Nordic Council of Ministers

The Nordic Air Pollution workshop 2024

opportunities for future Nordic cooperation

Contents

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Summary

On 7-8 October 2024, the Nordic Working Group for Climate and Air (NKL) organised the Nordic Air Pollution Workshop with the objective to outline future directions and priorities for Nordic cooperation on air pollution. The workshop was held in Copenhagen and gathered around 30 participants from Denmark, Finland, Norway and Sweden.

Nordic collaboration under the Nordic Council of Ministers (NCM) has for decades been successful in developing air pollution science and policies. Both for the Nordic countries themselves as well as for the Convention on Long-range Transboundary Air Pollution (CLRTAP/Air Convention) and the European Union. Decisions under the Air Convention and the European Union has large impact on Nordic air pollution.

Together with the presentations, the active and constructive discussions at the workshop form the basis for the proposals and conclusions presented in this report.

The report has been written by the workshop moderators reflecting the discussions at the workshop. The content does not necessarily reflect the view, opinions or recommendations of Nordic Council of Ministers'.

Proposed projects and other initiatives

The following project ideas/initiatives are proposed to be considered as activities that could fully or partly be coordinated and funded by the Nordic Council of Ministers for the period up to 2030. The presentation of project ideas/initiatives is grouped in accordance with the five discussion themes of the workshop:

Clean Air – Regionally and Globally,

Clean Air – for Cities and Societies,

Clean Air – Ecosystems & Climate,

Clean Air – Emission sectors,

Clean Air – Efficient Communication.

More detailed descriptions of the proposed project/initiatives, their Nordic dimension, as well as potential target groups for the outcome of these, are given in the main part of the report.

Clean Air – Regionally and Globally

The Nordic cooperation on air quality should aim to:

- Support the use of structural measures (such as dietary changes) in decision-support models.
- Stress the importance of using the effects-based approach during policy discussions.
- Enhance Nordic cooperation on how to best implement the monitoring requirements of the EU Air Quality Directive.
- Strengthen the Nordic engagement in the Air Convention's Forum for International Cooperation on Air Pollution (FICAP).
- Harmonize and improve ecosystems reporting.
- Encourage more monitoring, chemical transport modelling, and epidemiological research on ultra-fine particles (UFP) and black carbon (BC).
- Support the revision process of the Gothenburg Protocol, especially on abatement of ammonia from the agricultural sector.

Clean Air – for Cities and Societies

The Nordic cooperation on air quality should aim to:

- Ensure continued air quality monitoring even when concentrations of air pollutants are below WHO 2021 guideline values.
- Ensure that Nordic countries take leadership on setting ambitious (zero) emission targets for air pollution.
- Review existing Nordic evidence on health effects in low-pollution environments.
- Maximise Nordic benefits of current EU projects on air pollution and health.
- Produce Nordic guidelines for city development respecting the citizens right to clean air.
- Clarify the economic value of air quality-related ecosystem services in cities.

Clean Air – Ecosystems and Climate

The Nordic cooperation on air quality should aim to:

- Ensure the continuity of ecosystems monitoring.
- Further develop exposure and valuation metrics for biodiversity.
- Promote better exchange of knowledge between air pollution scientists and relevant working groups supporting the IPCC and CBD.
- Encourage integrated nitrogen-carbon management approaches.
- Assess effects of ozone on (semi)natural ecosystems.

Clean Air – Emission Sectors

The Nordic cooperation on air quality should aim to:

Agriculture

- Strengthen nitrogen policies by including structural measures such as dietary change (for example reduced meat consumption).
- Develop and improve knowledge sharing on agricultural emission abatement measures.
- Ensure the application of integrated approaches to nitrogen management.

Residential wood-burning

- Clarify opportunities and challenges with (temporal) bans on residential wood-burning in cities.
- Promote Nordic information sharing on ways to reduce emissions.
- Improve the knowledge on regional and time-dependent factors affecting health effects from residential wood combustion.
- Clarify to what extent residential wood combustion affects BaP emissions.

Shipping

- Promote Nordic collaboration on alternative fuels and propulsion systems.
- Provide Nordic leadership on ship emissions abatement.
- Support the expansion of Emission Control Areas to all sea areas around Europe.
- Support a revision of the IMO's NOx standards for ships.

