Understanding the process of setting air quality limit values and the associated compliance challenge

A Concawe modelling study examines how annual average PM and NO_2 concentrations would vary under different emission reduction scenarios, and assesses the cost and practicability of achieving compliance with air quality limit values (AQLVs). The study highlights the importance of undertaking a risk management process when setting AQLVs, to ensure that any new limit value can be achieved in practice.

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Introduction

In 2018, the European Commission initiated a fitness check[1] of the two EU Ambient Air Quality (AAQ) Directives (Directives 2008/50/EC[2] and 2004/107/EC[3]). A fitness check evaluates the relevance, effectiveness, efficiency, coherence and added value to the EU of a Directive. The AAQ Directives set air quality standards and require Member States to monitor and/or assess air quality in their area in a harmonised and comparable way.

The results of the fitness check will be used to assess whether the AAQ Directives remain the appropriate legislative instruments for protecting the environment and the European population from adverse impacts on human health associated with air pollutants.

In addition, as it has been stated by the European Commission in its Clean Air Programme for Europe, the long-term objective for air quality in the EU is to achieve no exceedances of the World Health Organization (WHO) guideline levels for human health.[4,5] These guideline concentration values are lower than the limit values set in the AAQ Directives for some pollutants.

Many Member States have difficulty in complying with the current conditions of the Directives and specifically meeting air quality limit values (AQLVs) that came into force as long ago as January 2010. The fitness check process therefore has a difficult task ahead. A recommendation in line with EU policy objectives to revise the AAQ Directives to include more stringent AQLVs will be difficult to achieve, considering efforts made by Member States to comply with present values.

The WHO guidelines[4] state that:

> *'... it should be emphasized, however, that the guidelines are health-based or based on environmental effects, and are not standards per se. In setting legally binding standards, considerations such as prevailing exposure levels, technical feasibility, source control measures, abatement strategies, and social, economic and cultural conditions should be taken into account.'*

Consequently, the fitness check and the Directive revision process that ensues should follow a two-step process of firstly assessing the environmental and human health risks presented by concentrations of air pollutants (risk assessment step), and secondly assessing how these risks may be managed (risk management step).

A consequence of underestimating the importance of the risk management step would be to incur potentially excessive costs without being effective, as illustrated by the case of nitrogen dioxide (NO_2). Risk management is the process of assessing how emissions of pollutants can be controlled and at what cost, and how successful the control measures are in reducing pollutant concentrations in the air. The WHO air quality guideline value for the annual mean concentration of 40 $\mu g/m^3$ was adopted as an AQLV for NO_2 in Europe. This has since proven to be extremely difficult to achieve, and many areas of Europe are non-compliant despite significant emission reduction efforts. In the US, the ambient air quality standard for NO_2 was set at 100 µg/m^3, which is more than twice the WHO guideline value.[6] If an AQLV higher than the WHO guideline of 40 µg/m^3 had been adopted in Europe, progress to reduce concentrations of NO_2 towards the WHO guideline value could have been made in a more measured way, and without the 'pressures' that non-compliance brings (e.g. the strict time frame for the adoption of emission control measures).

A more measured approach has been adopted for particulate matter ($PM_{2.5}$). The annual mean EU AQLV for $PM_{2.5}$ was set at 25 µg/m^3 compared to the WHO air quality guideline value of 10 µg/m^3. Since then, emission measures have led to a steady reduction in $PM_{2.5}$ concentrations. The revision of the AAQ Directives will certainly examine the level at which a new limit value might be set, but the risk management process must be robust enough to ensure that any new value can be achieved.

The risk management process has to consider how emission reductions affect the level of pollutant concentrations in the air. There are many emission sources, and each source reduction has an associated investment cost. These costs can vary widely. As the target value for the concentration of a pollutant in the air is reduced, finding the balance of mitigation measures that have the least overall cost gets more difficult, and the cost itself increases dramatically. Solving the problem is made more difficult by the formation of secondary pollutants in the atmosphere; these make the relationship between emission and concentration dependent on geography, climatic conditions and transboundary effects.

To assess the cost and the practicability of achieving compliance with lower ambient AQLVs, Concawe commissioned Aeris Europe to carry out a study that examines how annual average air concentrations of PM and NO_2 would vary under some potential emission reduction scenarios. The results were evaluated at each of the approximately 3,000 European air quality monitoring stations currently in place and are expressed in terms of compliance, i.e. whether or not the annual average concentration at the station would be less than a limit value. For brevity, this article examines compliance in two countries, Poland and France, which have been chosen as representative examples to demonstrate the results of the study.

Modelling approach

The concentrations of NO_2 and PM at the monitoring stations are predicted, for each of the emissions scenarios examined, using the AQUIReS+ model.[7] The model uses a gridded emission inventory and source-receptor relationships[8] that relate a change in emission to a change in concentration. These derive from regional chemical transport models (EMEP[9], CHIMERE[10]) used in air policy studies. The model takes into account the local environment, traffic and topographical characteristics of each station. Model predictions are compared with data from the EEA Air Quality e-Reporting dataset[11] to ensure that the model performs sufficiently well to reproduce concentrations of pollutants over historic years. The cost of certain emission reduction scenarios is calculated using Concawe's in-house Integrated Assessment Model (IAM) SMARTER, which takes its values from the IIASA GAINS model[12] used to develop European environmental policy.

Emissions scenarios

Current legislation baseline

The starting point of the study is the Current Legislation (CLE) scenario—the official EU projection of how emissions (based on multiple sector contributions) will evolve in time. The CLE scenario takes account of economic growth and evaluates the impact of European legislation currently in force. Projections are made in five-year steps. The geographic distribution of emissions is accounted for at a fine scale, and national emissions for the EU 28 Member States are calculated by spatial aggregation.

The CLE scenario is described in the Thematic Strategy on Air Pollution (TSAP) Report #16, published by IIASA.[13,14,15] The focus of that report is on $PM_{2.5}$, NO_x, SO_2, NH_3 and NMVOCs. For simplicity the many source emissions are aggregated into 10 different sectors according to the SNAP (Selected Nomenclature for sources of Air Pollution) method.

Figure 1 shows the CLE emissions projections of $PM_{2.5}$ for France and Poland, broken down by SNAP sector. $PM_{2.5}$ emissions are seen to decrease from 2015 onwards in both countries, falling by 30% in France and 20% in Poland by 2030. In both countries the largest contributor to $PM_{2.5}$ is residential combustion. In France, this accounts for more than 40% of total $PM_{2.5}$ emissions up to 2020, dropping to 35% of $PM_{2.5}$ emissions in 2030 (Figure 1a). In Poland, where coal and firewood are still widely used as domestic fuels, the contribution of residential combustion exceeds 70% of total $PM_{2.5}$ emissions in all years (Figure 1b).

