Synergies and interactions with other policy areas

At its forty-first session, the Executive Body endorsed the request of the WGSR at its fifty-ninth session, for the Gothenburg Protocol Review Group to prepare an informal document on synergies with other policy areas. In particular the focus was to be on air-climate synergies to inform consideration of methane in a future instrument, and requested that the pollutants covered in the informal document should include methane, black carbon, and nitrogen compounds. GPG prepared this document with the support of TFIAM, HTAP, CIAM and TFRN.

I Introduction

1. There are several synergies and interactions of air pollution policy with *inter alia* energy and climate policies, and agricultural and food policies. Reducing the use of fossil fuels, of transport volumes or of meat and dairy consumption would give multiple benefits among others for health and ecosystems. There can also be trade-offs: when policy is focussed on one environmental goal only, this could worsen the situation in other areas. For example, substitution of fossil fuels by biomass could increase air pollution related health risks and increase the loss of biodiversity. Also, the use of carbon capture and storage could be a potential source of additional emissions of air pollutants. An approach tackling climate change and air quality challenges simultaneously could effectively address such trade-offs.

What types of synergies can be distinguished?

i. A pollutant has multiple effects; for example, methane is both a greenhouse gas and is a precursor to ozone, which harms human health and damages crops and natural vegetation.

ii. A specific emission control strategy reduces multiple pollutants; for example, reducing fugitive emissions from leaking natural gas production infrastructure reduces both methane and VOCs.

iii. A change in the energy system leads to a cascade of emission reductions across multiple sectors; for example, deploying electric vehicles also reduces emissions from petroleum production, refining, and distribution sectors.

iv. A change in practices could lead to changes in biogeochemical cycles that enhance carbon storage and sequestration, for example, shifting away from uncontrolled agricultural burning would improve air quality and increase carbon storage in soils.

II Climate and air quality synergies

2. CIAM calculations indicate that full implementation of climate policies and measures could offer substantial and cost-effective emission reductions of air pollutants covered by the Gothenburg Protocol. Such measures would make attaining air quality and ecosystem protection targets more likely.

3. The goals and priorities announced in the European Green Deal, including zero pollution ambitions, provide an incentive to develop policies cutting greenhouse gas and air pollutants emissions simultaneously. Further promotion and improvement of energy efficiency standards in housing and industry sectors, reducing reliance on fossil fuels and policies towards circular economy are among actions leading to climate and air quality benefits.

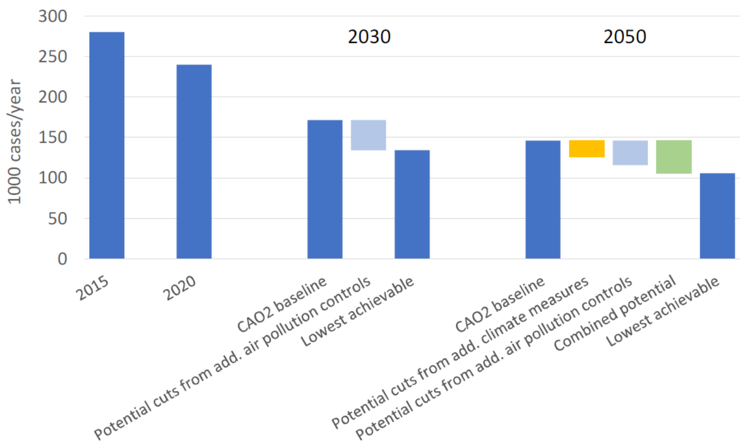


Figure 1: Illustration of co-benefits from additional climate measures (orange) for premature deaths due to PM2.5 exposure in EU27 (COM(2021) 3 final[1])

4. Mitigation of agricultural emissions plays an important role in achieving climate, air quality, and ecosystem protection targets. Significant synergies have been identified for measures addressing emissions of methane and ammonia, including dietary changes towards lower meat protein consumption. Policies addressing improved nitrogen use efficiency are estimated to bring reductions of ammonia, nitrogen oxides, nitrous oxide, and even carbon dioxide from fertilizer production, owing to lower demand for mineral nitrogen fertilizers. As livestock farming is an important source of methane emissions, methane abatement measures should be aligned with measures to reduce nitrogen emissions. Not all measures would work in the same direction. For example, biogas facilities typically require additional (to manure) sources of organic material and the digested slurry has an elevated pH and higher ammonium content, therefore could lead to higher ammonia emissions if no additional ammonia mitigation measures are taken (e.g., EI-AGI Focus Group, 2017[2]).

