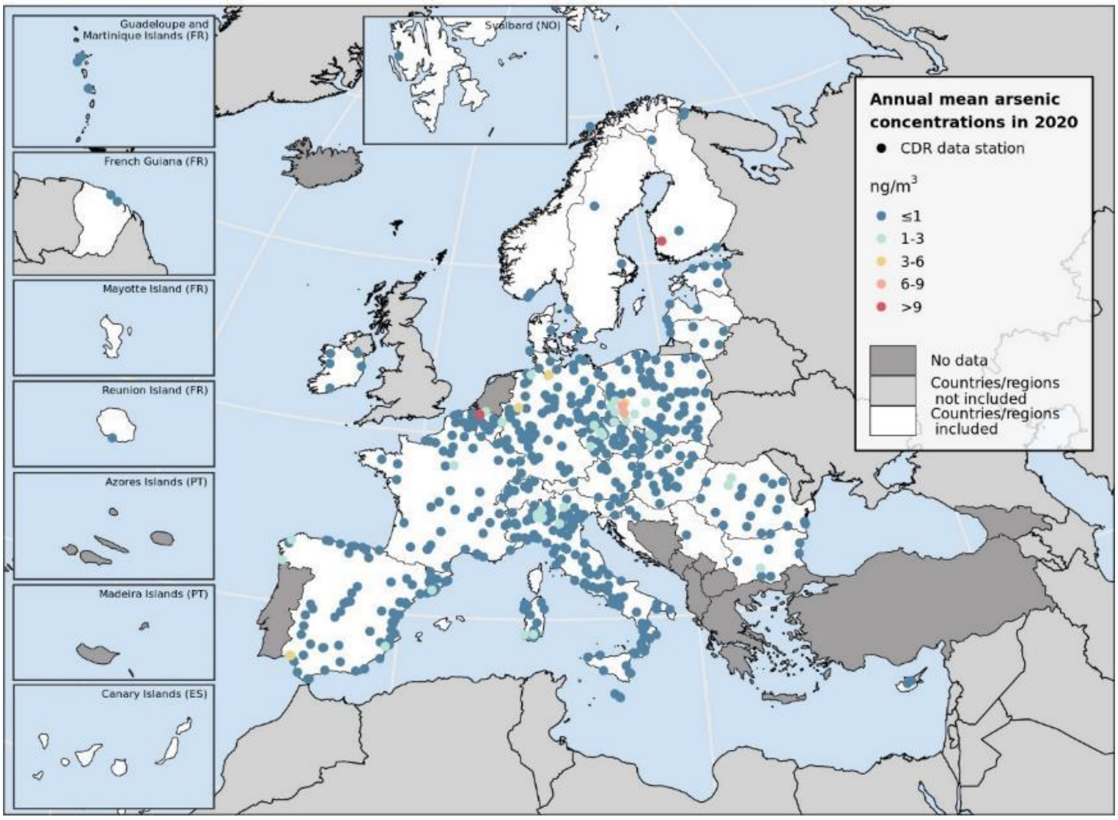


Figure A11.23 – Annual mean As concentrations in 2020

3.10 Cadmium (Cd)

Cadmium (Cd) data were reported from 680 stations.

b) Cd annual mean concentration

As shown in figure A11.24, concentrations above the target value of 5 ng/m^3 were measured at one station in Bulgaria.

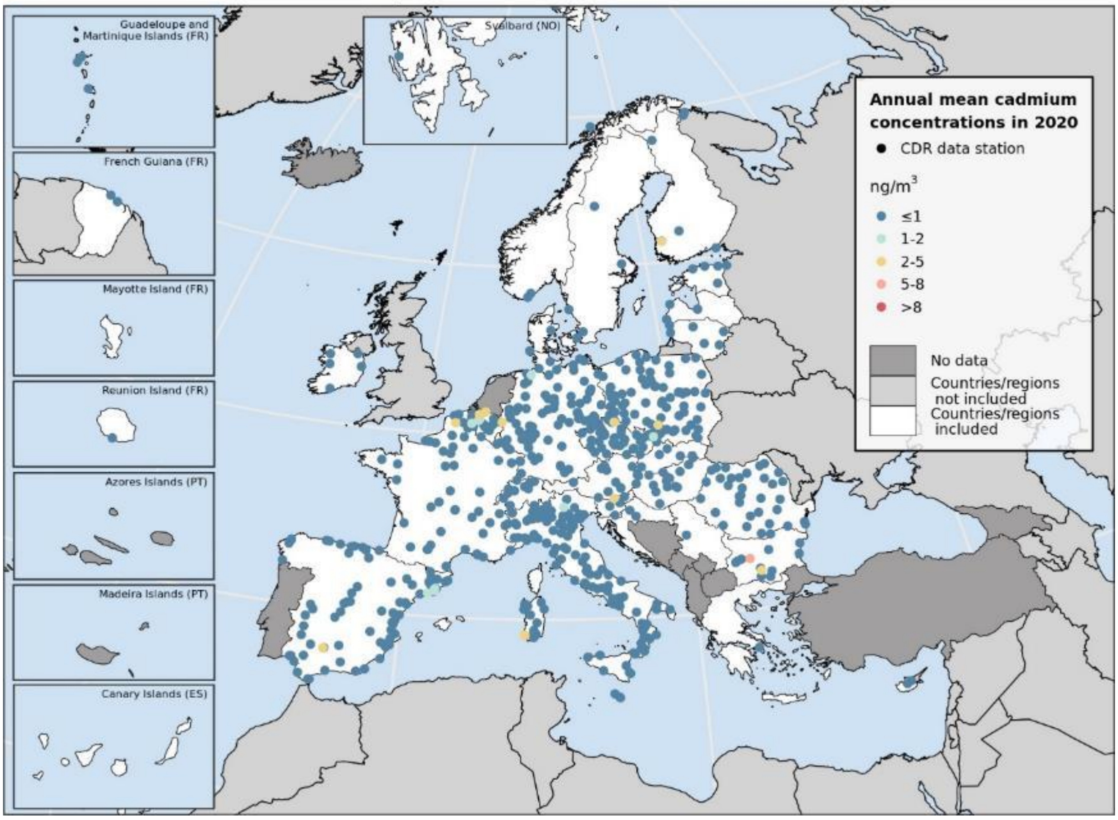


Figure A11.24 – annual mean Cd concentrations in 2020

3.11 Nickel (Ni)

Nickel (Ni) data were reported from 666 stations.

