Policy brief on potential targets to reduce risks for health and ecosystems

Draft document prepared by the Task Force on Integrated Assessment Modelling and the Centre for Integrated Assessment Modelling, revised version 3, 20 October 2024

Summary

At its 61st meeting the Working Group on Strategies and Review took note of the information presented by the Task Force on Integrated Assessment Modelling the EMEP Centre for Integrated Assessment Modelling on the feasibility of introducing a risk-based overarching goal for the Convention, particularly a health damage reduction target. The working group requested to provide a policy brief on the potential implications of introducing collective risk-based targets for the UNECE region to address air pollution impacts on health and ecosystems (work plan item 2.1.12). The present informal document provides version 3 of this policy brief. The document focusses on the attainability of an illustrative 50% reduction target of health risks due to exposure to particulate matter and ozone, as well as for the risk of biodiversity loss. The parties were invited to take note of the results and send comments. This and discussions within the Task Force and with experts from the Working Group on Effects have led to this revised 3rd version for the Informal Delegates Meeting (2-24 October 2024, Leuven) and EB-44 (9-12 December 2024, Geneva). Previous versions of the policy brief presented many possibilities for target setting options. Considering that the large number of tables and graphs might obscure a clear vision of what must be negotiated for a revised protocol, parties were consulted during the 63rd meeting of the Working Group on Strategies and review to narrow down some choices for the current modelling analyses. Comments received by countries during and after WGSR-63 resulted in recommendations, amongst others, for the choice of the base and target year; the health metrics to use in the search for least cost solutions to reaching a given target (optimization) and in ex-post analysis, respectively; for the indicators to use for assessing risk-reduction targets for biodiversity; to apply the risk metrics only to the anthropogenic part of air pollution; and to analyze reaching the risk reduction percentage both through UNECE wide cost-effectiveness optimization and through equal relative percentage reductions in all countries. Further discussion within the WGSR would be required to decide if the indicative 50% reduction target is supported or should be adapted, whether the risk reduction percentage should apply to the UNECE as a whole including North America, and which flexibilities would be accepted to reduce the cost-burden for EECCA and West-Balkan countries. Analyses presented in this policy brief are meant to be illustrative to explain the options for target setting when discussing a revised protocol.

1. Introduction

1. This report describes policy scenarios up to 2050, as calculated with GAINS for the UNECE region, including EU27, EFTA (Iceland, Norway, Switzerland), United Kingdom, Türkiye, EECCA (Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan, Tajikistan, Georgia, Ukraine, Belarus, Russia, Republic of Moldova), West-Balkan (Albania, Bosnia and Herzegovina, Kosovo, Republic of North Macedonia, Montenegro, Serbia), and North America (Canada, United States). The scenarios cover options to address particulate matter and ozone precursors, including methane and the potential policy targets that would be attainable.
2. Improvements in the GAINS and EMEP model include local scale modelling, health impacts assessment methods, soil NOx and NMVOC emissions from agriculture and a consistent representation of the condensable fraction of PM from residential heating. GAINS has been prepared to assess the sensitivity of results for sectoral policies (and ‘staged approaches’). The scenarios cover the whole UNECE region but some of the analyses, including cost-effective optimization, exclude North America (NA), unless indicated otherwise.

2. Policy scenarios

3. Three scenarios were developed by the Centre for Integrated Assessment Modelling (CIAM) for the Gothenburg Protocol review which were also used in versions 1 and 2 of the Policy Brief. The scenarios were now updated for the revision process (the LOW scenario will be updated around the end of the year):

    a. A baseline scenario, considering trends and policies included in established national air pollution control programs and, for the EU27, the European Green Deal including the 'Fit for 55' legislation package, RePowerEU initiatives, the revision of the IED, and results of the Member States (MS) consultation during the ongoing work supporting European Commission Clean Air Outlook 4. For West Balkan the baseline was developed with the same modelling tools as for EU27, including decarbonization targets and compliance with the Energy Community agreements, as well as results of the consultations with all countries within the EU4Green project. For selected EECCA (Moldova, Ukraine, Georgia) the scenario uses the same modelling tools as for EU, and for Moldova additional information from consultations between CIAM and national experts in a project supported by the UNECE. For the UK, Switzerland and Norway updates are based on engagements in consultation meetings. For the remaining countries, the scenario uses national submissions and reports, international statistics and projections based on recent IEA & FAO Outlooks[1]. The baseline includes air pollutants (SO_2, NO_X, $PM_{2.5}$, NH_3, NMVOC, as well as Black Carbon) and methane emissions up to 2050. The baseline assumes effective implementation of current legislation (CLE) and policy plans. This is not self-evident as in the past years several plans have been revised because of geopolitical developments, energy security issues and farmers' protests.

    b. A maximum technically feasible reductions (MTFR) scenario uses the same activity data as the baseline and includes implementation of technologies with lowest emission factors in the GAINS model database. These control options include measures to reduce ammonia emissions from agriculture, measures to reduce $PM_{2.5}$ and non-methane volatile organic compounds (NMVOC) emissions from residential solid fuel burning and agricultural waste burning, mitigation technologies to reduce emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and $PM_{2.5}$ for industrial combustion, process and transportation sources, measures to reduce NMVOC from solvent use, and liquid fuels' storage and distribution, as well as measures to reduce methane (CH_4) emissions from municipal waste treatment, the fossil fuel sector and agriculture. Maritime emission control areas or initiatives by port authorities are assumed to encourage clean ships and to provide shore-to-ship electricity access. The MTFR scenario uses information about the age structure of installations. Early shutdown or scrapping of cars or boilers is not assumed. Consequently, the mitigation potential increases towards 2050.

    c. An alternative 'LOW' scenario, that includes climate policies compatible with the two-degrees Paris Agreement goal for the whole world, MTFR measures (also for maritime shipping), and further transformational changes in agriculture. For agriculture, this scenario is based on the 'Growing Better report 2019'[2] (The Food and Land Use Coalition, 2019) and other studies considering ambitious improvements of nitrogen use efficiency (Kanter et al., 2020)[3] and assumes the adoption of a diet based on total human energy requirements of 2500 kcal/day (after waste) as laid out in the EAT-Lancet Commission proposal (Willet et al., 2019)[4]. The latter results in dietary shift towards lower meat protein consumption. The scenario is also consistent with the 30% methane pledge.

    d. An alternative LOW+ scenario will become available in 2025/26 that includes structural changes in energy systems, such as a shift towards the use of hydrogen and ammonia as energy carriers.

4. The baseline scenario shows strong reductions (Figure 1) of air pollutants between 2015 and 2040 (SO_2: -40% *to* -95%, NO_x: -45 *to* -70%, $PM_{2.5}$: -35 *to* -65%) in the EU, North America, and in West Balkan countries (owing to the Energy Community agreements that include commitments to strong reduction of emissions from stationary sources in the coming decades) as well as gradual decarbonization of the economies. Fossil fuel use in EECCA countries continues to grow, however, due to ongoing technical progress, emissions of SO_2 and NO_x are expected to be reduced over time, by approximately 40% and 10%, respectively, between 2015 and 2040. For NH_3, current abatement policies are modest, and the estimated reductions, if any, are mainly due to projected decline in livestock numbers in some regions.

5. The MTFR scenario shows that for SO_2 most of further mitigation potential is committed in the current legislation, except for EECCA. The picture for NOx is similar, although further potential is available. For NH_3, the mitigation potential is similar across all regions, however, compared to the baseline, the overall

potential is smaller than that for other air pollutants. Large further mitigation exists for $PM_{2.5}$, except for the EU+EFTA region, especially in EECCA and West Balkan. The LOW scenario shows that strong climate action brings additional air pollutant reduction although it is most significant for NH_3 and CH_4 (the latter not shown) and this is in fact due to modelled dietary changes and strong improvements of nitrogen use efficiency in agriculture. Further work in 2025 on the LOW and LOW+ (additional transformation in energy system, including hydrogen economy) scenarios will provide an update drawing on the most recent climate change mitigation strategies.

6. Analyses done for West Balkan and EECCA shows that the local contribution of residential combustion is dominating particulate matter concentrations in many cities. The power sector is an important regional source. In West Balkan, local residential heating sources cause 50% or more of the concentrations (see Figure 14). Even in cases where the baseline brings reductions, the future levels of pollution remain well above the WHO guidelines. This points to the need to develop further mitigation strategies that address both local, regional and transboundary sources to achieve significant reductions of the impact of air pollution in cities in the future.

7. Methane declines in the baseline in the EU (due to the Green Deal), EFTA as well as North America owing to reduction in fossil fuel use, progress in waste management and recent commitment to methane pledge. This contributes to a about 12% methane emission reduction in the UNECE region between 2015 and 2040. In the rest of the world an emission increase of 31% is expected, associated with the growth of the fossil fuel sector, agriculture and waste. There is a significant technical emission reduction potential, especially with measures in the fossil fuel and waste sector. This could result in a 53% reduction in the UNECE (including North America) and of 26% reduction in the rest of the world between 2015 and 2040. Combined with dietary change, the LOW scenario could reach a reduction of 60% in the UNECE (including North America) and of 40-45% in the rest of the world.

[1] World Energy Outlook 2023 (IEA, 2023, https://www.iea.org/reports/world-energy-outlook-2023), The future of food and agriculture – Alternative pathways to 2050 (FAO, 2018, https://openknowledge.fao.org/server/api/core/bitstreams/3ea2aa72-7e4f-482a-9af0-2251e6d62984/content)

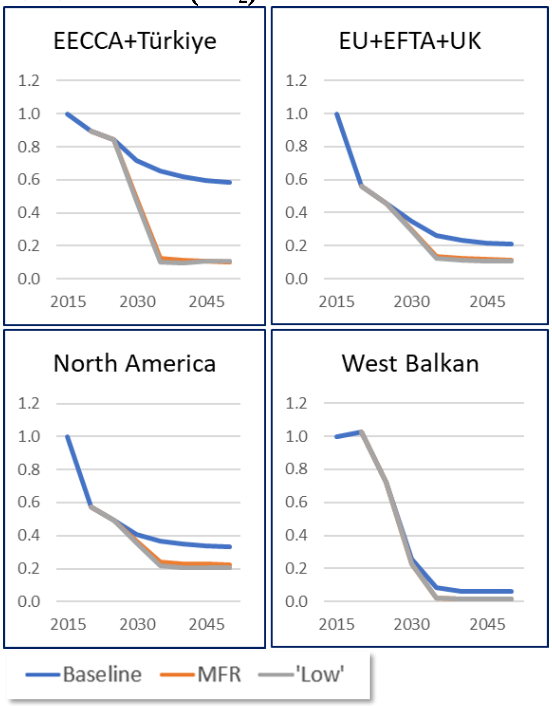
[2] https://www.foodandlandusecoalition.org/global-report/