Figure 1: Sectoral $PM_{2.5}$ emissions for France and Poland under the CLE scenario

(Source: IIASA GAINS TSAP report #16).

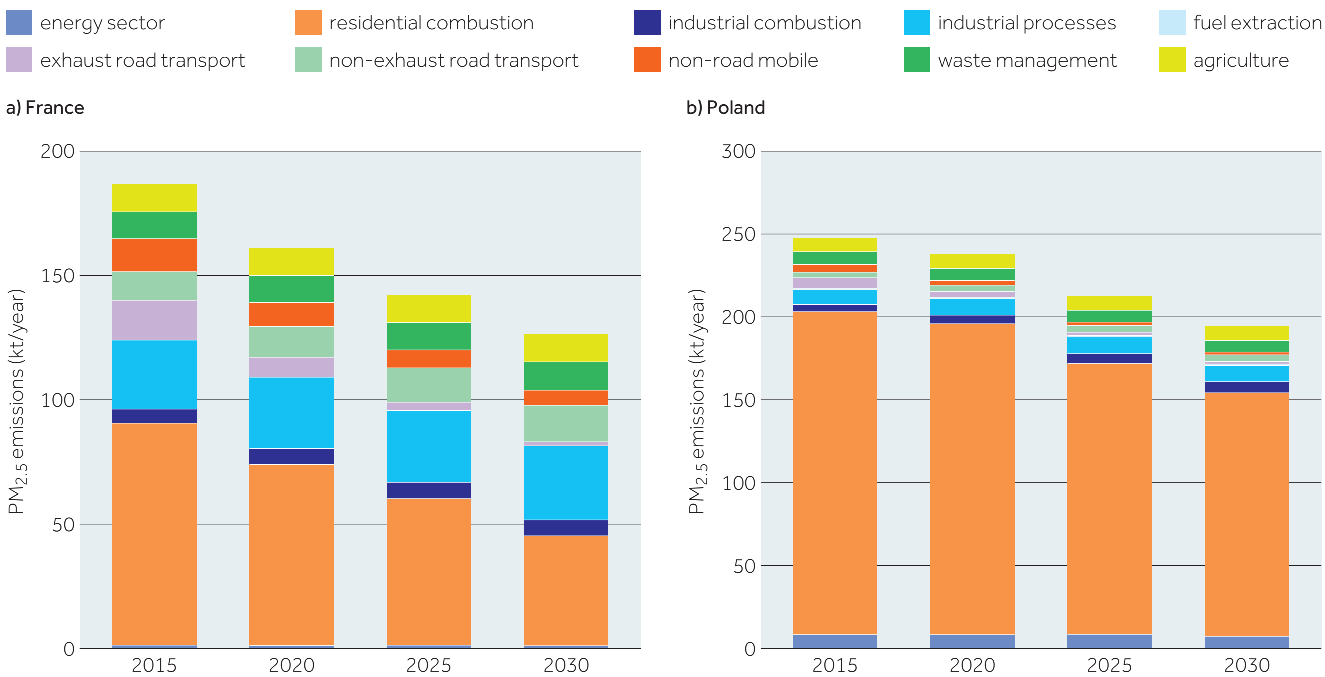
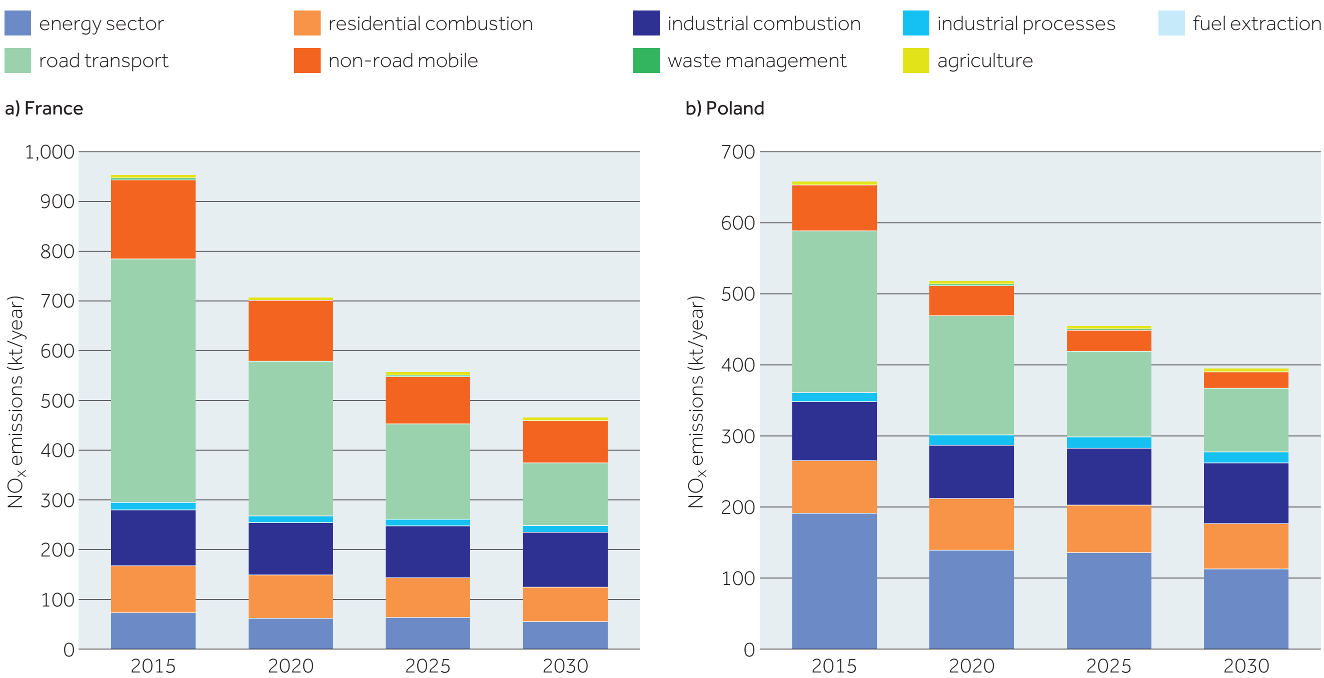


Figure 2 shows the CLE emissions projections of NO_x for France and Poland broken down by SNAP sector. Emissions show a clear downward trend in both countries. In 2030, NO_x emissions in France are expected to be 50% lower than in 2015 (Figure 2a), while in Poland the reduction is approximately 40% (Figure 2b).

