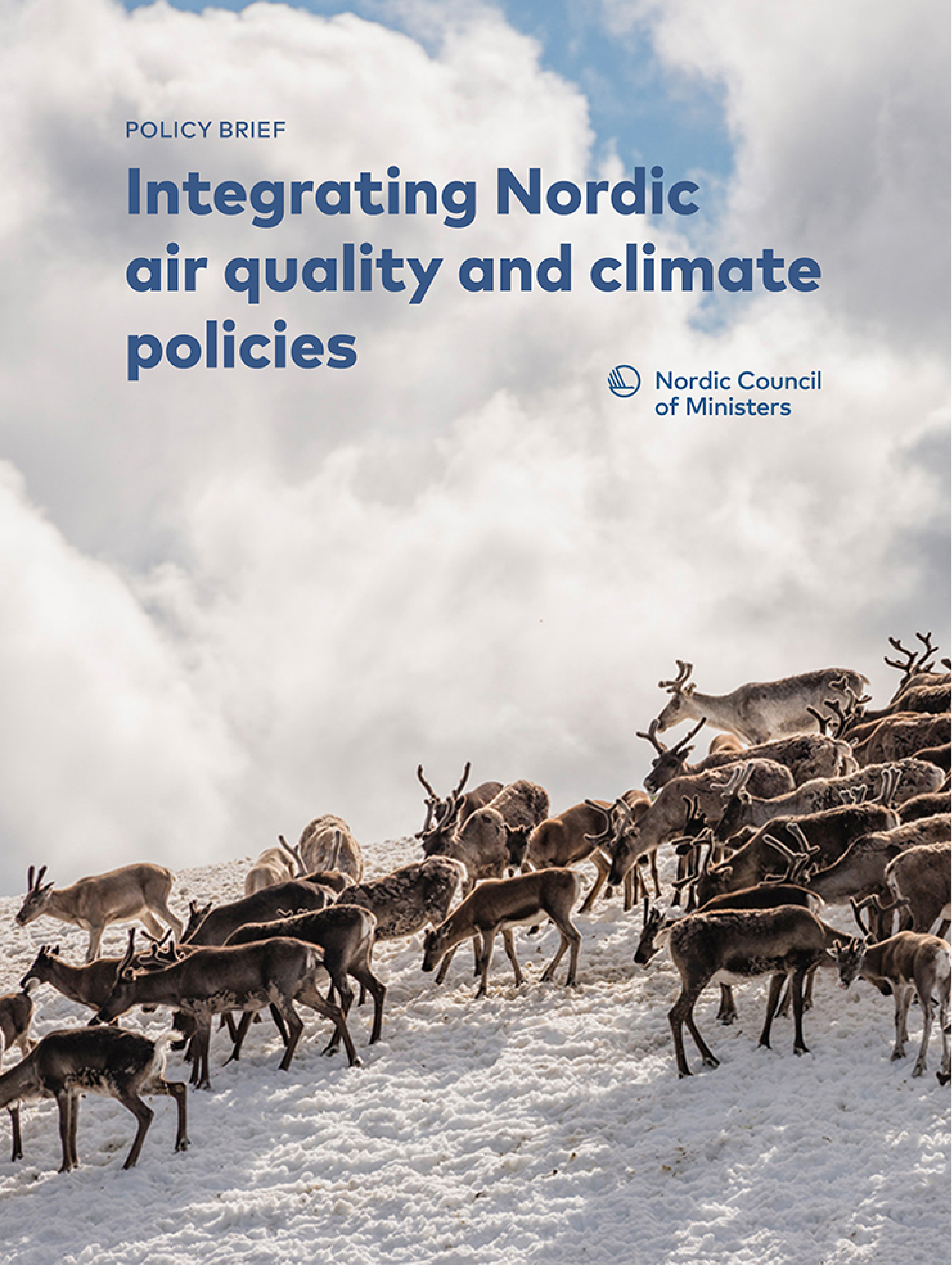
POLICY BRIEF

Integrating Nordic air quality and climate policies

Nordic Council of Ministers



Contents

Introduction 3

Air pollutants and greenhouse gases both have a large climate impact 4

Past regulation of air pollution emissions has increased warming. However, it is feasible to reach a climate-neutral emission reduction scheme 8

Estimating climate impacts of different air pollutants 11

An integrated air quality and climate change strategy can be developed 13

About this publication 15

This publication is also available online in a web-accessible version at:
https://pub.norden.org/nord2023-047/

Introduction

The aim of the Nor-FORCeS project *Integrating Nordic air quality and climate policies using FORCEeS* was to investigate to what extent aerosol particles and greenhouse gases contribute to climate warming in the context of the Nordic emission picture. This knowledge is necessary to meet the Paris Agreement while simultaneously addressing harmful air pollution.