[3] Kanter, D., Winiwarter, W., Bodirsky, B., Bouwman, L., Boyer, K., 2020. Nitrogen futures in the shared socioeconomic pathways. Glob. Environ. Change 13 2003 277–29361. https://doi.org/DOI:10.1016/j.gloenvcha.2019.102029

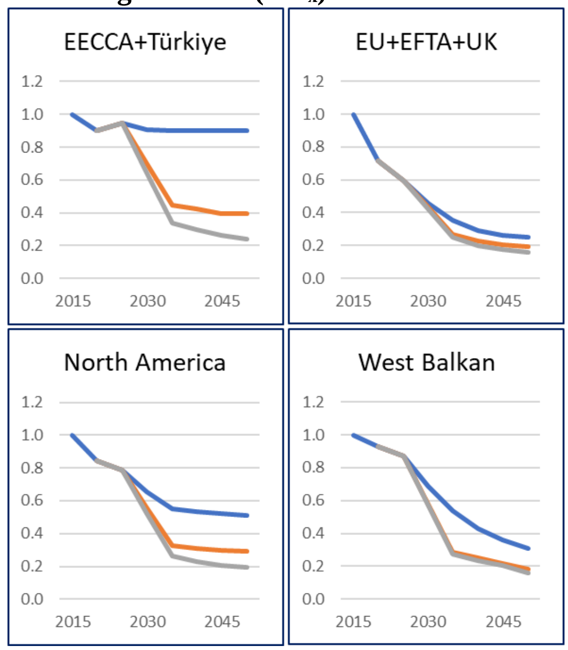
[4] Willet *et al.* (2019) Food in the Anthropocene: the EAT-*Lancet* Commission on healthy diets from sustainable food systems. https://doi.org/10.1016/S0140-6736(18)31788-4

Figure 1: Emission trends, relative to 2015, in baseline (CLE), MTFR and LOW scenario

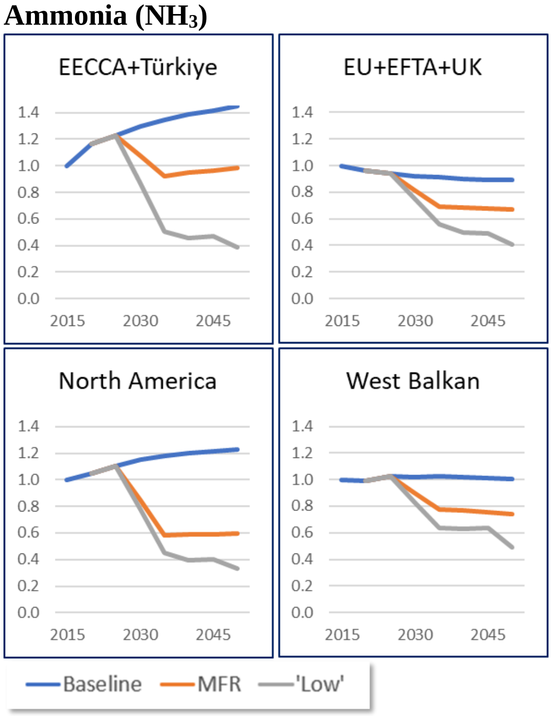
Sulfur dioxide (SO_2)



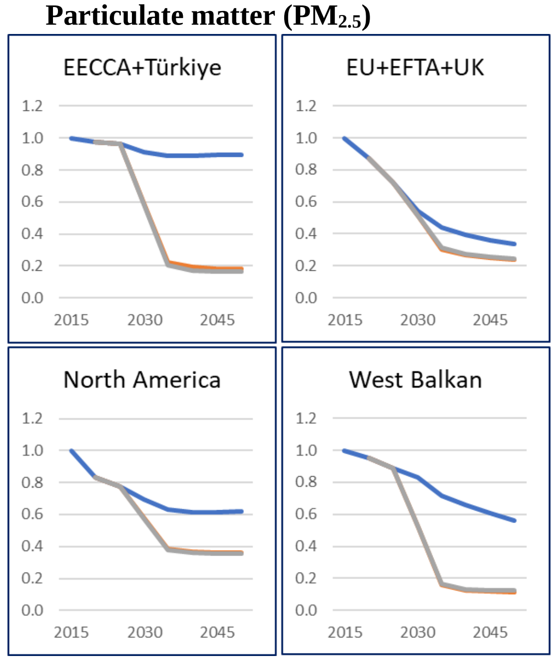
Nitrogen oxides (NO_x)



Ammonia (NH_3)



Particulate matter ($PM_{2.5}$)

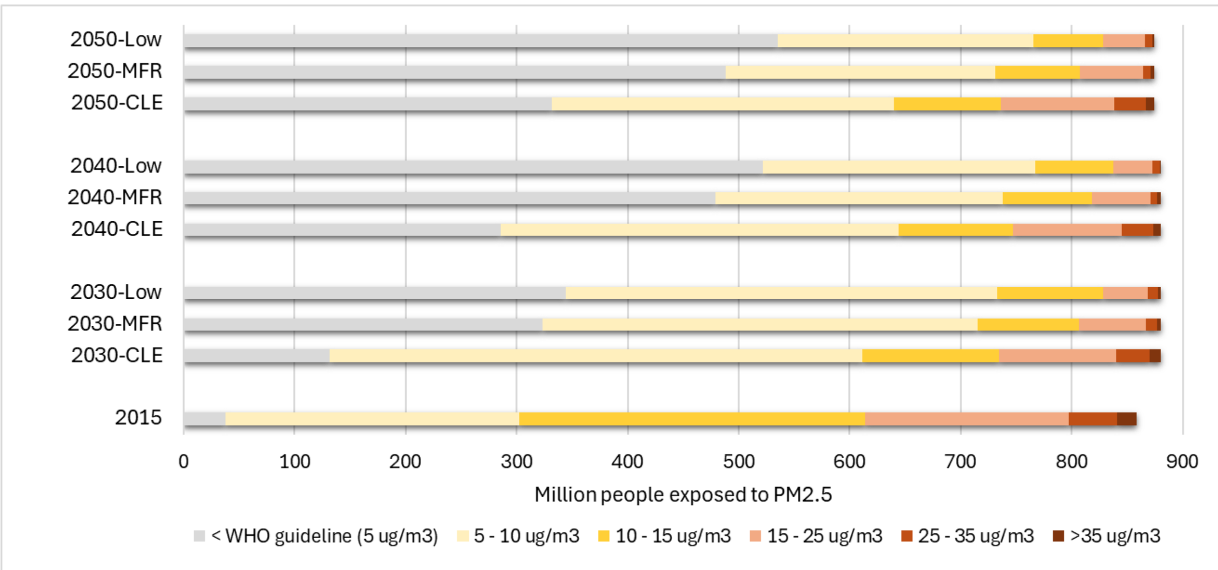


Source: GAINS model (CIAM)

3. Impacts for health and ecosystems

8. Calculations with the GAINS model show that most of the population in the UNECE domain (excl. North America) lives in areas where $PM_{2.5}$ is above the current WHO annual mean guideline value of 5 µg/m^3 (see Figure 2). Policies in the baseline scenario result in declining concentrations in the EU and the current EU limit value (25 µg/m^3) will be met in 2030. Still elevated concentrations persist in Balkan and EECCA countries. Overall levels in large parts of the EMEP domain remain above the WHO guideline in 2030. The MTFR and LOW scenarios for 2030 bring an improvement reducing concentrations and health impacts. While the number of people exposed to $PM_{2.5}$ levels below the WHO guideline more than doubles, compared to the Baseline (CLE), over 60% of population in the UNECE region (excluding NA) is exposed to levels exceeding the guidelines (Figure 2). Both MTFR and LOW are not yet fully effective in 2030 due to the short time available for full introduction of abatement measures or transformations embedded in the LOW scenario.

Figure 2: Population exposure to $PM_{2.5}$ in the UNECE (excluding North America)



Source: GAINS model (CIAM)

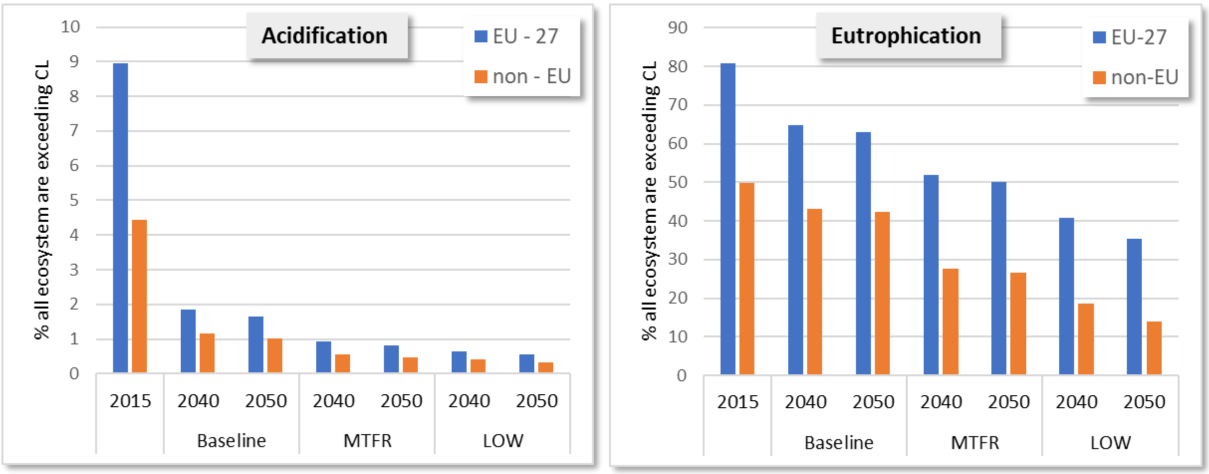
9. The baseline for 2040 and 2050 shows further improvements, yet the WHO guideline level would only be attained for about 1/3 of the population. MTFR brings large scale improvements, also across the Balkan, as there is enough time to introduce further technical measures. Finally, the LOW scenario gives even lower concentrations. A little more than 10% of the population in the UNECE (excluding North America) would still be exposed to more than 10 µg/m^3. However, more than 60% would be exposed to $PM_{2.5}$ levels below the WHO guideline by 2050 (over 80% in the EU+EFTA+UK, 30% in EECCA + Türkiye).

10. For the EU, the exceedance of the critical loads for acidification will be reduced in the baseline scenario from about 9% of all ecosystems in 2015 to 2% in 2040 and less than 1% in 2050 (Figure 3: Area with exceedance of critical loads for acidification and eutrophication in Europe. Non-EU includes West Balkan, UK, Iceland, Norway, Switzerland, Belarus, Ukraine, Moldova, European part of Russia up to 42°E.). In the LOW scenario, the exceedance in the EU could drop to about 0.5% of the ecosystems by 2050. For non-EU countries in the EMEP domain, the exceedance will decline from about 4% of the ecosystems in 2015 to 1% in the 2050 baseline and less than 0.5% in the LOW scenario.