In both countries, emissions of NO_x from transport are a significant but decreasing component of NO_x emissions. The reduction is due to the implementation of the Euro VI (for heavy-duty) and Euro 6 (for passenger) vehicle regulations and the progressive retirement of older vehicles from the fleet. The energy sector and industry are also significant contributors to total NO_x emissions. In Poland, the energy sector is expected to be the largest source of NO_x emissions after 2025.

Figure 2: Sectoral NO_x emissions for France and Poland under the CLE scenario

(Source: IIASA GAINS TSAP report #16).



Maximum Technically Feasible Reductions (MTFR) scenario

A second scenario used in policy planning is the Maximum Technically Feasible Reductions (MTFR) scenario. This is historically named and refers to the case where emissions from stationary sources are reduced by using all available technical measures. It gives a reference point for both 'minimum emissions' and 'maximum costs' for these sources. It is important to note that not all sources are included, and non-technical measures can also be used to reduce emissions. The implementation of non-technical measures would require specific political will, and their feasibility is not considered. Foreseen plant closures, such as the phasing out of some older fossil-fuelled power stations, are accounted for in the CLE scenario.

Optimised emissions scenarios

To estimate the cost contribution from traditional abatement measures used to reduce emissions from stationary sources, a number of optimised scenarios were generated over the range between the CLE and MTFR cases. The optimisation used aims to find the most cost-effective way to achieve a target. In these calculations the target is the EU-wide human health benefit associated with reducing concentrations of pollutants in the air. The results from the optimised scenarios are shown in the section on *Estimated costs of reducing the AQLV for* $PM_{2.5}$ *and* NO_2 on pages 22–25.

Emissions scenarios evaluated

In addition to the CLE and MTFR scenarios described above, additional emissions scenarios are examined by Concawe. These scenarios involve measures that are not included as technical measures in the GAINS model and therefore have no attributed costs. They are non-technical measures, the implementation of which would require specific political will, and their feasibility is not considered. Table 1 provides a list of the additional scenarios examined in this study, and a brief description of each follows below.

Table 1: Scenarios examined in this study and the corresponding year(s).

SCENARIO	DESCRIPTION	INTRODUCTORY YEARS
1	Electrification of Passenger Car Diesel (PCD)	2025, 2030
2	Electrification of Passenger Car Gasoline (PCG)	2025, 2030
3	Electrification of Light-Duty Vehicles (LDV)	2025, 2030
4	Electrification of all Road Transport	2025, 2030
5	Early introduction of hypothetical EURO 7 PCD	2025, 2030
6	Substitution of Domestic Solid Fuels with Heating Oil	2025, 2030
7	Removal of Agricultural Ammonia (NH_3) Emissions (SNAP 10)	2030

Scenarios 1–4: Electrification of the vehicle fleet

Specific vehicle categories are assumed to be replaced by electric vehicles with zero tailpipe emissions of NO_x, PM ($PM_{2.5}$ and PM_{10}) and SO_2. Each substitution scenario is assumed to have an immediate effect on the vehicle category emissions from the year of introduction onwards.

The following substitutions with electric vehicles are explored individually:

- Scenario 1: Diesel passenger cars
- Scenario 2: Gasoline passenger cars
- Scenario 3: Light-duty vehicles
- Scenario 4: All vehicles (including heavy duty vehicles, buses/coaches and motorcycles/mopeds).

Non-exhaust emissions of $PM_{2.5}$ remain unmodified in these scenarios because there is no certainty as to how regenerative braking, heavier vehicles, changes in driving habits, etc. will affect total fleet tyre and brake wear.

Scenario 5: Introduction of a hypothetical Euro 7 emissions standard

In this scenario, all Euro 6 or earlier Euro standard (i.e. Euro 4, Euro 5, etc.) diesel passenger cars are assumed to be taken off the road and replaced with diesel passenger cars meeting a hypothetical Euro 7 standard. This hypothetical Euro 7 standard is derived from the GAINS database and varies by country. However, across Europe, this scenario results in an approximate 80% reduction in NO_x emissions for the PCD element of the fleet.

Scenario 6: Domestic solid fuel substitution

All solid fuel (coal, wood, other biomass) used in the domestic sector is substituted by either gas or heating oil. Emissions of $PM_{2.5}$, SO_2 and NO_x are considered. For $PM_{2.5}$, emission factors for heating oil have been used for the substitution to give a conservative estimate of the emissions reduction (97.5% reduction for oil compared with 99% for gas, on an energy released basis).

Scenario 7: Removal of NH_3 emissions

Scenario 7 assumes the removal of all ammonia (NH_3) emissions from the agricultural sector. It should be noted that Scenario 7 does not affect the emissions of primary PM and NO_x. However, NH_3 plays an important role in the formation of secondary PM, and therefore it can be an important contributor to total $PM_{2.5}$ concentrations. The impacts on PM concentrations are examined under this scenario.

Results

Projected emissions of primary $PM_{2.5}$ in 2030 are shown in Figure 3 for France and Poland. The 2030 emissions of NO_x are shown in Figure 4.

Figure 3: Projected $PM_{2.5}$ emissions for France and Poland in 2030 under the different scenarios examined