5. Some of the policies attractive from a climate mitigation perspective are associated with potential trade-offs that need to be evaluated carefully. An example is the promotion of biomass in residential heating and in the power sector. While effective technology to reduce PM2.5 emissions from biomass combustion exist, the particulate matter emissions are larger than when burning, for example, gas. It is essential to minimize these emissions while at the same time setting path towards cleaner energy sources, such as solar electricity. Furthermore, depending on the source of biomass, its carbon neutrality as well as carbon dioxide emissions associated with production and transport should be considered.

6. Reducing air pollution has an impact on radiative forcing and consequently on surface temperatures. E.g. sulfur has a cooling effect. To limit the effects of air pollution policy on climate change, a balanced approach is needed, which will mean a focus on reducing emissions of air pollutants that have a warming effect, such as black carbon and ozone precursors**.** Methane reduction plays a key role in reaching synergetic effects, as methane is both a greenhouse gas and an increasingly important determinant of ozone formation.

7. Measures addressing sulfur dioxide emissions, e.g., from poorly abated power and industrial sources burning coal still in operation in West Balkan and some EECCA countries, will result in air quality improvements, but result in additional near-term warming (owing to cooling role of sulfate in the atmosphere). Therefore, it is of high importance to promote measures addressing simultaneous mitigation of carbon

[1] https://ec.europa.eu/environment/air/clean_air/outlook.htm
[2] https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_fg_livestock_emissions_final_report_2017_en.pdf

dioxide by energy efficiency improvements and increasing the share of clean energy sources[3]; this will also result in additional methane mitigation.

8. Moreover, it is worthwhile to mention that the introduction of climate policies reducing fossil fuels use and addressing agriculture will lead to reduced costs of air pollution control (e.g., Rafaj et al, 2018[4]). And health co-benefits could significantly compensate for the climate mitigation costs (e.g., Markandya et al., 2018[5], Vandyck et al., 2018[6]).

9. A wide-spread attainment of recently announced air quality guidelines by the World Health Organization[7], which set more ambitious health protection goals than before, appears to be only possible when the technology and policy synergies addressing climate, air quality, and ecosystem protection are explored.

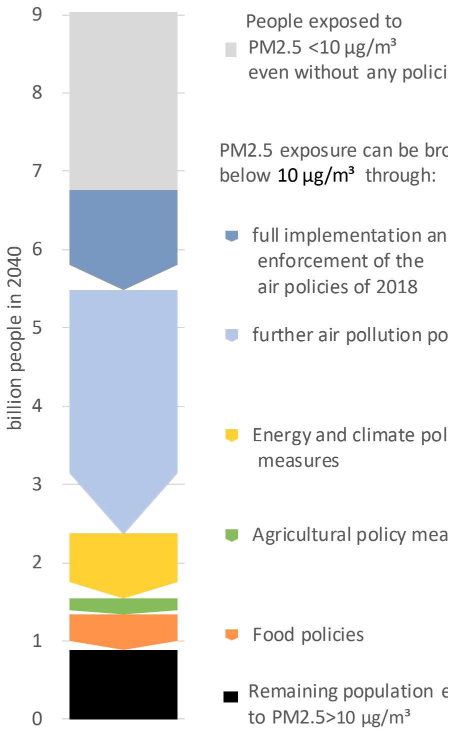


Figure 2: Contribution of various measures to the reduction in global population exposed to higher PM2.5-concentations than 10 µg/m³ (WHO 2005 air quality guidelines) from anthropogenic sources in 2040. Energy and climate measures in orange, agricultural measures and food policies in green and pink. (Amann et al., 2020[8])

III Methane

10. Global methane emissions are an important contributor to ground-level ozone concentrations. Figure 3 illustrates the contribution of NOx and reactive carbon sources (including global anthropogenic and natural methane emissions) to annual average ozone for different world regions (Butler et al., 2020).[9] These results are consistent with the findings of Van Dingenen et al. (2018),[10] who estimated that global anthropogenic methane emissions contributed between 9% to 16% of the highest 6-monthly mean of daily maximum 1-hour average (6mDA1) ozone concentration in Europe.