11. The exceedance of the critical loads for eutrophication in the EU will be reduced in the baseline scenario from 80% of all ecosystems in 2015 to 65% in 2040 and about 62% in 2050. In the LOW scenario, the area with exceedances could be more than 50% less than in 2015, but 35% of the ecosystems in the EU will remain with an exceedance, even in 2050. For non-EU countries in the European EMEP domain, the exceedance will

decline from 50% of the ecosystems in 2015 to around 42% in the 2050 baseline and to less than 15% in the LOW scenario.

Figure 3: Area with exceedance of critical loads for acidification and eutrophication in Europe. Non-EU includes West Balkan, UK, Iceland, Norway, Switzerland, Belarus, Ukraine, Moldova, European part of Russia up to 42°E.



Source: GAINS model (CIAM)

4. Options for policy targets

12. One of the Saltsjöbaden workshop recommendations is to formulate a common target for air pollution related health risks. Halving the pollution related mortality was suggested. Could this be feasible for the UNECE-region? Can the target be the same for all parties? Can a target be applied to $PM_{2.5}$ related mortality only, or also to mortality due to other pollutants, such as ozone? Should the target focus on mortality, or could it also include morbidity? Discussions following the Saltsjöbaden meeting brought in consideration if also targets for biodiversity and ecosystems protection should be included.

13. Several factors influence the attainability of a 50% reduction target:

    a. The choice of the base year and the target year: For countries for which reliable data are available, 2005 as base year will make attainability easier than more recent years, as improvements after 2005 can be considered. For EU and EFTA the target would already be met without additional policy measures. For several of the current non-parties, however, reliable data is unavailable for 2005, and the availability of data is better in 2015. Comments received from countries after WGSR-63 suggest 2015 as the first choice for the base year. Naturally, also the choice of the target year influences attainability. Several countries considered 2050 as too distant, and no country expressed opposition to the use of 2040 as target year.

    b. Whether the target is applied to the UNECE or to each country (or even major cities): Obviously, it is easier to meet the target for a larger area than for each densely populated area. None of the countries expressed opposition against analyzing reaching the risk reduction percentage both through UNECE wide cost-effective solutions and through equal relative percentage reductions in all countries, i.e., community-wide vs country based ‘gap closure’ (the ‘gap’ is defined as the distance between the Baseline (CLE) and the lowest attainable levels (MTFR, LOW)).

    c. The health risk metric: Comments received after WGSR-63 were in favor of using the risk-based indicator for attributable mortality (i.e. deaths per 100.000 inhabitants) in target setting. Unlike the absolute number of attributable deaths, the risk-based indicator will not be influenced by population growth between 2015 and 2040, hence countries will not be penalized in reaching the 50% target because of strong population growth. However, both indicators are influenced by aging of the population if we do not keep population fixed at the base year. Countries expressed a preference for using dynamic demography.

d. Whether the health target is formulated for $PM_{2.5}$ only, or for the combined effect of air pollutants: Inclusion of ozone would make attainability harder due to the increasing emissions of ozone precursors, such as methane. Countries expressed the wish to see analyses for reaching health targets separately for $PM_{2.5}$ and O_3, but to also analyze the possibility for a combined target.

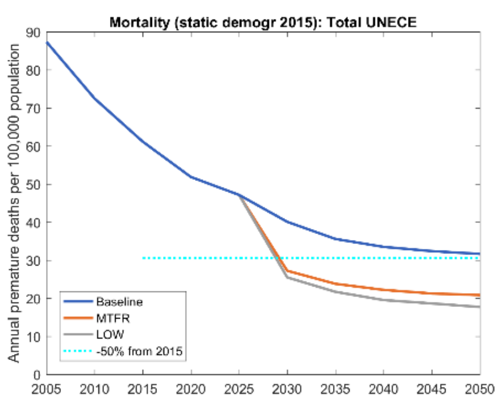
e. Whether to include in the health impact assessment the risks of natural PM, or to focus the target on the avoidable (anthropogenic) PM-exposure: Countries agreed to basing target setting on the anthropogenic PM exposure. Independent of this choice, results can still be presented for the total PM-exposure.

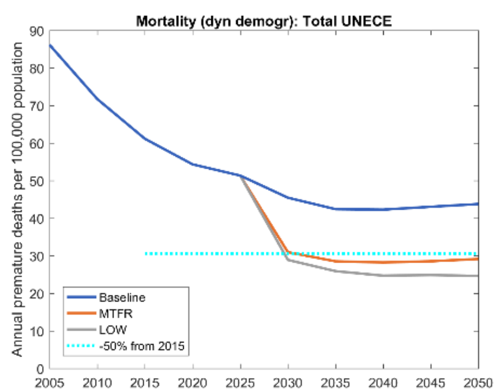
f. Whether to include a biodiversity target addressing the risk of biodiversity loss due to air pollution. Countries supported assessment of feasibility and level of ambition assuring habitat-specific empirical critical loads for nitrogen deposition. The WGE recommended using minimum and average critical load levels.

5. Options for $PM_{2.5}$ health targets

14. Figure 4 shows the scope for reducing the health risk indicator (premature deaths per 100.000 inhabitants) related to anthropogenic $PM_{2.5}$ in the UNECE as a whole as estimated with the GAINS model. This scope for additional measures is given by the space between the baseline scenario and the MTFR and LOW scenarios. Existing policies as accounted for in the baseline scenario contribute to approximately half of the 50 % reduction target in mortality in 2040 (from the 2015 level), with static population. When considering population aging more effort is required to meet the indicative 50% target. The current assessment indicates that the indicative 50% reduction target for health appears feasible for the UNECE region (incl. North America). Consideration of population growth and aging makes attainment of the 50 % reduction target more challenging.

Figure 4: Mortality risk due to anthropogenic $PM_{2.5}$ (annual premature deaths per 100.000 population) in the UNECE-region (incl. North America), using static population (left) and accounting for aging (right)



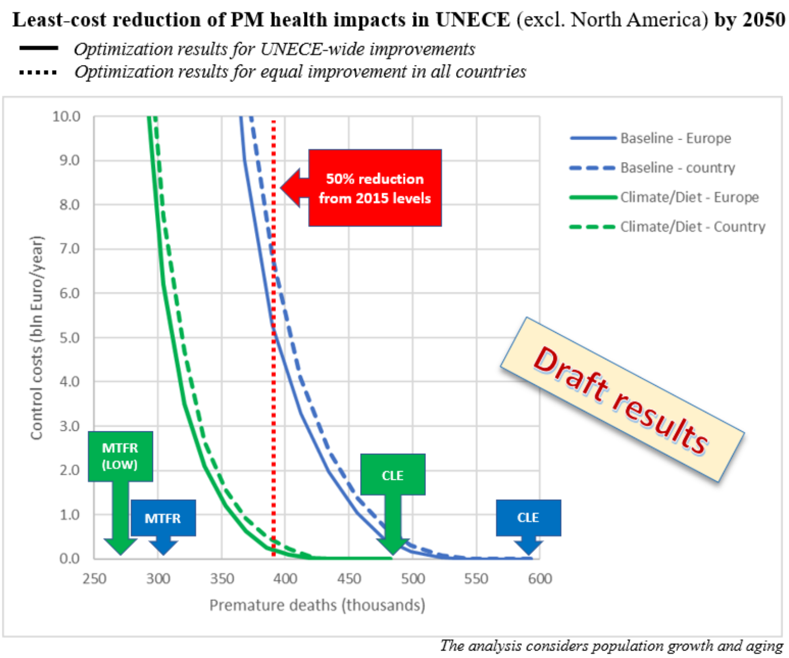


Source: GAINS model (CIAM)

15. For some countries, a 50% reduction of absolute premature death numbers between 2015 and 2050 would not be feasible, even with the LOW scenario. The GAINS model has been made ready to compute alternative, justifiable approaches, such as the least cost outcome to meet the health target for the UNECE as a whole (excluding North America, because data for the costs of additional measures need further discussion), or an approach that requires an equal reduction percentage of the gap between baseline and MTFR by each party. The following paragraphs describe possible outcomes of such approaches. ***Note*** that they are preliminary and only meant as illustrations of the available modelling tool and target setting options. Absolute premature deaths are used as a health indicator for the purpose of demonstrating the concept in Figure 5 and Figure 6, whereas the mortality indicator (premature deaths per 100,000 population) is used in Figure 7. This can be adapted, or supplemented with morbidity indicators, in subsequent analyses.

16. Based on the analysis of scenarios developed for the GP review, full enforcement of baseline policies will achieve over 20% reduction of absolute premature deaths by 2050 compared to 2015 when considering population growth and aging. A UNECE-wide 70% gap closure of the range between baseline and MTFR would be sufficient to meet the 50% health risk reduction target (solid lines in Figure 5). An equal 70% gap closure per country would be more equitable. However, this will result in 30% higher costs (dashed lines in Figure 5). Inclusion of additional climate and dietary change policies (as in the LOW scenario) would already achieve over half of the emission reduction needed in 2040 or 2050 to reach a 50% reduction target from 2015 in absolute numbers of premature deaths (note that in Figure 5, the 'CLE' starting point for the LOW scenario refers to the case where only current legislation, climate and dietary changes are implemented but not the additional MTFR measures as described in the LOW scenario definition in 3c; the latter case is indicated by the MTFR point on this line). Additional air pollution control costs would then be over ten times lower. Nevertheless, some countries are not achieving the 50% target or even show an increase in premature mortality compared to 2015 (see annex 1). Updated analysis is being developed using scenarios for the GP revision.

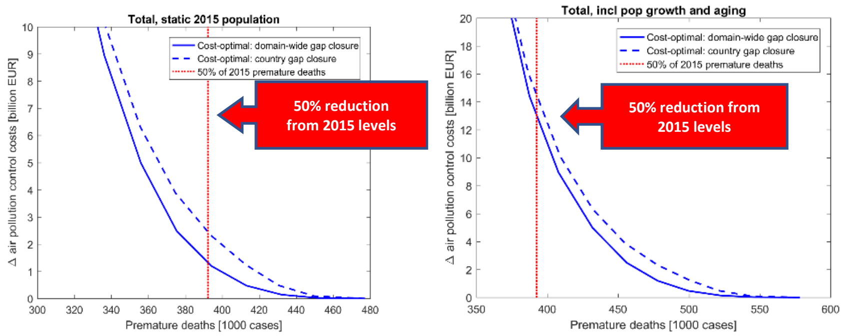
*Figure 5: Cost curves (least cost options) for reducing the number of premature deaths (with dynamic population) in **2050**. The target of 50% reduction between 2015 and 2050 is indicated as red dotted line. Two different starting points are used (blue – Baseline, green – Alternative low baseline with increased climate policies and dietary changes) and two different ways of target setting are explored (solid line = UNECE-Europe region wide gap closure, dashed line = gap closure in each country)*



Source: GAINS model (CIAM) - Chart based on analysis presented in WGSR and EMEP SB/WGE in 2023

17. Inclusion of population growth and aging (right chart, Figure 6) would make it around ten times more expensive to meet the 50% reduction in premature mortality than if considering static 2015 population (left chart, Figure 6). For illustration the 50% health target is applied for the period 2015-2040.