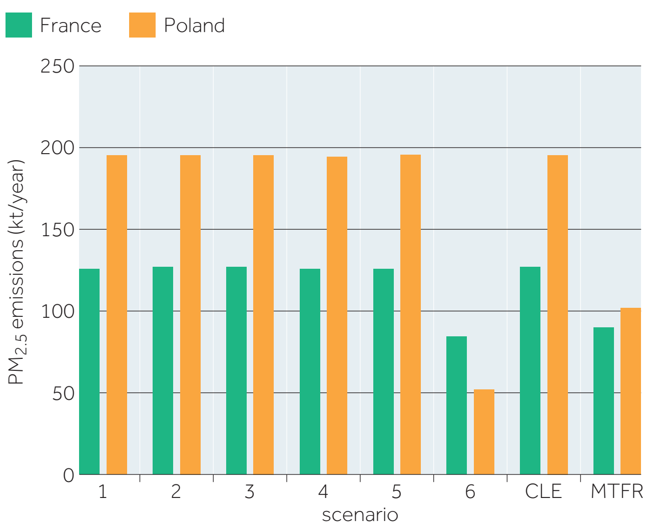
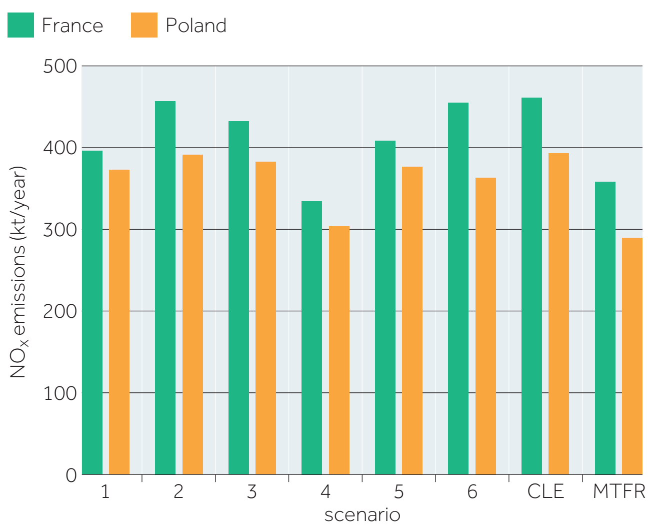


Figure 4: Projected NO_x emissions for France and Poland in 2030 under the different scenarios examined



Figures 5 and 6 on pages 19 and 21 show the predicted percentage of non-compliant monitoring stations for $PM_{2.5}$ and NO_2, respectively, in France and Poland, under the different scenarios examined. It is helpful to note the following with regard to these two figures:

- The left hand vertical axis represents the percentage of monitoring stations in the country where pollutant concentrations in the air do not meet the current AQLV for that pollutant ($PM_{2.5}$ on Figure 5; NO_2 on Figure 6). The percentage of monitoring stations for each scenario is shown by the blue bars. If there is no blue bar, all stations comply with the current AQLV for that pollutant.
- The right hand vertical axis represents the annual average concentration in the air of either $PM_{2.5}$ or NO_2, depending on the figure. The horizontal red line shows the current EU AQLV. The horizontal green line shows the current WHO guideline value for $PM_{2.5}$. For NO_2 the WHO guideline value and the EU AQLV are the same, and a red line is therefore used for both.
- The orange dashes for each scenario on the figures relate to the right-hand axis (pollutant concentration) and represent the highest concentration occurring at any monitoring station. The highest concentration may occur at different monitoring stations according to the scenario tested. If the orange dash lies above the EU AQLV (red line) the station is non-compliant and the distance above the line indicates by how much. If the orange dash lies above the green line ($PM_{2.5}$) this indicates the gap between the highest concentration and the WHO guideline value.
- The horizontal axis combines time and the scenarios listed above, and shows the CLE results for 2015, 2020, 2025 and 2030, and the MTFR results for 2030. The results of the individual scenarios are also shown for 2025 and 2030.

Particulate matter ($PM_{2.5}$)

(a) France

Figure 5a shows the results for $PM_{2.5}$ in France. The EU AQLV for the annual average $PM_{2.5}$ concentration is 25 µg/m^3 and the WHO air quality guideline value for $PM_{2.5}$ is 10 µg/m^3.

In 2015, only a small number of stations are non-compliant with the EU AQLV, while from 2020 onwards, $PM_{2.5}$ compliance is achieved at all stations in France.

In 2025, scenarios 1, 2, 3 and 4 have little impact on the highest $PM_{2.5}$ concentration which is similar to that expected under the CLE scenario. A reduction in the EU AQLV of more than 1 µg/m^3 would result in at least one monitoring station reporting an exceedance (non-compliance). The substitution of domestic solid fuel (scenario 6) gives the largest reduction in $PM_{2.5}$. However, note that the distance to the WHO guideline value of 10 µg/m^3 is still large in this scenario (>11 µg/m^3 in 2025).

In 2030, all maximum concentrations are reduced, though not by much. Scenario 6 (domestic fuel substitution) is as effective as the MFTR scenario in this compliance test. The sensitivity scenario of eliminating NH_3 emissions from the agricultural sector (Scenario 7) gives only a small further reduction in $PM_{2.5}$ concentration.

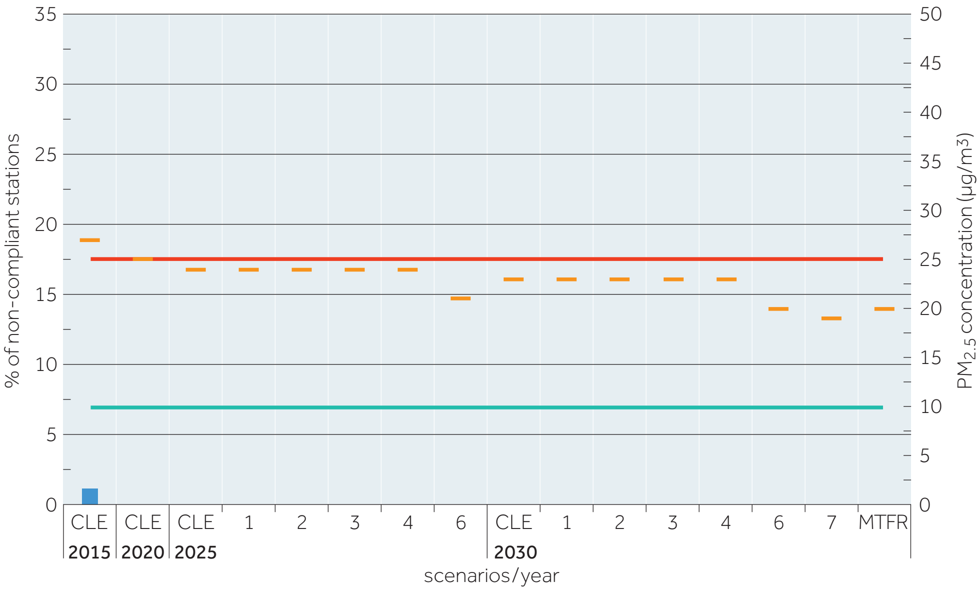
Figure 5: Predicted percentage of $PM_{2.5}$ non-compliant stations in France and Poland over the years and under the different scenarios examined

The blue bars on the figures below relate to the left axis. The orange dashes indicate the predicted changes in $PM_{2.5}$ concentration (µg/m^3) at the highest-recording monitoring station in each country, and these relate to the right axis.

