Forty-first session of the Executive Body

Informal document

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by 7 January 2022

Cost of inaction

Summary

This draft report to policymakers on the costs of air pollution emission control versus costs of inaction is prepared by the Task Force on Integrated Assessment Modelling (TFIAM) and responds to item 2.1.7 of the 2020–2021 workplan for the implementation of the Convention (ECE/EB.AIR/144/Add.2). The objective of the report is to encourage future ratification and implementation of Air Convention protocols, primarily the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone as amended in 2012, clarifying to policymakers what would be the costs of inaction on air pollution. The preparation of this guidance document was made available through the funding from the Norwegian Ministry of Climate and Environment (contract nr. 12/3850-92).

The report compares the costs of inaction, defined as the damage to health, ecosystems and economy, with the costs of taking action, defined as the costs of abatement measures.

A presentation of this document was given to the 58th and 59th Working Group on Strategies and Review for consideration. Due to COVID-related delays it is expected that the final document will be discussed at the 60th Working Group on Strategies and Review, and a revised version could be adopted at the 42nd session of the Executive Body.

I. Extended summary

1. In nearly half of the UNECE countries (26 of 56) the current monetary damage costs to health and ecosystems due to ambient air pollution corresponds to more than 5% of GDP. In at least 6 countries, the damage is more than 10% of GDP. The largest part of the damage costs consists of reduced life expectancy, followed by morbidity costs (e.g., hospital admittance, sickness leave, medicines costs), and damage to ecosystems. The monetized damage is – as a percentage of GDP - in the eastern part of the UNECE region higher than in the western part. Globally, labor productivity losses due to air pollution make up ~5-9% of the total damage costs.

2. There are societal values yet to be monetized and included in the damage cost estimates, foremost the damage to biodiversity. There are also considerable information gaps between the eastern and western parts of the UNECE region, especially with respect to valuation studies made by East-European research groups and scenarios for future air pollution levels in Eastern Europe. Dedicated efforts are still needed to reduce these missing values and gaps.

3. Thanks to existing policies, the monetary damage in Europe up to 2030 is expected to be reduced by 14%. The implementation of national emission reduction obligations and current emission limit values for vehicles, installations, non-road mobile machineries and products will reduce damages. The current energy transition plans will reduce the damage costs by 21% in the next decade. The expected damage reduction will (as a percentage of GDP) be higher in the western part of the UNECE-region since this region is expected to implement stricter emission reductions.

4. Up to 21% of the monetary damage in the EU-27 in 2030-2050 could be avoided by additional (not included in the current legislation) policy actions targeting air pollution. Applying technically feasible measures (not entailing excessive costs) could reduce the annual monetary damage by 4% (compared to the baseline) in 2030-2050. If implementing all air pollution measures regardless of costs (MTFR) the damage costs can be reduced by 20-21%. If MTFR is further combined with climate measures, the damage reduction in 2050 might reach 26%. Especially in the eastern part of the UNECE-region there is a large potential to reduce the costs of inaction.

5. The abatement costs (the costs of taking action) are significantly lower than the costs of inaction. Benefits tend to be higher than costs. Abatement costs of available additional actions in EU-27 on top of current ambition levels in the National Air Pollution Control Programmes (NAPCP) are more than 20 times lower than the avoided damage.

II. Introduction

6. Since in the 1960-ies, economists have developed methods to monetize welfare effects of adverse ecosystem and human health effects caused by poor air quality. Although early (and partly biased) attempts showed that costs of reducing emissions far exceeded the benefits, it is by now well established that the situation is the opposite in almost all cases. Failure to act on improving air quality is thereby imposing avoidable welfare losses. In other words, failure to take the costs of action leads to costs of inaction.

7. In preparing this report, the best available knowledge on damage costs of air pollution has been reviewed and synthesized. From this we extract the most important messages to policy makers from the state-of-the-art science in this discipline. The work has been guided by the following questions:

Question #1: Can we confidently estimate welfare effects of poor air quality?

Question #2: How high are the damage costs when we don’t take action on air pollution?

Question #3: Are these damage costs expected to go up or down in the future?

Question #4: How can we further reduce the costs of inaction?

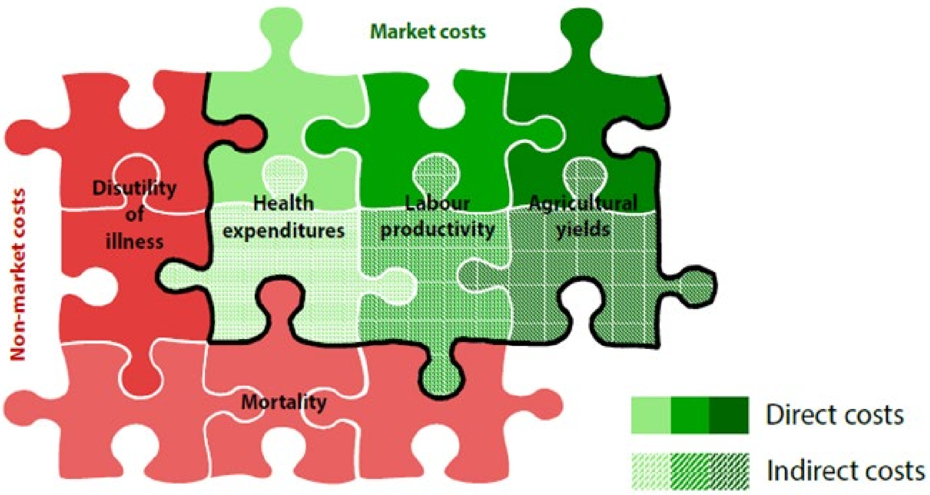
Question #5: Will human welfare improve if we do more?

8. Below we present a conceptual overview of the costs of inaction and the most relevant literature. This is followed by an estimate of the current amount of the damage costs from air pollution in the UNECE region, the expected future reduction in damage costs, as well as the available improvement potential.

III. Monetizing damages from air pollution

9. Although the exact terminology differs between practitioners, in this report we consider the following terminology when writing about the economic effects of poor air quality. The welfare losses for society of poor air quality comes in two main types: market costs and non-market costs (Figure 1).

Figure 1: Market and non-market costs of air pollution damage, split into their main categories. Figure copied from OECD, 2016[1].



10. As examples of market costs, it has been shown that poor air quality causes productivity losses by reducing the number of days we can go to work and reducing the harvest size of forests, crops and vegetables. Furthermore, mitigating the negative effects of poor air quality consumes societal resources, such as health care sector expenditures. All these are directly measurable costs that depend on the current market prices as well as labour and health care costs. More indirect market costs also exist – for instance, the reduction of available financial resources for investments. Market costs are also called macroeconomic costs since they concern economics of society in general and its production and utility functions; they could be easily linked to expenditures. Methods and data needed to estimate market costs are well described in recent reports by Organisation for Economic Cooperation and Development (OECD) (Atkinson et al., 2018[2]; OECD, 2016[3]).

11. Non-market costs, or welfare costs, occur since poor air quality reduces our quality of life through illnesses leading to pain, suffering and discomfort, and through preterm mortality. Non-market costs are the type of damage costs typically used in cost-benefit analyses supporting policy decisions. Non-market costs do not directly result in expenses and cannot be quantified in the same way as market costs. There is a range of studies setting economic values on mortality and morbidity based on how much individuals themselves perceive the value of a change in life expectancy, risk of fatal accidents, or health status – i.e., by applying willingness-to-pay (WTP) methods. To assess costs of premature mortality

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[1] OECD, 2016. The Economic Consequences of Outdoor Air Pollution – Policy Highlights. Note that the OECD did not include (non-market) ecosystem damage in their approach.

[2] Atkinson, G. et al., 2018. Cost-Benefit Analysis and the Environment - Further Developments and Policy Use

[3] OECD, 2016. The Economic Consequences of Outdoor Air Pollution – Technical Report http://dx.doi.org/10.1787/9789264257474-en

due to air pollution, two main approaches exist – one involves a valuation metric called the Value of Life Year (VOLY), another one uses the Value of Statistical Life (VSL) (Box 1). Whether VOLY or VSL is used in a mortality cost estimate can significantly affect the results – therefore, we try to indicate the chosen metric in the numbers we present[4], where possible by writing (VSL) or (VOLY) after the value presented.

Box 1: VOLY and VSL approaches to valuation of premature mortality caused by air pollution.

The VOLY and VSL approaches to valuation of life-shortening from air pollution differ since the life years lost from air pollution typically is around 11 years, which is lower than the halved life expectancy typically associated with VSL studies. In detail, the VOLY method is based on life tables; it takes into account at what age people die from air pollution and gives results in terms of life expectancy. The VSL method does not use life tables and instead operates with mortality rates. As the VSL method does not take into account age or death reasons, it is sometimes considered to be overestimating health benefits from air pollution reduction (Desaigues et al., 2011)* while VOLY approach is considered as more conservative. On the other hand, the VOLY approach is criticized for not valuing vulnerable populations (sick and elderly) as high as average populations.

Operationally in most impact assessments, the effect of air pollution on life expectancy or mortality is calculated through a fixed % change on a baseline life expectancy or relative risk. An outcome of this method is that in countries with short baseline life expectancy (i.e., high relative risk of mortality), air pollution affects more life years. Correspondingly, the numerical difference between mortality valuation with the VSL and VOLY approach will be higher in countries with long life expectancy and lower in countries with short life expectancy.

* Desaigues, B. et al. 2011. Economic valuation of air pollution mortality: A 9-country contingent valuation survey of value of a life year (VOLY). Ecological Indicators. Economic and Social Research Institute, No. 282

12. In this report, we use the term ‘damage costs’ as the sum of all the above-mentioned cost types and categories.

IV. Data, method, sources

13. This synthesis report summarizes the most recent knowledge about the current and projected damage costs due to air pollution and the costs of taking action to reduce the damage. Most of the data is found in relevant articles and reports published the last 10 years. In addition, the authors conducted supplementary analysis of region-specific health damage with the help of widely used models GAINS and Alpha RiskPoll.

A. Modelling made in this report as input into the data synthesis

14. In 2020, the International Institute for Applied System Analysis (IIASA) published scenarios for the second Clean Air Outlook[5] exploring future air quality different levels of ambitions regarding air pollution and climate measures in EU-27. The underlying baseline GAINS scenario (CAO2_Baseline_2030 in the scenario group Clean Air Outlook 2) is publicly available and reflects the current and projected development in the entire GAINS modelling domain. To estimate current and projected health damage in the selected regions including countries outside EU-27 (described below), we used the GAINS model outputs (population-weighted concentrations of $PM_{2.5}$ and SOMO35 in the receptor countries) as inputs into the Alpha RiskPoll model where the health effects and the corresponding damage

[4] Where both options are available, we chose to present the numbers in VSL – i.e., when we present the results of own calculations based on Amann, M. et al., 2020. Support to the development of the Second Clean Air Outlook, Specific Contract 6 under Framework Contract ENV.C.3/FRA/2017/0012. VSL is chosen since this metric, unlike VOLY, allows equal valuation for lives of people of different ages and “pre-existing conditions”. Furthermore, VSL is used by OECD in their recent studies that we often refer to in this report. We are, however, aware that the European Commission more often uses VOLY in its assessments and policy suggestions.