c) Ni annual mean concentration

As shown in Figure A11.25, concentrations were above the target value of 20 ng/m^3 were measured at two stations, one in Finland and one in France. Both of these stations were industrial stations.

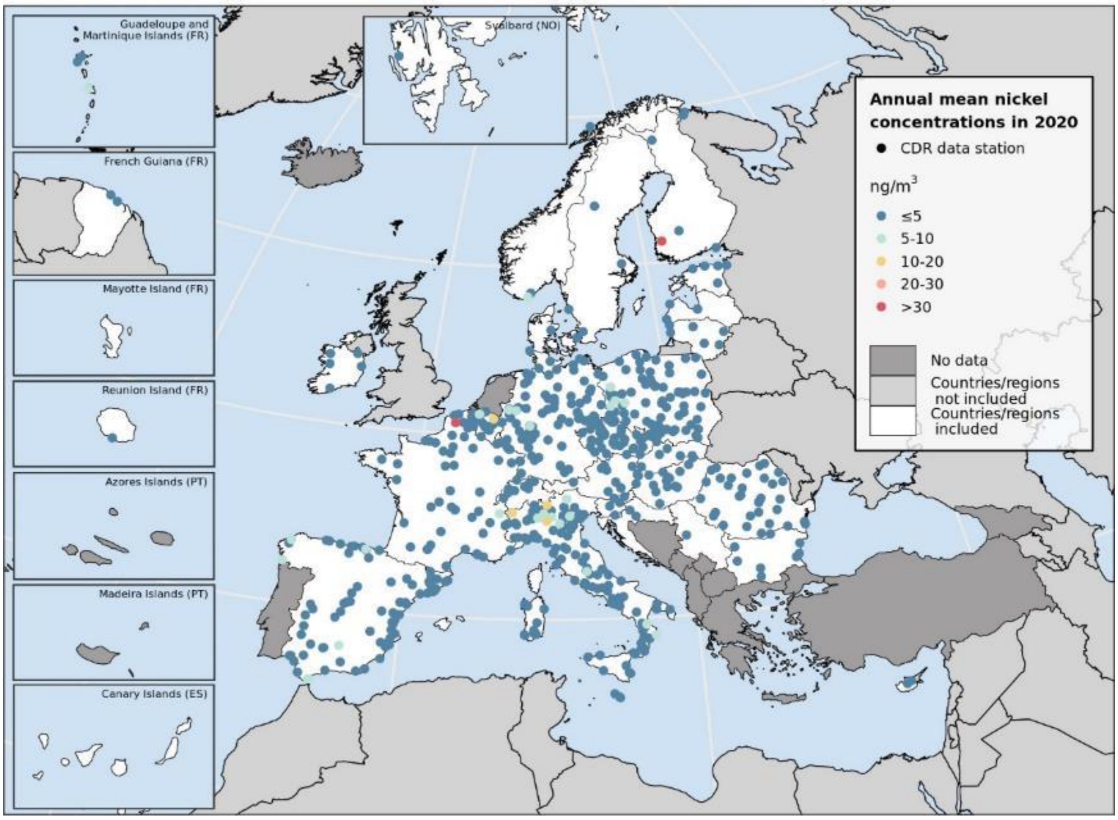


Figure A11.25 – Annual man concentrations of Ni in 2020

4. Exposure to air pollution in the EU

In 2020, less than 1% of Europe's urban population was exposed to levels of $PM_{2.5}$ and NO_2 above EU legal standards in 2020, while 12% was exposed to O_3, and 11% to PM_{10}, levels above respective EU standards. Of note, 2020 concentrations of NO_2, PM_{10} and $PM_{2.5}$ fell as a direct result of reductions in road transport during COVID-19 lockdown measures, so reducing urban exposure to air pollution.

Nevertheless, poor air quality remains a problem, with 96% of the urban population in the EU exposed to levels of $PM_{2.5}$ above the latest health-based WHO Air Quality Guidelines. The figures for NO_2 and O_3 are 89% and 95%, respectively (see Figure A11.26).