The project has been executed by a Nordic research team from Stockholm University, Finnish Meterological Institute, CICERO and Aarhus University and supported by grants from the Nordic Council of Ministers' working group for Climate and Air (NKL).

The project conclude that an integrated air quality and climate change strategy s needed and argues that a climate neutral air quality strategy is possible.

Air pollutants and greenhouse gases both have a large climate impact

Several air pollutants affect climate, some cool and some warm the climate. Sulfuric dioxide (SO_2), nitrogen oxides (NOx), and organic gases (VOCs) can form airborne particles, i.e. aerosols, which cools the climate, while emissions of black carbon (BC), colloquially called soot, warm the climate. Nitrogen oxides can form ozone through chemical reactions with organic gases (e.g., methane), and ozone acts as a greenhouse gas besides being harmful to health and plants. The total climate warming by methane is to a quarter through the formation of ozone. Figure 1 describes the influence that these pollutants have today on the global surface temperature. It shows that the effects are often complex. For example, increasing concentrations of nitrogen oxides cause chemical reactions resulting in warming, via the formation of ozone, as well as cooling, via the destruction of N_2O. It also shows how air pollutants influences climate in two ways, through blocking incoming solar radiation and through changing the radiative properties of clouds.

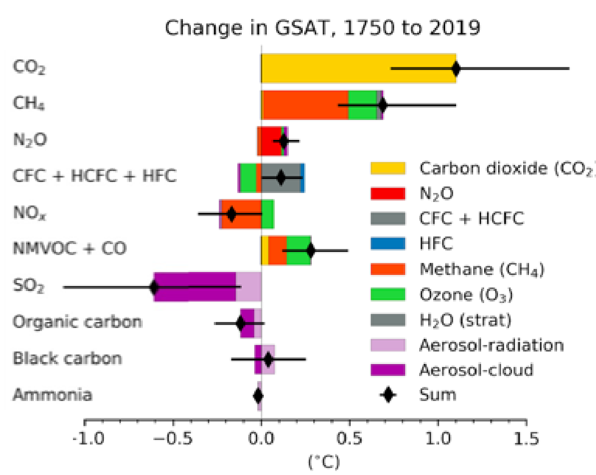


Figure 1: Contribution to global mean surface air temperature (GSAT) change from component emissions between 1750 to 2019 based on CMIP6 models (Thornhill et al., 6 2021) *(Taken from IPCC AR6 WG1 chapter 6 Figure 6.12).*

Air pollutants cool the climate on average. Aerosols generally cause strong cooling while methane, ozone, and black carbon warm the climate. Air pollutants are short-lived in the atmosphere and a total reduction of all present particulate matter would therefore rather rapidly warm the climate in the range of 0.5-1 degree C with a total reduction of anthropogenic emissions, thus unmasking the true warming by the greenhouse gases. However, this can at least to some extent be balanced by a reduction of black carbon, methane- and ozone-forming components, such as nitrogen oxides and organic gases.

Future air quality improvement is necessary – can save a million premature deaths

Recently the Artic Monitoring and Assessment Program (AMAP) presented a report on the effects of Short-Lived Climate Forcing pollutants (SLCFs) including SO_2, BC, methane, and organic carbon. To estimate the future effect of emission reductions, two scenarios were used; one with reductions resulting from current legislation (CLE) and one where maximum technical feasible reductions (MFR) are applied. The resulting PM2.5 concentrations, i.e., airborne particles with a diameter less than 2.5 micrometers, were calculated and the resulting number of premature deaths was calculated through established risk estimates. The CLE scenario gives air pollution reductions of 15-30% in the different Arctic Council countries, while MFR gives 40-70% lower air pollution concentrations.

The main health effects resulting from the lower air pollution concentrations will be in the most populated areas with the highest air pollution concentrations. These areas are typically in the Arctic Council observer countries i.e., in Asia. This is reflected in the calculated decrease in the number of premature deaths which are about 600 thousand for the CLE scenario and almost one million per year for MFR (see table below). The improvement in health is remarkable even in the CLE scenario.