Clean Air – Efficient Communication

The Nordic cooperation on air quality should aim to:

- Ensure better access to air quality forecasts for Nordic municipalities and citizens.
- Link air quality forecasts with well-thought out 'action advice' for citizens.
- Clarify that air quality has improved over time, but that more needs to be done.
- Raise the profile of nature protection.
- Ensure public information on air quality.

Abbreviations

AAQD	Ambient Air Quality Directive (EU)
AQG	Air Quality Guidelines (WHO)
BaP	Benzo(a)pyrene
BC	Black Carbon
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity (UN)
CCAC	The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants
CLRTAP	The Convention on Long-range Transboundary Air Pollution, in this report called the Air Convention
ECA	Emission Control Area (IMO)
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme (Air Convention)
ERF	Exposure Response Function
EU	European Union
EVA	Economic Valuation of Air pollution model system
FICAP	Forum for International Cooperation on Air Pollution (Air Convention)
GBD	Global Burden of Disease
IMO	International Maritime Organisation
IPPC	Intergovernmental Panel on Climate Change (UN)
NECA	NOx Emission Control Area (IMO)

NECD	National Emission reduction Commitments Directive (EU)
NKL	Nordic Climate and Air Group under the Nordic Council of Ministers
NNB	National Nitrogen Budget
NMR	Nordic Council of Ministers (Nordiska Ministerrådet)
OC	Organic Carbon
PM	Particulate Matter
PAHs	Polyaromatic Hydrocarbons
RWC	Residential Wood Combustion
SECA	Sulphur Emission Control Area (IMO)
TFIAM	Task Force on Integrated Assessment Modelling (Air Convention)
TFRN	Task Force on Reactive Nitrogen (Air Convention)
UFP	Ultra-Fine Particles
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation

Introduction

For many years, the Nordic cooperation has contributed to the Nordic countries' pressing work under the UNECE Air Convention, as well as within the EU and nationally to continue reducing emissions of air pollutants harmful to the environment and health. Despite significant reductions in air pollution in recent decades, substantial challenges remain. Many people in the Nordics experience illness and die prematurely due to air pollution, and ecosystems continue to suffer from adverse effects.

Measures to abate climate change and reduce air pollution often go hand in hand. Air pollutants and greenhouse gases frequently originate from the same sources, sharing common causes and consequently common solutions, which are often linked to the combustion of fossil fuels and agricultural activities. However, there are some solutions that rather induce trade-offs, and it is important that these become known and avoided. Therefore, the Nordic countries should continue to contribute to promote synergies through increased integrated work in the air pollution and climate change areas.

As net importers of air pollution, the Nordic countries are dependent on international agreements that accelerate emission reductions in surrounding countries. By producing and contributing information, scientific data and strategic policy inputs to the international air pollution work, the Nordic countries can continue to influence the priorities and ambition levels of international agreements, leading to direct air quality benefits in the Nordic countries.

The NKL would like to thank warmly Christer Ågren and Stefan Åström for their valuable contribution as well as all the workshop participants for their active contributions and fruitful discussions.

Katja Asmussen
Co-Chair of the Nordic Working Group for Climate and Air (NKL)

Background and objective of the workshop

International work to address air pollution is evolving, and recent developments will have significant impact on the countries' national work on air protection. In 2021, the World Health Organisation (WHO) presented new recommendations for air quality to limit negative effects on the environment and health. The EU has recently revised the Ambient Air Quality Directive (AAQD), resulting in more stringent requirements, and a review of the National Emission reduction Commitments Directive is (NECD) underway (to be presented in 2025), with a subsequent revision as a possible outcome. After having completed a review, the Air Convention decided in 2023 on a comprehensive revision of the Gothenburg Protocol, that is expected to be finalised by 2026. In addition, the United Nations Environment Assembly (UNEA) adopted in February 2024 a resolution calling for increased global cooperation on air pollution.

The Nordic region has a unique opportunity to make meaningful contributions to these key initiatives. To do so effectively, it is essential to anticipate future challenges and identify the most impactful ways through which the Nordic countries can offer support. Recognizing this, it was agreed that a workshop with Nordic air pollution experts would be both timely and necessary. The objective of the workshop was to identify which issues are most urgent and most suitable for Nordic cooperation.

This Nordic Air Pollution workshop took place in Copenhagen 7–8 of October 2024 and some 30 civil servants and researchers participated with presentations and discussions.