[5] Amann, M. et al., 2020. Support to the development of the Second Clean Air Outlook, Specific Contract 6 under Framework Contract ENV.C.3/FRA/2017/0012

from $PM_{2.5}$ and ozone are calculated and aggregated by region. Damage assessment is done for 2020 (current situation) and 2030 (projection).

B. Regionalization

15. Within the assessment of the monetized damage from air pollution to human health and ecosystems in this report, total and unit damage costs are summarized and analyzed separately for each of the chosen four regions of the larger UNECE region:

- Eastern Europe, Caucasus and Central Asia (EECCA) countries – Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine, Russian Federation, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan,
- South Eastern Europe – Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, Serbia, Turkey,
- Western and Central Europe – EU-27, Iceland, Luxembourg, Norway, Switzerland, UK,
- North America – US, Canada.

C. Currency recalculations and value transfer

16. All monetary estimates are presented in 2015-euros ($€_{2015}$). When translating non-market (intangible) health damage estimates available in the literature to $€_{2015}$, we account for total inflation (Consumer Price Index - CPI) and change in GDP per capita PPP (GDP with respect to Purchasing Power Parity) in the considered country or region and apply a VSL income elasticity of 0.8 (as recommended in OECD, 2012[6]). For estimates of technical costs and damage costs from the literature that include a large share of market-based costs, the values are recalculated to $€_{2015}$ considering CPI only.

17. In the damage estimates based on GAINS and Alpha RiskPoll made for this report, valuation of health effects is harmonized with the recommended values used in Amann et al., 2020[5]. Health damage value estimates are first translated from $€_{2005}$ to $€_{2015}$ by applying CPI and change in GDP per capita PPP across EU-28 with an income elasticity of 0.8 (as in Amann et al., 2020[5]). Then, depending on which type of results are presented, one of the two spatial value transfer methods is chosen:

- When assessing damage as % of a country's GDP, the country-specific damage is adjusted with the income difference between the considered country and the EU-27. An income elasticity is assumed to be 0.8 for countries with higher income than the EU average, and 1.2 – for countries with lower income than the EU average[7]. The adjusted values are compared to GDP PPP.
- When presenting the absolute damage numbers per region (EECCA countries / South Eastern Europe / Western and Central Europe) in $€_{2015}$, the damage is adjusted with the income difference between the UNECE Europe and the EU-27, applying an income elasticity of 1.2 (since average income in the UNECE Europe is lower than in EU-27).

18. It is worth noting that some of the morbidity-related costs (market costs) are estimated with other methods than WTP, so to adjust all morbidity values with respect to income elasticity leads to some underestimation of cost of inaction (COI). However, since over 90% of the health damage is attributable to mortality as well as pain and suffering from illness, the underestimation of applying a 0.8 income elasticity has an insignificant effect on total COI.

19. Our estimates of the damage as % of a country's GDP are done for the year 2020 (for some countries in the Caucasus and Central Asia – for 2010). These values should not be

[6] OECD 2012. Mortality Risk Valuation in Environment, Health and Transport Policies, OECD Publishing. http://dx.doi.org/10.1787/9789264130807-en

[7] A VSL income elasticity of 1.2 is recommended for lower- and middle-income countries and an elasticity of 0.8 for higher income countries (Narain, U., Sall, C. 2016. Methodology for valuing the health impacts of air pollution – Discussion of challenges and proposed solutions. World Bank, Washington DC. License: Creative Commons Attribution CC BY 3.0 IGO)

mixed up with values referred to as "% of GDP change" adopted from the OECD study[1] – those are percentages of GDP in 2060, compared to the baseline scenario.

20. All data used to convert literature values and Alpha RiskPoll values to €2015 are taken from the World Bank, the OECD and the European Central Bank. GDP PPP, GDP per capita PPP and population data are downloaded from the World Bank database[8]. CPI are obtained from the OECD database[9]. Currency exchange rates are taken from the European Central Bank page[10].

V. How large is the monetized damage from air pollution to human health and ecosystems?

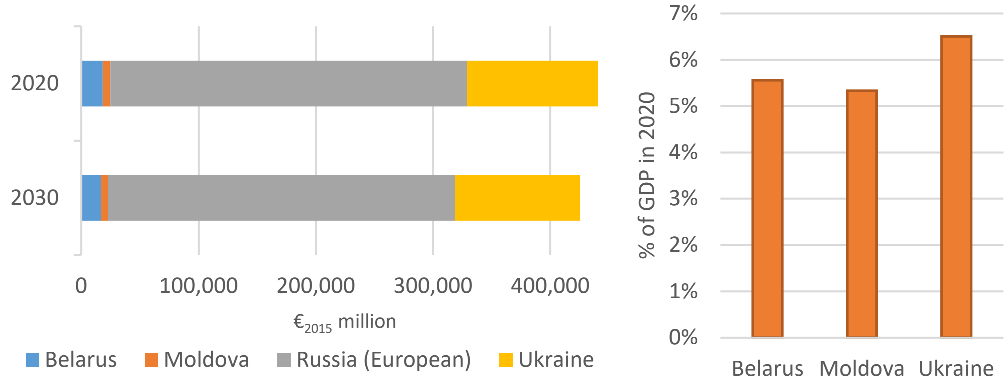
21. The first question answered in this overview relates to the total size of the damage costs and is presented for the regions EECCA countries, South-Eastern Europe, Western and Central Europe, North America, and Global. EECCA is split between the countries within the EMEP[11] domain represented in GAINS Europe (v.3) and the countries outside.

A. EECCA countries

Total damage and % of GDP

22. The total health damage from air pollution in the EECCA countries within the EMEP domain shows the descending trend (Figure 2, left panel). The damage is expected to go down by $€_{2015}$ 17.5 billion (4%) between 2020 and 2030 – still, annual damage will account to $€_{2015}$ 425 billion in 2030. The damage from air pollution for the countries with national borders within the EMEP domain corresponds to 5-7% of the countries' GDP (Figure 2, right panel).

Figure 2: Health damage from air pollution in EECCA countries within the EMEP domain (own calculations based on the current legislation scenario in Amann et al., 2020[5]).



23. For the Caucasus and Central Asia outside the EMEP domain, the damage from preterm mortality attributable to poor air quality varies from $€_{2015}$ ~9.8 billion in Armenia to over $€_{2015}$ 70 billion in Uzbekistan in 2010 (Figure 3). This estimate is based on the mortality rates due to ambient air pollution presented in WHO&OECD, 2015[12] and a VSL value of $€_{2005}$ 3.06 million[13] as in Amann et al., 2020[5]. Mortality-related damage attributable to air pollution corresponds to 3-12% of the countries' GDP.

[8] https://data.worldbank.org/indicator

[9] https://stats.oecd.org/#

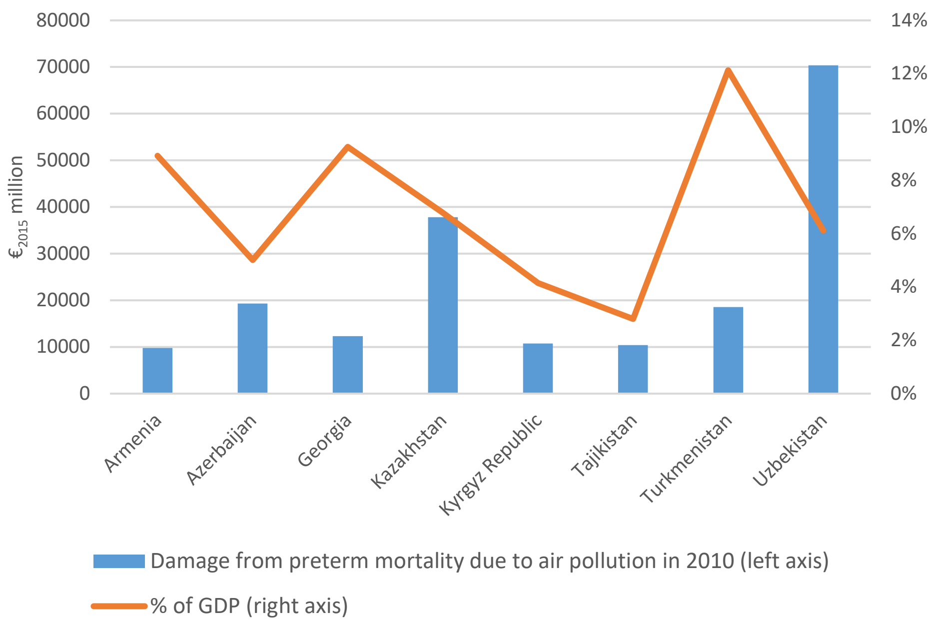
[10] https://www.ecb.europa.eu/stats/policy_and_exchange_rates/html/index.en.html

[11] Cooperative Programme for Monitoring an Evaluation of the Long-Range Transmission of Air Pollutants in Europe

[12] WHO Regional Office for Europe, OECD, 2015. Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. Copenhagen: WHO Regional Office for Europe

[13] VSL values in $€_{2005}$ are further adjusted with CPI-based inflation rates and changes in GDP per capita between 2005 and 2015 in EU-28, and differences in GDP per capita in 2015 between EU-28 and the considered countries

Figure 3: Health damage from ambient air pollution in Caucasus and Central Asia in 2010 (based on mortality presented in WHO&OECD, 2015[12]).



Reduced labour productivity and other morbidity effects

24. Costs of reduced labour productivity (lost working days) due to illnesses constitute about 0.6% of the total health damage costs, while all morbidity effects correspond to 5% of the total damage. OECD, 2016[1,3] estimates that damage from morbidity is in all regions is dominated by costs of restricted activity days – for example, in Russia, welfare costs of illness in 2060 are projected to be about $€_{2015}$ 205 per capita, from which 68% is attributable to restricted activity. Labour productivity effect of air pollution is expected to reduce Russian GDP by 0.8% in 2060.

Damage to crops

25. In addition to premature mortality and illness in population, air pollution has negative effects on crops – mainly, through the plants' exposure to ground-level ozone. These effects are rather easily monetized through the market prices. OECD, 2016[3] projects that in the Russian Federation, by 2060 agricultural production will be by 0.8% lower than in a less polluted future due to air pollution.

Costs by sectors and pollutants

26. Costs of air pollution per ton emissions are country specific. Values presented for main pollutants in Table 1 are obtained from the detailed modelling of pollutant transfer and health effects (Schucht et al., 2021[14]) and can be easily applied in damage costs assessments supporting air quality related decision-making.

[14] Schucht, S., Real, E., Létinois, L., Colette, A., Holland, M., Spadaro, J.V., Opie, L., Brook, R., Garlnad, L., Gibbs, M., 2021. European Environment Agency. Costs of air pollution from European Industrial facilities 2008-2017, Eionet Report - ETC/ATNI 2020/4

Table 1: Damage from air pollutants in Eastern Europe and the Caucasus, €2015/ton, VSL (source – Schucht et al., 2021[14]).