% non-compliant stations — highest reporting monitoring station

EU AQLV — WHO guideline value

a) France



CLE - Current Baseline Scenario

1 - Electrification of PCD

2 - Electrification of PCG

3 - Electrification of LDV

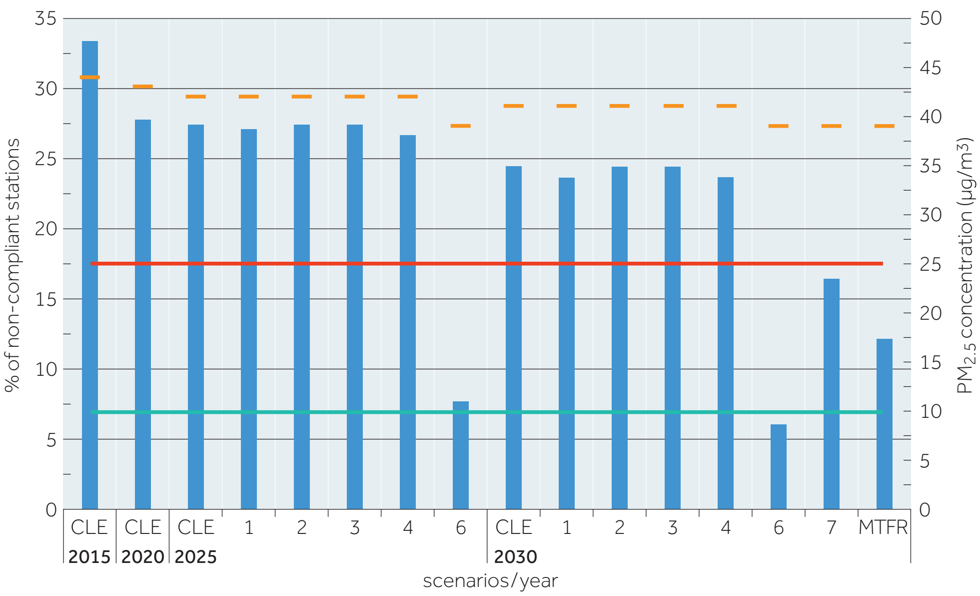
4 - Electrification of all road transport

6 - Domestic solid fuel substitution

7 - Removal of NH_3 agriculture emissions

MTFR - Maximum Technically Feasible Reduction

b) Poland



None of the scenarios examined here is able to reduce the concentration of $PM_{2.5}$ at the highest-recording monitoring station in France to the WHO guideline value of 10 µg/m^3. A significant downward change in the EU AQLV is likely to present compliance problems.

(b) Poland

Figure 5b shows results for $PM_{2.5}$ in Poland. Under current legislation, Poland is predicted to have significant compliance problems with $PM_{2.5}$ across about a quarter of the monitoring network through to 2030.

Of the scenarios considered, only Scenario 6 (the substitution of domestic solid fuels with heating oil) has a large effect on reducing the number of non-compliant monitoring stations. Maximum concentrations remain significantly higher than the EU AQLV even in 2030, and full compliance is not predicted to be achieved.

Nitrogen dioxide (NO_2)

(a) France

Figure 6a shows the results for NO_2 in France. The current EU AQLV is 40 µg/m^3 and equal to the WHO air quality guideline value for NO_2.

The results show that, despite a steady reduction in NO_x emissions with time, compliance with the EU AQLV still remains an issue, both under the CLE scenario and the more ambitious scenarios considered.

In 2025, scenarios 1, 3, 4 and 5 all reduce the highest NO_2 concentration and the number of non-compliant stations compared to the CLE scenario. Scenarios 2 and 6 have no substantial effect.

In 2030, the pattern is the same and, although concentrations are lower, there are still exceedances at several monitoring stations. Even if the extreme measure of electrification for the entire vehicle fleet was implemented (Scenario 4), non-compliance is indicated at one site. This is an important finding as it relates to the inclusion of a risk management process in setting AQLVs, as the application of technical measures may not be sufficient to enable France to meet the current EU AQLV, even if cost and social considerations are not barriers.

Reducing the EU AQLV clearly has important implications for making compliance more challenging in France even in 2030 and with maximum abatement measures in place.

(b) Poland

Figure 6b shows results for NO_2 in Poland. By 2025 all stations should be compliant with the current EU AQLV under the CLE scenario, and also under the other emission reduction scenarios considered. As in France, scenarios 1, 3, 4 and 5 are predicted to reduce the highest NO_2 concentrations. Measures on transport have a larger effect than maximum reductions on stationary sources. Under the ambitious Scenario 4 (complete electrification of road transport), the maximum indicated NO_2 concentration is 25 µg/m^3 but, realistically, concentrations are likely to remain above those indicated by the MTFR scenario (34 µg/m^3).

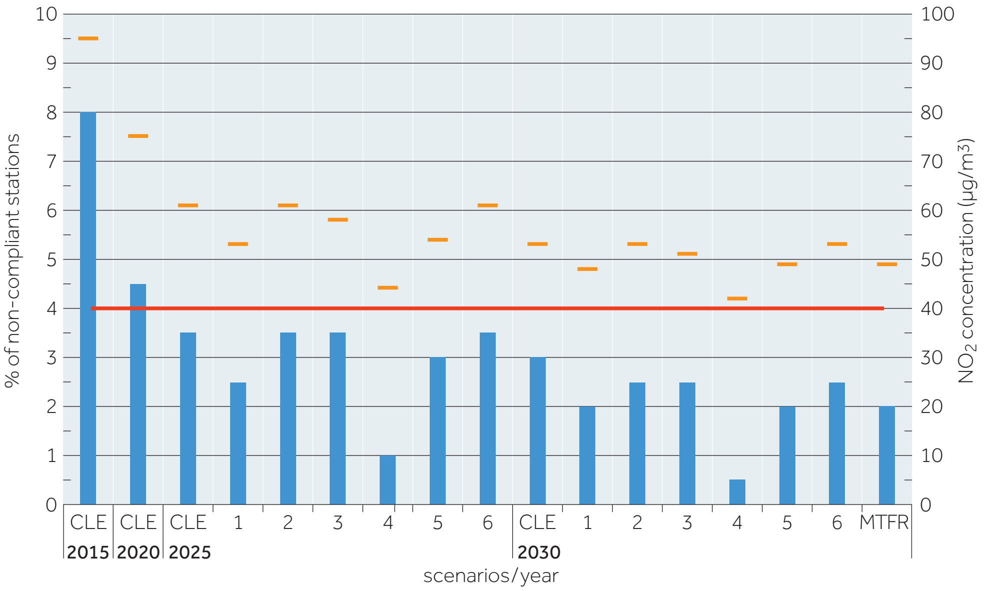
Figure 6: Predicted percentage of NO_2 non-compliant stations in France and Poland over the years and under the different scenarios examined

The blue bars on the figures below relate to the left axis. The orange dashes indicate the predicted changes in NO_2 concentration (μg/m^3) at the highest-recording monitoring station in each country, and these relate to the right axis.