[3] https://www.iea.org/reports/recommendations-of-the-global-commission-for-urgent-action-on-energy-efficiency
[4] https://doi.org/10.1016/j.gloenvcha.2018.08.008
[5] https://doi.org/10.1016/S2542-5196(18)30029-9
[6] https://doi.org/10.1038/s41467-018-06885-9
[7] WHO Global Air Quality Guidelines. WHO. 2021
[8] http://dx.doi.org/10.1098/rsta.2019.033 1
[9] https://doi.org/10.5194/acp-20-10707-2020
[10] https://doi.org/10.2760/820175

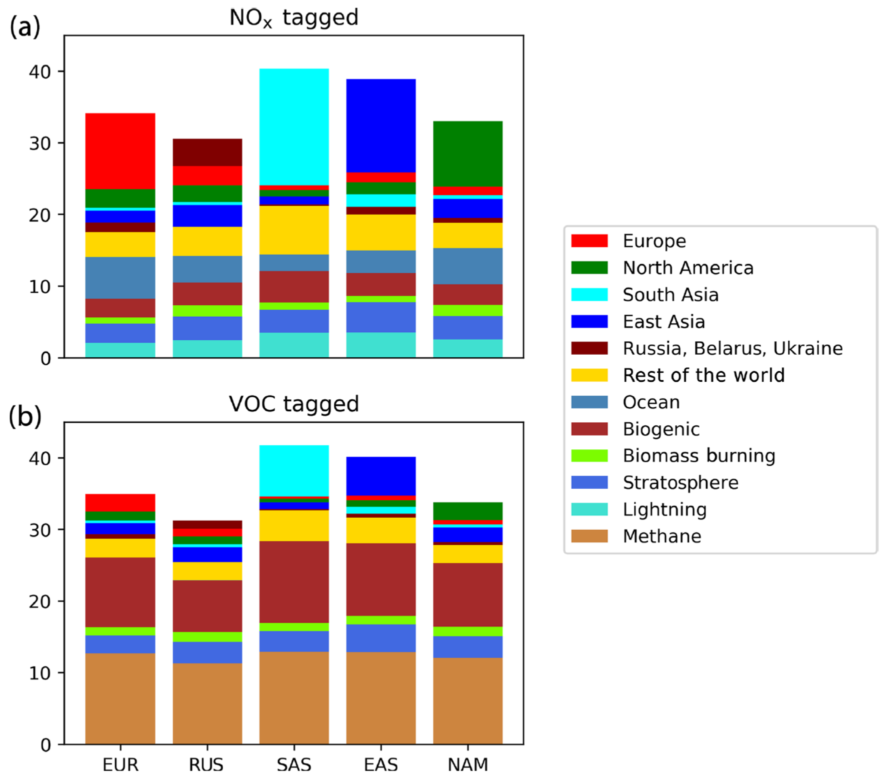


Figure 3. Source–receptor relationships for annual average surface ozone (ppb) in major Northern Hemisphere regions: EUR (Europe), RBU (Russia, Belarus, and Ukraine), SAS (South Asia), EAS (East Asia), and NAM (North America) as defined in the HTAP2 experiments (Galmarini 2016). The attribution relates the annual average surface ozone modelled in each region to the emitted precursors – NOx (a) and reactive carbon (b) – from all HTAP Tier 1 regions. (Based on Figure 4 in Butler et al., 2020.)