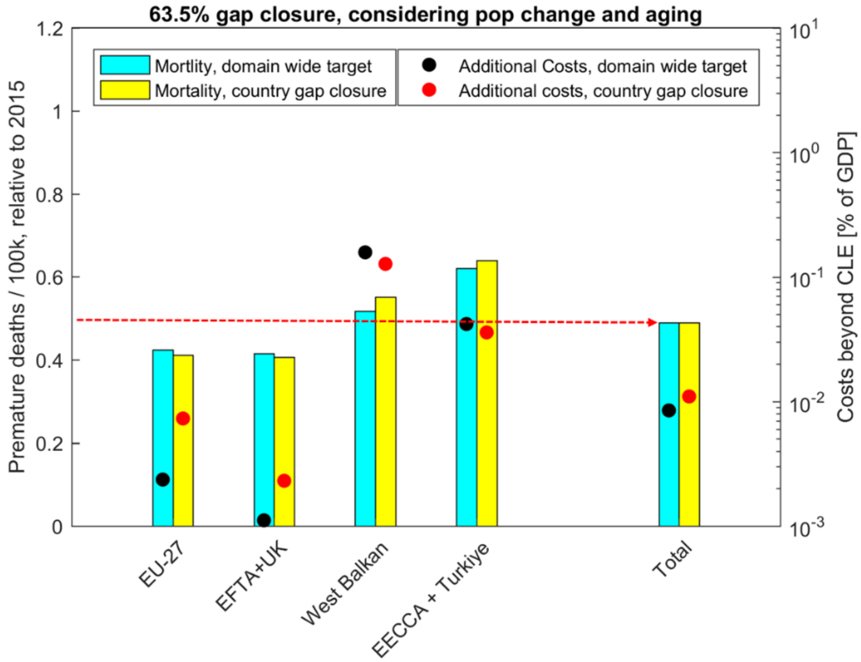
*Figure 6: Least cost reduction of premature deaths due to anthropogenic $PM_{2.5}$ in the UNECE (excl. North America) by **2040** for static population (left) and for dynamic population including growth and aging (right). Country gap closure percentages would be 40% in the static population case and 80% in the case with dynamic population.*



Source: GAINS model (CIAM) - Chart based on analysis presented in WGSR in 2024

18. Figure 7 shows illustrative results per country groups and for the UNECE (excl. NA) overall. The cyan bars represent a least-cost (optimization) approach for the UNECE as a whole, the yellow bars a gap closure per country approach (equal relative reductions in all countries, yellow bars) starting from the baseline projection for 2040. Premature deaths relative to 2015 are shown as bars (left axis) and costs beyond baseline relative to GDP as dots (right axis; note the logarithmic scale). A domain-wide target without any country target (cyan bars, black dots) has a different distribution of impacts and costs, and lower total domain-wide costs, than a case where each country by itself would be required to achieve the same relative reduction (gap closure) between baseline and MTFR. As a 50% health target will, in the EU, already be met with current legislation, these scenarios would mainly lead to additional costs in non-EU countries and in some countries exceed an equivalent of 0.5% of GDP. Relative differences in mortality between the two variants within each country are typically lower than differences in costs to achieve the target. In the case with dynamic population shown here, a gap closure of 63.5% between the 2040 baseline and MTFR is sufficient to reach the 50% reduction in premature deaths for the whole region. In this case, the additional costs for non-EU countries will generally be lower than equivalent of 0.05% of GDP in most countries.

Figure 7: Country-group outcomes of least cost scenarios for 2040 to reduce the mortality indicator by 50% between 2015 and 2040, exploring two different variants of target setting: (cyan bars/black dots: domain wide gap closure without country targets; yellow bars/red dots: equal gap closure in each country)



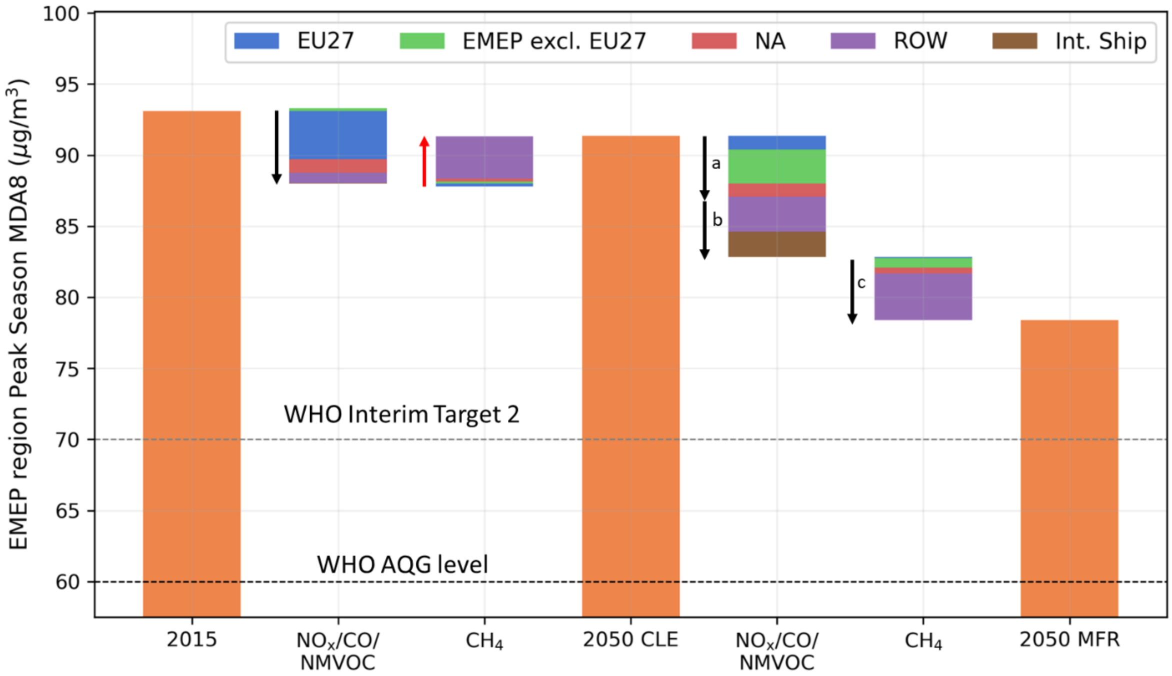
Source: GAINS model (CIAM)

6. Options for ozone policy targets

19. In the baseline scenario, average ozone concentrations in the UNECE (excl. North America) will increase by 2-5% between 2015 and 2050 (not shown here). Peak season concentrations will be reduced by around 5-10%. In both cases, the global methane emission increase in the baseline scenario is partly offsetting the impact of the ozone decline expected from global NOx/VOC reductions (Figure 8).

20. Based on the CIAM scenarios, MSC-W estimates that the application of maximum technical feasible reductions (MTFR) could reduce peak season tropospheric ozone in 2050 relative to the baseline by over 15percent in the EMEP domain. This difference can be attributed for roughly a) ⅓ to the reduction of UNECE (including North America) non-methane precursor emissions (NOx, NMVOCs), b) ⅓ to the reduction of non-methane precursor emissions from the rest of the World, with about a third of that reduction contributed by international shipping and c) ⅓ to the reduction in global methane emissions, of which about a quarter from the UNECE region (including North America); see Figure 8.

Figure 8: Reductions in the maximum 8-hours daily average concentrations (MDA8) in the ozone season



Source: EMEP model (MSC-W)

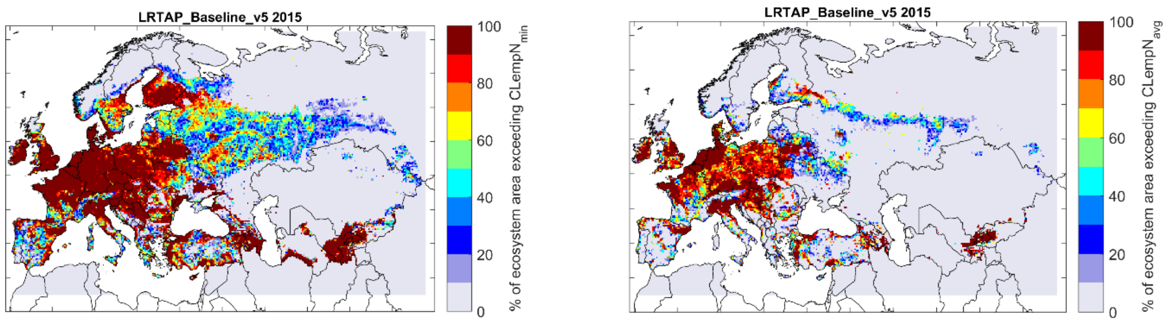
21. Calculation of health impacts of ozone is forthcoming. It is expected that a 50% reduction of mortality risks due to ozone will be more challenging than for $PM_{2.5}$, even with static population. The mortality risk of ozone is probably about 10 times lower than that of $PM_{2.5}$. These estimates, based on the peak-season ozone exposure, are preliminary.

7. Options for the reduction of biodiversity risks

22. On the basis of data on the empirical critical loads for nitrogen, the risk of biodiversity loss due to air pollution can be assessed for various ecosystems.[5] Areas with an exceedance of the nitrogen critical load can be found throughout the UNECE-region. Figure 9 shows the share of the ecosystem area in a grid cell with an exceedance of the empirical nitrogen critical loads in 2015. The left graph refers to the minimum value for the critical load, the right to the average value. Marine ecosystems are not included in the analysis.

[5] Nitrogen deposition is one of the determinants of biodiversity loss. Also, climate change, drought, land use changes, pesticides, invasive species, ozone, etc. play a role. We apply the 50% target only to the air pollution related risks. That is comparable with the approach of health risks, that are only applied to PM-related impacts, although there a more factors influencing health, such as smoking, drinking, unhealthy diets and lack of exercise.