% non-compliant stations — highest reporting monitoring station

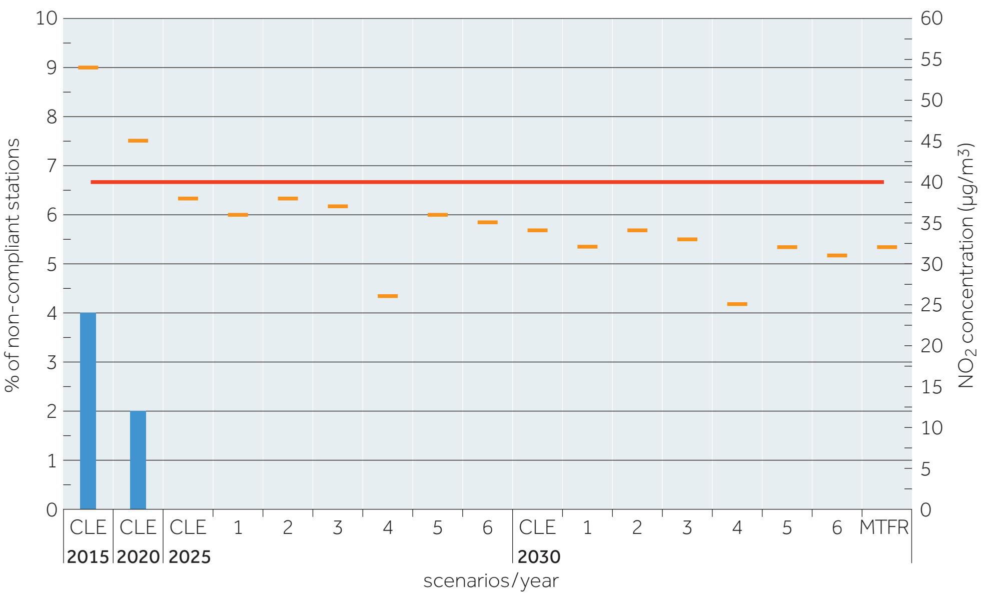
EU AQLV / WHO guideline value

a) France



CLE - Current Baseline Scenario
1 - Electrification of PCD
2 - Electrification of PCG
3 - Electrification of LDV
4 - Electrification of all road transport
5 - Introduction of Euro 7 PCD
6 - Domestic solid fuel substitution
MTFR - Maximum Technically Feasible Reduction

b) Poland



Estimated costs of reducing the AQLV for $PM_{2.5}$ and NO_2

A number of optimised scenarios were generated, over the range between the CLE and MTFR cases, to estimate how costs would increase, if traditional abatement measures on stationary sources were implemented to reduce concentrations in the most economic way. These are estimated incremental costs beyond the associated cost of implementing the measures described under the CLE scenario, which is already significantly high. The costs were calculated using Concawe's in-house Integrated Assessment Modelling (IAM) tool, SMARTER, which takes its values from the IIASA GAINS model[12] used to develop European environmental policy.

The optimised scenarios follow the 'gap closure' concept adopted during the Clean Air for Europe Programme[5] as an indicator of policy ambition level. The gap closure can be considered as the expected further reduction of health-related impacts (i.e. improvements in life expectancy) that can be achieved in moving from the CLE scenario to the MTFR scenario. For example, a '70% gap closure' indicates an optimised emission scenario where additional measures beyond the CLE scenario have been implemented in the most cost-effective way, and result in an additional 70% reduction in health-related impacts (beyond the CLE scenario). Respectively, the '0% gap closure' is equivalent to the health-related impacts reductions achieved under the CLE scenario, and a '100% gap closure' is the maximum further reduction of health-related impacts that can be achieved beyond the CLE scenario and which is equivalent to the MTFR scenario.

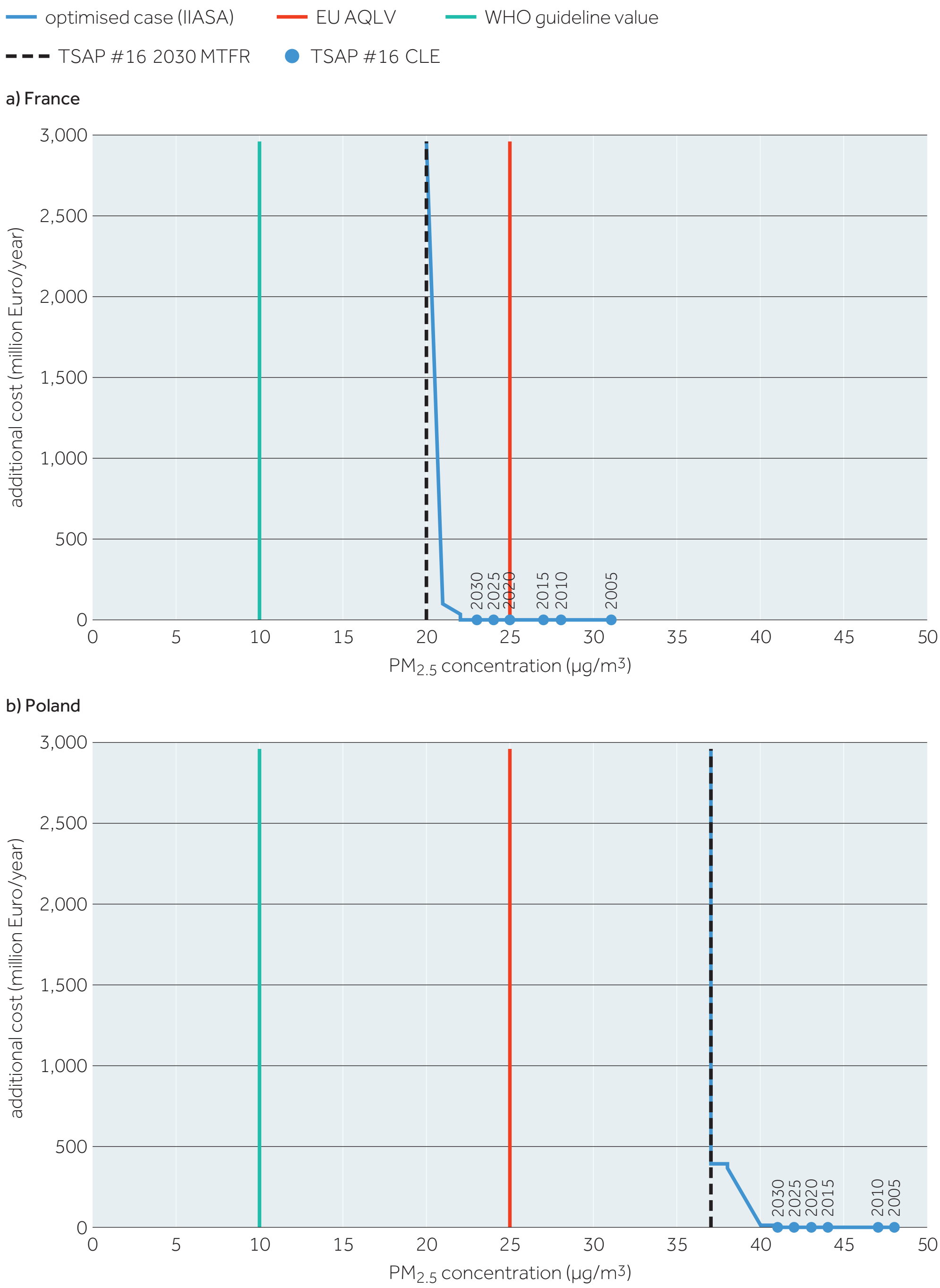
It should be noted that the additional emissions scenarios described under *Emissions scenarios evaluated* on pages 16–17 are not considered here, since they involve measures that are not included as technical measures in the GAINS model and therefore the associated cost is not known.