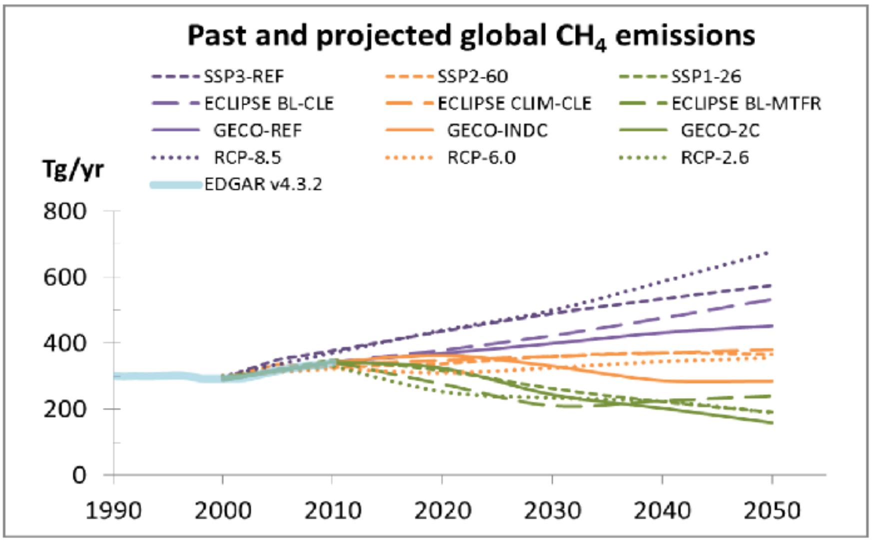
[11] van Dingenen et al., 2018). Furthermore, additional NOx emissions control, including for maritime shipping, will also decrease the contribution of methane to global background ozone concentrations (Butler et al. 2020).

11. Turnock et al. (2018)[12] found that annual average surface ozone concentrations in 2050 in Europe and North America are expected to be relatively similar to 2010 under a current legislation scenario, despite strong decreases in regional NOx emissions within those regions. In both Europe and North America, the contribution of extra-regional sources of non-methane precursors outside the region does not change much, but an expected increase in global methane concentrations offsets the decreases in surface ozone due to NOx and NMVOC controls within those regions. Under a climate policy scenario, methane emissions are decreased, as is methane's contribution to ozone concentrations. Climate policies are also expected to decrease some sources of NOx and NMVOC in North America, Europe, and elsewhere. Under a maximum technically feasible scenario, the contributions of NOx and NMVOC sources within the UNECE and outside the UNECE, as well as methane sources globally, are all decreased. Under this scenario, the largest ozone benefits in Europe

[11] https://doi.org/10.1029/2008JD010816
[12] https://doi.org/10.5194/acp-18-8953-2018

and North America come from the control of NOx and NMVOC sources outside these regions.

12. Most business as usual or current legislation scenarios assume a further increase of global methane emissions (see the violet projections in figure 5). Scenarios that include additional policies project a decline with 30-50% compared to the 2015 level (see the green lines).



Source: JRC elaboration of emission data

13. The main anthropogenic sources of methane emissions are agriculture, fossil fuel production and distribution, and waste management (see figure 6). In Europe, livestock is the largest source; in North America oil and gas, agriculture and landfill waste are the main sources of methane emissions, and in Russia it is oil and gas operations.