Health effects	CLE 2030 Premature deaths/year	MFR 2030 Premature deaths/year
Arctic Council: USA, Canada, Nordic countries, Russia	-66 000	-97 000
Arctic Council observers: China, India, South Korea, Japan, several EU countries	-540 000	-880 000

Past regulation of air pollution emissions has increased warming. However, it is feasible to reach a climate-neutral emission reduction scheme

Using a multi-model approach for the two different scenarios, CLE and MFR, the influence of different air pollutants on both historic and projected climate was calculated. The AMAP study shows that the reduction of SO_2 emissions has contributed to almost half of the observed warming in the Arctic since 1990 (see figure 2). BC and methane have only minor contributions mainly due to the small emission changes. The relative contributions are true also for the midlatitudes even though the warming there has been about half of the warming in the Arctic. This means that almost half of the warming at midlatitudes is caused by the reduction of SO_2 emissions.

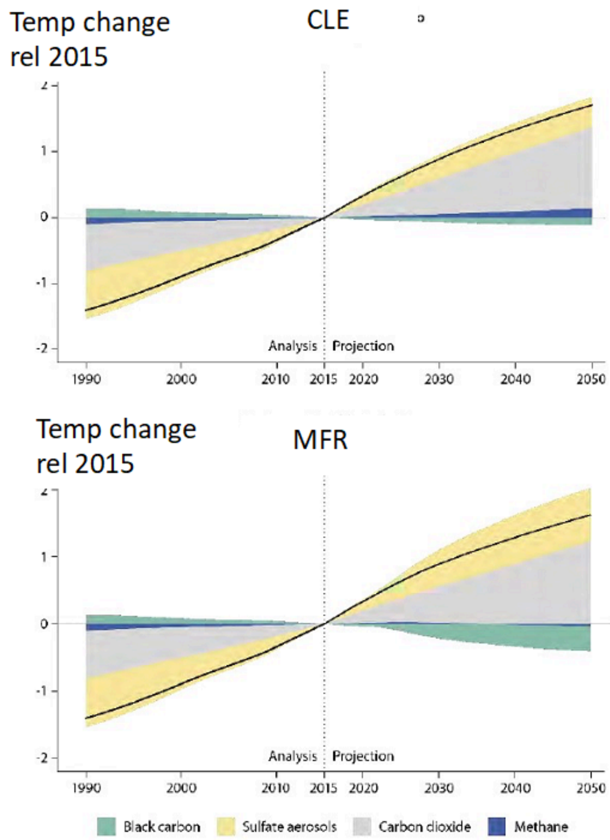


Figure 2: Mean Arctic temperature changes in the MFR and CLE scenarios. The shaded areas indicate the contributions of emitted pollutants to the net changes (black lines). ***(Taken from AMAP SLCF report chapter 8 Figure 8.37).***

In 2050, the SO_2 emission reduction according to the CLE projection is estimated to contribute to about 30% of the total expected warming of 1.6 degrees, while the climate impacts of the expected increase in emissions of methane and decreasing emissions of BC balance each other. For the MFR projection, the larger emission reduction of SO_2 is balanced by a larger reduction of BC and no increase in methane emissions. In total, the MFR scenario gives slightly less climate impact than the CLE scenario, but the change in air pollutants in both scenarios still makes a significant contribution to climate warming.

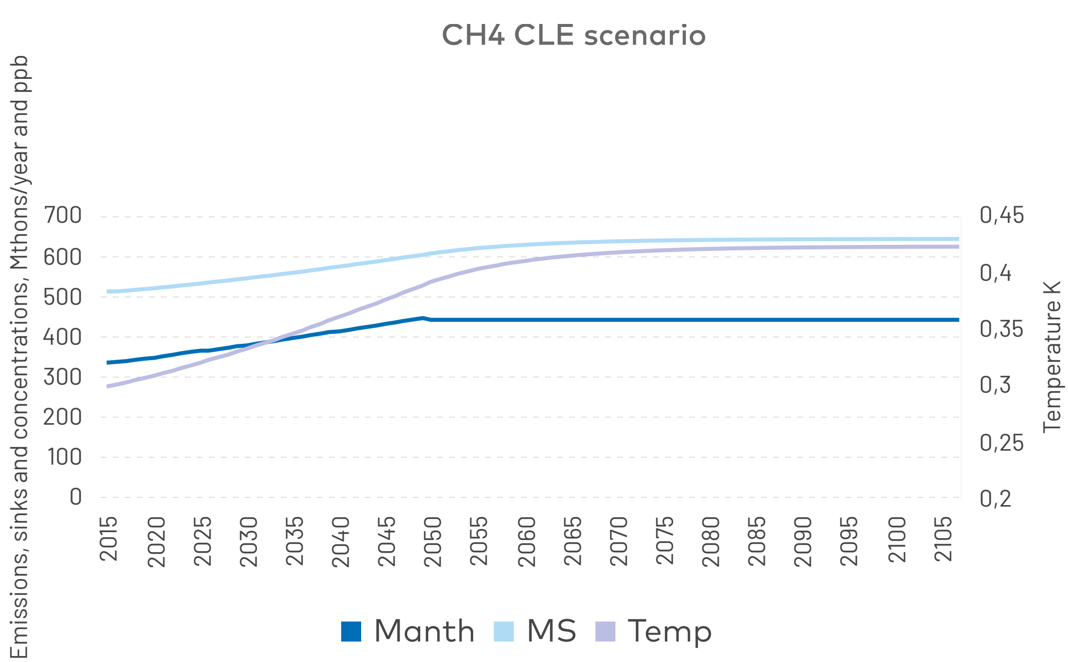
An almost climate-neutral reduction scheme for air pollutants could be achieved by reducing SO_2 emissions according to the CLE scenario while reducing BC and methane following the MFR scenario. The total warming would then be reduced by about 0.3 degrees C compared to either the CLE or the MFR scenarios. The health outcome for such a scenario will be in between the outcome for the CLE and MFR scenario, i.e., between 600 thousand and 1 million fewer premature deaths, depending on how much other components besides BC in PM2.5 are reduced, such as organic compounds and nitrates.