Country	NO_x	$PM_{2.5}$	SO_2	NMVOC	NH_3
Belarus	4 100	77 300	20 400	100	11 000
Moldova	7 000	105 200	17 900	100	19 800
Russia (EMEP)	4 500	110 500	34 700	1 400	37 700
Armenia	10 000	311 800	73 800	7 000	48 800
Azerbaijan	15 000	39 100	28 100	400	8 900
Georgia	11 200	448 600	68 800	3 500	16 400
Ukraine	12 700	115 400	26 300	3 600	64 700

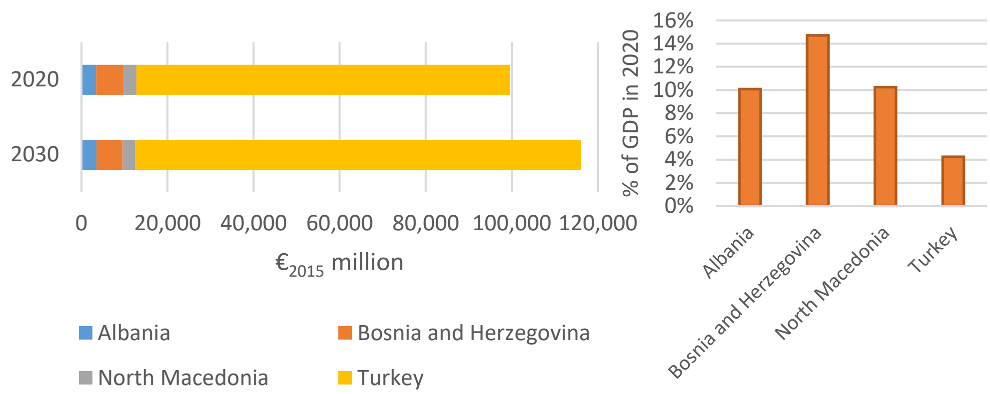
*Data for Ukraine is not updated in Schucht et al., 2021[14]; instead, the numbers from the previous modelling of damage from industrial air pollution in Europe (Holland et l., 2014)[15] are presented in Table 1

B. South Eastern Europe

Total damage and % of GDP

27. Health damage from ambient air pollution in the South Eastern Europe shows an ascending trend (Figure 4, left panel): it is expected to increase from $€_{2015}$ 100 billion in 2020 to $€_{2015}$ 116 billion in 2030 (17% increase) if no additional action is taken. Health damage attributable to air pollution constitutes 4 - 15% of the countries' GDP in this region (Figure 4, right panel).

Figure 4: Health damage from air pollution in the South Eastern Europe (own calculations based on the current legislation scenario in Amann et al., 2020[5]).



Reduced labour productivity and other morbidity effects

28. Costs of reduced labour productivity due to illnesses is 0.7% of the total health damage costs, and all morbidity effects constitute 10% of the total health damage.

Costs by sectors and pollutants

29. Pollutant- and country-specific unit damage costs for the South Eastern Europe are summarized in Table 2. Like in the EECCA countries, the largest damage per ton pollutant results from emissions of $PM_{2.5}$, and the smallest – from NMVOC.

Table 2: Damage from air pollutants in South Eastern Europe, €2015 /ton, VSL (source – Schucht et al., 2021[14]).

Country	NO_x	$PM_{2.5}$	SO_2	NMVOC	NH_3
Albania	20 900	148 900	46 000	1 900	21 800
Bosnia and Herzegovina	27 200	104 600	40 600	2 700	50 600

[15] Holland, M. et al., 2014. Costs of air pollution from European industrial facilities 2008 -2012 – an updated assessment. EEA Technical report No 20/2014, ISSN 1725-2237

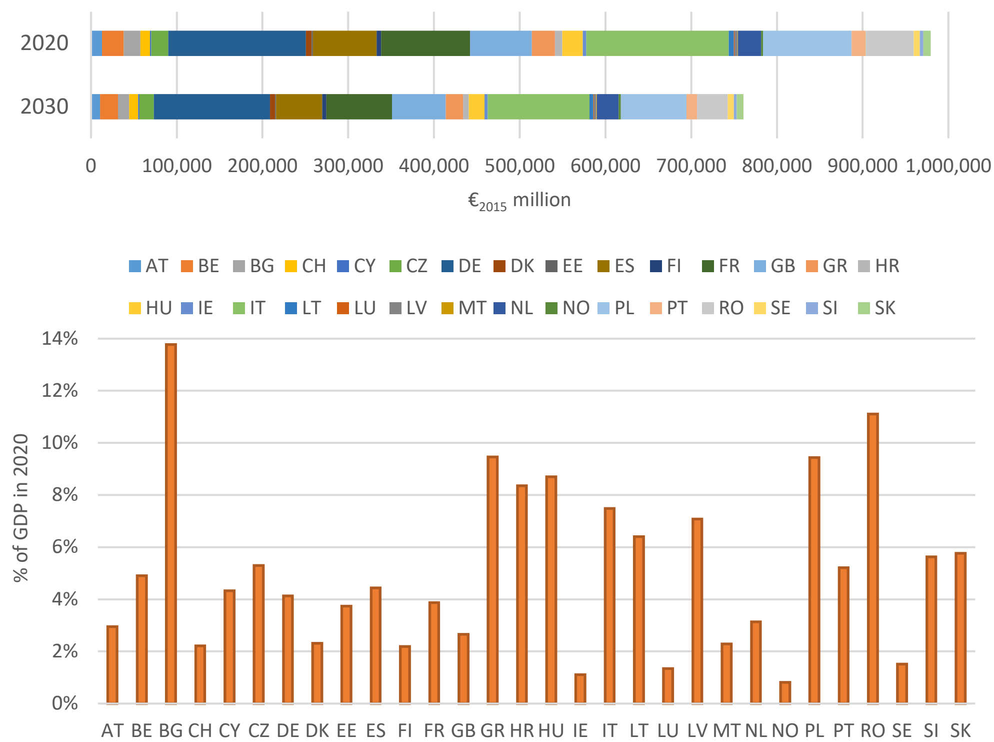
Country	NO_x	$PM_{2.5}$	SO_2	NMVOC	NH_3
Serbia	20 900	168 900	44 200	2 800	74 400
Montenegro	14 700	36 700	26 500	1 700	30 700
Macedonia	13 600	139 000	34 500	3 000	46 300
Turkey	10 100	90 800	23 600	1 700	23 400

C. Western and Central Europe

Total damage and % of GDP

30. In the entire Western and Central Europe, the total health-related damage from air pollution is estimated at €$_{2015}$ ~980 billion in 2020 (Figure 5, upper panel). By 2030, this number is expected to decrease to €$_{2015}$ ~760 billion (a reduction by 22%). In relation to GDP, country-specific damage varies from 1% to around 14% (the average value is 5%) (Figure 5, lower panel).

Figure 5: Health damage from air pollution in Western and Central Europe (own calculations based on the current legislation scenario in Amann et al., 2020[5]).



Reduced labour productivity and other morbidity effects

31. Costs of lost working days constitute about 1.1% of the total health damage costs; all morbidity effects account for 7% of the total damage (for comparison – Holland et al., 2014[16] estimated the share of morbidity in the total health damage from air pollution at about 9%). According to a recent study exploring air pollution damage in Finland (Kukkonen et al., 2020[17]), productivity losses account for 0.3-3.4% of health damage in 2015, depending on the emission source (the largest impact on labour productivity is observed for $PM_{2.5}$ emissions from non-road machinery in the urban areas). Expected GDP reduction in 2060 due to labour productivity losses in the Western and Central Europe is 0.1-0.3% (OECD, 2016[1]).

[16] Holland, M., 2014, Cost-benefit Analysis if Final Policy Scenarios for the EU Clean Air Package, corresponding to IIASA TSAP Report #11

[17] Kukkonen, J., et al., 2020. Modelling of the public health costs of fine particulate matter and results for Finland in 2015. Atmos. Chem. Phys., 20, 9371–9391, 2020, https://doi.org/10.5194/acp-20-9371-2020

32. Levels and sources of air pollution are different in the rural areas and in cities. Damage from air pollution in European cities exceeds €$_{2015}$ 150 billion and to a large extent depends on transport policies and corresponding emissions (see Box 2).

Box 2: Air pollution damage at the city level (source - CE Delft, 2020[18]).

Zooming in pollution – city perspective

Recent analysis of health-related damage from air pollution in 432 large Western European cities (CE Delft. 2020*) estimates the total damage at over €$_{2015}$ 166 billion in 2018. From this, 76% is attributable to mortality (VOLY) while 24% - to pain and suffering from illness. Annual damage per capita is €$_{2015}$ 1250, which corresponds to -9% of the cities' income. City size is identified as a key factor in the social costs of air pollution.

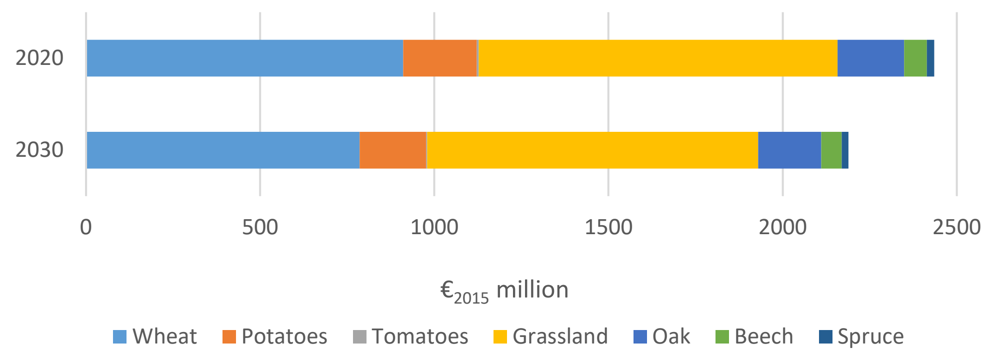
The study highlights the link between transport policies and the social costs of air pollution. It is estimated that a 1% increase in the number of cars in a city results in 0.5% increase of the air pollution-related damage.

*de Bruyn, S., de Vries, J., CE Delft, 2020. Health costs of air pollution in European cities and the linkage with transport

Damage to crops

33. Production of crops and wood in Europe is reduced by 15% due to the harmful effects of ground-level ozone. Annual losses for wheat production are estimated to be over €$_{2015}$ 46 billion (Maas&Grennfelt, 2016[19]). A more recent study of effects of air pollution on crops and vegetables in France (Schucht et al., 2019[20]) indicates that the damage might be larger – the study estimates that in France alone, current economic losses for production of crops and wood account to €$_{2015}$ ~2.4 billion (Figure 6). The damage is expected to decrease by 10% within the next decade – still, it will be equivalent to 8% of the health damage from air pollution in France.

Figure 6: Economic losses from air pollution effects on crops and vegetables in France, based on Schucht et al., 2019[20].



