Synergies and interactions with other policy areas

At its forty-first session, the Executive Body endorsed the request of the Working Group on Strategies and Review at its fifty-ninth session, for the Gothenburg Protocol Review Group (GPG) to prepare an informal document on linkages with other policy areas. The focus was to be on the co-benefits and trade-offs between addressing air-issues versus climate policy, and to inform considerations to include methane in a future instrument. It was requested that pollutants covered in the informal document should include methane, black carbon, and nitrogen compounds. GPG prepared this document with the support of the Task Forces on Integrated Assessment Modelling (TFIAM), Hemispheric Transport of Air Pollution (TFHTAP), Reactive Nitrogen (TFRN) and the Centre for Integrated Assessment Modelling (CIAM).

I. Introduction

1. There are several linkages and interactions of air pollution policy with inter alia other policy areas, energy policies (aimed at limiting global warming), agricultural policies (aimed at efficient use of nutrients) and food policies (aimed at healthier human diets and reducing food waste) could supplement traditional technical emission reduction measures. Climate policies that reduce the use of fossil fuels, stimulate zero-emission vehicles and reduce meat and dairy consumption could lead to additional improvement of air quality, health and ecosystems. In contrast, climate policies that would promote the burning of biomass, for example, would increase the emission of air pollutants.

Some potential types of co-benefits

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<td>i.</td>
<td>A pollutant has multiple effects; and therefore, reductions can have several positive impacts; for example, reducing levels of methane has positive impacts on climate, human health and ecosystems because methane is both a greenhouse gas and is a precursor to ozone, which harms human health and damages crops and natural vegetation.</td>
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<td>ii.</td>
<td>A specific emission control strategy reduces multiple pollutants; for example, reducing fugitive emissions from leaking natural gas production infrastructure reduces both methane and VOCs.</td>
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<td>iii.</td>
<td>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.</td>
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<td>iv.</td>
<td>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.</td>
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2. In addition to co-benefits there are also trade-offs. Trade-offs occur when policy is focused on one environmental goal only, which could worsen the situation in other areas. For example, without stricter emission limit values the use of hydrogen in industry might increase emissions of nitrogen oxides and related health risks and 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.
II. Climate and air quality linkages

3. CIAM calculations indicate that full implementation of proposed European climate policies and measures for coming decades 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.

4. For example, 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. Measures to implement energy efficiency standards in housing and industry sectors, will also reduce reliance on fossil fuels imports. Policies to move towards a circular economy aim to reduce wasting natural resources but will also entail climate and air quality benefits.

5. Last but not least, climate policies aimed at reducing fossil fuels use will lead to reduced costs of air pollution control (e.g., Rafaj et al, 2018). And health co-benefits could significantly compensate for the climate mitigation costs (e.g., Markandya et al., 2018, Vandyck et al., 2018).

6. Mitigation of agricultural emissions also plays an important role in achieving climate, air quality, as well as ecosystem protection targets. Significant complementarities have been identified for measures simultaneously addressing emissions of methane and ammonia, including human dietary changes towards lower meat and dairy consumption. Policies addressing nitrogen use efficiency (such as reducing nitrogen losses to air, soil and water and replacing mineral fertilizer with organic fertilizers, such as manure and compost) 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 both methane and ammonia emissions, abatement measures should be aligned. Not all measures would have the same positive impact. For example, cattle feed changes to reduce methane could increase ammonia emissions, and biogas facilities not only require manure but also additional sources of organic material, while the digested slurry has an

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3 https://doi.org/10.1038/s41467-018-06885-9.
elevated pH and higher ammonium content, and could therefore lead to higher ammonia emissions if no additional ammonia mitigation measures are taken (e.g., EI-AGI Focus Group, 2017\(^5\)). In the case of poorly managed or unsealed anaerobic digestion facilities neither methane, nor nitrogen abatement will be optimal.

7. 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. Technologies are available to reduce PM\(_{2.5}\) emissions from biomass combustion. But, gas or electric heating appliances (like heat pumps) have even lower or no direct emissions. It is essential to minimize or prevent these emissions in setting a path towards clean(er) energy sources, such as solar electricity. Furthermore, depending on the source of biomass, the extent of its carbon neutrality as well as carbon dioxide emissions associated with production and transport should be considered. Emissions of black carbon (a short-lived climate pollutant and air pollutant) that result from the burning of biomass may even reduce the so-called climate benefits associated with the use of biomass.\(^6\)

8. Reducing air pollution has an impact on radiative forcing and consequently on surface temperatures. Some air pollutants, such as sulphur dioxide have a cooling effect. To limit the negative effects of air pollution policy on climate change, an informed approach is needed, which will require enhancing climate and clean air co-benefits by prioritizing emission abatement 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 contributor to ozone formation.

9. Measures addressing sulphur 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 sulphate in the atmosphere). Therefore, it is of high importance to promote measures addressing simultaneous mitigation of carbon dioxide by energy efficiency improvements and increasing the share of clean energy sources\(^7\) (e.g. through phasing out of fossil fuels); this will also result in additional methane mitigation.