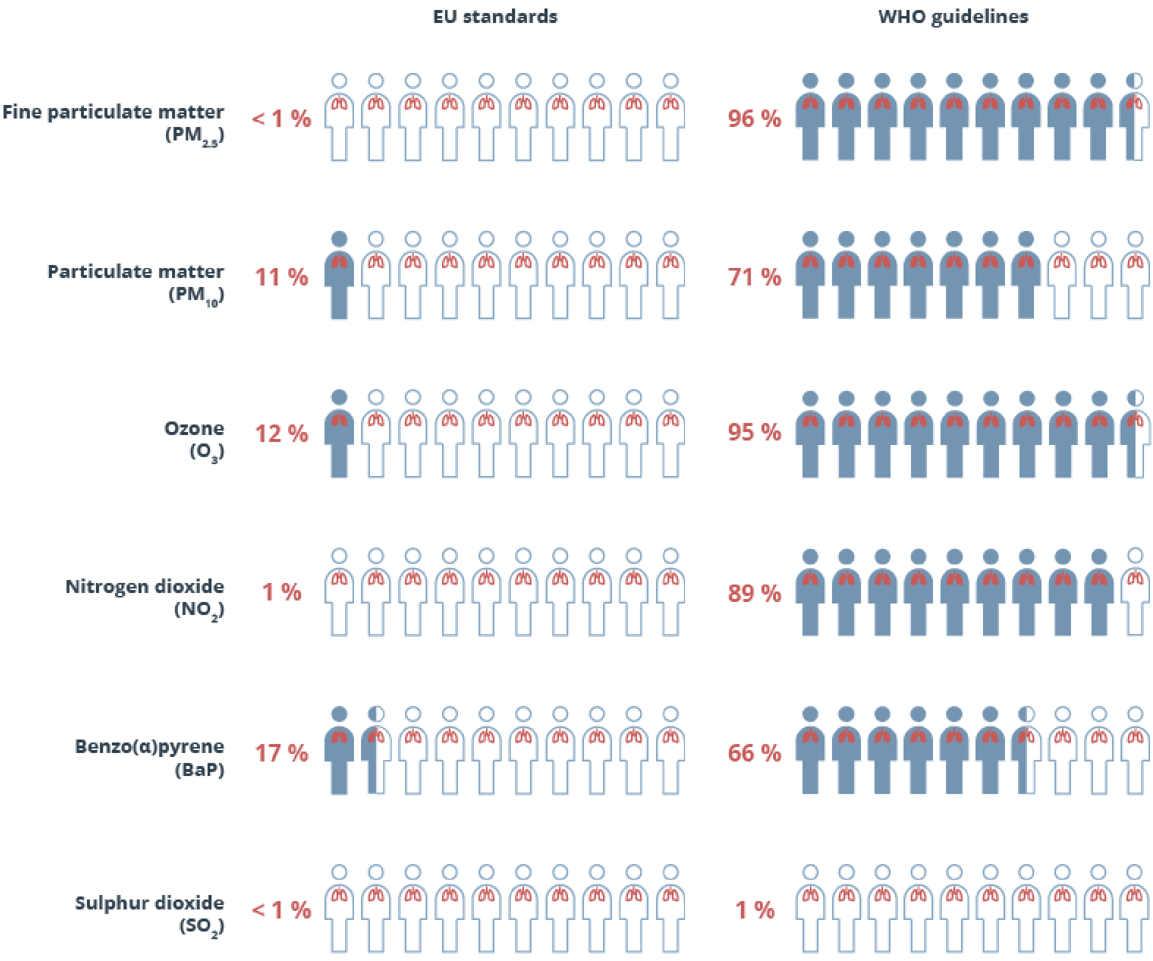


Figure A11.26 - Share of the EU urban population exposed to air pollutant concentrations above EU standards and WHO Air Quality Guidelines in 2020

ANNEX 12: INFRINGEMENT CASES AND LITIGATION UNDER THE AMBIENT AIR QUALITY DIRECTIVES

1. EU COURT PROCEEDINGS AGAINST MEMBER STATES FOR FAILURE TO FULFIL OBLIGATIONS UNDER AMBIENT AIR QUALITY LEGISLATION (2008 TO MAY 2022)

This section provides an overview of the cases referred to the Court of Justice of the EU based on the Ambient Air Quality Directives.

In a first wave of cases (2008 to 2012), the Commission initially decided to refer seven Member States to the Court of Justice of the EU on the basis of Article 258 TFEU due to exceedances of PM_{10} limit values: Italy, Portugal, Slovenia, and Sweden, as well as Cyprus, France and Spain.

The decision was executed only against the first four of the above Member States. Judgments delivered by the Court of Justice of the EU in these four cases (Table A12.1) confirmed the violations for a specific period in the past, but did not address the lack of appropriate measures to keep exceedance periods as short as possible.

The Commission saw a need to also address the absence or insufficiency of the measures dealing with the different sources of PM_{10} pollution. Accordingly, the earlier decisions regarding the other three Member States (Cyprus, Spain and France) were not confirmed at the time, as the Commission considered necessary to review its strategy.

Table A12.1 – Period 2008 to 2012: Focus on breaches of limit values over a given period, based on Directive 1999/30/EC (i.e. former First Daughter Directive)

Member State	Case	Infringement Case no.	Pollutant	Judgment
Italy	C-68/11	2008/2194	PM_{10}	Infringement established (EU:C:2012:815)
Portugal	C-34/11	2008/2200	PM_{10}	Infringement established (EU:C:2012:712)
Slovenia	C-365/10	2008/2202	PM_{10}	Infringement established (EU:C:2011:183)
Sweden	C-479/10	2008/2204	PM_{10}	Infringement established (EU:C:2011:287)

A second wave of infringement procedures on the basis of Article 258 TFEU was initiated and resulted in a number of referrals to and judgments of the Court of Justice of the EU, in the period 2013 to 2022 (Table A12.2).

In 2020, the Commission also decided to refer a Member State to the Court of Justice of the EU on the basis of Article 260 TFEU, i.e. for failing to take the necessary measures to remedy a previously established infringement by the Court of Justice of the EU (Table A12.3).