The workshop was set up around five discussion themes:

- Clean Air – Regionally and Globally
- Clean Air - for Cities and Societies
- Clean Air – Ecosystems and Climate
- Clean Air – Emission sectors
- Clean Air – Efficient Communication

Each theme was introduced by two-three short presentations by experts. After the presentations, all participants selected three questions for in-depth discussions on needs and opportunities for Nordic cooperation. The discussions were moderated by Christer Ågren (independent expert), and Stefan Åström (Anthesis AB), who also

chaired the meeting. Christer Ågren have been engaged in European and national air pollution policies for more than 40 years, and Stefan Åström has been involved in national and international applied science-policy research for nearly 20 years.

This workshop report summarizes the issues discussed during the meeting and includes recommendations for potential future initiatives and projects that resulted from the workshop presentations and discussions. Although the outcome of the workshop is a product of joint discussions, the moderators are responsible for the precise wording of the proposals.

Clean Air – Regionally and Globally

The Nordic countries are net importers of air pollution and consequently dependent on emission control action in surrounding countries to protect health and environment. By providing science-based information and strategic policy inputs to the international work, the Nordic countries can continue to influence the direction and ambition.

Although the Europe and North America were first in establishing an international environmental agreement to combat air pollution, many other regions in the world have established, or are on their way to establish, international cooperation aimed at reducing air pollution. Correspondingly, there is an opportunity for inter-regional knowledge-sharing and capacity building to ensure that air pollution control is done efficiently and where it is most needed.

Abstracts of presentations

Stefan Åström – Overview

There are several ongoing and important policy processes affecting Nordic air pollution in one way or the other. Within the EU, the revised EU AAQD was finally adopted on the 14th of October 2024, and it is expected that a revision of the EU NEC Directive will start soon. Wider, the UNECE Gothenburg protocol is currently undergoing a revision. Wider still, there is an important ongoing process within the International Maritime Organisation (IMO) on establishment of new emission control areas.

There are also important environmental policy processes that more indirectly will affect Nordic air quality. The Arctic Council target year for emission reductions of short-lived climate forcers is fast approaching. This target is now also complemented with the Global Methane Pledge which has been signed by all Nordic countries and aims for a 30% reduction of 2020 emission levels by 2030. In addition, high-profile negotiations are ongoing in the global conventions on

biodiversity and climate change, both which will be affected by (or affect) air pollution.

Anna Engleryd, Swedish Environmental Protection Agency

By providing valuable information and strategic policy input to the Air Convention and EU policy processes, the Nordic countries have been able to influence their direction and level of ambition, ensuring that specific Nordic concerns are addressed. Compared to global initiatives, regional collaborations, with fewer participants, allow for more significant impact and easier engagement. The Nordic countries have since long had a close relationship, particularly with the Air Convention, where the Nordic Council is regarded as a key and trusted partner.

The period leading up to 2030 presents numerous opportunities for the Nordic countries to contribute to advancing the international agenda on air pollution. The EU has revised its Air Quality Directive, introducing stricter requirements to be met by 2030. Nordic cooperation in implementing these new standards could prove highly beneficial.

Under the Air Convention, a comprehensive revision of the Gothenburg Protocol is underway and is expected to conclude by December 2026, and after conclusion of the review, a revision of the EU National Emission reduction Commitments Directive (NECD) is expected. These two processes largely run in parallel, though the Air Convention covers a broader geographic region. Contributions to one process are likely to influence also the other. Key negotiation topics for the Gothenburg Protocol, which are expected to impact on the NECD, include new emission reduction commitments (with a particular focus on ammonia emissions) further reductions in black carbon emissions, addressing methane, updating the technical annexes, new flexibilities to facilitate ratification and implementation by non-parties, integrated approaches (climate, energy, air), and overarching collective risk-based targets.

While these regional developments are significant, there is a growing call for greater global responsibility and enhanced international cooperation on air pollution management. This is reflected in the recent resolution on air pollution by the United Nations Environment Assembly. The Air Convention's Forum for International Cooperation on Air Pollution (FICAP) aims to facilitate international exchange of information and mutual learning on both the scientific/technical and policy levels and complement ongoing efforts by making the Air Conventions 45 years of experience, tools, methods and expertise available also to other regions, countries and organizations. To engage with the Forum could be one way for the Nordic countries to contribute to the global agenda.