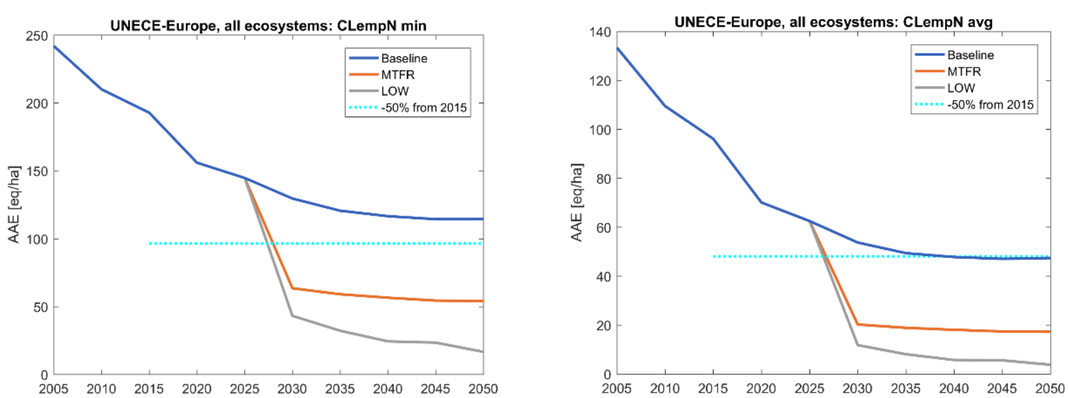
Figure 9: Percentage of ecosystem area exceeding the empirical nitrogen critical load in 2015 (minimum critical load values left, average values right)



Source: GAINS model (CIAM)

23. The Working Group on Effects sees the average amount of exceedance of critical loads in an area as a better indicator for the risk of biodiversity loss than the percentage of the area with a (sometimes very low) exceedance. Figure 10 shows the development of average accumulated exceedance (AAE) between 2005 and 2050 for all ecosystems in the UNECE (excl. North America) using the lower levels of nitrogen critical loads (left) and average levels (right). The dotted lines show the 50% reduction target compared to 2015 (cyan). The lower and average critical loads limits show a big difference in policy implication. The average limit will not require additional policy ambitions.

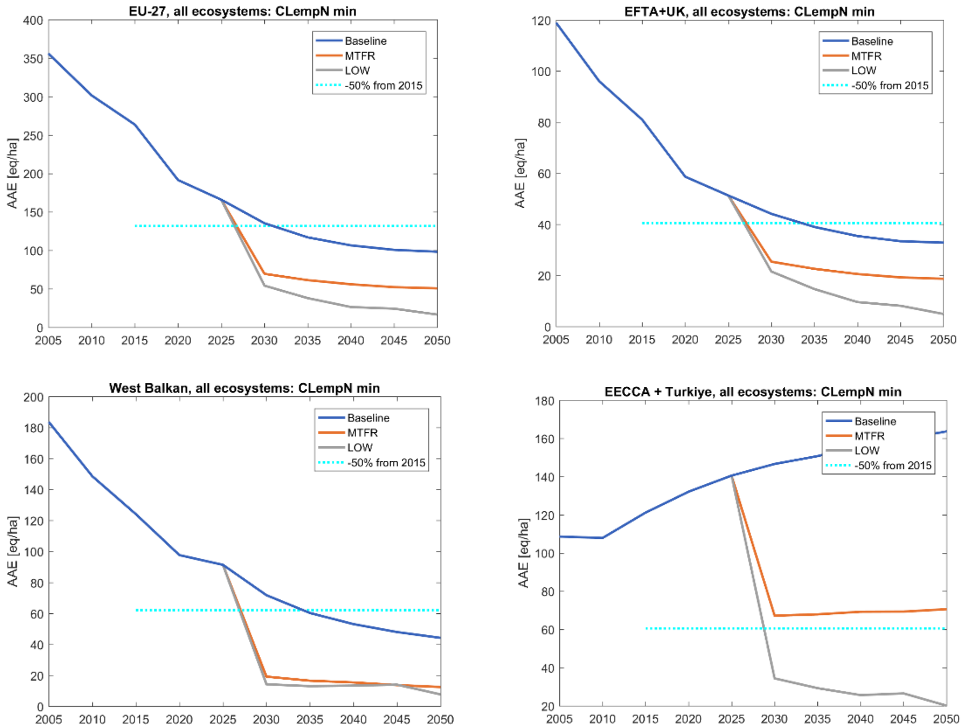
Figure 10: Attainability of 50% reduction of the average accumulated exceedance of the nitrogen critical loads for all ecosystems in the UNECE region, excluding North America. (Lower critical load levels left, average critical loads right)



Source: GAINS model (CIAM)

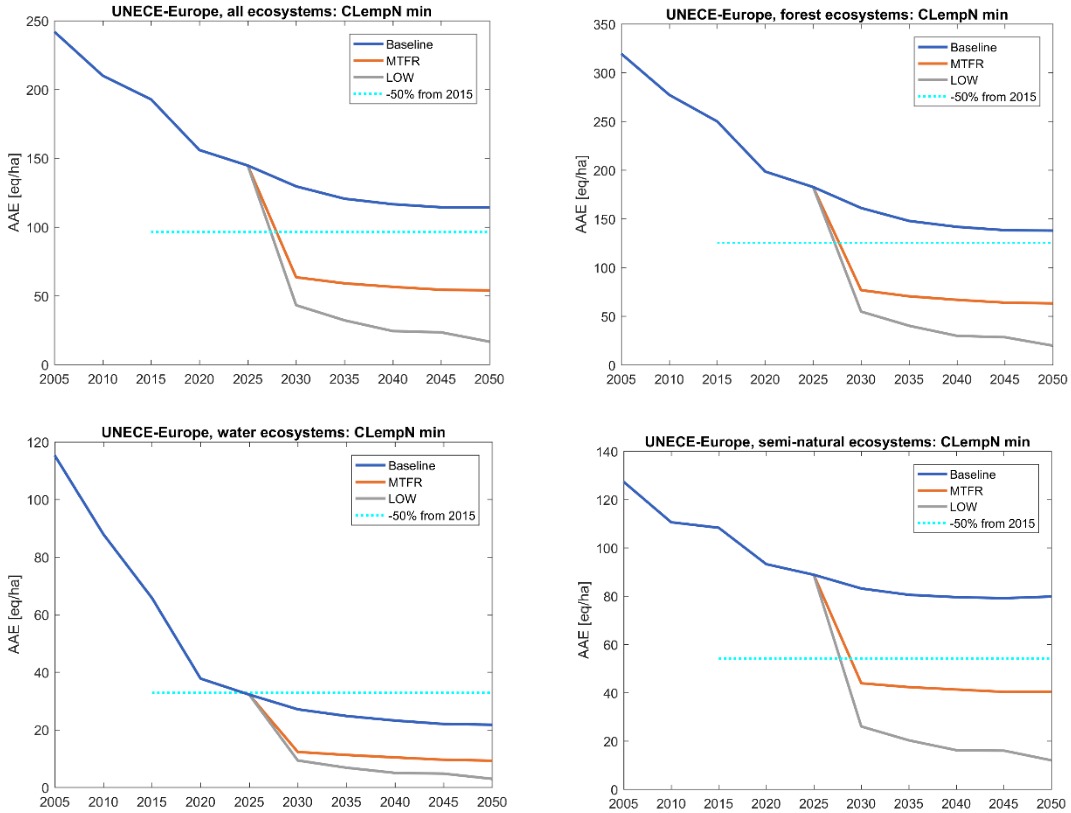
24. The attainability of the 50% reduction target differs among countries and among ecosystem types (see Figure 11 and Figure 12). A 50% reduction of the average accumulated exceedance can be met in most countries even when using the lower critical loads levels. The exceptions are EECCA and Türkiye where a large increase in fertilizer use is included in the baseline (Figure 11).

Figure 11: Attainability of 50% reduction of the average accumulated exceedance of the minimum nitrogen critical loads for all ecosystems within UNECE regions, compared to 2015



Source: GAINS model (CIAM)

Figure 12: Attainability of 50% reduction of the average accumulated exceedance of the minimum nitrogen critical loads for specific ecosystems



Source: GAINS model (CIAM)

25. Additional efforts seem to be needed to reach a 50% risk reduction relative to 2015 for forests and semi-natural ecosystems (such as heathlands, mountain meadows and dunes) (Figure 12). Additional ammonia emissions reduction would play a key role here. MTFR measures for ammonia emissions as well as the dietary measures in the LOW scenario could offer sufficient scope for meeting the 50% target. Of course the attainablity will be different at the national level. This requires further analyses and exploration of least cost scenarios. This is foreseen for the last quarter of 2024. Also, if data can be provided by the Working Group on Effects, comparisons can be made with the use of the calculated critical loads for nitrogen and acidification based on a mass-balance approach.

8. Options for the inclusion of sectoral and staged/phased approaches

26. Additional hybrid scenarios are under discussion and development aiming at flexibilities that could encourage ratification by EECCA and West Balkan countries. For this, so called ‘staged’ or gradual ‘phase-in’ approaches are under discussion, which could include prioritization of measures addressing, for example, particular sectors where not only significant impact benefits can be achieved, but that have already high policy priority owing to other ongoing European processes or the existence of experiences in how significant reductions can be achieved.

27. Discussions are ongoing on the development of such scenarios that exclude West Balkan, EECCA and Türkiye from the optimization and allow them to comply with emission limit values for specific sources at a

certain point in time. The optimized scenarios will then apply to EU and EFTA+UK. Sectors that have been proposed for a staged/phased adoption of the EU emission limit values are:

PP: Power- and heating plants;

DOM: Residential-commercial combustion;

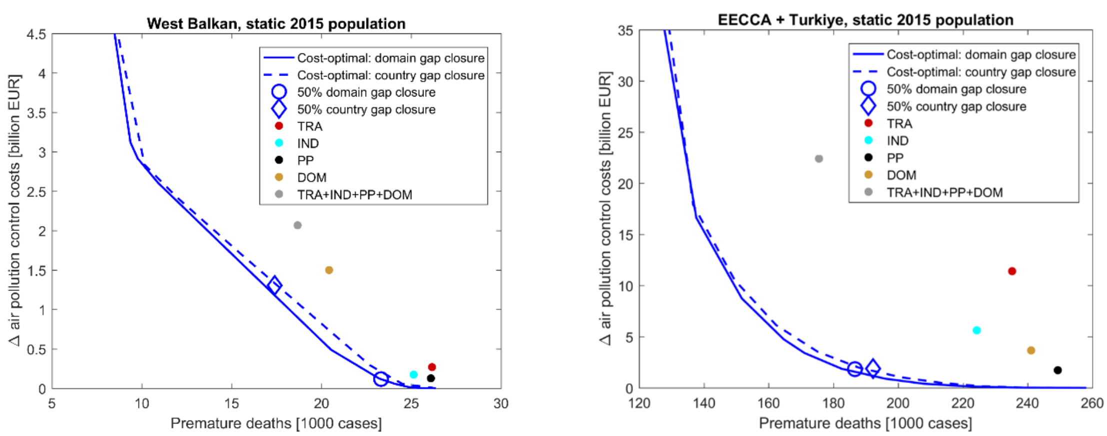
IND: Industrial combustion and processes;

TRA: Road and off-road machinery.