Table A12.2 – Period 2013 to 2022: Focus on persistent breaches of limit values and the lack of adequacy of the measures aimed at attaining compliance (based on Directive 2008/50/EC, i.e. Ambient Air Quality Directive)

Member State	Case	Infringement Case no.	Pollutant	Judgment
Bulgaria	C-488/15	2010/2109	PM_{10}	Infringement established (EU:C:2017:267)
Bulgaria	C-730/19	2009/2135	SO_2	Infringement established (EU:C:2022:382)
Germany	C-635/18	2015/2073	NO_2	Infringement established (EU:C:2021:437)
Greece	C-70/21	2008/2192	PM_{10}	*Pending case*
Greece	C-633/21	2018/2361	NO_2	*Pending case*
Spain	C-125/20	2015/2053	NO_2	*Pending case*
France	C-636/18	2015/2074	NO_2	Infringement established (EU:C:2019:900)
France	C-286/21	2008/2190	PM_{10}	Infringement established (EU:C:2022:319)
Italy	C-644/18	2014/2147	PM_{10}	Infringement established (EU:C:2020:895)
Italy	C-573/19	2015/2043	NO_2	Infringement established (EU:C:2022:380)
Hungary	C-637/18	2008/2193	PM_{10}	Infringement established (EU:C:2021:92)
Poland	C-336/16	2008/2199	PM_{10}	Infringement established (EU:C:2018:94)
Portugal	C-220/22	2015/2045	NO_2	*Pending case*
Romania	C-638/18	2009/2296	PM_{10}	Infringement established (EU:C:2020:334)
Slovakia	C-342/21	2008/2201	PM_{10}	*Pending case*
Other	**Case**	**Infringement Case no.**	**Pollutant**	**Judgment**
United Kingdom	C-664/18	2014/4000	NO_2	Infringement established (EU:C:2021:171)

Table A12.3 – Cases brought on the basis of Article 260 TFEU (failure to take the necessary measures to comply with a judgment of the Court of Justice of the EU)

Member State	Case	Infringement Case no.	Pollutant	Judgment
Bulgaria	C-174/21	2010/2109	PM_{10}	*Pending case*

2. INFRINGEMENT CASES INITIATED BY THE COMMISSION FOR NON-COMPLIANCE WITH AMBIENT AIR QUALITY LEGISLATION (2008 TO MAY 2022)

This section provides an overview of the infringement cases initiated on the basis of Article 258 TFEU and/or Article 260 TFEU during the assessment period, either for excessive NO_2 (Table A12.3), excessive PM_{10} and/or $PM_{2.5}$ (Table A12.4), excessive SO_2 (Table A12.5), or related to monitoring insufficencies (Table A12.6).

Table A12.4 – Infringement cases for excessive nitrogen dioxide (NO_2)

Member State	Case no.	Current status
Belgium	2016/2005	Reasoned Opinion (February 2021)
Czechia	2016/2062	Reasoned Opinion (February 2021)
Denmark	2016/2080	Closure (November 2019)
Germany	2015/2073	Judgment establishing infringement (June 2021) (see table A12.2)
Greece	2018/2361	Referral to Court (July 2021) (see table A12.2)
Spain	2015/2053	Referral to Court (July 2019) (see table A12.2)
France	2015/2074	Judgment establishing infringement (October 2019) (see table A12.2) Letter of formal notice (Art. 260 TFEU) (December 2020)
Italy	2015/2043	Judgment establishing infringement (May 2022) (see table A12.2)
Luxembourg	2017/2101	Letter of formal notice (October 2017)
Hungary	2016/2085	Letter of formal notice (July 2016)
Austria	2016/2006	Letter of formal notice (February 2016)
Poland	2016/2010	Reasoned Opinion (February 2021)
Portugal	2015/2045	Referral to Court (November 2021) (see table A12.2)
Romania	2020/2206	Letter of formal notice (May 2020)
Other	**Case no.**	**Current status**
United Kingdom	2014/4000	Judgment establishing infringement (March 2021) (see table A12.2)

Table A12.5 – Infringement cases for excessive particulate matter (PM_{10} and/or $PM_{2.5}$)

Member State	Case no.	Current status
Belgium	2008/2184	Closure (November 2018)
Bulgaria	2010/2109	Judgment establishing infringement (April 2017) (see table A12.2) Referral to Court (Art. 260 TFEU) (December 2020) (see table A12.3)
Czechia	2008/2186	Additional Reasoned Opinion (March 2015)
Denmark	2008/2187	Closure (June 2010)
Germany	2008/2191	Closure (April 2022)
Estonia	2008/2188	Closure (May 2011)
Greece	2008/2192	Referral to Court (December 2020) (see table A12.2)
Spain	2008/2203	Additional Reasoned Opinion (October 2014)
France	2008/2190	Judgment establishing infringement (April 2022) (see table A12.2)
Croatia	2020/2298	Reasoned Opinion (May 2022)

Italy	*2008/2194* 2014/2147	*Judgment establishing infringement based on Directive 1999/30/EC (December 2012) (see table A12.1) Closure (June 2013)*** Judgment establishing infringement (November 2020) (see table A12.2)
Italy	2020/2299	Letter of formal notice (October 2020)
Cyprus	2008/2185	Closure (February 2012)
Latvia	2008/2195	Closure (May 2020)
Hungary	2008/2193	Judgment establishing infringement (February 2021) (see table A12.2)
Malta	2008/2197	Closure (September 2010)
Austria	2008/2183	Closure (April 2015)
Poland	2008/2199	Judgment establishing infringement (February 2018) (see table A12.2) Letter of formal notice (Art. 260 TFEU) (July 2019)
Portugal	*2008/2200* 2013/2135	*Judgment establishing infringement based on Directive 1999/30/EC (November 2012) (see table A12.1) Closure (June 2013)*** Closure (July 2020)
Romania	2009/2296	Judgment establishing infringement (April 2020) (see table A12.2)
Slovenia	*2008/2202* 2012/2212	*Judgment establishing infringement based on Directive 1999/30/EC (March 2011) (see table A12.1) Closure (October 2011)*** Reasoned Opinion (May 2020)
Slovakia	2008/2201	Referral to Court (February 2021) (see table A12.2)
Sweden	*2008/2204* 2012/2216	*Judgment establishing infringement based on Directive 1999/30/EC (May 2011) (see table A12.1) Closure (October 2011)*** Reasoned opinion (June 2015)
Other	**Case no.**	**Current status**
United Kingdom	2008/2205	Closure (February 2013)