Estimating climate impacts of different air pollutants

To facilitate estimates of the climate impact of different air pollution reduction schemes, the Nordic Council of Ministers project NorForces has calculated the climate impact in a specific region of emission of one Megaton of an air pollutant in another or the same region. This measure is called Absolute Regional Temperature Potential (ARTP).

For SO_2, the ARTP for the Arctic considering northern hemisphere emission regions, besides southern Asia, is about -0.02 K/Mton, while for mid-latitudes is about half that. BC warms the climate but the ARTPs is more uncertain ranging between 0.05 and 0.3 K/Mton. For organic carbon (OC), the ARTP's are even more varying. Nevertheless, anthropogenic OC can be considered climatically insignificant given the relatively small emissions of OC (compared to SO_2).

Methane is a gas with a long atmospheric lifetime compared to other air pollutants, about 12 years, giving a delayed climate response with changing emissions. In the CLE scenario, with continuously increasing emissions, the global climate impact reaches after time about 0.001 K/Mton. But it takes more than 30 years to reach full effect (see figure 3).



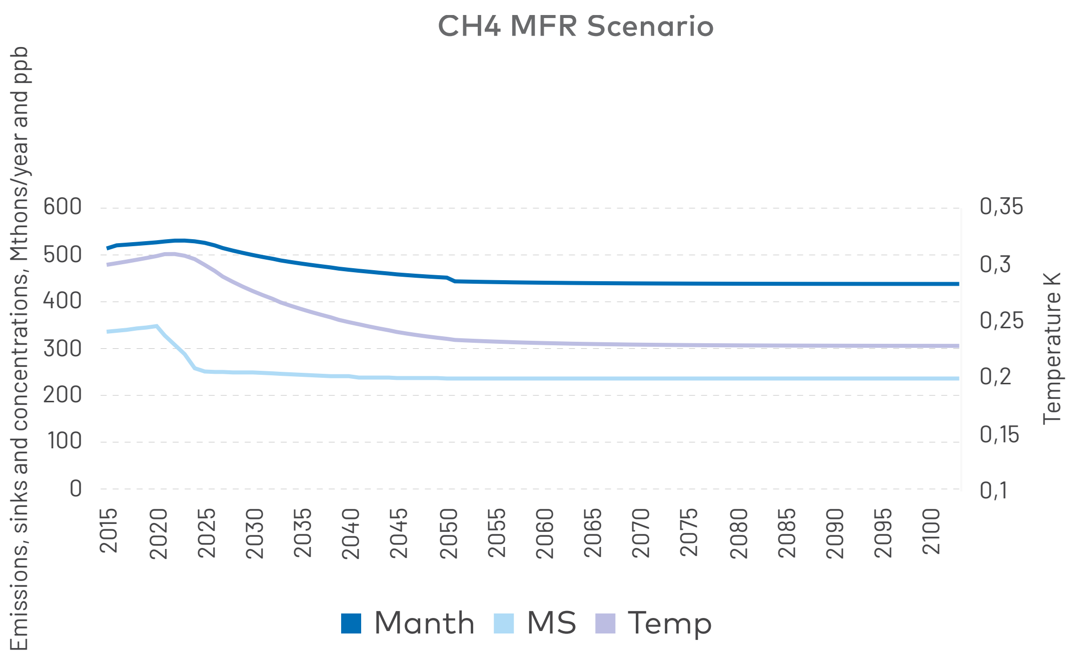


Figure 3: CLE and MFR scenarios showing the evolution of emissions (Manth), sinks (Ms), and the contribution of methane to the global temperature (Temp).