Costs by sectors and pollutants

34. In Europe, the main sector contributing to air pollution is transport (Gonzales Ortiz et al., 2020)[21]. The total annual damage costs from road transport in EU-28 are estimated at up to €$_{2015}$ 80 billion (CE Delft, 2018)[22], with large variations between countries (Figure 7). About 75-83% of the damage from road transport is attributable to diesel sources.

[18] de Bruyn, S., de Vries, J., CE Delft, 2020. Health costs of air pollution in European cities and the linkage with transport

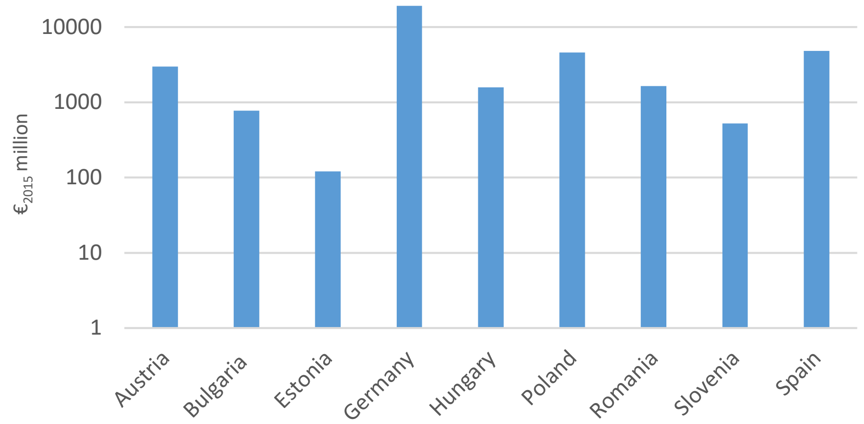
[19] Maas, R., P. Grennfelt, P., 2016. Towards Cleaner Air – Scientific Assessment Report 2016. EMEP Steering Body and Working Group on Effects of the Convention on Long-Range Transboundary Air Pollution, Oslo

[20] Schucht, S., Tognet, F., Colette, A., Létinois, L, Lenoble, C., Agasse, S., Mathieu, Q., 2019. Coût économique pour l'agriculture des impacts de la pollution de l'air par l'ozone – APollO : Analyse économique des impacts de la pollution atmosphérique de l'ozone sur la productivité agricole et sylvicole en France

[21] Gonzales Ortiz, A., Guerreiro, C., Soares, J., European Environment Agency, 2020. Air quality in Europe – 2020 report, EEA Report No 09/2020

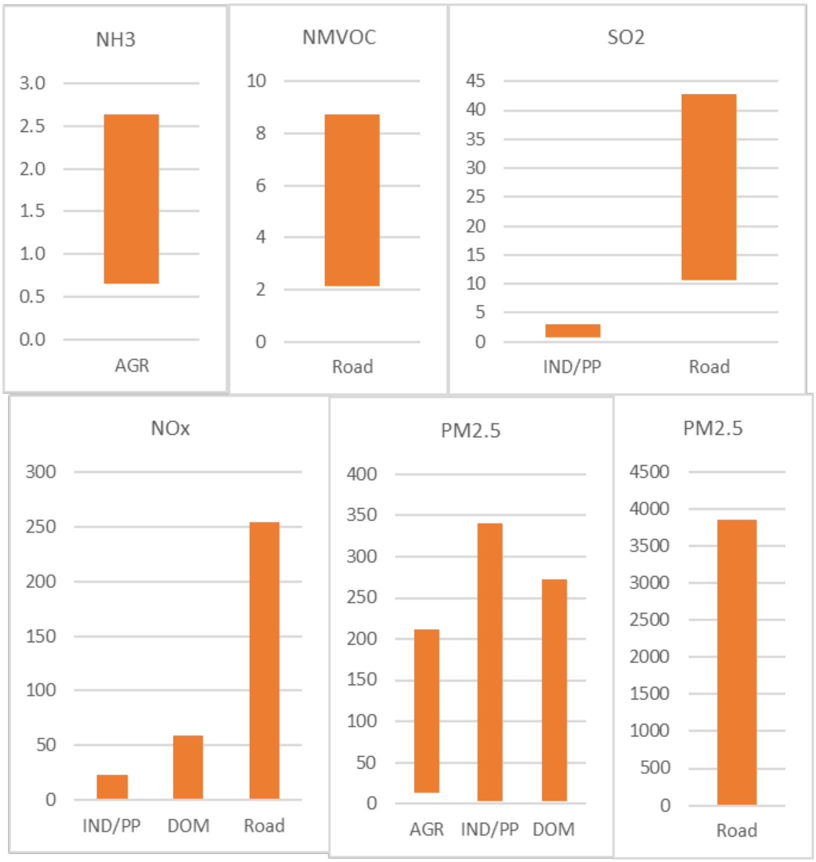
[22] CE Delft, 2018. Health impacts and costs of diesel emissions in the EU

Figure 7: Traffic related air pollution damage costs in 2016 based on CE Delft, 2018[22]. Note the logarithmic scale of Y-axis.



35. Available estimates of sector-specific costs of air pollution per ton emissions indicate large variations between sectors and pollutants (Figure 8).

Figure 8: Sector-specific damage cost ranges from air pollutants in Western and Central Europe, thousands €$_{2015}$ /ton (sources – Kukkonen et al., 2020[17], Trafikverket, 2018[23], Birchby et al., 2019[24], Trafikverket, 2019[25], CE Delft, 2018[26]). AGR – Agriculture, Road – road transport, Ind/PP – industries and energy, DOM – residential combustion.



[23] Trafikverket, 2018. Analysmetod och samhällsekonomiska kalkylvärden för transportsektorn: ASEK 6.1

[24] Birchby, D., Stedman, J., Whiting, S., Vedrenne, M., Ricardo Energy & Environment, 2019. Air Quality damage cost update 2019, Report for Defra, AQ0650

[25] Söderkvist, T. et al., Trafikverket, 2019. Underlag för reviderade ASEK-värden för luftföroreningar, Slutrapport från projektet REVSEK

[26] the Bruyn, S., Bijleveld, M., de Graaff, L., Schep, E., Schroten, A., Vergeer, R., Ahdour, S., CE Delft ,2018. Environmental Prices Handbook EU28 version – Methods and numbers of valuation of environmental impacts

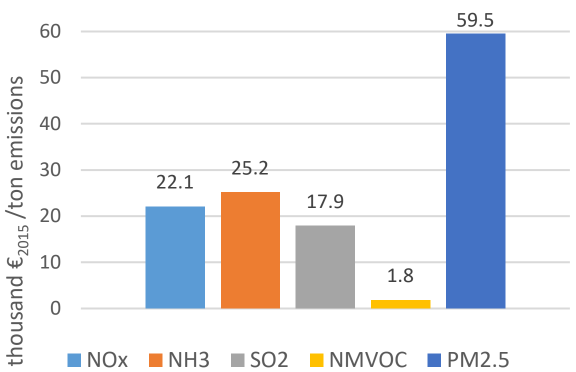
36. The costs of air pollution per ton emissions (Table 3) also vary between the countries depending on factors such as population structure and proximity to other countries. The unit costs of $PM_{2.5}$ are high (up to €$_{2015}$ ~570 000/ton), while unit costs of NMVOC have the lowest values – €$_{2015}$ 100-15 000 /ton, indicating the same relative input into the total damage from different pollutants like in other countries in Europe.

Table 3: Country-specific damage from air pollutants in Western and Central Europe, €$_{2015}$ /ton, VSL (source – Schucht et al., 2021[14]).

Country	NO_x	$PM_{2.5}$	SO_2	NMVOC	NH_3
Austria	48 800	206 400	102 300	7 400	68 300
Belgium	39 700	465 200	144 100	7 100	147 900
Bulgaria	22 600	281 300	41 900	2 500	52 700
Croatia	38 000	174 700	71 500	4 700	54 300
Cyprus	6 200	44 000	16 200	800	13 300
Czechia	30 700	256 600	64 100	7 300	119 600
Denmark	14 300	112 800	49 000	1 300	23 100
Estonia	2 300	24 300	6 000	400	11 300
Finland	2 700	59 400	15 400	500	12 300
France	37 500	189 200	100 800	5 500	38 400
Germany	40 600	242 300	105 200	5 000	82 100
Greece	4 600	132 400	33 100	3 100	37 200
Hungary	36 200	237 600	69 900	4 300	67 300
Ireland	21 400	45 600	70 700	1 600	14 000
Italy	62 100	538 500	85 000	14 000	84 100
Latvia	4 100	89 600	25 900	600	15 300
Lithuania	6 200	56 500	23 000	600	18 500
Luxembourg	49 400	224 900	135 900	4 100	75 100
Malta	900	136 500	15 200	2 200	79 100
Netherlands	44 100	267 700	122 800	5 400	101 800
Norway	4 400	51 600	13 900	1 000	8 800
Poland	12 000	117 500	38 100	2 700	63 800
Portugal	10 900	212 600	32 000	1 900	23 000
Romania	29 100	197 500	55 700	3 300	44 100
Slovakia	29 200	212 100	54 400	5 100	94 500
Slovenia	57 900	339 000	84 500	9 000	72 900
Spain	15 500	183 200	65 300	3 200	20 600
Sweden	5 700	48 600	18 200	800	15 700
Switzerland	88 100	278 600	210 300	11 000	58 800
UK	28 000	243 700	106 400	4 200	93 100

37. CE Delft, 2018[26] provides aggregated damage unit costs for EU-28 (Figure 9) that also show that the highest damage per ton emission occurs from $PM_{2.5}$.

Figure 9: Damage from air pollutants in EU-28, high VOLY (source – CE Delft, 2018)[26].



D. North America

Total damage and % of GDP

38. Estimates of historical total annual damage from air pollution in the US and Canada vary within the range from €$_{2015}$ 145 billion to over 1000 billion (0.4-8% of GDP), depending on year, effects considered, and chosen valuation metrics (Table 4).

Table 4: Estimates for damage from air pollution in the North America, in billion €$_{2015}$.

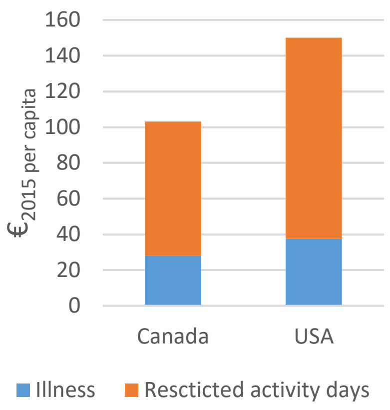
Country	Year	Damage	% of GDP	Included effects; chosen metric for valuation (if available)	Source
US	2010	150	1%	Mortality, morbidity; VOLY	Im et al., 2018[27]
US	2011	510	3%	Mortality; VSL	Goodkind et al., 2019[28]
US	2014	340	2%	AP3 IAM model	Tschofen et al., 2019[29]
US	2005	>980	>7%	Mortality, morbidity	Fann et al., 2012[30]
Canada	2008	6.7	0.5%	Mortality, morbidity	Canadian Medial Association, 2008[31]
Canada	2015	27	2%	Mortality and morbidity; VSL	Smith&McDougal, 2017[32]

Reduced labour productivity and other morbidity effects

39. The total annual costs of lost labour output in Canada are estimated to around €$_{2015}$ 570 million (Canadian Medical Association, 2008[31], Smith&McDougal, 2017[32]). This constitutes about 9% of the total economic costs of air pollution in 2008 (Canadian Medical Association, 2008[31]).