*** The case was closed due to a change of legal basis; a new case was initiated to accommodate for this.*

Table A12.6 – Infringement cases for excessive sulphur dioxide (SO_2)

Member State	Case no.	Current status
Bulgaria	2009/2135	Judgment establishing infringement (May 2022) (see table A12.2)
Czechia	2009/2136	Closure (January 2010)
Spain	2007/2180	Closure (June 2010)
France	2007/2181	Closure (November 2010)
Italy	2007/2182	Closure (May 2009)
Poland	2009/2137	Closure (January 2011)
Portugal	2009/2138	Closure (May 2011)
Romania	2009/2337	Closure (November 2013)

Slovenia	2007/2183	Closure (November 2008)
Other	**Case no.**	**Current status**
United Kingdom	2007/2184	Closure (May 2008)

Table A12.7 – Infringement cases related to the monitoring network

Member State	Case no.	Current status
Romania	2017/2024	Additional letter of formal notice (July 2019)
Slovakia	2017/2116	Closure (May 2022)

3. Selected case law of the Court of Justice of the EU related to the implementation of the Ambient Air Quality Directives

C-237/07, Janecek (EU:C:2008:447) - Entitlement of a third party, whose health has been impaired, to have an action plan drawn up

The case involved a dispute between Mr Dieter Janecek and Bavaria, over excessive PM_{10} pollution in the city of Munich. Mr Janecek filed a lawsuit, requesting an air quality plan to address the exceedances. The question was raised via a preliminary reference whether he would have such a right, based on the Air Quality Framework Directive (Directive 96/62/EC) applicable at the time.

The Court of Justice of the EU decided that where there is a risk that the emission limit values in respect of particulate matter PM_{10} or alert thresholds may be exceeded, persons directly concerned must be in a position to require the competent national authorities to draw up an action plan. This applies even in cases where, under national law, those persons may have other courses of action available to them for requiring those authorities to take measures to combat atmospheric pollution.

Furthermore, Member States are obliged, subject to judicial review by the national courts, to take measures – in the context of an action plan and in the short term – that are capable of reducing to a minimum the risk that the emission limit values in respect of particulate matter PM_{10} or alert thresholds may be exceeded.

C-404/13, ClientEarth (EU:C:2014:2382) - National courts' obligation to ensure an air quality plan is established in case of exceedances

Due to excessive nitrogen dioxide (NO_2) pollution in many zones in the UK, the environmental organisation 'ClientEarth' brought a claim in front of UK courts, seeking an order requiring the Secretary of State for the Environment, Food and Rural Affairs to revise the air quality plans to ensure that they demonstrate how conformity with the nitrogen dioxide limit values will be achieved as soon as possible. One of the questions raised via a preliminary reference was related to remedies that national courts must provide in cases like this one.

In its decision, building up on the *Janecek* judgment (see above), the Court of Justice of the EU decided that where a Member State has failed to comply with limit and target values under Directive 2008/50/EC, it is for the national court having jurisdiction, should a case be brought before it, to take, with regard to the national authority, any necessary measure, such as an order in the appropriate terms, so that the authority establishes the plan required by the directive in accordance with the conditions laid down by the latter.

As regards the content of the plan, while Member States have a degree of discretion in deciding which measures to adopt, those measures must, in any event, ensure that the period during which the limit values are exceeded is as short as possible.

C-723/17, Craeynest (EU:C:2019:533) - Locating sampling points and establishing exceedances

A number of residents of the Belgian Brussels-Capital Region and the environmental organisation 'ClientEarth' were in dispute with the Brussels competent authorities as to whether an adequate air quality plan had been established for the Brussels zone. In that regard, the court in Brussels deciding on the dispute asked the Court of Justice of the EU to give interpretation on the relevant provisions of Directive 2008/50/EC. It sought to clarify, first, the extent to which national courts may review the siting of sampling points and, second, whether the results from different sampling points may be averaged in order to assess compliance with the limit values.

Building up on the above case law, the Court of Justice of the EU decided that it is for a national court, hearing an application submitted for that purpose by individuals directly affected by the exceedance of the limit values from Directive 2008/50/EC, to verify whether the sampling points located in a particular zone have been established in accordance with the criteria laid down in that directive (i.e. that the sampling points are placed in areas where the highest concentrations occur) and, if they were not, to take all necessary measures in respect of the competent national authority, such as, if provided for by national law, an order, with a view to ensuring that those sampling points are sited in accordance with those criteria. Furthermore, in order to establish whether a limit value with an averaging period of one calendar year has been exceeded, it is sufficient that a pollution level higher than that value be measured at a single sampling point, and in that case the obligation to draw up an air quality plan is triggered.

C-752/18, Deutsche Umwelthilfe (EU:C:2019:1114) - Enforcement of obligations against competent authorities

The case involved a dispute between the NGO 'Deutsche Umwelthilfe' (a German non-governmental environmental protection organisation) and the Land of Bavaria concerning the latter's persistent refusal to adopt, in implementation of Directive 2008/50/EC, the measures necessary in order for the limit value set for nitrogen dioxide (NO_2) to be complied with in the city of Munich. Following several court orders (one in 2011, one in 2016 and one in 2017) requiring Bavaria to amend its air quality action plan applicable in Munich and imposing financial penalties, Bavaria nevertheless refused to observe those injunctions. Following which, Deutsche Umwelthilfe brought a new action seeking, *inter alia*, the coercive detention of the persons at the head of the Land of Bavaria (namely of the Minister for the Environment and Consumer Protection or, failing that, of the Minister-President). The Higher Administrative Court of Bavaria decided to request a preliminary ruling from the Court of Justice of the EU regarding whether EU law had to be interpreted as empowering, or even obliging, the national courts to order coercive detention.