10. A wide-spread attainment of recently announced air quality guidelines by the World Health Organization (Global Air Quality Guidelines, WHO, 2021) which set more ambitious health protection goals than before, appears to be only possible when complemented by technology and policy complementarities addressing climate, air quality, and ecosystem protection.

\(^7\) https://www.iea.org/reports/recommendations-of-the-global-commission-for-urgent-action-on-energy-efficiency.
Figure 2. Contribution of various measures to the reduction in global population exposed to higher PM2.5 concentrations 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)
III. Methane

11. 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). These results are consistent with the findings of Van Dingenen et al. (2018), 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.

![Figure 3. Decomposition of annual average ozone concentrations (in ppb) in Northern Hemisphere regions: EUR (Europe), RUS (Russia, Belarus, and Ukraine), SAS (South Asia), EAS (East Asia), and NAM (North America) according to the origin of the ozone precursors NOx (above) and VOC, including methane, (below), based on Butler et al., 2020. It shows that in all regions methane and biogenic VOC-emissions play a big role, that regional NOx-sources are important everywhere and that in Europe and North America NOx from marine shipping is the second largest contributor.](image-url)

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9 [https://doi.org/10.5194/acp-20-10707-2020](https://doi.org/10.5194/acp-20-10707-2020).
10 [https://doi.org/10.2760/820175](https://doi.org/10.2760/820175).
Given the slow rate of methane oxidation in the atmosphere, the decrease in surface ozone arising from methane emission control is largely independent of source location; i.e., decreasing methane emissions anywhere globally would provide benefits within the UNECE. However, the local ozone response to global methane changes is stronger in locations where local NOx emissions are high. Urban areas and other areas downwind of significant NOx sources may benefit more from global methane decreases than areas with few NOx emissions (Fiore et al. 2009; van Dingenen et al., 2018). Furthermore, additional NOx emissions controls, including for maritime shipping, will also decrease global background ozone concentrations formed due to ozone (Butler et al. 2020).

Turnock et al. (2018) found that annual average surface ozone concentrations in 2050 in Europe and North America are expected to be relatively similar to 2010 under the current legislation scenario, despite strong decreases in regional NOx and NMVOC emissions within those regions. In both Europe and North America, the contribution of sources of non-methane precursors outside the region is not expected to change much under this scenario. However, the expected increase in global methane concentrations offsets the decreases in surface ozone due to NOx and NMVOC controls within Europe and North America. Under a climate policy scenario, methane emissions and their contribution to ozone concentrations both decrease. Climate policies are also expected to reduce fossil fuel related 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. In this scenario, where methane is tackled globally, additional control of NOx and NMVOC sources outside Europe and North America has the largest benefit for ozone reduction within these regions.

An inventory of available global scenarios show a large variation in possible futures. Most business-as-usual scenarios do not include methane abatement measures and lead to a further increase of global methane emissions (see the violet projections in figure 4). Scenarios that include additional policies project a decline with 30-50% compared to the 2015 level (see the green lines). The scenarios in between (orange lines) assume implementation of current legislation measures. These scenarios do not however take into account the further expected reductions from the collective methane emissions reductions goal of the 2021 Global Methane Pledge.

![Past and projected global CH4 emissions](image)

Figure 4: Past and projected global methane emissions (Van Dingenen et al., 2018. doi:10.2760/820175, JRC, 2018)

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11 [https://doi.org/10.1029/2008JD010816](https://doi.org/10.1029/2008JD010816)

12 [https://doi.org/10.5194/acp-18-8953-2018](https://doi.org/10.5194/acp-18-8953-2018)
The main anthropogenic sources of methane emissions are livestock farming, fossil fuel production and distribution, and waste management (see figure 5). In Europe, livestock is the largest source; in Russia oil and gas operations are dominant, and in North America oil and gas, livestock and landfill waste are the main sources of methane emissions.

Figure 5: Methane emission sources in 2017 by world region (UNEP, Global Methane Assessment, 2021)

The methane mitigation potential, and respective air quality and ecosystem co-benefits vary across the UNECE countries owing to the structure of methane sources in the countries. Compared to the projected baseline emissions in 2050, the percentage of methane emissions that can be mitigated under the maximum technical feasible scenario varies 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. Abatement options include ventilation and degasification of coal mines, controlling leakages from gas extraction and gas networks, recovery of waste gas from oil production, composting of organic waste, aerobic wastewater treatment, anaerobic digestion of manure with biogas recovery, cattle feed additives and a ban on open burning of field residuals. The waste management sector offers the largest mitigation potential in Europe, while fossil fuel production and distribution (mostly oil and gas) emissions represent major mitigation opportunities in Russia, North America, and some EECCA countries (see figure 6). The estimated mitigation potential of 46% in the EPA assessment (US EPA, 2019)\(^{13}\) is smaller than the 79% globally for the oil and gas sector in the GAINS model (Högström-Isaksson et al. (2020)\(^{14}\), owing to different assumptions about future emissions from unconventional gas production.