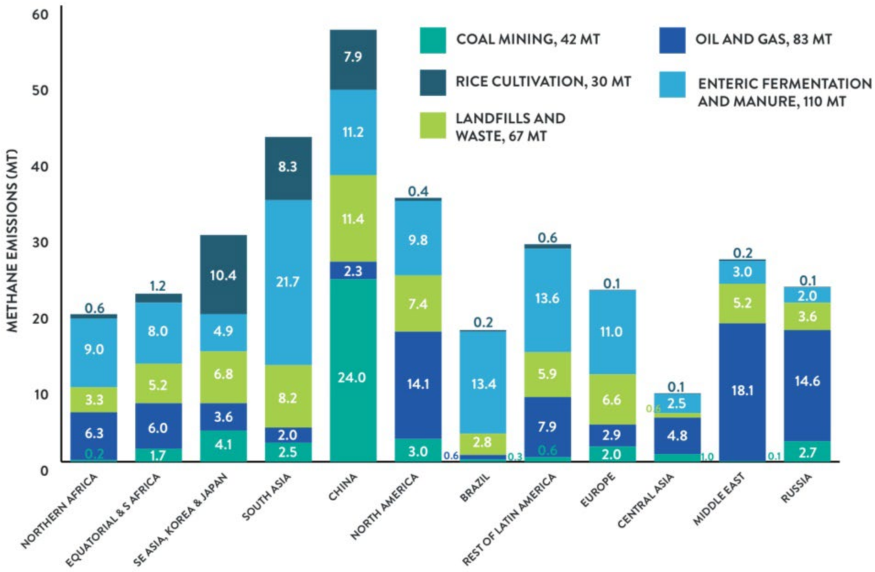


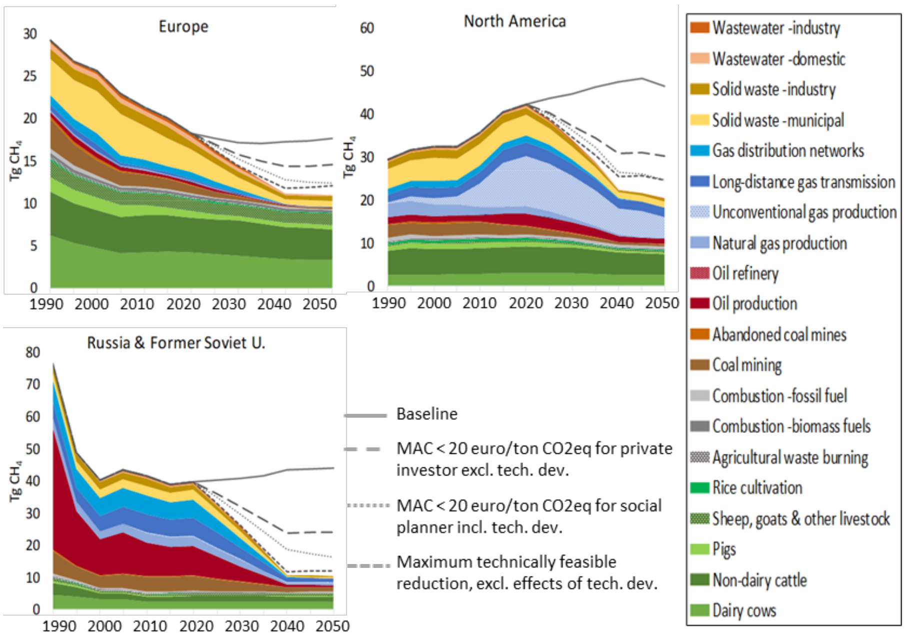
Figure 2.6 Estimated annual sectoral methane emissions by region and global sector totals, excluding Oceania, 2017, million tonnes

Source: Saunois et al. (2020).

UNEP, Global Methane Assessment, 2021)

Click here to enter text.