Figures 7 and 8 on pages 23 and 25 show the predicted reductions in $PM_{2.5}$ and NO_2 concentrations, respectively, for the highest-recording monitoring station in France and in Poland, compared to the associated cost, under different optimised scenarios; these scenarios assume the adoption of additional measures beyond the CLE scenario (2005–2030) and towards the MTFR scenario, following the 'gap closure' concept. It is helpful to note the following with regard to these two figures:

- The left hand vertical axis represents the annualised costs of meeting the target value considered in the optimisation procedure (i.e. the EU-wide human health benefit associated with reducing air concentrations). These incorporate the discounted capital and operating cost of introducing new measures using the GAINS methodology. Costs are additional to those already agreed in reducing emissions according to the CLE scenario.
- The horizontal axis represents a range of concentrations of $PM_{2.5}$ (Figure 7) and NO_2 (Figure 8). The vertical red line shows the current EU AQLV. The vertical green line shows the current WHO guideline value for $PM_{2.5}$.
- On each graph, a blue line is constructed using the optimisation procedure to determine how costs would increase if emission reductions beyond the CLE scenario were pursued in the most economic manner. The highest concentration over all monitoring stations in the country that is associated with these measures is used on the horizontal axis to plot this line.

Figure 7: Predicted reduction in $PM_{2.5}$ concentration for the highest-recording monitoring station in France and Poland

Predicted concentrations are compared to the associated cost, under different optimised scenarios that assume the adoption of additional measures beyond the CLE scenario (2005–2030) and towards the MTFR scenario, following a 'gap closure' concept.



Particulate matter ($PM_{2.5}$)

(a) France

Figure 7a shows the results for $PM_{2.5}$ in France. There are zero extra costs for each of the CLE scenarios from 2005–2030 (blue dots on the Figures) as the cost of achieving these reductions is already accepted.

$PM_{2.5}$ is significantly reduced as a result of the agreed measures under CLE. The current EU AQLV is met in 2020. For additional $PM_{2.5}$ reduction measures beyond CLE, there is an associated cost which rapidly increases when moving towards the MTFR scenario. In the MTFR scenario, a $PM_{2.5}$ concentration of 20 µg/m^3 is achieved, still significantly above the WHO guideline, but at a very high additional cost of some 3,000 million €/year.

(b) Poland

Figure 7b shows the results for $PM_{2.5}$ in Poland. As seen previously, $PM_{2.5}$ concentrations at the monitoring stations exceed the EU AQLV, and the application of technical measures will not result in the current EU AQLV being met despite the additional cost of some 3,000 million €/year. Interventions, such as those explored in the non-technical measures referred to in the section on *Emissions scenarios* (pages 14–17) would be required. For Poland, the largest reduction seen in the scenarios evaluated is associated with the substitution of domestic solid fuels by a lower-emission alternative. The cost of this substitution, however, has not been considered in the IIASA GAINS model.

Nitrogen dioxide (NO_2)

(a) France

Figure 8a (page 25) shows the results for NO_2 in France. As seen previously, the application of MTFR measures does not lead to full compliance with the existing EU AQLV, and the gap at the highest-recording monitoring station is significant, at 10 µg/m^3. The additional costs involved rise to beyond 600 million €/year under the MTFR scenario.