All other sectors will remain as in the baseline.

28. Indicative results show that such a hybrid scenario might give less health risk reduction between 2015 and 2040 for the countries involved and would be less cost-effective. Figure 13 shows – for the regions involved - the costs and health impacts for the application of emission limit values for the four sectors separately (red, cyan, beige and black dots) and for all three sectors together (grey dots), compared with their costs and impacts according to a domain wide optimized approach (solid lines) and country-specific optimisation approach (dashed lines). While a sizable health improvement is estimated in the staged approach (especially for EECCA), the costs are much larger relative to the achieved benefits in this preliminary staged approach case. This is so because some of the mitigation potential mobilized in the staged approach case is beyond the cost-effective portfolio of solutions to reach domain wide or country specific goals.

Figure 13: Premature deaths and abatement costs in 2040 for West-Balkan (left) and EECCA+Türkiye (right) according to domain wide and country specific optimization (blue lines) and with application of EU-emission limit values for selected sectors (colored dots).

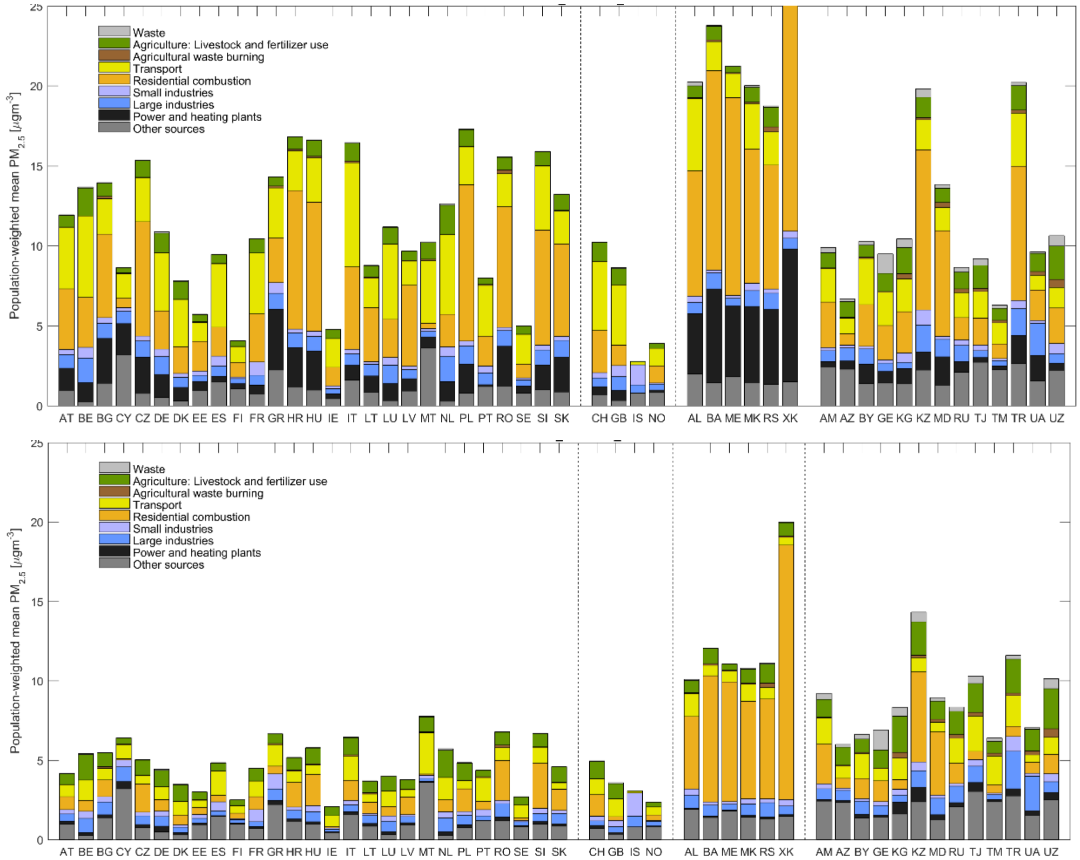


Source: GAINS model (CIAM), chart presented at the EMEP SB/WGE meeting in September 2024

29. For power plants (black dots), the results of the staged approach and the domain wide optimized scenario are comparable. For West Balkan that is also the case for the large industrial installations (cyan dots). For transport (red dots) the staged approach would mobilize additional mitigation compared to the optimized approach, especially for the EECCA region where current polices assume low ambition. Since the staged approach explores full potential of abatement measures, including those that are beyond what is found cost-effective in the optimized solutions, the costs for transport are much higher in the staged approach vs optimized case. The optimized scenarios also address other sectors, especially residential combustion. Significant health benefits cannot be reached without addressing residential combustion (see Figure 14). Refined and additional staged scenarios will be discussed and analyzed after receiving feedback.

30. Moving from the baseline in 2015 (top chart in Figure 14) to the baseline in 2040 (bottom chart) shows that strong reductions in contributions to population weighted country mean $PM_{2.5}$ concentrations are expected in West Balkan in the power sector, and lesser in transport. In EECCA countries reductions are expected in the residential sector and to some extent in transport. The relative importance of the agricultural sector increases between 2015 and 2050 in this region.

Figure 14: Sector contributions to population weighted country mean anthropogenic $PM_{2.5}$ concentrations in 2015 (top) and according to the baseline in 2040 (bottom)



Source: GAINS model (CIAM); charts presented at the EMEP SB/WGE meeting in September 2024

9. Conclusions

31. Compared to the first two versions of the policy brief, the target setting options presented in this 3rd version were narrowed down for the moment for a clearer vision of what must be negotiated for a revised protocol. Choices applied in the current version are based on the comments received by countries during and after WGSR-63. These include: the choice of 2015 as base year and 2040 as target year; the use of the risk-based mortality indicator together with dynamic population in optimization; with results to be presented also for the health metrics premature deaths, years of life lost and for morbidity indicators; the use of mean and average empirical critical loads for nitrogen deposition risk-reduction targets for biodiversity expressed as average accumulated exceedance by habitat type; the use of the anthropogenic part of air pollution in target setting; the analysis of reaching the risk reduction percentage both through UNECE wide least cost optimization and through equal relative percentage reductions in all countries.

32. Considering the choice by the parties of the health metric (premature mortality per 100,000 population with dynamic population), it should be noted that WHO favours excluding demographic change from health impact assessments. This would call for using static population. Furthermore, basing target setting calculations on exposure reduction instead of on health impacts, would altogether eliminate the health impact parameters from the equation and so if recommended exposure-response function change, the target could remain unchanged. Nevertheless, in the impact-based approach of the Gothenburg Protocol our preference would be for premature mortality per 100,000 population with static population in the target setting, as it would make it easier to combine risks of PM, with the risks of other pollutants.

33. A 50% health target between 2015 and 2040 (in terms of premature deaths due to anthropogenic PM) appears achievable in the UNECE region as a whole, for most regions (groups of countries) and for many single

countries, but not all. Feasibility depends on details of the calculation, formulation of other potential targets (e.g., for cities, adding morbidity). For the EU, the target is achieved in the baseline scenario. For this region, full implementation and enforcement remains a key priority and an important assumption. Some non-EU countries may struggle to achieve such a target especially when aging is taken into account. A 50% target for the whole region would be more cost-effective, however less equitable, than the same target for all countries. This preliminary analysis shows that pursuing additional climate measures and dietary change policies (such as in the LOW-scenario) could reduce additional air pollution control costs ten-fold.

34. Total costs and the distribution of costs vary significantly between the cases (equivalent to less than 0.01% GDP to approximately 0.2% GDP at the regional level [see Figure 7], with some countries reaching equivalent of 0.5% GDP) with higher costs for the case where equal improvements in all countries are achieved. Further analysis would be required to assess the impact of a constraint for each country setting the maximum costs per GDP (this is scheduled for 2025).

35. A 50% target for the reduction of premature deaths due to ground level ozone between 2015 and 2050 is challenging. Current air pollution policies are largely offset by the global increase in methane emissions. Contrary to $PM_{2.5}$, the feasibility of the ozone target is more dependent on global cooperation to reduce ozone precursors, including methane. In the 2050 MTFR scenario (relative to the 2050 CLE), reductions of NOx and NMVOC-emissions within the UNECE (incl. North America) and in the rest of the world (incl. international shipping) would each contribute 1/3, respectively to the reduction of ozone levels, and global methane reduction would also contribute 1/3, of which about a quarter would come from the reductions in the UNECE region (incl. North America) (see Figure 8). Global action on methane would be a key part of the solution and further NOx and NMVOC emission mitigation would still be important to reduce ground level ozone within the UNECE region.

36. The 2050 LOW scenario would, in EU and non-EU countries compared to 2015, lead to more than 50% reduction in the area with an exceedance of critical loads, for acidification as well as for eutrophication. A domain wide 50% reduction of the area average exceedance between 2015 and 2040 is attainable but would require additional (ammonia) reduction measures when applied for forests or semi-natural vegetation. Optimization scenarios (identifying least cost solutions) for biodiversity targets are planned (first results are envisaged for late 2024).