40. In the US and Canada, air pollution is calculated to result in the GDP decrease of ~0.1% in 2060 compared to a non-polluted situation due to reduced labour productivity (OECD, 2016[1,3]). Welfare costs of morbidity per capita in the North America in 2060 are projected to be around €$_{2015}$ 100-150 per year (Figure 10).

Figure 10: Welfare costs of morbidity in the US and Canada in 2060, based on OECD, 2016[1].



[27] Im, U. et al., 2018. Assessment and economic valuation of air pollution impacts on human health over Europe and the United States as calculated by a multi-model ensemble in the framework of AQMEII3. Atmos Chem Phys. 2018 April 27; 18(8): 5967–5989. doi:10.5194/acp-18-5967-2018

[28] Goodkind, A.L., Tessum, C.W., Coggis, J.S., Hill, J.D., Marshall, J.D., 2019. Fine-scale damage estimates of particulate matter air pollution reveal opportunities for location-specific mitigation of emissions. PNAS, April 2019, vol.116, no.18, p.8775-8780, www.pnas.org/cgi/doi/10.1073/pnas.1816102116

[29] Tschofen, P., Azevedo, I.L., Muller, N.Z., 2019. Fine Particulate matter damages and value added in the US economy. PNAS, October 2019, vol.116, no.40, p.19857-19862, www.pnas.org/cgi/doi/10.1073/pnas.1905030116

[30] Fann, N., A. Lamson, S.C. Anenberg, K. Wesson, D. Risley and B.J. Hubell, 2012. Estimating the national public health burden associated with exposure to ambient PM2.5 and ozone. Risk Analysis, 32:81-95

[31] Canadian Medical Association, 2008. No Breathing Room – National Illness Costs of Air Pollution

[32] Smith, R., McDougal, K., International Institute for Sustainable Development (IISD), 2017. Costs of air pollution in Canada – Measuring the impacts on families, businesses and governments

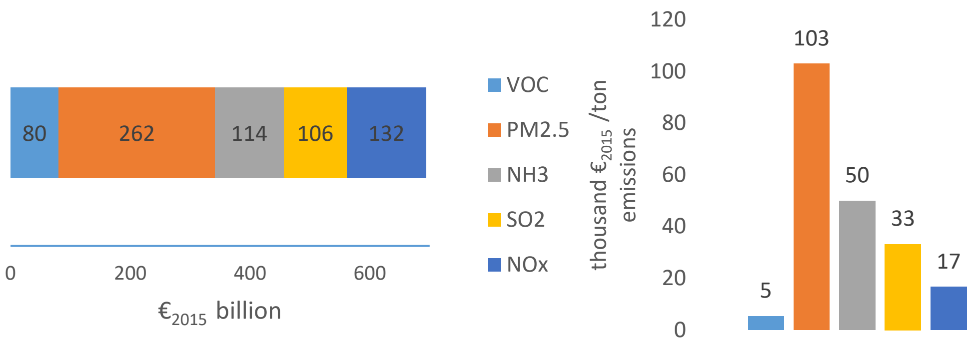
Damage to crops

41. The effects of the air pollution on crops are quite significant in the region. OECD projections[3] indicate that in the US, by 2060 agricultural production will go down by 4.9% due to air pollution – this is the largest impact on agriculture in the entire OECD, which, however, would not result in as large changes in GDP – the corresponding GDP decrease is projected at ~0.1%. For Canada, the GDP decrease due to effect on crops is estimated at ~0.05%, and damage to the agricultural sector – at 0.6%. Losses from reduced agricultural yields in Canada are estimated at €$_{2015}$ 68 million in 2015 (Smith&McDougal, 2017[32]).

Costs by sectors and pollutants

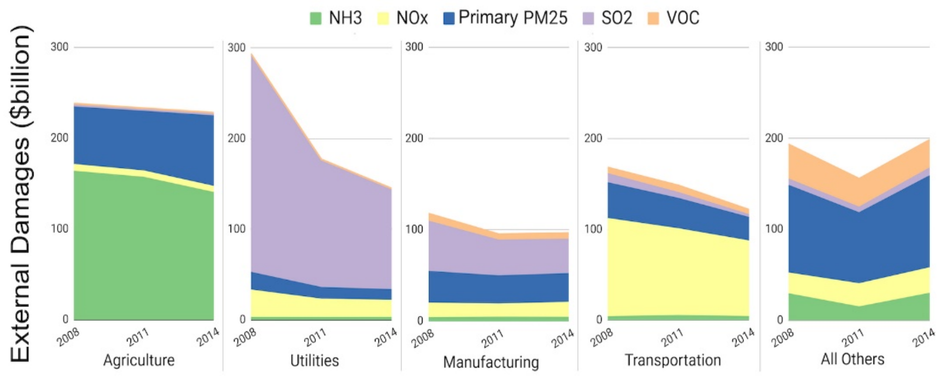
42. In the total costs of damage due to exposure to $PM_{2.5}$ in the US (Figure 11, left panel), primary emissions of $PM_{2.5}$ contribute about twice as much as contributions from secondary particles from NMVOC, NH_3, SO_x or NO_x emissions. Damage costs per unit emitted pollutant is highest for $PM_{2.5}$ as well (Figure 11, right panel).

Figure 11: Contribution of pollutants into the total damage from secondary $PM_{2.5}$ in the US in 2011 (left, Goodkind et al., 2019[28]) and damage costs per unit emissions in the US, as estimated in Tschofen et al., 2019[29] (right).



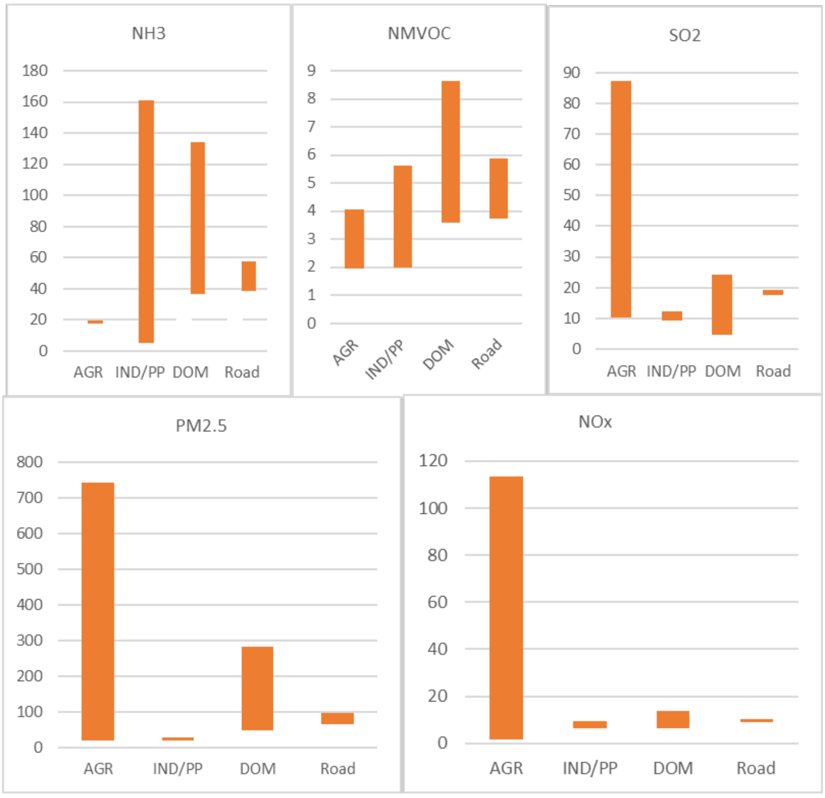
43. About 75% of the total damage from air pollution in the US is estimated to be caused by activities in four sectors responsible for less than 20% of GDP – agriculture, energy sector (utilities), manufacturing industries and transport (Tschofen et al., 2019)[29]. These sectors have different pollution profiles: from agriculture, a major part of the damage is caused by NH_3, in the energy sector and industries – by SO_x, and in the transport sector – by NO_x emissions (Figure 12).

Figure 12: Health damage from air pollution in the US, copied from Tschofen et al., 2019[29].



44. Intervals for sector-specific costs of these pollutants are summarized in Figure 13 – like in Europe, the highest unit damage is observed for $PM_{2.5}$, and the lowest – for NMVOC.

Figure 13: Sector-specific damage from air pollutants in the US, thousands €2015 /ton (sources – Goodkind et al., 2019[28], Schrader et al., 2018[33]). AFR – Agriculture, Road – road transport, Ind/PP – industries and energy, DOM – residential combustion.



45. The total damage costs from fossil fuel air pollution in the US are estimated to €2015 490 billion per year (Greenpeace, 2020[34]).

E. On a global scale

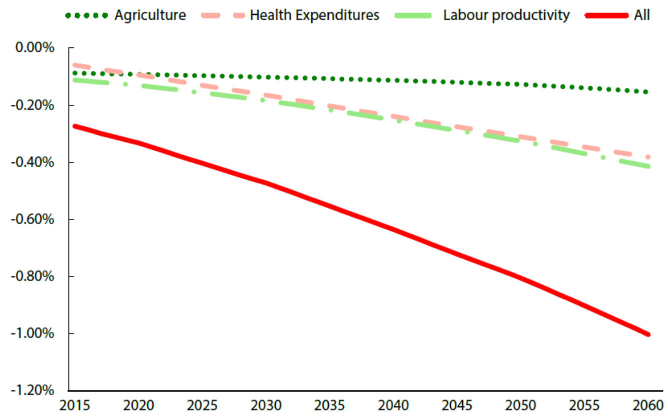
Total damage and % of GDP, reduced labour productivity and other morbidity effects

46. The recent study by OECD[1] estimates that by 2060, the annual welfare costs of premature mortality world-wide will increase from €2015 2.4 trillion in 2015 to around €2015 15-20 trillion in 2060. The total damage from pain and suffering from illness is estimated to rise from €2015 0.2 trillion in 2015 to €2015 1.8 trillion, the annual number of lost working days is expected to reach 3.7 billion, and healthcare costs – €2015 143 billion. Reduced labour productivity from air pollution is expected to cause a global GDP loss of 0.4%. The share of labour productivity effects on the total market effects of air pollution is estimated at ~40% (Figure 14). Non-market effects (costs of premature death and morbidity) exceed market effects by at least a factor 8 (OECD, 2016[1]). Given this relationship, the total share of labour productivity losses in the total air pollution-related damage can be estimated at 5-6%.

[33] Shrader, J., Unel, B., Zevin, A., Institute of Policy Integrity, New York University School of law, 2018. Valuing pollution reductions – How to monetize greenhouse gas and local air pollutant reductions from distributed energy resources

[34] Farrow, A., Miller, K.A., Myllyvirta, L., Greenpeace, 2020. Toxic air: The price of fossil fuels

Figure 14: Global market costs from air pollution, copied from OECD, 2016[1].