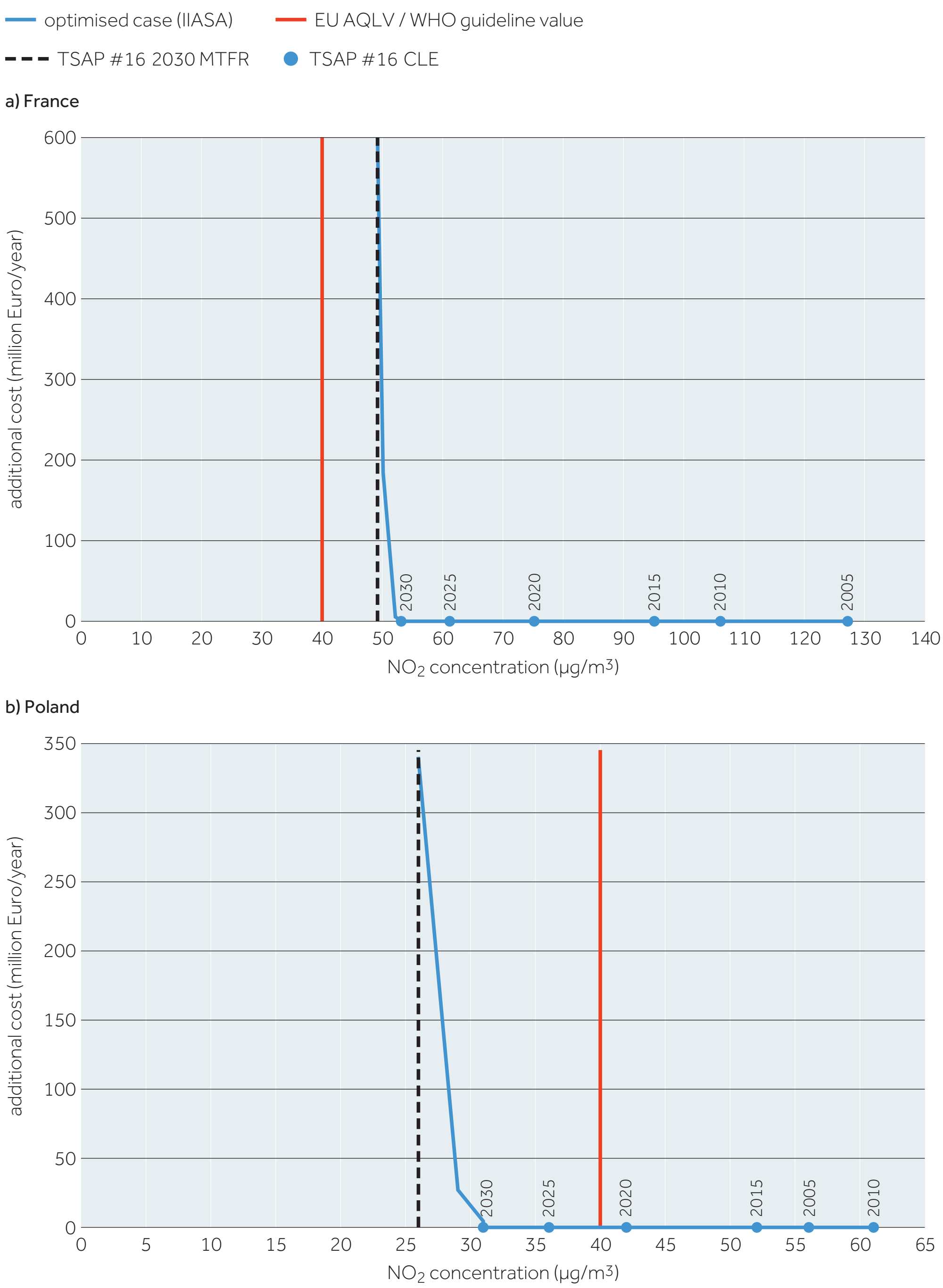
(b) Poland

Figure 8b (page 25) shows the results for NO_2 in Poland. There are no compliance issues under the CLE scenario. Current legislation reduces the NO_2 concentration at the highest-recording monitoring station to just over 30 µg/m^3. The application of MTFR could reduce this to about 26 µg/m^3 at an additional cost of ~350 million €/year.

This demonstrates that the situation in each Member State is unique, and that the country variation should be considered when setting binding limit values by the inclusion of a risk management step.

Figure 8: Predicted reduction in NO_2 concentration for the highest-recording monitoring station in France and Poland

Predicted concentrations are compared to the associated cost, under different optimised scenarios that assume the adoption of additional measures beyond the CLE scenario (2005–2030) and towards the MTFR scenario, following a 'gap closure' concept.[1]



1 The optimised scenarios presented here do not take into account vehicle measures that are defined in GAINS. If these measures had been considered, the associated cost would be higher than that shown on Figure 8.

Conclusions

To inform the ongoing EU AAQ Directives fitness check and potential revision process, Concawe conducted a study to highlight the importance of following a two-step process of firstly assessing the environmental and human health risks presented by concentrations of air pollutants (risk assessment step) and secondly, assessing how these risks may be managed (risk management step) when binding AQLVs are set.

The study assesses the practicability of achieving compliance with the current EU AQLVs for $PM_{2.5}$ and NO_2, as well as lower limit values, under some potential emission reduction scenarios. Results for two countries (Poland and France) are used as representative examples, and show that:

- The current emissions legislation, as described under the CLE scenario, will be effective in reducing $PM_{2.5}$ and NO_2 concentrations from 2025 onwards. However, full compliance with the existing EU AQLVs will not necessarily be achieved in all EU countries. Importantly, even ambitious non-technical measures taken to address what are widely seen as the root causes of non-compliance are not in themselves entirely effective.
- Reductions beyond the already legislated emission reduction measures, and towards MTFR, will require a substantial economic investment for only a small impact on the reduction of PM and NO_2 concentrations and the subsequent compliance improvement. In some cases (e.g. Poland for $PM_{2.5}$ and France for NO_2), full compliance with the current EU AQLV remains unachievable even if all MTFR measures are implemented.
- For $PM_{2.5}$, alternative non-technical emission reduction scenarios (not included in the IIASA GAINS model) such as the substitution of solid fuels with gas or liquid alternatives in the domestic sector, reduce concentrations significantly and improve compliance. The effects are particularly substantial in Eastern European Member States where coal is still widely used domestically. Measures targeting NH_3 emissions from agriculture are also predicted to offer further PM reductions, while the electrification of road transport is not expected to have a significant effect on PM levels, regardless of the vehicle categories or proportion of the vehicles substituted. The substitution of domestic solid fuel, however, is not necessarily enough to achieve full compliance with the current AQLVs everywhere in Europe; however, the reductions are significant enough to warrant an evaluation of the associated costs.
- For NO_2, road transport measures are predicted to lead to additional concentration reductions. However, even forcing the electrification of all vehicles on the road, which is not feasible in such a short time frame, would still fail to achieve compliance at some EU monitoring stations by 2030. Similarly, the full application of technical measures (MTFR scenario) will not achieve compliance everywhere.
- For both pollutants, the country variation is significant. In the examples shown, France has an issue with compliance for NO_2 but not $PM_{2.5}$, and Poland has an issue with $PM_{2.5}$ but not NO_2.
- A revision of the AAQ Directives that would adopt the WHO air quality guideline value of 10 µg/m^3 for $PM_{2.5}$ may result in widespread non-compliance in most European countries, regardless of the measures applied to control emissions.

It is extremely important that all consequences of changing the AQLVs embedded in the Air Quality Directive are considered from the perspective of implementation. Managing the risk of increasing challenges with non-compliance needs to be a priority for the review. It is clear that the application of further technical measures to address major sources of emissions has limited potential to affect concentrations, and that such measures have very high additional costs associated with them.

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