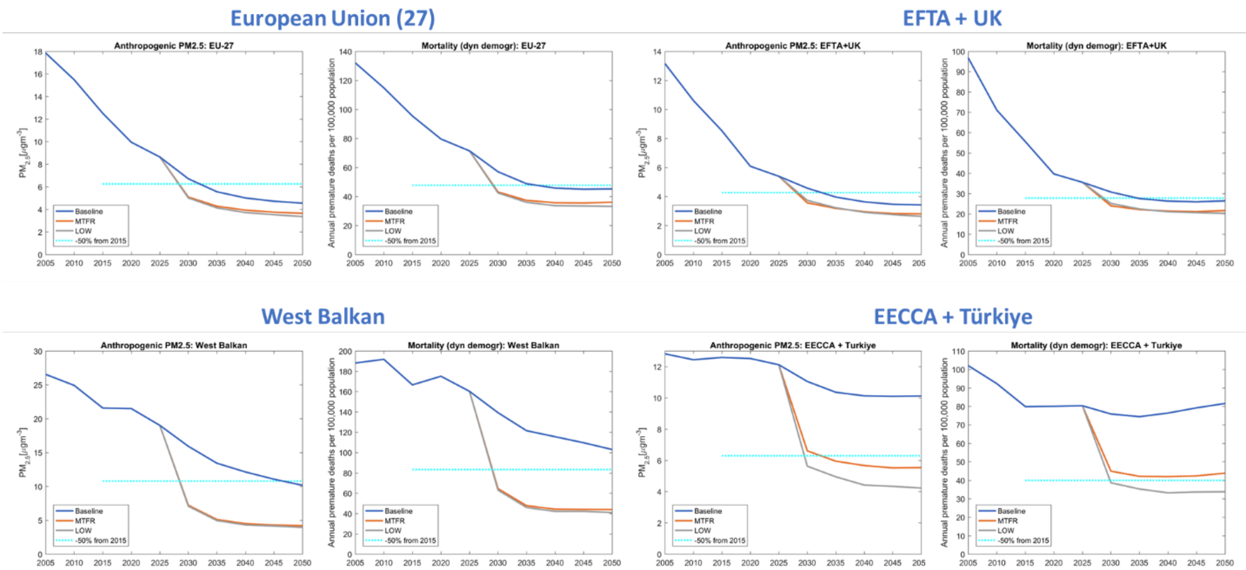
37. Next steps envisaged in 2025 include implementing the analysis for ozone impacts, for the identification of least cost solutions (optimization) for reducing ozone health impacts and assessing the possibility for combined PM and ozone health impact optimization, as well as combined optimization for health and biodiversity impacts. Further analysis could consider, inter alia, alternative metrics for target setting, including achievement of other health end-point indicators (e.g. population attributable fraction) or marine ecosystem targets. The implications of adding morbidity for the attainability of a 50% health impact reduction target would require further analysis. The impact of constraining optimization by further egalitarian principles is also planned. Ex-post analysis could look into implication of scenarios for black carbon, or for urban hot-spots. Further work is needed to include the latest climate measures (i.e. the use of hydrogen and ammonia as well as peat land restoration – LOW+ scenario), and on sensitivity of outcomes for uncertain input data, such as uncertainties in emission estimates (e.g. of condensables), uncertainties in full implementation of climate policies and uncertainties in cost estimates. Feedback and recommendations from the EECCA and West Balkan regions and Türkiye are needed in order to select options for staged-phased approaches that should be analyzed.

38. If agreed by the WGSR, where relevant, such elements will also have to be included in the workplan of other scientific bodies under the Convention than TFIAM and CIAM.

A compilation of the comments received on the policy brief is available at the TFIAM web-site: Task Force on Integrated Assessment Modelling (TFIAM) under the LRTAP Convention - TFIAM - IIASA

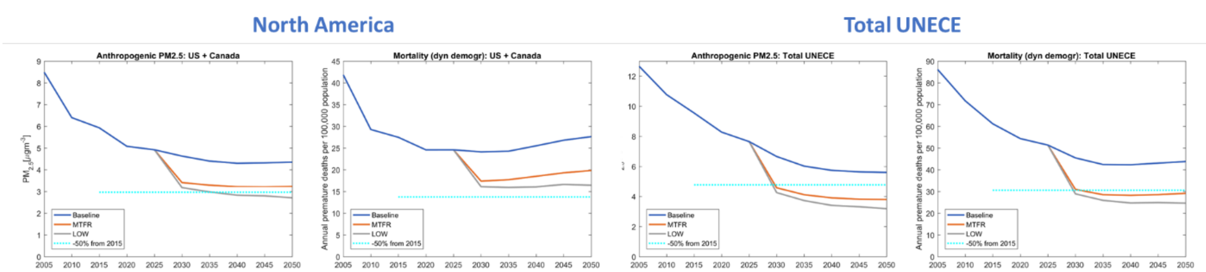
Annex 1: Attainability of health improvement goals in selected regions

Figure A.1: Change in $PM_{2.5}$ concentrations and mortality (taking into account population change and aging – dynamic demography) for Baseline, MTFR, and LOW scenarios (1) for EU27, EFTA+UK, and West Balkan, and EECCA+Türkiye



Source: GAINS model (CIAM)

Figure A.2: Change in $PM_{2.5}$ concentrations and mortality (taking into account population change and aging – dynamic demography) for Baseline, MTFR, and LOW scenarios (1) for North America and the whole UNECE region (2)



Source: GAINS model (CIAM)

Annex 2: Country tables

Table A.1 shows emissions for the scenarios analyzed so far, aggregated to country groups, for 2015, 2040 and 2050. Tables A.2-A.6 show emissions for the scenarios analyzed so far by country. Further information and data tables, including also sectoral emissions will be made available on the CIAM/TFIAM web site: https://iiasa.ac.at/policy/applications/centre-for-integrated-assessment-modelling-ciam

Table A.1: Emissions in GAINS-LRTAP scenarios by country groups

SO2 - kt SO2		Baseline		MTFR		LOW	
Region	2015	2040	2050	2040	2050	2040	2050
EU-27	2361	497	443	254	219	255	219
EFTA+UK	321	125	123	84	87	53	60
West Balkan	1040	64	65	14	14	14	14
EECCA+Turkiye	4571	2821	2679	520	471	447	498
North America	4674	1621	1550.5	1070	1053	966	962
Total	**12967**	**5128**	**4860**	**1942**	**1844**	**1734**	**1753**

NOx - kt NO2 (soil NOx is included)

Region	2015	2040	2050	2040	2050	2040	2050
EU-27	7578	2197	1853	1729	1463	1456	1141
EFTA+UK	1414	440	373	323	277	337	265
West Balkan	318	136	98	80	57	75	50
EECCA+Turkiye	5591	5046	5039	2370	2222	1669	1345
North America	14427	7673	7381	4451	4182	3269	2770
Total	**29328**	**15492**	**14745**	**8953**	**8202**	**6806**	**5571**

NH3 - kt NH3

Region	2015	2040	2050	2040	2050	2040	2050
EU-27	3610	3238	3192	2451	2394	1757	1454
EFTA+UK	354	337	339	258	255	206	171
West Balkan	142	145	142	109	106	89	70
EECCA+Turkiye	2293	3185	3319	2172	2250	1042	888
North America	4482	5377	5509	2633	2673	1778	1486
Total	**10882**	**12282**	**12501**	**7624**	**7677**	**4872**	**4068**

NMVOC - kt NMVOC (agricultural NMVOC are included)

Region	2015	2040	2050	2040	2050	2040	2050
EU-27	6747	4426	4163	3488	3289	3227	2907
EFTA+UK	1035	871	848	666	649	669	654
West Balkan	275	223	193	92	85	100	97
EECCA+Turkiye	5214	5126	5123	3187	3075	2471	2273
North America	13588	10376	9861	7123	6665	5347	4625
Total	**26859**	**21022**	**20188**	**14557**	**13762**	**11813**	**10556**

PM2.5 - kt PM2.5

Region	2015	2040	2050	2040	2050	2040	2050
EU-27	1567	597	508	411	362	414	363
EFTA+UK	120	64	61	42	42	48	46
West Balkan	125	82	70	16	15	16	16
EECCA+Turkiye	1512	1348	1358	306	286	282	273
North America	1456	890	900	534	528	528	521
Total	**4779**	**2982**	**2898**	**1309**	**1233**	**1289**	**1219**

Black Carbon - kt BC

Region	2015	2040	2050	2040	2050	2040	2050
EU-27	279	66	45	36	28	37	29
EFTA+UK	24	9	8	5	4	5	4
West Balkan	16	13	11	2	1	2	1
EECCA+Turkiye	193	156	148	30	22	24	18
North America	275	138	138	65	61	57	50
Total	**787**	**382**	**349**	**137**	**117**	**124**	**102**

CH4 - kt CH4

Region	2015	2040	2050	2040	2050	2040	2050
EU-27	16546	11409	10857	9106	8083	7275	5211
EFTA+UK	3208	1913	1837	1339	1310	1192	935
West Balkan	797	843	750	407	283	392	200
EECCA+Turkiye	21748	26450	27716	12485	10834	10737	6951
North America	41734	33358	32628	15692	12063	15495	10064
Total	**84032**	**73972**	**73787**	**39030**	**32573**	**35090**	**23361**

Source: GAINS model (CIAM)

Table A.2: SO_2 emissions in GAINS-LRTAP scenarios by country

Source: GAINS model (CIAM)

Table A.3: NOx emissions in GAINS-LRTAP scenarios by country

Source: GAINS model (CIAM)

Table A.4: NH_3 emissions in GAINS-LRTAP scenarios by country

Source: GAINS model (CIAM)

Table A.5: NMVOC emissions in GAINS-LRTAP scenarios by country

Source: GAINS model (CIAM)

Table A.6: $PM_{2.5}$ emissions in GAINS-LRTAP scenarios by country

Source: GAINS model (CIAM)

Table A.7: BC emissions in GAINS-LRTAP scenarios by country

Source: GAINS model (CIAM)

Table A.8: CH_4 emissions in GAINS-LRTAP scenarios by country

Source: GAINS model (CIAM)

Tables A.9-A.12 show health and ecosystem impact indicators across all countries for 2015 and for 2040 and 2050 for the scenarios analyzed so far.

Table A.9: Population exposed to $PM_{2.5}$ levels above 5 µg/m^3 (million)

Source: GAINS model (CIAM)

Table A.10: Years of life lost due to anthropogenic $PM_{2.5}$ exposure (million), cumulative over population lifetime