Short overview of discussions

The group mainly discussed opportunities for the Nordic countries and the Nordic Council of Ministers to contribute to the ongoing revision of the Gothenburg Protocol, the implementation of the current and the revised EU AAQD, and the review and possible revision of the EU NECD. It was generally agreed that now is a good time to influence these three processes. As regards specific pollutants, most attention was given to ammonia, methane and black carbon.

Recommendations

Initiatives & Projects

The Nordic cooperation on air quality should aim to:

Support the use of structural measures (such as dietary changes) in decision-support models. A common theme for all three policy processes discussed here, was emissions of ammonia from agriculture. It is important for Nordic decision-makers to acknowledge that ecosystems in the Nordic region often are more sensitive than those in other regions. Therefore, safeguarding the health of Nordic ecosystems will likely require measures beyond those primarily technical ones that are currently modelled by existing decision-support models. Structural measures, such as dietary changes, often have the additional advantage of also reducing methane emissions.

Stress the importance of using the effects-based approach. This is important in the processes where decision-support models are used for setting targets and objectives, especially in order to ensure the safeguarding of sensitive Nordic ecosystems. The Nordic countries have vast ecosystem areas, many of which are not (yet) beyond rescue.

Enhance Nordic cooperation on how to best implement the monitoring requirements of the EU Ambient Air Quality Directive. The revised AAQD set up ambitious but vague requirements for monitoring of air quality. The vagueness will require interpretation and discussions to make the requirements concrete and enforceable. It is likely that coordinated Nordic efforts will be more effective than stand-alone efforts.

Strengthen the Nordic engagement in the Air Convention's Forum for International Cooperation on Air Pollution (FICAP). FICAP aims to facilitate international exchange of information and mutual learning at both scientific/technical and policy levels. Building on the Air Convention's nearly five decades experience of air pollution cooperation and control in Europe and North America, methods and expertise are made available also to other regions, countries and organizations. To

engage with FICAP provides an opportunity for the Nordic countries to contribute to the clean air work globally, as well as in the Nordics.

Harmonize and improve ecosystems reporting. Over the next few years, the EU's NEC Directive is up for review and possible revision, which provides an opportunity to improve and harmonize the ecosystem reporting (Article 9 and Annex V in the NECD). The reporting should include potential links to commitments under the Air Convention, UN Convention on Biological Diversity (CBD), EU Natura 2000, EU Nature Restoration Act, EU Nitrate Directive, EU Water Framework Directive. To enable improvement and harmonization, one solution is to develop coordinated reporting routines amongst relevant Nordic stakeholders.

Encourage more monitoring of ultra-fine particles (UFP) and black carbon (BC), as well as chemical transport modelling and epidemiological research to clarify the role of UFP and BC in $PM_{2.5}$ health effects. The Nordic countries are exposed to high levels of imported PM pollution, and more monitoring data of these pollutants, as well as high-resolution long-term exposure data, are needed to build stronger scientific evidence on the health impact. This knowledge is needed also to help disentangle potential differences in the impacts of various types of PM pollution.

Support the revision process of the Gothenburg Protocol, including Nordic reports and regional topic-specific capacity building, especially on abatement of ammonia from the agricultural sector. The Nordic countries have a long tradition of linking air pollution science and policy, and safeguarding the sensitive Nordic ecosystems require significant additional emission reductions. However, ambitious ammonia abatement efforts have met resistance from stakeholders, much due to disputed effects on productivity in the agricultural sector. Efforts are needed to remove barriers to effective implementation of necessary emission control solutions.

Wider thoughts on potential target groups

The discussions under the theme 'Clean Air – Regionally and Global' were mainly aimed at the EU's AAQD and NECD policy processes, and the Air Convention's Gothenburg Protocol. But it is conceivable that several of the projects and initiatives presented above are applicable also to many other international arenas, such as the Arctic Council, the Climate and Clean Air Coalition (CCAC), and the Global Methane Pledge.

Clean Air – Cities and Societies

Health impacts of air pollution is currently the main driving force for action towards reducing emissions. As three quarters of the EU population live in cities, and cities are air pollution hot-spots, urban citizens are particularly exposed to and affected by air pollution. It is therefore especially interesting to discuss how the Nordic cooperation can improve air quality in cities.