The Court of Justice of the EU held that, in circumstances in which a national authority persistently refused to comply with a judicial decision enjoining it to perform a clear, precise and unconditional obligation flowing from EU law, in particular from Directive 2008/50/EC, it was incumbent upon the national court having jurisdiction to order the coercive detention of persons at the head of the Land of Bavaria provided that two conditions were met. First, domestic law must contain a legal basis for adopting such a measure which is sufficiently accessible, precise and foreseeable in its application in order to avoid all risk of arbitrariness. Second, the principle of proportionality must be observed. In this regard, the Court of Justice of the EU stated that, since the ordering of coercive detention entails a deprivation of liberty, recourse may be had to such an order only where there are no less restrictive measures (such as, in particular, high financial penalties that are repeated after a short time and the payment of which does not ultimately benefit the budget from which they are funded). It is for the national court to ascertain whether these two conditions are met. If those two conditions were to be met, EU law would not only authorise, but require, recourse to a measure such as coercive detention.

C-177/19, Germany - Ville de Paris and Others v Commission; C-178/19 P, Hungary - Ville de Paris and Others v Commission and C-179/19 P, Commission v Ville de Paris and Others (three appeals) (EU:C:2022:10) - Annulment of EU type approval provisions - Powers of a municipal authority in the field of air quality to limit the circulation of certain vehicles (discussed under admissibility)

The City of Paris, the City of Brussels and the Municipality of Madrid ('the respondents') each brought an action for annulment of Commission Regulation (EU) 2016/646 ('the contested regulation') which sets limit values for emissions of oxides of nitrogen which must not be exceeded during real driving emissions tests, in so far as it prevented them from imposing restrictions on the circulation of passenger vehicles in relation to their pollutant emissions. Those actions were partially upheld by the General Court, which held that the contested regulation was of direct concern to the applicant cities and that the action was therefore admissible.

Ruling on appeals brought by the Federal Republic of Germany (Case C-177/19 P), Hungary (Case C-178/19 P) and the Commission (Case C-179/19 P), the Court of Justice of the EU set aside the judgment of the General Court. The Court of Justice of the EU held that the interpretation given by the General Court of Directive 2007/46/EC (i.e. the Framework Directive on which the contested regulation is based) was too broad in scope by concluding that it precludes certain local restrictions on circulation which are intended, inter alia, to protect the environment. Such an interpretation is not consistent with the context, the objectives and the legislative history of Directive 2007/46/EC.

Consequently, the Court of Justice of the EU concluded that the General Court erred in law in holding that the contested regulation is of direct concern to the applicant cities. As regards the applicant cities' concerns with regard to the possibility of infringement proceedings being brought against one of the Member States to which they belong for infringement of the contested regulation, the Court of Justice of the EU pointed out that the adoption of legislation limiting the local circulation of certain vehicles for the purposes of protecting the environment is not liable to infringe the prohibition imposed by the contested regulation, with the result that it cannot have a direct effect on any action for failure to fulfil obligations. In the light of the foregoing, the Court of Justice of the EU sets aside the judgment under appeal and, considering that the state of the proceedings so permits, gives final judgment in the matter, dismissing the actions for annulment brought by the applicant cities as inadmissible.

C-61/21, JP / Ministre de la Transition écologique, Premier ministre - Right of individuals to compensation for damage to health from air pollution [183]

The underlying case concerns a proceeding in which a citizen requested the prefect of Val-d'Oise to take measures to resolve his health problems linked to environmental pollution (i.e. establishment of an air quality plan that ensures respecting air quality limit values) and the French state to pay compensation for damage to his health. The request for a preliminary ruling had been referred to the Court of Justice of the EU by the Cour administrative d'appel de Versailles (France) and regards the interpretation of Articles 13(1) and 23(1) of Directive 2008/50/EC, namely (1) whether these provisions entitle individuals, in case of a serious breach by a Member State, to claim compensation for health damage from that Member State; and (2) what the conditions would be for such an entitlement, in particular with regard to the date on which the existence of the failure attributable to the Member State concerned must be assessed.

In her Opinion of 5 May 2022, the Advocate General takes the view that an infringement of limit values set under Directive 2008/50/EC may give rise to entitlement to compensation from the State under the classic conditions for State liability. In particular, the first condition of state liability is satisfied since the limit values for pollutants in ambient air and the obligations to improve air quality laid down by EU directives were intended to confer rights on individual. The Advocate General's Opinion is not binding on the Court of Justice of the EU. The judgment will be delivered at a later date.

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[183] Note that this case is still pending at the time of drafting of this document.

C-375/21, Sdruzhenie "Za Zemyata – dostap do pravoadie" - Link between obligations under Directive 2008/50/EC and Directive 2010/75/EU [184]

The underlying case concerns proceedings before the Supreme Administrative Court of Bulgaria in which the association Sdruzhenie 'Za Zemiata – dostap do pravosadie' ('For the Earth – Access to Justice' Association) and other non-profit civil associations brought appeals in cassation against the judgment of the Administrative Court of Stara Zagora of 28 August 2020, by which the first association's action against the decision of the Executive Director of the Executive Agency for the Environment of 21 December updating Integrated Permit No 50/2005 issued to the Maritsa-iztok 2 EAD thermal power plant located in the village of Kovachevo, municipality of Radnevo, administrative district of Stara Zagora, was dismissed. The Supreme Administrative Court of Bulgaria referred three preliminary questions to the Court of Justice of the EU.