The MFR case, with a very strong decrease after 2021 that levels off around 2026 is difficult to summarize in one number. The lesson learned is that a cut of at least 30 Mton/year, i.e., about 10% of present emissions, is needed just to stop the increase in atmospheric methane concentrations. To get an immediate decrease as in the MFR case, an emission decrease of 90 Mton is needed.

In conclusion, for a climate-neutral emission scenario, each Mton reduction of SO_2 emissions has to be balanced with 100 – 250 ktons of reduced BC emissions. If the reduction of BC is limited, strong emission reductions of methane are necessary, starting immediately with at least 30%.

An integrated air quality and climate change strategy can be developed

From an air quality viewpoint, pollutants affecting health and ecosystems should be minimized. From a climate change viewpoint, the main focus should be on reducing emissions of greenhouse gases, mainly CO_2 and methane, as they in the longer time perspective will have the largest influence on climate.

However, it should be noted that traditional air pollutants also have an impact on climate and that the greenhouse gas methane is a precursor gas for ozone, which has an impact on both health and ecosystems, e.g., by reducing crops. Furthermore, greenhouse gases and air pollutants have common sources, e.g., combustion is the main anthropogenic source of CO_2 and air pollutants, such as NOx, BC, VOC, and SO_2. This fact strongly argues for a co-beneficial, commonly useful strategy for reducing emissions to mitigate both climate change and air pollution.

From a health perspective, PM2.5 concentrations should be reduced. PM2.5 usually is dominated by sulfates, nitrates, and organic carbon. BC is usually less than 10 % of the PM2.5, except close to large combustion sources. Sulfates are in the order of 30% of the PM2.5 mass with similar amounts of nitrate and organic carbon. However, BC has in several studies been shown to have a much larger health impact per microgram than PM2.5. Ammonia emissions have been shown to increase particle formation besides having serious ecosystem effects. Consequently, large health and ecosystem benefits can be achieved not only by decreasing the emission of SO_2, but also by decreasing BC, OC, NOx, and ammonia emissions.

Ozone is a secondary component formed in the atmosphere from NOx and VOCs, including methane. Besides being a greenhouse gas, ozone is not only harmful to health but also to crops. A substantial decrease in emissions of ozone precursors will have a positive effect on health, ecosystems including crop yield, and climate change.

An optimal strategy reduces the impact of air pollutants on health and ecosystems but also limits climate warming. The discussed reductions of air pollutants will have large positive effects on health, ecosystems, and climate change, besides the negative climate effect of SO_2 reductions.

Strong reductions of NOx, VOCs (including methane), BC, and particulate organic carbon - in line with the MFR scenario – together with reductions of SO_2 according to the CLE scenario, will improve air quality and reduce health impacts considerably, somewhere between the CLE and MFR scenario described above. Strong reductions of methane and BC will not only give health and ecosystem benefits but will significantly contribute to climate change mitigation. Combined, these reductions can give a fully climate-neutral air pollution emission reduction scheme and then reduce the projected climate warming according to the CLE or the MFR scenario in the Arctic and the Midlatitudes by about 30% in 2050.

About this publication

Policy brief: Integrating Nordic air quality and climate policies

Authors:
Hans-Christen Hansson, Department of Environmental Science, Stockholm University; Annica Ekman, Department of Meteorology, Stockholm University; Ulas Im, Department of Environmental Science, Aarhus University; Srinath Krishnan, CICERO, Oslo; Risto Makkonen, Finnish Meteorological Institute; Maria Sand, CICERO, Oslo

Nord 2023:047
ISBN 978-92-893-7769-0 PDF
ISBN 978-92-893-7770-6 ONLINE
http://dx.doi.org/10.6027/nord2023-047

Published: 9.1.2024
Frontpage photo: Helena Wahlman/imagebank.sweden.se

Nordic co-operation

Nordic co-operation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and the Faroe Islands, Greenland and Åland.

Nordic co-operation has firm traditions in politics, economics and culture and plays an important role in European and international forums. The Nordic community strives for a strong Nordic Region in a strong Europe.

Nordic co-operation promotes regional interests and values in a global world. The values shared by the Nordic countries help make the region one of the most innovative and competitive in the world.

The Nordic Council of Ministers
Nordens Hus
Ved Stranden 18
DK-1061 Copenhagen
pub@norden.org

Read more Nordic publications on www.norden.org/publications