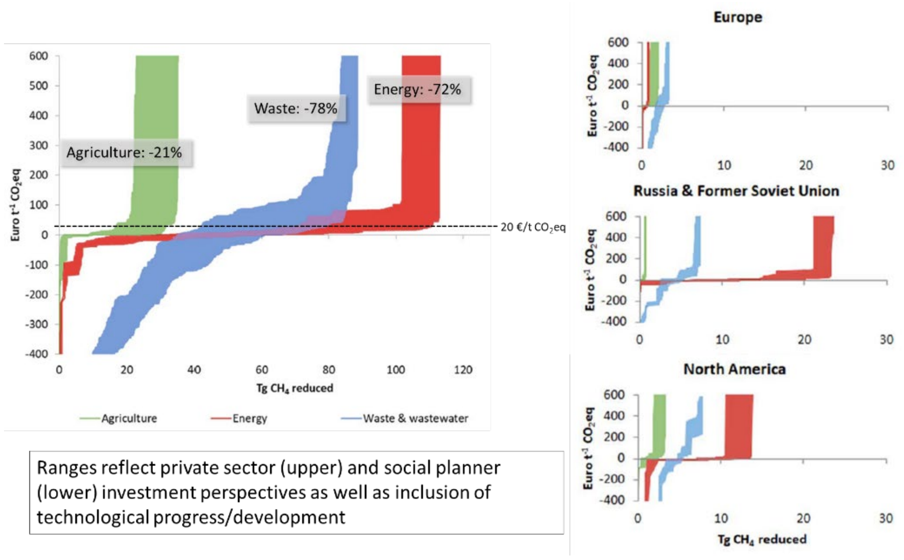
14. The methane mitigation potential, and respective air quality and ecosystem synergies vary across the UNECE countries owing to the structure of methane sources, i.e., compared to the projected baseline emissions in 2050, they vary from about 30% in Europe to potentially as high as 50% in North America, and over 50% in Russia and some of the EECCA countries. Waste management sector offers largest potential in Europe, while fossil fuel production and distribution (mostly oil and gas) emissions represent larger share of emissions in Russia, North America, and some EECCA countries representing major mitigation opportunities (see figure 7). The estimate of the mitigation potential for the oil and gas sector is lower in the EPA assessment (US EPA, 2019),[13] about 46% globally compared to 79%, owing to different assumptions about emissions from unconventional gas production than in Höglund-Isaksson et al. (2020) [14].



15. A significant cost neutral as well as low cost (< 20 €/ton CO_2eq) mitigation potential for methane is identified primarily for fossil fuel production as well as to some extent waste management. An important factor determining the size of that potential is also consideration of investment perspective (social planner versus private sector using different interest rates) and assumptions about the technological progress (see figure 7 and 8).

[13] https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases

[14] Höglund-Isaksson et al. (2020). Technical potentials and costs for reducing global anthropogenic methane emissions in the 2050 timeframe –results from the GAINS model. Environ. Res. Commun. 2 (2020) 025004 https://doi.org/10.1088/2515-7620/ab7457,



16. In order to reduce methane emissions from livestock, less technological options are available. Here, behavioural change leading to less (over-) consumption of meat and dairy products could offer synergetic impacts on health, climate, ozone formation, as well as nitrogen pollution.

17. The Global Methane Assessment (UNEP 2021)[15] estimates that all technical abatement measures, combined with changes in food patterns could reduce global methane emission by 45%, contribute significantly to efforts to limit global warming to 1.5 degrees, and avoid 255.000 ozone related premature deaths. Also hospital admissions, lost work hours and crop losses would be reduced. (Recently, many countries have joined the Global Methane Pledge to reduce methane emissions by 30% from 2020 levels by 2030. A 30% reduction in UNECE emissions would include 25 Mt CH_4 and lead to 3,600 fewer premature respiratory-related mortalities within the UNECE region and 18,000 fewer globally. (see Table 1). Additional benefits may include reduction in cardiovascular related mortalities, hospitalizations, and asthma-related emergency department visits. Note that these estimated health benefits are larger than those developed in a recent JRC report, Global trends of methane emissions and their impacts on ozone concentrations (van Dingenen et al., 2018), due to updated epidemiological evidence linking ozone exposure and health effects. Finally, some methane emission sources, such as natural gas production and landfills, also emit volatile organic compounds that can increase local ozone production. Methane emission controls could also reduce these VOC emissions, leading to larger, local ozone-related health benefits.

[15] Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions | UNEP - UN Environment Programme

Table 1. Reduction in respiratory-related mortalities by region due to a 30% reduction in methane emissions in the UNECE region. These estimates are calculated using health benefits per ton of methane emission reduction, provided by the Global Methane Assessment (2021).