Damage to crops

47. The share of agriculture in the global GDP is relatively small – this is why global impact of air pollution on the agricultural output is not significant and corresponds to ~0.1% of GDP reduction in 2060 (OECD, 2016[1]).

Sector and pollutant contributions

48. The sector responsible for the largest contribution to the global health damage costs from air pollution are road transport, household fuel combustion, agriculture and industrial coal burning (WHO&OECD, 2015[12]). About 50% of the total health damage in OECD countries is due to pollution from road transport. In 2010, the damage cost from this sector is estimated at $€_{2015}$ 690 billion (OECD, 2014[35]). The global cost of air pollution from all fossil fuel combustion is estimated to $€_{2015}$ ~7 billion per day, or 3.3% of the world's GDP – a significant part of this damage occurs due to burning of fossil fuels in Bulgaria, Hungary, Ukraine, Serbia, Belarus, Romania (Greenpeace, 2020[34]).

VI. How much benefit do we get in the future from expected action?

A. How large economic benefits have we gained so far?

49. European air quality policies have resulted in a range of improvements during the past decades. For example, ammonia emission compliance with the National Emission reduction Commitments Directive (NECD) is estimated to result in $€_{2015}$ 14.6 billion in socio-economic benefits from avoided premature deaths in EU-28 in 2016 (VSL) (Giannakis et al., 2019)[36]. Estimates for the Netherlands show that in 2015, the avoided monetary health damage amounted to $€_{2015}$ 35 billion per year (VOLY), compared to the "no action 1980-2015" scenario. From this, 53% is attributable to emission reductions in the Netherlands, while almost half is due to emission reductions in other European countries – Germany, Belgium, UK, France, and others (Velders et al., 2020)[37].

50. In North America, the US Clean Air Act was estimated to result in annual benefits of $€_{2015}$ ~2 trillion – this is from avoided premature deaths (VSL), morbidity, damage to crops and materials and recreational values. From this, $€_{2015}$ 10 billion are benefits in the agricultural sector, and $€_{2015}$ 20 billion from reduced medical expenditures. The country's

[35] OECD, 2014. The Cost of Air Pollution – Health Impacts of Road Transport

[36] Giannakis, E., Kushta, J., Bruggeman, A., Lelieveld, J., 2019. Costs and benefits of agricultural ammonia emission abatement options for compliance with European air quality regulations, Environ Sci Eur (2019) 31:93, https://doi.org/10.1186/s12302-019-0275-0

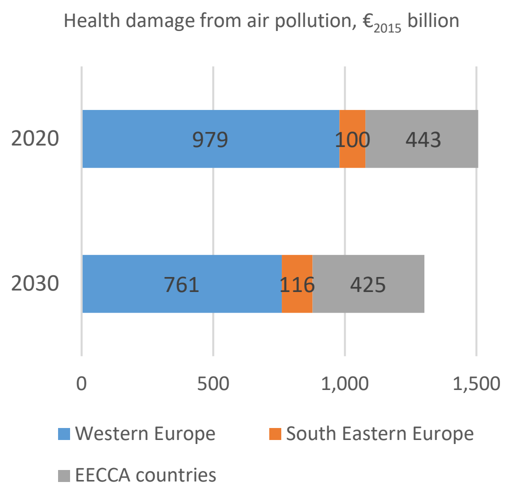
[37] Velders, G.J.M., Maas, R.J.M., Geilenkirchen, G.P., de Leeuw, F.A.A.M., Ligterink, N.E., Ruyssenaars, P., de Vries, W.J., Wesseling, J.,2020. Effects of European emission reductions on air quality in the Netherlands and the associated health effects. Atmospheric Environment 221 (2020) 117109, https://doi.org/10.1016/j.atmosenv.2019.117109

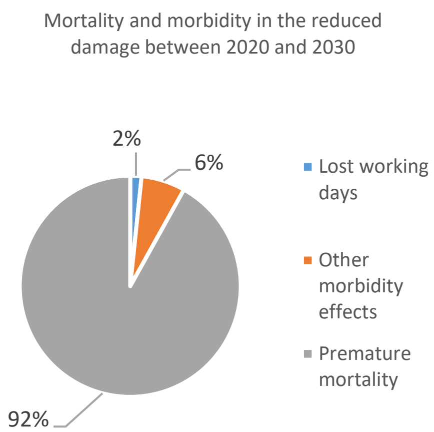
GDP growth due to the health effects of Clean Air Act implementation is estimated at 0.02% (US EPA, 2011[38]).

B. European countries – coming benefits from measures in place

51. Within Europe, trends for health damage from air pollution depend on the considered region. In the Western and Central Europe and in the EECCA countries the damage is expected to decrease in the next decade – the total annual benefits in 2030 are estimated at €$_{2015}$ 218 billion (~0.9% of current GDP, on average) and €$_{2015}$ 17 billion (~0.4% of current GDP), respectively, compared to the 2020 level (Figure 15). 2% of the gained benefits are due to increase in labour productivity, 6% - due to other morbidity effects, and 92% is attributable to avoided premature mortality. In the South Eastern Europe, the total damage trend is ascending – in 2030, air pollution is expected to cost €$_{2015}$ 16.5 billion more than in 2020. The total avoided annual health damage from air pollution within the EMEP domain in 2030 is estimated at €$_{2015}$ 219 billion (14%, in relation to the 2020 level).

Figure 15: Estimated health benefits in European countries from agreed actions reducing air pollution (own calculations based on the current legislation scenario in Amann et al., 2020[5]).

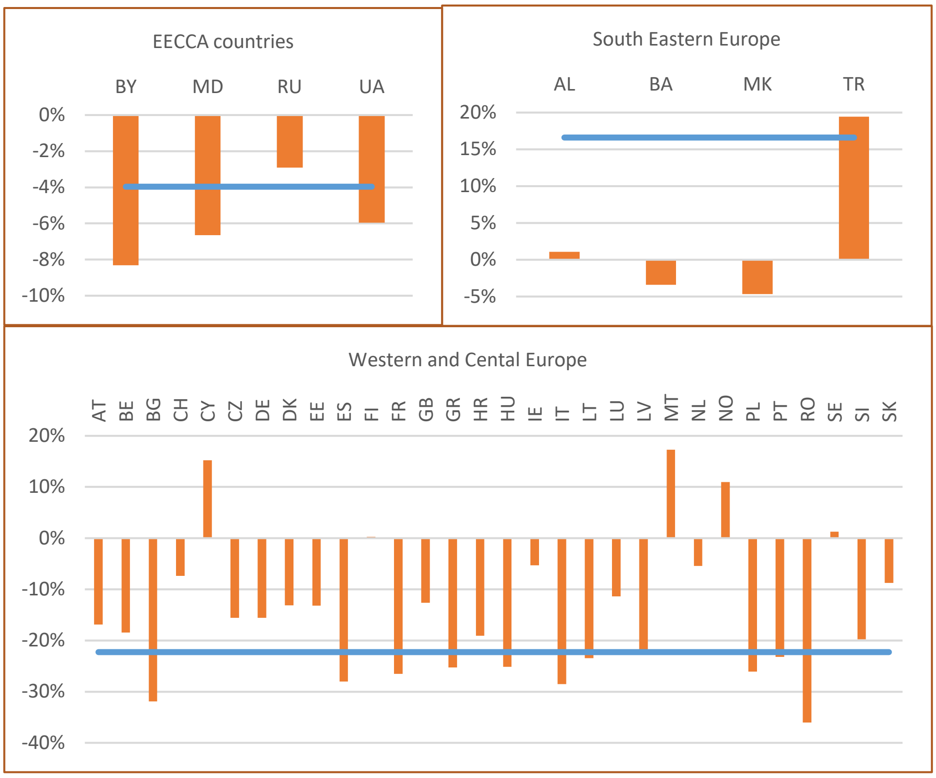




52. Some countries are expected to face total increase in total premature mortality by 2030 despite the actions to be taken to reduce emissions: quick population growth and aging are factors that in some cases overweight positive effects of emission reductions and improved air quality on the total health damage – this is especially pronounced for the South Eastern Europe where changing population structure in Turkey seem to result in the higher total health damage in 2030 than now (Figure 16).

[38] US EPA, Office of Air and Radiation, 2011. The Benefits and Costs of the Clean Air Act from 1990 to 2020

Figure 16: Variations in the baseline damage reduction in 2030, in % to the 2020 level (own calculations based on the current legislation scenario in Amann et al., 2020[5]). Blue line corresponds to the regional average.



53. IIASA's analysis for EU-27[5] shows that with already agreed measures, by 2050 the total damage from premature mortality due to exposure to $PM_{2.5}$ in is expected to decrease by 39%, compared to the 2020 level. Within the same period, deaths attributable to ground-level ozone will decline by 19%.

54. Existing policy measures in the transport sector are expected to bring significant benefits in the Western and Central Europe in the next decade – at about $€_{2015}$ 54 billion per year in 2030, compared to the 2016 level. In this avoided damage, about 91% is attributable to the health effects, and 9% are benefits from improved ecosystem services and prevented deterioration of buildings and materials (CE Delft, 2018)[22].

C. Air pollution and climate actions – what are the co-benefits?

55. Costs of technical air pollution measures and damage from air pollution could be reduced if air pollution legislation is enhanced by climate and energy policies. As a recent example, the Climate and Energy (C&E) framework adopted by the European Commission in 2014 is expected to result in reduced emissions of air pollutants by up to 10% in 2030, compared to the emission levels estimated in a previously used baseline scenario that did not consider the C&E framework. When considering the C&E framework, the air pollution abatement costs become 4% lower and the avoided damage costs 5% higher than in the previous baseline. IIASA[39] estimated that 27% of the health improvement target set by the European Commission for 2030 would be achieved through realization of the Climate and Energy framework scenario.

56. By comparing the projected damage reduction obtained in baseline scenarios with and without respect to the Climate and Energy Framework (CEP and REF scenarios in Amann et al., 2018[40]), we estimate that within the annual damage reduction expected to happen between 2020 and 2030, about 71% is due to the air quality legislation implemented

[39] Amann, M., Heyes, C., Kiesewetter, G., Schöpp, W., Wagner, F., IIASA, 2014. Air Quality – Complementary Impact Assessment on interactions between EU air quality policy and climate and energy policy

[40] Amann, M. et al., IIASA, 2018. Progress towards the achievement of the EU's air quality and emission objectives

before 2014, 8% - due to the EU Clean Air Policy Package, and 21% results from fuel shifts, reduced energy consumption and other measures to reduce greenhouse gas emissions.