Abstracts of presentations

Thomas Ellerman, Aarhus University

There are many implementation challenges with the current and the revised EU Ambient Air Quality Directive in the Nordic countries. The Danish air quality monitoring program provides experiences useful for discussions on how to implement the revised AAQD. These experiences are likely common for most Nordic countries.

The revised EU AAQD is nearly fully adopted[1] and the requirements for monitoring must likely have to be followed from 1 January 2027. This implies also that the supersites must be started up with measurements of all the new air pollutants and that the new requirements for modelling will have to be incorporated.

In addition to new requirements for monitoring and supersites, there are also new air quality limit values as well as requirements on Average Exposure Reduction Targets. The new limit values and target values are entering into force from 2030 as well as the requirements on the Average Exposure Reduction Target. Denmark is already in compliance with the new limit values, and most likely fulfil the requirements on the Average Exposure Reduction Target in 2030.

1. The Nordic Air Pollution workshop on took place on October 7–8, 2024, the revised AAQD was adopted on October 14, 2024.

There are some aspects that from a scientific and technical viewpoint seems to be inadequate when compared to the aim of the revised directive. In the context of this workshop, the following four questions are of special interest:

- Are the required measurements in accordance with the aim of the directive?
- Are the data objectives in line with the aim of the revised directive and are the reference methods good enough?
- How shall the requirements for spatial representativity be understood in praxis?
- Is it the most important air pollutants that are included?

Leo Stockfelt, University of Gothenburg

Air pollution is generally estimated to be the single largest environmental health risk, both globally and in the Nordic countries. The majority of health burden and excess deaths are usually attributed to long-term exposure to fine particulate matter ($PM_{2.5}$). $PM_{2.5}$ is estimated to annually cause 5–9 million excess deaths globally, around half a million in Europe, and a few thousand in each Nordic country. There is clearly "evidence enough for actions" regarding health effects of ambient air pollution even at low exposure levels, and a wide consensus that the burden of disease is large. The WHO 2021 Air Quality Guidelines (AQG) are in the Nordic countries mostly exceeded in the larger cities where road traffic is intense and in the southern parts of the Nordics. For the burden of disease due to air pollution it is most important to reduce exposure levels where the population density is the highest. Reductions even below the WHO 2021 AQG are expected to yield further health benefits.

Examples of issues left to solve are:

The large differences in burden of disease estimations. For example, Gustafsson 2022 estimated 6,740 annual deaths due to air pollution in Sweden, compared to 911 deaths in 2021 due to $PM_{2.5}$ in the Global Burden of Disease (GBD) estimation 2021. For solid fuel use/wood burning Gustafsson et al estimated 708 deaths in 2019, compared with 0.24 for indoor exposure due to solid fuel use in 2021 in the GBD (somewhat different exposure definitions). GBD estimates for the other Nordic countries are mostly comparable, but with some interesting differences. A discussion on the best methods to estimate burden of disease and how to communicate the results is warranted. Strengthened evidence for "new" health outcomes might be needed to include in burden of disease and cost estimations, but mortality generally represents the main burden.

The remaining knowledge deficiencies regarding which particle constituents/ sources that incur the most health effects. To solve this knowledge gap, more measurements of UFP and BC are required for the high-resolution exposure modelling of long-term exposure that is needed for the epidemiological studies of the health effects of these exposures, and to what extent these differ from those of $PM_{2.5}$ mass. The relative effects of local emissions compared to long-range-transported particles also need to be elucidated. More knowledge on the toxicity of non-exhaust emissions from traffic (i.e. road, breaks and tyre wear) is also important, since the relative contribution of these components in total $PM_{2.5}$ concentrations is increasing. Human chamber studies would be valuable to evaluate the relative toxicity, especially regarding cardiovascular effects.

The question on whether control of air pollution levels is more effective than a focus on "healthy cities"? Preventive efforts are likely to yield benefits also through reduced co-exposures, and especially increased physically active transport. Focus needs to be both on "low-hanging fruits", such as the dirtiest vehicles and wood stoves, and on the most common emission sources.

The balance between local preventive efforts versus international legislation? The burden of disease due to air pollution in the Nordic countries would also decrease substantially if emissions are reduced in nearby countries. Rapid introduction of the WHO 2021 AQG into EU legislation is thus a priority. Additional limits on locally emitted air pollutants should however also be considered. Local preventive measures should especially consider sensitive groups, such as children and the elderly.