All the three questions ask the Court of Justice of the EU to clarify the link between Directive 2010/75/EU and Directive 2008/50/EC. More precisely, the referring Court is seeking confirmation whether, when considering a request for a BAT derogation under Article 15(4) of Directive 2010/75/EU, the competent national authorities should be guided by the purpose of achieving compliance with the limit values set by Directive 2008/50/EC and, in the event of exceedances – be limited by the measures included in the air quality plans, established pursuant to Article 23 of Directive 2008/50/EC, and whether it must refrain from granting a derogation if less stringent emission limit values for air pollutants from a the installation would contribute to the exceedance

4. ILLUSTRATIVE OVERVIEW OF CLEAN AIR CASES BEFORE NATIONAL COURTS

This illustrative overview gives an updated overview of clean air cases before national Courts similar as presented in Annex 6 of the Commission's Fitness Check of the Ambient Air Quality Directives (2019).[185] *This update is based on articles published on public websites of national judiciary and/or NGOs.*

Austria: The Austrian Administrative Court (Österreichischer Verwaltungsgerichtshof), ruled in February 2018 that based on the Aarhus Convention environmental NGOs can order a review of compliance with the legal provisions arising from EU environmental law. Moreover, the Austrian Administrative Court ruled in September 2019 that an individual has the right to apply for the establishment of sampling points in conformity with Directive 2008/50/EC to check compliance with limit values and, subsequently, ruled in October 2021 that such an application does not require the individual to demonstrate direct concern. [186]

Belgium: In December 2021, the Brussels Court of Appeal (Hof van beroep Brussel) ruled in favour of Greenpeace and condemned the Flemish government for its deficient policy against air pollution. The Court concluded that the Flemish government failed to set up an air quality

[184] Note that this case is still pending at the time of drafting of this document.
[185] Deutsche Umwelthilfe (2019), 'Legal Actions for Clean Air' (accessed: 10/06.2022)
[186] Austrian Administrative Court, Direct concern under the Air Quality Directive and application for the establishment of sampling points and EU Air Quality Directive: An application for the establishment of sampling points in conformity with the Directive does not require direct concern (accessed: 10/06.2022)

plan in accordance with Article 23 of Directive 2008/50/EC. It thereby confirmed the financial penalty that was imposed on the government by two prior judgments of the Brussels Court of First Instance (10/10/2018 and 08/07/2020) and that amounted to 850 000 EUR. [187]/[188]

Bulgaria: In June 2019, the Supreme Administrative Court of Bulgaria (Върховният административен съд) denied legal standing to residents and NGOs to appeal city air quality plans for the period 2015-2020.[189] Additionally, in January 2021, the Supreme Administrative Court of Bulgaria rejected the appeal of the Bulgarian NGO Za Zemiata (Friends of the Earth) against the city of Sofia's air quality plan for the period 2021-2026.[190] Both times, the Court held that air quality plans do not affect the rights, freedoms or legitimate interests of citizens or legal entities. This ruling is final, no national remedies against this ruling are available.

Czech Republic: In several cases in the Czech Republic, administrative courts have annulled air quality plans because of their lack of effectiveness. In December 2017, the Supreme Administrative Court (Nejvyšší správní soud České republiky) rejected the air quality plan for the agglomeration of Ostrava as not being appropriate. In February 2018, Prague's Municipal Court (Městský soud v Praze) revoked the city's air quality plan because it was deemed unfit to serve its purpose, i.e. swift achievement of binding air quality standards.[191] Additionally in February 2018, the Supreme Administrative Court revoked the air quality plan for the region of Usti referring to low effectiveness.[192] In May 2018, the Supreme Administrative Court revoked the air quality plan for the city of Brno for the same reasons.[193]

France: The NGO 'Les Amis de la Terre' with support of the NGO 'ClientEarth' brought a case against the French government. In its judgment of 11 July 2017, the Supreme Administrative Court (Conseil d'État) stated that Directive 2008/50/EC sets an obligation of results and ordered the adoption of new and more effective air quality plans by 31 March 2018. In July 2020, the Supreme Administrative Court concluded that the French government had still not taken the necessary measures to remedy the situation. It gave the state six more months to comply, failure of which would result in a lump sum payment of 10 million euro. In August 2021, the Supreme Administrative Court imposed the financial penalty of 10 million euro after establishing the continued failure of the French government to execute the judgment of 11 July 2017. Additionally, the Supreme Administrative Court held that it would re-evaluate the situation every six months and possibly impose a new lump sum of 10 million euro if the state had still not taken the necessary measures to comply.[194]

Germany: In February 2018, the Federal Administrative Court (Bundesverwaltungsgericht) ruled that health protection takes precedence over economic interest and thus cleared the way

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[187] Greenpeace (2021), press release (accessed: 10.06.2022)
[188] Greenpeace (2022), press release (accessed: 10.06.2022)
[189] UNECE (2020), Case Summary on ruling No. 9614, 13138, 16049 (accessed: 10.06.2022)
[190] Zazemiata.org (2022) Court decides citizens cannot appeal air program (accessed: 10.06.2022)
[191] Frank Bold.org (2018), A Major Win for Air Quality in Prague (accessed: 10.06.2022)
[192] Frank Bold.org (2018), A Major Win for Air Quality in Usti region of the Czech Republic (accessed: 10.06.2022)
[193] Frank Bold.org (2018)A Major Win for Air Quality in Brno, Czech Republic (accessed: 10.06.2022)
[194] Conseil D'État (2021), Pollution de l'air : le Conseil d'État condamne l'État à payer 10 millions d'euros (accessed: 10.06.2022)

for restrictions on the use of diesel vehicles. In February 2020, the Federal Administrative Court held in its ruling that traffic bans for diesel vehicles can be introduced as an appropriate measure to reduce NO_2 if they are the only means to keep the exceedance periods of the limit values as short as possible. However, it underlined the importance of the principle of proportionality and thereby partially overturned the judgment of the Higher Administrative Court.[195]