VII. Can damage costs be further avoided in the future?

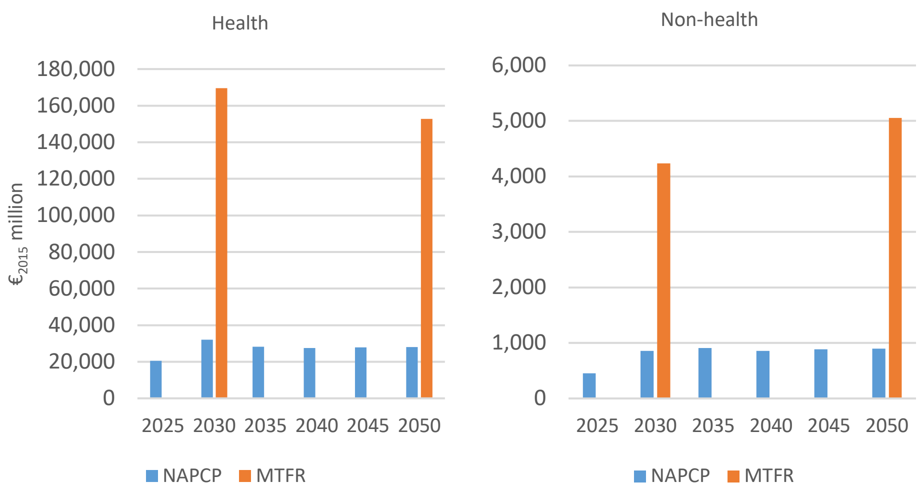
57. Legislation in place will reduce health damage in the near future – but more benefits can be gained by raising the ambition level.

58. OECD, 2020[41] estimates that a 1 µg/m³ decrease in annual $PM_{2.5}$ concentration in Europe would increase Europe's GDP by 0.8%. A 10% reduction in $PM_{2.5}$ average concentration across Europe would increase European GDP by $€_{2015}$ 93-185 billion, or $€_{2015}$ 185-370 per capita. About 95% of the total effect of $PM_{2.5}$ concentration on economic output is due to reduced labour productivity per worker.

A. EU-27 beyond the baseline

59. Recent analysis in the second Clean Air Outlook[5] shows that within the EU-27 implementation of measures in accordance with National Air Pollution Control Programmes (NAPCPs) would result in additional health benefits of about $€_{2015}$ 20-30 billion annually (Figure 17, left panel). In addition, the EU countries would gain about $€_{2015}$ 400-900 million each year from reduced negative effects of air pollution on crop yields. These are benefits achieved without excessive costs. If all technically feasible measures are applied irrespective of costs (scenario Maximum Technically Feasible Reduction, or MTFR) – the annual health benefits would reach $€_{2015}$ 153 billion in 2050, accompanied by $€_{2015}$ 5 billion in non-health benefits.

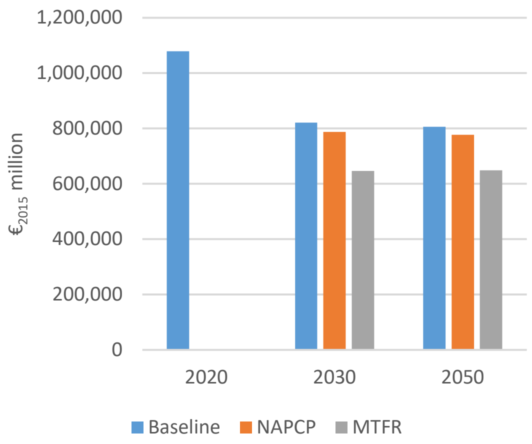
Figure 17: Total health and environmental damage in EU-27 (source – Amann et al., 2020[5]).



60. While baseline development will lead to 24% damage reduction in 2030, compared to the 2020 level, introducing NAPCP measures will mean 27% reduction, and applying all technically feasible measures – 40% reduction (Figure 18).

[41] Dechezleprêtre, A, Rivers, N., Stadler, B., OECD, 2020. The economic cost of air pollution: Evidence from Europe, Economic Department working papers No.1584

Figure 18: Avoided damage in EU-27 due to additional measures beyond the baseline scenario (source - Amann et al., 2020[5]).



61. In the EU transport sector, a faster uptake of zero emitting vehicles and a ban of pre-Euro 6 vehicles in all major cities would result in welfare benefits corresponding to $€_{2015}$ 5.2 billion per year in 2030 due to improved health, reduced mortality (VOLY), better crop yields and biodiversity. Making transport policies even more ambitious – ban of pre-Euro 6 vehicles on all roads, road pricing, urban policies to reduce car use in the cities – would bring $€_{2015}$ 10.5 billion in benefits (CE Delft, 2018[22]).

B. Potential benefits in Eastern and South Eastern Europe

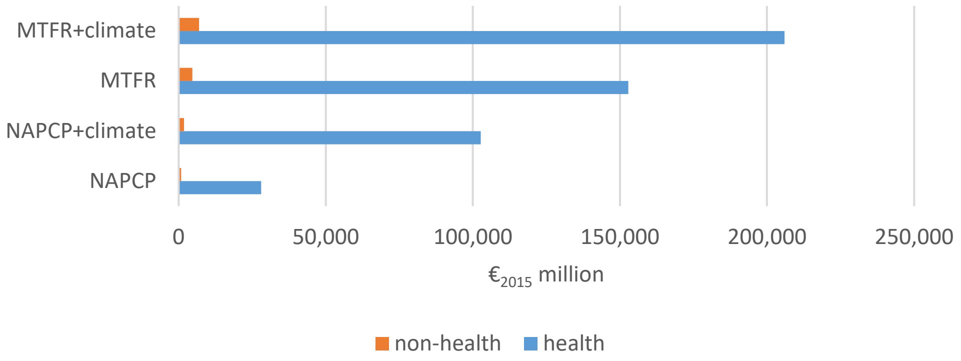
62. While within the EU air pollution reduction strategies have already brought benefits and reduced potential of additional reductions, in the Eastern and South Eastern European countries the emission reduction potentials are much higher. As an example, measures in the energy sector could result in 60% reductions of SO_2, in relation to the baseline emissions (Maas&Grennfelt, 2016[19]). During the revision of the Gothenburg Protocol in 2011, potential emission reductions in the EECCA and non-EU Balkan countries (MTFR scenario) in 2020 were estimated at 75% lower than baseline scenario emissions for $PM_{2.5}$, and 39% – for NO_x, with the resulting 43 million years of life gained (Amann et al., 2011[42]).

C. More co-benefits from climate action

63. Even greater benefits can be achieved if air pollution reduction measures are effectively combined with policies and measures targeting greenhouse gas (GHG) emissions, such as fuel transitions or behavioral changes reducing energy demand. The second Clean Air Outlook[5] indicates significant additional damage reductions (both health and other effects included) in EU-27 if air pollution reduction measures are applied on the 1.5 LIFE scenario of the EU 2050 climate strategy vision – $€_{2015}$ 76 billion for NAPCP measures, and additional $€_{2015}$ 55 billion – for MTFR in 2050 (Figure 19).

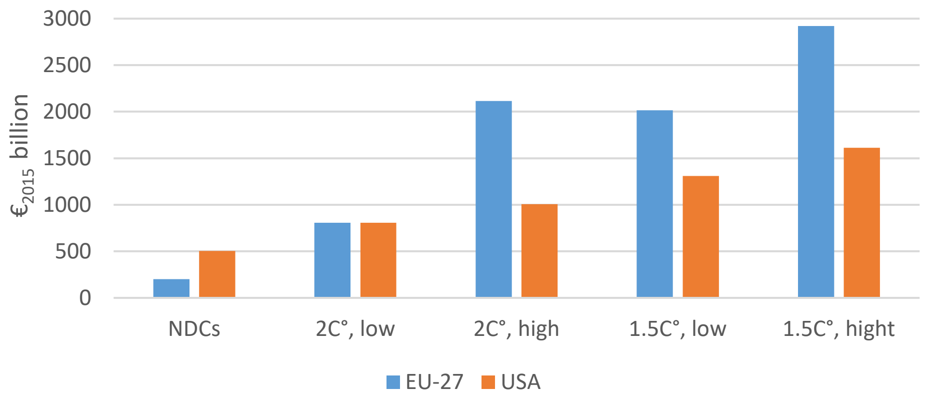
[42] Amann, M. et al., 2011. An updated set of scenarios of cost-effective emission reductions for the revision of the Gothenburg Protocol, CIAM report 4/2011

Figure 19: Damage Environmental and health benefits in EU-27 in 2050, based on Amann et al., 2020[5].



64. Health co-benefits from different ambition levels of climate policies provided in Markandya et al., 2018[43] show that while current Nationally Determined Contributions (NDCs) would result in $€_{2015}$ 200 billion lower damage in Europe (cumulative over the period 2020-2050), a 2°C target implies $€_{2015}$ 800 – 2100 billion health co-benefits, and with the target of 1.5°C – $€_{2015}$ 2000-2900 billion health damage can be avoided by climate policy. For the US, health co-benefits are estimated at $€_{2015}$ 500 billion with current NDCs, and up to $€_{2015}$ 1600 billion – with higher ambition levels of climate policy (Figure 20).

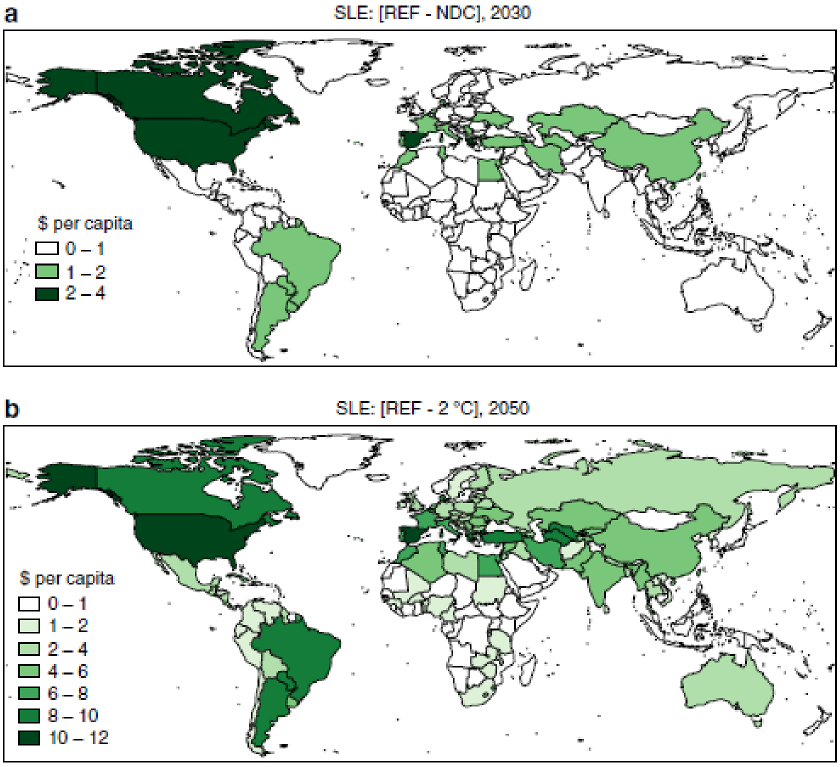
Figure 20: Cumulative health co-benefits (VSL) from climate policies 2020-2050, based on Markandya et al., 2018[43].



65. Effective climate policies bring co-benefits from crop yields as well. Crop productivity improvements per capita resulting from NDCs and the 2°C target are the highest in the Western part of the UNECE region – in particular, the US and Canada, and in certain European countries such as Portugal (see Figure 21).