EECCA	215
UNITED KINGDOM	390
RUSSIA	270
REST OF EUROPE	1,700
U.S. AND CANADA	1,200
ALL UNECE	3,600
GLOBALLY	18,000

18. At its sixtieth session, the Working Group on Strategies and Review is expected to discuss the need, best approach and potential options to address methane in a future instrument: e.g., if and how to include methane in the Gothenburg Protocol, which emission sources to focus on, and how to link with the Forum for International Cooperation on Air Pollution, the UNFCC, the Climate and Clean Air Coalition (CCAC), and the Global Methane Initiative (GMI). The European Union will also explore the possible inclusion of methane among regulated pollutants in the review of the NEC Directive (due by 2025).

IV Black Carbon

19. Black carbon has multiple environmental effects. It contributes to health effects associated with $PM_{2.5}$ and it absorbs light and heats the atmosphere, contributing to global warming. When deposited onto ice and snow, it accelerates melting - a significant issue in the Arctic and mountain glaciers. Emission scenarios that stabilize global warming at 1.5° C include global black carbon emission reductions of 40-60 per cent by 2030. Black carbon is co-emitted with other particles that reflect light and contribute to cooling. Because black carbon is emitted in population centres, it contributes to highly localized air quality issues. The Convention intends to coordinate with the Artic Council and the CCAC to develop the best strategy to address black carbon. Sources of black carbon emissions are also associated with emissions of NO_x and ammonia (e.g. from low efficiency combustion of biomass and coal residential sector, older diesel vehicles and ships and 'ammonia slip' from selective catalytic reduction technology installed in industry and in trucks and cars in order to reduce NO_x-emissions). Therefore, strategies to reduce black carbon emissions can be expected to offer co-benefits in reducing nitrogen air pollution.

20. Black carbon is one of the components of PM2.5. Tackling PM2.5 emissions would in many cases also reduce black carbon (elemental carbon) emissions and emissions of organic carbon. As PM2.5 emissions from some sectors contain more black carbon than others, the synergetic effects would be larger if PM2.5 reduction is focussed on domestic heating, road transport, non-mobile machinery, ships, waste treatment or agricultural residue burning (see figure 9) and the document on prioritizing reductions of particulate matter from sources that are also significant sources of black carbon ECE_EB.AIR_2021_6-2113500E.pdf (unece.org)

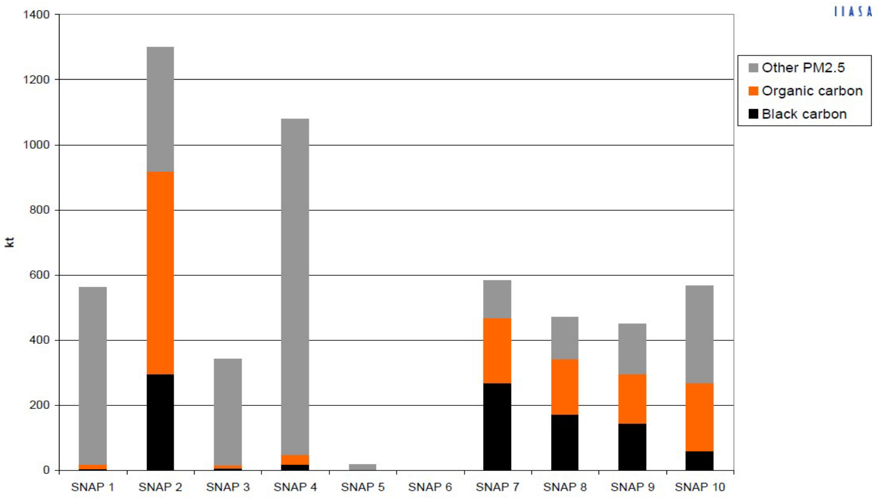


Figure 9:: Modelled emissions of PM2.5/BC/OC in the UNECE area in 2005 (Klimont 2011). SNAP 1: combustion in energy and transformation industries, *SNAP 2: non industrial combustion plants, including domestic heating*, SNAP 3: combustion in manufacturing industries, SNAP 4: production processes, SNAP 5: extraction and distribution of fossil fuels and geothermal energy, SNAP 6: solvent and other product use, *SNAP 7: road transport, SNAP 8: other mobile sources and machinery, SNAP 9: waste treatment and disposal, SNAP 10: agriculture*

21. Reduction of PM2.5 emissions could also reduce emissions of other components of PM2.5 particles, such as heavy metals (especially in PM2.5 from metal industry or waste incineration), microplastics (from tyre wear), ultrafine particles (e.g, from kerosine burning) or zoonoses (from intensive livestock farming). Depending on the composition of PM2.5 particles health risks can vary.