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\(^{13}\) \url{https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases}.

A significant part of the available abatement options will be cost neutral or have low cost (meaning marginal abatement costs (MAC) of less than 20 € per ton CO$_2$-eq). A large low-cost mitigation potential for methane is identified primarily for fossil fuel production as well as to some extent waste management. Important factors determining the size of that abatement potential are assumptions about technological progress and the investment perspective that is used: the social planner perspective assuming a relatively long pay-back period on public investments versus the private sector perspective, where a shorter pay-back time on private investments is required (see figures 6 and 7). The investment perspective depends on who will finance the abatement measures: governments or private companies.
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. The Global Methane Assessment (UNEP 2021) estimates that assuming implementation of all available technical abatement measures, combined with changes in food patterns global methane emission would be 45% lower than the baseline projection for 2030 which will contribute significantly to efforts to limit global warming to 1.5 °C, and contribute to avoiding 255,000 ozone related premature deaths globally per annum. Additional benefits may include reduction in cardiovascular related mortalities, hospitalizations, and asthma-related emergency department visits. Also lost work hours and crop losses would be reduced. 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. Note that UNEPs 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.

Recently, many countries have joined the Global Methane Pledge to reduce methane emissions by 30% from 2020 levels by 2030. If the UNECE were to implement a 30% reduction in UNECE emissions this would include a 25 Mt reduction of methane and lead to 3,600 fewer premature respiratory-related mortalities annually within the UNECE region and 18,000 fewer globally (see Table 1).

Table 1. Reduction in respiratory-related mortalities by region due to a 30% reduction in methane emissions between 2020 and 2030 in the UNECE region. These estimates are calculated using health benefits per ton of methane emission reduction, provided by the Global Methane Assessment (2021)

<table>
<thead>
<tr>
<th>Region</th>
<th>Reduction</th>
</tr>
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<tbody>
<tr>
<td>EECCA</td>
<td>215</td>
</tr>
<tr>
<td>UNITED KINGDOM</td>
<td>390</td>
</tr>
<tr>
<td>RUSSIA</td>
<td>270</td>
</tr>
<tr>
<td>REST OF EUROPE</td>
<td>1,700</td>
</tr>
<tr>
<td>U.S. AND CANADA</td>
<td>1,200</td>
</tr>
<tr>
<td>ALL UNECE</td>
<td>3,600</td>
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<tr>
<td>GLOBALLY</td>
<td>18,000</td>
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20. The Working Group on Strategies and Review is expected to further 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 UNFCCC, the Climate and Clean Air Coalition (CCAC), and the Global Methane Initiative (GMI). The European Commission will also explore the possible inclusion of methane among regulated pollutants in the review of the NEC Directive (due by 2025).

IV. Black Carbon

21. Black carbon has multiple environmental effects. It contributes to health effects associated with PM2.5 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. Because black carbon is emitted in population centres, it contributes to highly localized air quality issues. The science community of the Convention intends to coordinate with the Arctic Council and the CCAC to assess the best strategy to address black carbon. Sources of black carbon emissions are also associated with emissions of NOx 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 NOx-emissions). Therefore, strategies to reduce black carbon emissions can be expected to offer co-benefits in reducing nitrogen air pollution.

22. 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. Black carbon is co- emitted with other particles that reflect light and contribute to cooling. 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 8 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 8: Breakdown of sectoral PM2.5 emissions in the UNECE area in 2015 with an emphasis on organic carbon and black carbon](image-url)
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 (for example from kerosine burning) or zoonoses (from intensive livestock farming). Depending on the composition of PM2.5 particles health risks can vary.

V. Nitrogen

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 in nitrogen reduction requires action through the agri-food system, offering many synergies linking biodiversity, climate change, water quality, healthy diets and circular economy.

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 particulate 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.

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 voluntary nature of reporting this information 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).

Agricultural and integrated nutrient management policies outside the Air Convention offer additional potential to reduce ammonia and other nitrogen pollution. For example 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.

Energy and climate policy measures proposed to date will likely not lead to ammonia emissions reductions. Increased use of biomass could even increase the pressure on land use and the use of fertilizers with associated ammonia emissions. Adaptation of livestock feed aimed at reducing methane emissions could increase ammonia emissions. Inefficient domestic wood burning can also increase ammonia emissions. A simultaneous approach would be required to effectively address such trade-offs.
VI. Towards meeting Sustainable Development Goals

29. Air pollution policy is linked to several UN-Sustainable Development Goals (SDGs). It has direct benefits on health (SDG3) as well as to the protection of life on land (SDG15) and in rivers, lakes and seas (SDG14). Air policy also addresses health and wellbeing in urban areas (SDG11). 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.

VII. Conclusions

30. 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 healthier human diets and reduced food waste.

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

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