		Baseline		MTFR		LOW	
Country	2015	2040	2050	2040	2050	2040	2050
Austria	5.8	2.03	1.810	1.58	1.465	1.509	1.359
Belgium	8.9	3.509	3.226	2.719	2.524	2.458	2.154
Bulgaria	7.1	2.785	2.382	1.692	1.526	1.595	1.392
Croatia	4.9	1.526	1.275	1.016	0.882	0.962	0.812
Cyprus	0.6	0.437	0.432	0.324	0.327	0.309	0.312
Czech Rep.	10.6	3.492	2.817	2.593	2.077	2.423	1.853
Denmark	2.7	1.206	1.092	0.932	0.855	0.852	0.734
Estonia	0.5	0.282	0.257	0.206	0.194	0.195	0.18
Finland	1.3	0.797	0.760	0.627	0.614	0.604	0.581
France	39.3	16.787	15.674	13.66	13.191	13.101	12.338
Germany	52.2	21.216	19.188	16.665	15.194	15.408	13.425
Greece	9.9	4.6	4.576	3.597	3.681	3.47	3.536
Hungary	11.9	4.214	3.428	3	2.406	2.798	2.163
Ireland	1.2	0.546	0.521	0.473	0.457	0.44	0.405
Italy	56.0	21.946	19.867	18.759	17.075	17.845	16.045
Latvia	1.5	0.587	0.521	0.391	0.365	0.37	0.338
Lithuania	2.0	0.871	0.790	0.573	0.53	0.532	0.473
Luxembourg	0.3	0.111	0.103	0.089	0.083	0.083	0.075
Malta	0.3	0.198	0.203	0.182	0.188	0.18	0.184
Netherlands	12.3	5.534	5.126	4.476	4.176	4.065	3.609
Poland	46.7	13.357	11.812	8.797	8.003	8.113	7.071
Portugal	5.0	2.734	2.594	2.342	2.241	2.334	2.229
Romania	22.9	10.167	7.896	6.762	5.119	6.399	4.663
Slovakia	5.0	1.756	1.493	1.271	1.055	1.18	0.936
Slovenia	2.0	0.835	0.605	0.504	0.436	0.477	0.4
Spain	24.8	12.646	12.749	10.729	11.105	10.446	10.772
Sweden	2.6	1.395	1.352	1.184	1.155	1.134	1.082
EU-27	**338**	**136**	**123**	**105**	**97**	**99**	**89**
Albania	**4**	1.964	1.717	0.897	0.871	0.926	0.891
Armenia	2	1.789	1.747	1.012	0.993	1.179	1.217
Azerbaijan	5	4.744	4.820	2.892	2.779	2.614	2.489
Belarus	8	5.169	4.963	2.497	2.385	2.323	2.096
Bosnia-H	6	3.146	2.610	1.122	1.024	1.094	0.994
Georgia	3	1.792	1.795	1.09	1.049	0.9	0.823
Iceland	0	0.055	0.058	0.046	0.047	0.02	0.019
Kazakhstan	25	18.476	18.138	12.334	11.998	6.842	6.758
Kosovo	4	2.415	1.954	0.598	0.549	0.574	0.513
Kyrgyzstan	4	3.747	3.910	1.844	1.897	1.363	1.352
North Macedonia	3	1.499	1.329	0.589	0.585	0.573	0.549
R Moldova	4	2.86	2.623	1.182	1.088	0.891	0.807
Montenegro	1	0.465	0.370	0.163	0.148	0.161	0.144
Norway	1	0.618	0.581	0.456	0.453	0.59	0.617
Russia	73	72.109	70.230	38.459	35.675	31.96	28.637
Serbia	9	5.553	4.608	2.181	1.996	1.99	1.755
Switzerland	4	1.948	1.780	1.636	1.492	1.645	1.445
Tajikistan	5	6.259	6.528	3.129	3.18	2.634	2.652
Turkey	97	58.974	58.523	33.896	33.078	27.501	26.851
Turkmenistan	2.584	2.676	2.765	1.448	1.441	1.226	1.197
Ukraine	35	28.551	28.909	13.799	13.603	11.535	10.818
United Kingdom	33	13.597	12.879	11.035	10.525	10.695	9.607
Uzbekistan	23	24	24	14.045	13.996	9.416	9.11
Non-EU	**352**	**262**	**257**	**146**	**141**	**119**	**111**
Total	**690**	**398**	**379**	**251**	**238**	**218**	**200**

Source: GAINS model (CIAM)

Table A.11: Acidification (% of ecosystem area exceeding critical loads)

			Baseline		MTFR		LOW	
Country	Ecosystem area [km2]	2015	2040	2050	2040	2050	2040	2050
Austria	38,901	0.6						
Belgium	15,482	42.4	28.9	27.7	22.4	21.3	16.4	13.0
Bulgaria	54,242	0.0						
Croatia	36,341	3.5	0.3	0.1				
Cyprus	1,692							
Czech Rep.	23,831	74.8	1.1	0.6	0.1	0.1	0.0	0.0
Denmark	6,657	14.3	0.9	0.3				
Estonia	30,583							
Finland	281	0.4	0.3	0.3	0.1	0.1	0.1	0.0
France	176,852	6.0	1.0	0.7	0.0	0.0		
Germany	103,401	48.3	14.7	13.4	7.6	6.4	3.7	3.0
Greece	77,626	0.6	0.1	0.1	0.1	0.1		
Hungary	29,969	6.5	1.7	1.5	0.0			
Ireland	16,195	1.1	0.5	0.5	0.2	0.2	0.0	0.0
Italy	100,954	0.5	0.1	0.1	0.0	0.0	0.0	0.0
Latvia	44,142	1.9	0.1					
Lithuania	26,331	23.2	4.9	4.5	0.0	0.0		
Luxembourg	1,376	13.5	0.0	0.0				
Malta	35							
Netherlands	2,755	72.4	70.7	70.5	69.9	69.5	65.2	59.1
Poland	95,931	38.2	1.9	1.5	0.1	0.1	0.1	0.1
Portugal	41,903	2.1	0.3	0.3	0.0	0.0	0.0	0.0
Romania	109,259	0.9	0.0	0.0	0.0	0.0	0.0	
Slovakia	26,757	5.3	0.2	0.2				
Slovenia	14,052	0.0	0.0					
Spain	251,625	0.6	0.1	0.1	0.0	0.0	0.0	0.0
Sweden	391,665	3.2	0.9	0.8	0.6	0.5	0.6	0.6
EU-27	**1,718,839**	**9.0**	**1.8**	**1.7**	**0.9**	**0.8**	**0.6**	**0.5**
Albania	19,947	0.3						
Armenia								
Azerbaijan								
Belarus	66,499	5.0	0.4	0.4	0.0	0.0		
Bosnia-H	36,959	12.6	0.4	0.0				
Georgia								
Iceland								
Kazakhstan								
Kosovo	4,693	14.4						
Kyrgyzstan								
North Macedonia	16,846	1.3						
R Moldova	3,773							
Montenegro	9,041	1.3						
Norway	320,380	9.4	3.5	3.0	2.0	1.6	1.6	1.3
Russia	643,092	0.4	0.2	0.2	0.0	0.0	0.0	0.0
Serbia	33,005	21.9	0.2	0.0				
Switzerland	9,733	15.6	8.8	8.5	6.0	5.8	2.7	2.2
Tajikistan								
Turkey								
Turkmenistan								
Ukraine	97,758	0.6	0.0	0.0				
United Kingdom	75,806	10.6	2.4	2.1	0.8	0.7	0.4	0.1
Uzbekistan								
Non-EU	**1,337,532**	**4.4**	**1.2**	**1.0**	**0.6**	**0.5**	**0.4**	**0.3**
Total	**3,056,371**	**7.0**	**1.5**	**1.4**	**0.8**	**0.7**	**0.5**	**0.5**

Source: GAINS model (CIAM)

Table A.12: Eutrophication (% of ecosystem area exceeding critical loads)

			Baseline		MTFR		LOW	
Country	Ecosystem area [km2]	2015	2030	2050	2030	2050	2030	2050
Austria	50,489	65.7	26.9	24.7	12.0	10.2	3.0	0.8
Belgium	15,552	67.6	48.7	45.8	41.3	39.9	34.2	29.3
Bulgaria	54,322	87.8	72.3	69.8	41.9	41.0	35.1	33.5
Croatia	36,411	90.9	77.8	76.3	64.8	63.2	51.6	46.2
Cyprus	1,691	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Czech Rep.	23,831	95.3	58.8	51.4	32.2	23.6	5.3	0.3
Denmark	6,665	100.0	99.5	99.1	98.5	97.0	90.8	60.5
Estonia	30,592	43.5	28.8	27.9	18.5	16.5	12.6	9.8
Finland	41,047	10.2	0.9	0.6	0.0	0.0	0.0	0.0
France	176,937	85.3	59.6	57.0	43.9	41.3	24.2	13.2
Germany	103,988	79.9	60.0	57.9	49.8	47.5	34.7	24.4
Greece	77,844	100.0	100.0	99.9	99.9	99.9	99.7	99.4
Hungary	30,007	91.4	69.8	68.9	66.2	63.6	57.9	49.9
Ireland	16,776	48.8	43.7	43.4	36.5	35.7	18.3	7.1
Italy	105,815	71.9	47.8	45.3	32.0	29.7	19.5	15.8
Latvia	44,159	91.0	61.2	57.8	43.6	42.4	39.2	38.0
Lithuania	26,352	98.8	92.1	90.5	69.7	65.0	45.9	33.7
Luxembourg	1,377	100.0	96.6	96.1	91.6	90.0	80.8	57.3
Malta	35	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Netherlands	2,976	87.9	75.7	72.7	65.7	64.2	41.2	27.3
Poland	95,929	75.0	51.0	49.4	22.5	20.9	7.0	2.6
Portugal	42,008	85.7	68.7	67.6	60.1	59.8	59.0	58.4
Romania	109,333	94.5	87.0	84.6	72.2	69.4	55.1	44.4
Slovakia	26,799	96.0	82.8	80.1	63.4	57.4	39.3	30.0
Slovenia	14,066	86.8	58.0	55.6	41.6	39.3	32.0	24.2
Spain	251,922	96.1	90.0	89.4	82.6	82.1	77.2	75.2
Sweden	58,643	14.3	11.7	10.8	6.0	4.9	4.2	2.2
EU-27	**1,445,569**	**80.7**	**64.8**	**63.1**	**51.8**	**50.0**	**40.8**	**35.5**
Albania	19,971	97.1	95.0	94.8	88.6	85.9	91.3	84.1
Armenia								
Azerbaijan								
Belarus	66,500	100.0	99.8	99.6	87.4	86.7	49.3	26.3
Bosnia-H	37,044	76.7	70.6	68.8	62.3	59.9	55.5	48.0
Georgia								
Iceland								
Kazakhstan								
Kosovo	4,703	89.0	68.6	59.6	40.2	38.5	36.7	29.2
Kyrgyzstan								
North Macedonia	16,892	91.9	74.1	72.4	60.2	57.0	55.6	51.6
R Moldova	3,774	99.8	99.8	99.8	73.1	72.8	56.0	51.8
Montenegro	9,059	69.2	55.5	53.0	43.5	41.8	35.8	34.0
Norway	303,446	12.3	5.3	4.2	2.3	1.7	0.9	0.4
Russia	643,119	49.9	43.3	42.6	17.7	16.4	8.0	5.6
Serbia	33,064	92.5	86.6	84.3	69.7	67.4	52.4	43.7
Switzerland	24,248	57.4	41.7	41.4	33.1	31.7	15.4	7.4
Tajikistan								
Turkey								
Turkmenistan								
Ukraine	97,773	100.0	99.9	99.9	97.2	96.7	86.3	66.5
United Kingdom	71,070	25.8	11.5	10.1	4.2	3.6	2.0	0.5
Uzbekistan								
Non-EU	**1,330,663**	**49.8**	**43.2**	**42.4**	**27.6**	**26.5**	**18.7**	**14.0**
Total	**2,776,232**	**65.9**	**54.5**	**53.1**	**40.2**	**38.8**	**30.2**	**25.2**

Source: GAINS model (CIAM)