V Nitrogen

22. Nitrogen losses to the environment, including ammonia emissions, are strongly dependent on agricultural and food policies. While abatement techniques offer a large reduction potential, agricultural funding schemes, pricing policies, and other agricultural policies are also important to ensure cost-effective emission reductions. Achieving substantial progress nitrogen pollution requires action through the agri-food system, offering many synergies linking biodiversity, climate change, water quality, healthy diets and circular economy.

23. Ammonia reduction is linked to several environmental issues. Reduction of ammonia emissions is crucial to meet nitrogen deposition targets and halt the loss of biodiversity. It will also reduce the exposure of the population to secondary particle matter and PM2.5 related health risks. As part of an integrated nitrogen management approach focussed on increased nutrient use efficiency, ammonia emission reduction could go hand in hand with reducing other forms of nitrogen pollution, such as nitrate leaching to water and emissions of nitrous oxide (a strong greenhouse gas) and nitrogen oxides from agricultural soils.

24. A new way to promote integrated nitrogen management is reporting of National Nitrogen Budgets which provide an opportunity to optimise for multiple benefits in relation to environment, climate, health and economy. However, nitrogen budgets have been only reported by a few Parties. (The main barriers appear to be the lack of any mandatory requirement in the Gothenburg Protocol as amended in 2012, availability of national funding, and lack of resources for awareness raising on the benefits of an integrated approach).

25. Agricultural and integrated nutrient management policies outside the Air Convention offer great potential to reduce ammonia and other nitrogen pollution, for example through: the European Union Reform of agricultural funding; the European

Union Farm-to-Fork and Biodiversity Strategies aim to "reduce nutrient pollution by 50 per cent by 2030", which directly builds on the UN-Colombo Declaration; and the present initiatives in global negotiations on biodiversity and climate to take into account the negative effects of nitrogen emissions.

26. Ammonia policy will most likely not profit from energy and climate policy measures. Increased use of biomass could increase the pressure on land use and the use of fertilizers and associated ammonia emissions. Adaptation of livestock feed aimed at reducing methane emissions could increase ammonia emissions. Poor burning of biomass can also increase ammonia emissions. A simultaneous approach would be required to effectively address such trade-offs.

VI. Towards meeting Sustainable Development Goals

27. Air pollution policy is linked to several UN-Sustainable Development Goals (SDGs). It has direct benefits on health (SDG3) as well as the protection of life on land (SDG15) and under water (SDG14). Air policy also addresses health and wellbeing in urban areas (SDG11). And, as shown above, there are several ways air policy can contribute to climate action (SDG13). Measures to enhance energy efficiency and access to clean energy could help to reduce energy poverty (SGD7), while improved nutrient use efficiency could help to reduce hunger (SDG2). These linkages are also applicable beyond the UNECE region, which illustrates the need for a global approach.

28. A comprehensive global clean air scenario would consist of a combination of four policy domains:

- 'Air pollution policies': Maximum technically feasible add-on emission controls
- 'Energy and climate policies': An energy and transport policy aimed at limited global warming to 1.5 degrees
- 'Agricultural policies': Low-emissions agricultural practices: including anaerobic digestion of manure, more efficient use of mineral fertilizers and increasing nitrogen use efficiency.
- 'Food policies': Lower meat production driven by alternative human diets and reduced food waste.

This illustrates the need for a closer co-operation between these policy domains.

29. In conclusion: a comprehensive policy approach could offer more health and ecosystem benefits than with traditional air pollution measures alone. It could also increase the cost-effectiveness and consistency of public policy.