[43] Markandya, A., Sampedro, J., Smith, S.J., Van Dingenen, R., Pizarro-Irizar, C., Arto, I., Gonzales-Eguino, M., 2018. Health co-benefits from air pollution and mitigation costs of the Paris Agreement: a modelling study, Lancet Planet Health 2018; 2: e 126–33

Figure 21: Crop yields co-benefits from climate policies, copied from Vandyck et al., 2018[44]. Upper panel – difference between reference scenario and NDC in 2030; lower panel – difference between reference scenario and 2° reduction scenario in 2050.



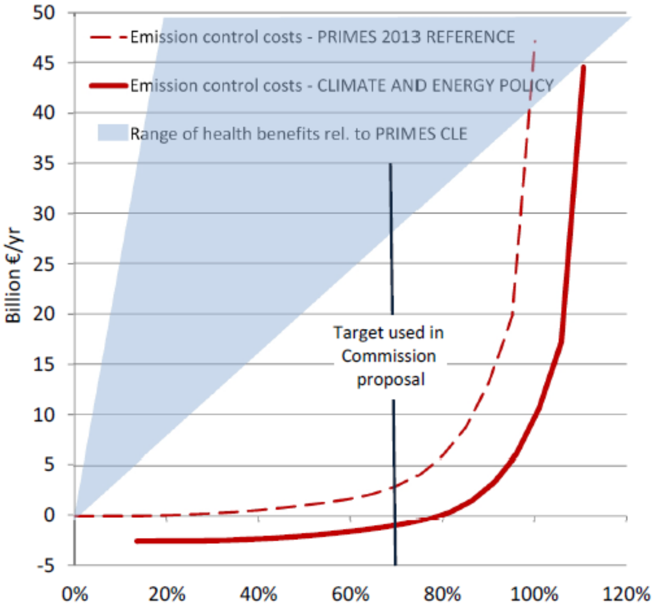
VIII. Are the avoided costs of inaction larger than emission control costs?

66. Several previously performed cost-benefit analyses supporting policy decisions in the UNECE region indicated that significant part of potential emission reductions can be done at costs that are lower than benefits gained from improved air quality. For instance, welfare benefits from the Clean Air Act implemented in the United States are estimated to be more than 30 times higher than implementation costs (US EPA, 2011[38]).

67. According to the cost-benefit analysis (CBA) of final policy scenarios for the EU Clean Air Package (Holland et al., 2014[16]) annual net health benefits from the suggested national emission ceilings range from $€_{2015}$ 42 to 164 billion in 2030, at costs around $€_{2015}$ 4 billion. This means that benefits are about 10-40 times higher than costs. Considering the Climate and Energy framework that implies lower abatement costs and larger benefits (Figure 22), the benefit-to-cost ratio and the net benefits at the same ambition level are even higher.

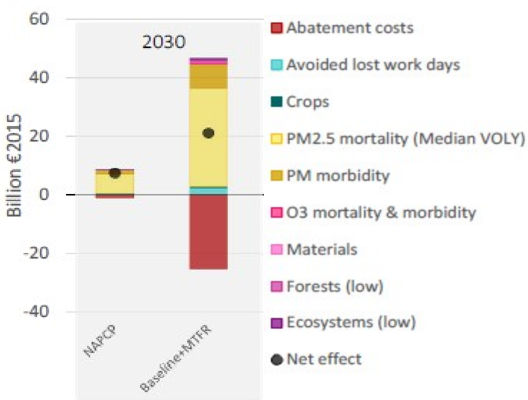
[44] Vandyck, T., Keramidas, K., Kitous, A., Spadaro, J.V., Vad Dingenen, R., Holland, M., Saveyn, B., 2018. Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges, NATURE COMMUNICATIONS | DOI: 10.1038/s41467-018-06885-9

Figure 22: Costs and benefits of different ambition levels of air pollution policies (100% corresponds to full implementation of all possible air pollution measures on top of the PRIMES 2013 reference economic scenario), in €2005. Copied from Amann et al., 2014[39].



68. The latest assessment of costs and benefits from potential additional policy measures in EU-27 (Amann et al., 2020[5]) concludes that annual net welfare benefits (VSL) from the NAPCP measures in 2030 would account to €$_{2015}$ 31 billion while the full implementation of technical measures would result in the net benefits of €$_{2015}$ 146 billion. Benefits are estimated to be ~25 times higher than costs in the NAPCP scenario, and ~7 times higher – in the MTFR scenario where the costs are also high. The further analysis of macro-economic effects also shows that total benefits are higher than abatement costs (Figure 23).

Figure 23: Welfare costs Cost-benefit assessment for the EU-27 relative to the baseline. Copied from Amann et al., 2020[5].



69. The average costs of an optimal air pollution strategy are 0.01–0.02% of GDP (Maas&Grennfelt, 2016)[19] – this could be compared to the ~5% of GDP that air pollution welfare damages correspond to in the Western and Central Europe.

70. Cost of action could be compared to cost of inaction also for specific pollutants, industries or facilities. Recent analysis of steel industry in Europe (Scarbrough et al., 2019[45]) indicates that measures assuring Best Available Techniques conclusions (BATC) compliance

[45] Scarbrough, T., Sykes, J., Anderson, N., Madzharova, G., Birchby, D., Holland, M., Wiesenberger, H., Duerinck, J., Pribylova, M., 2019. Ex-post assessment of costs and benefits from implementing BAT under the Industrial Emissions Directive. Final Report for the European Commission – DG Environment, ED 10483, Issue Number 7

in the sector would bring benefits that are 3.3-14 times higher than costs. Costs of action to abate ammonia are compared to the avoided damage in the TFIAMs recent Assessment report on ammonia[46] – the comparison show that benefits (17.5 $€_{2015}$/kg, as in CE Delft, 2018[26]) are 1.2-4.4 times higher than costs (4-15 $€_{2015}$/kg, as in Wulf et al., 2017[47]).

71. Through analysis of costs and benefits at the facility level, decision-makers could make use of the estimated damage costs per ton pollutant, available for all the European UNECE countries. Comparing avoided damage costs and comparing with costs of suggested technical solutions, as illustrated in the example given in Box 3, could provide justification of investment decisions resulting in emission reductions beyond the levels required by law.

Box 3: Air Cost of action vs Cost of Inaction at the level of facilities

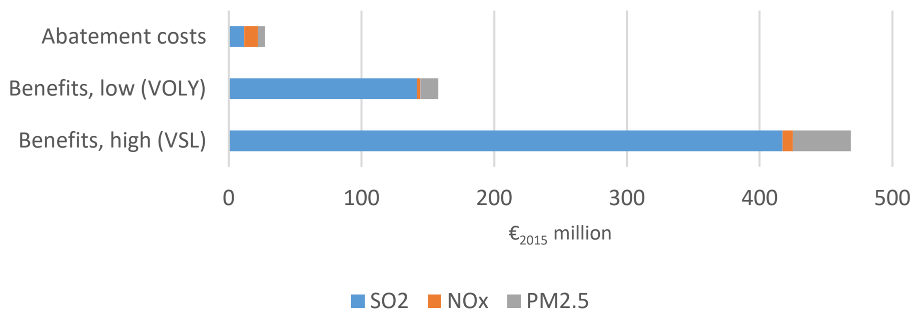
Case study of the Apatity coal plant

The Apatity combustion plant in North-Western Russia (1530 MWth thermal output) is in operation since 1959, using coal as main fuel to produce heat and power. Expert group on Techno-economic Issues (EGTEI)[1] estimated annual abatement costs of installing equipment to reduce emissions of SO_2, NO_x and TSP – with wet flue gas desulphurisator, selective catalytic reduction, and electrostatic precipitator, respectively (see Table 5). Costs of avoided damage to health, crops and materials due to these abatement techniques are estimated by applying country-specific unit damage costs as in Schucht et al., 2021[2] (see Table 5 for high VSL) – the range is from $€_{2015}$ 158 million to $€_{2015}$ 469 million, depending on the chosen metric for health valuation. Irrespective of whether VSL or VOLY is chosen, total benefits from avoided damage significantly exceed costs. The total annual costs are estimated at $€_{2015}$ 27.4 million, so the benefit-to-cost ratio lies between 6 and 17 (see Figure 24).

Table 5: Parameters used for calculation of costs and benefits of installation of cleaning technologies at Apatity coal plant, based on EGTEI, 2011[1], Schucht et al., 2021[2], and GAINS model scenarios as in Amann et al., 2020[3].

Pollutant	Emissions in 2008/2010, kt	Removal efficiency of equipment, %	Removed emissions, kt	Abatement costs, $€_{2015}$ million	Avoided damage, $€_{2015}$ million	
					Low VOLY	High VSL
TSP	6.23	99.9%	6.18	5.3	-	-
$PM_{2.5}$	0.37	96%	0.36		13	44
NO_x	2.4	75.4%	1.8	10.5	2.7	7.9
SO_2	12.6	95.4%	12.0	11.6	142	417
Total	-	-	-	27.4	158	469

Figure 24: Costs and benefits of installation of cleaning technologies at Apatity coal plant, based on EGTEI, 2011[1] and Schucht et al., 2021[2].



[1]Data EGTEI, 2011. Apatity combustion plant – SO2, NOx and TSP emission reduction cost abatement, provisional report

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IX. Closing remarks

72. Economic valuation of air pollution provides useful information on damage costs (socio-economic welfare losses) of air pollution and thereby enables direct comparisons of economic activities with environmental and human health effects. It also enables valuation of reduced damages/increased benefits of further emission reductions. Or, in the case when available solutions are available but not implemented, the damage costs of inaction.

73. The damage cost approach is a useful tool to assess unintentional welfare effects of new infrastructure investments or installations but requires further development. To support decisions on new projects or permits, several countries apply damage costs per unit of emission, to quickly scan the potential additional damage to health and ecosystems from those activities and to decide if additional air pollution measures are required and proportional. Often these assessment tools only look at local or national damage, while (avoided) transboundary damage is omitted. Other important omitted damages are damages on biodiversity. A comprehensive assessment would require including all external effects, including transboundary impacts. There are also considerable information gaps between the eastern and western parts of the UNECE region, especially with respect to valuation studies made by East-European research groups and scenarios for future air pollution levels in Eastern Europe.

74. The welfare costs of air pollution is today substantial. For almost half of the countries in the UNECE region, the aggregated damage costs correspond to ~5% of GDP. Future scenarios are foremost available for Western Europe. Through existing policies, the monetary damage in Europe is be expected to be 14% lower in 2030 than today. Of the European damage costs expected to remain in 2030, 21% can be removed through additional policy actions. In most cases, the costs reducing emissions are far lower than the corresponding reduction of damage costs. As an example, the benefits of the national air pollution control programmes in the EU-27 are more than 20 times higher than the emission control costs.

75. It is important to continue efforts to improve the coverage of the values included in valuation studies, and there is a need for more assessments of current and future sector-specific marginal damage costs, especially for Eastern and South Eastern Europe.