Hungary: In January 2021, the Budapest Supreme Court (Curia) rejected the claim of the NGO Clean Air Action Group for a reviewed air quality plan that reduces air pollution in a meaningful way. It held that such plans do not constitute administrative acts against which judicial action can be brought and thus they cannot be effectively challenged in court. Consequently, the NGO has brought a claim before the European Court on Human Rights in Strasbourg for breach of access to justice and public health rights (Article 6 of the European Convention on Human Rights).[196]

Italy: In 2018, a citizens' association in Milan promoting the need for cleaner air for the region of Lombardy (Associazione Cittadini per l'Aria), supported in its claims by ClientEarth, introduced legal proceedings against the region of Lombardy claiming that the latter had failed to draw up an air quality plan in accordance with Article 23 of Directive 2008/50/EC. In July 2019, the Lombardy Regional Administrative Court **(**Tribunale Amministrativo Regionale per la Lombardia) ruled that the association had legal standing to bring these claims and thus found the action to be admissible, contrary to the arguments put forward by the region of Lombardy. However, the Lombardy Regional Administrative Court rejected all the pleas made by the association on their substance.[197]

The Netherlands: Following a court ruling from September 2017 by the Court of The Hague (Gerechtshof Den Haag) in a case brought by the environmental protection organisation 'Milieudefensie', the Netherlands was ordered to take concrete measures to comply with all EU limit values in a 'foreseeable and demonstrable' manner. In a subsequent ruling on appeal in May 2019, the Court of The Hague did not recognize a breach of the fundamental rights to life and health by the state, when only aiming at complying with EU law and not targeting a higher goal, for instance WHO Air Quality Guidelines.[198]

Poland: In Poland, residents, supported by the NGO 'Frank Bold', went before the Constitutional Court (Trybunał Konstytucyjny) to claim their right to challenge air quality plans. The Polish residents put forward that the restrictive legal standing requirements established by Polish law, which prevented them from challenging air quality plans, were contrary to the Polish Constitution. In July 2021, the Constitutional Court rejected this claim but nevertheless pointed out that this did not change the fact that the underlying problem of the case (i.e. lack of standing of Polish citizens to challenge air quality plans) should be reconsidered by the legislator in light of the case law of the Court of Justice of the EU and the importance of protecting and improving the environment.[199] Moreover, in December 2021,

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[195] Bundesverwaltungsgericht (2020), Press release no. 13/2020 (accessed: 10.06.2022)
[196] Levego Munkacsoport (2021), Clean Air Action Group takes Budapest air quality plan to Strasbourg Court (accessed: 10.06.2022)
[197] Sentenze Italia - Cittadini per l'Aria (cittadiniperlaria.org)
[198] Rechtspraak (2019), https://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:GHDHA:2019:915 (accessed: 15.06.2022)
[199] Trybunal.gov (2021), Judgement Ref No. SK23/17 (accessed: 10.06.2022)

the District Court in Gliwice (Sąd Okręgowy w Gliwicach), confirmed that the state is liable for its failure to attain the EU air quality standards and awarded the claimant 30 000 PLN in compensation damages.[200]

Romania: In November 2020, the Municipal Court of Bucharest (Tribunalul Municipiului București) annulled the integrated air quality plan developed by the city's authorities, following an action initiated by a group of NGOs and residents claiming that the plan did not comply with the national legislation on ambient air quality transposing Directive 2008/50/EC (Law no. 104/2011). Two actions were joined; one challenging the substance of the air quality plan and one challenging the adoption process of the air quality plan and the lack of citizen's consultation during this process.[201]

Slovakia: In February 2017, a group of citizens from Bratislava and NGOs 'Cyklokoalicia' and 'ClientEarth', with the assistance of Via Iuris, took legal action against the Bratislava air quality plan. In November 2018, the Slovak Regional Court (Krajský súd v Bratislave) dismissed the air quality plan, stating it was vague and insufficient. A new plan must include effective measures to improve air quality in the city in the shortest possible time. The Municipality of Bratislava did not appeal the ruling.

Spain: The environmental NGO 'Ecologistas en Acción' filed a lawsuit against the lack of an air quality plan addressing illegally high levels of ozone in the region Castilla y León. In October 2018, the High Court of Castilla y León (Tribunal Superior de Justicia de Castilla y León) ordered the regional government to prepare within one year an air quality plan to tackle levels of ozone exceeding the EU air quality standards. This judgment was confirmed by the Spanish Supreme Court (Tribunal Supremo) in June 2020, which held that regional air quality plans are independent from the national plan, the non-existence of which cannot be an excuse for lack of action at regional level.[202] Moreover, in December 2021, the High Court of Navarre (Tribunal Superior de Justicia de Navarra) gave the regional government a year to prepare and approve the mandatory air quality plan for ozone in the Ribera Navarra area. By imposing a specific deadline by which the regional government has to comply, the Court goes beyond the ruling of the Spanish Supreme Court.[203]

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200 Frank Bold.pl (2021), Breakthrough court ruling in Poland – state must pay for air pollution to citizen (accessed: 10.06.2022)

201 Aerlive.ro, Victorie în instanță pentru cetățenii capitalei! » Aerlive Aerlive | Platformă pentru măsurarea calității aerului din București

202 Ecologistas en acción.org (2020), El Tribunal Supremo obliga a las comunidades autónomas a aprobar planes de calidad del aire para reducir el ozono (accessed: 10.06.2022)

203 Ecologistas en acción.org (2022), El Tribunal de Justicia de Navarra da un año al Gobierno Foral para adoptar un plan de calidad del aire que reduzca el ozono (accessed: 10.06.2022)