Lise Marie Frohn, Aarhus University

Health effects as a consequence of air pollution levels amount to several million premature deaths worldwide, also in Europe, despite decreases in air pollution concentrations over the last decades. Mortality constitutes the biggest share financially and gets the most attention, but effects on morbidity also contribute significantly to reduced welfare and socioeconomic costs.

With the integrated assessment modelling done with the EVA system (Economic Valuation of Air pollution), it is possible to follow the pathway from emissions to socio-economic costs through emission inventories, air pollution modelling, population exposure and response and valuation of health effects.

An example of a current EU project that applies the EVA system for generation of policy input is the MARCHES project, focusing on general and national characteristics of all the European countries with respect to health effects.

There are several more projects that have utilised the EVA system. The NordicWelfAir project showed among many other things, how detailed emission

data based on national knowledge and approaches play a crucial role in health impact assessments. Several previous and ongoing NMR funded projects have focused on the impact of different emission sectors (e.g. residential wood combustion - NordSmoke, shipping – Epitome, etc.) on human health, and the understanding of the similarities and differences between the Nordic countries has been greatly advanced.

Still, these recent projects have also revealed the need for continued research within all aspects of the impact-pathway chain. For the Nordic region this is especially related to:

- the exposure-response functions in the regime of low air pollution levels,
- the influence of different emission sources on local air concentrations, and
- the current and future composition of particulate air pollution (e.g. with respect to non-exhaust emissions).

Such research could directly support improved policy actions in the Nordic countries and enable cost effective protection of human health.

Short overview of discussions

Discussions focused on economic valuation of health impacts, health-effect studies, the need to maintain air quality monitoring also in "low-pollution" areas, co-benefits of improved city-planning (e.g. air quality, noise, mobility, green areas), and on a zero-pollution target for the Nordic.

Recommendations

Initiatives & Projects

The Nordic cooperation on air quality should aim to:

Ensure continued air quality monitoring even when concentrations of air pollutants are below WHO 2021 guideline values. The air quality in the Nordic countries have improved over the last decades and is now amongst the best in the world. It can be expected that many Nordic cities will soon have air pollution levels lower than the WHO 2021 AQG for many pollutants. When this happens, there is commonly a push from policymakers to save expenditures by ending regular monitoring. However, there are still fundamental scientific challenges related to air pollution and health, such as the separate effect of UFP and BC on health, and the health effects of air pollutants in low-exposure environments (i.e. areas with air cleaner than WHO AQG). In order to get more solid scientific knowledge about these questions, it is essential to continue monitoring also in areas where the air quality is better than

WHO AQG. It should be remembered that there still are substantial health effects even at levels below the WHO 2021 guidelines. Furthermore, population growth and economic development has always so far been pushing air pollution levels up. So even if the Nordics in the near future can reach air quality levels below WHO AQG, it is important to maintain monitoring to ensure that the trend isn't reversed. It must be recalled that increasing pollution levels have large socio-economic costs.

Ensure that Nordic countries take leadership on setting ambitious (zero) emission targets for air pollution. As explained above, the Nordic countries have a rather unique position with respect to air quality. Whilst some EU countries try to water down increased EU/European ambitions with respect to air quality, countries in other regions of the world are looking for inspirational examples of how to allow cities and countries to grow, whilst at the same time reduce emissions of air pollution and improving air quality. Now the Nordic countries have an opportunity to show leadership with respect to air quality.

Review existing Nordic evidence on health effects in low-pollution environments. The Nordic countries have a fortunate combination of good-quality population data, high-quality exposure assessments and low pollution environments. Therefore, there is now a good opportunity to help Nordic policy making and policy decision support modelling by reviewing Nordic air pollution health studies. It is currently expected that the relative impact of a change in air quality is larger per microgramme in low-pollution environments than in high-pollution environments, if this expectation can be confirmed for the Nordic setting, it would likely change the advice from Nordic policy support modelling to policy makers.

Maximise Nordic benefits of current EU projects on air pollution and health. In a recent EU Horizon call focused on environmental stressors and human health, Nordic research groups had a very good success rate. During 2023-2026, several Nordic research bodies are in a leadership position of the research projects BestCost, Marches, and VALESOR, which are coordinated under the Meteor cluster. [2] These projects study air pollution effects on health and its socio-economic consequences, which is of high relevance for Nordic decision-making related to air pollution and air quality. The Nordic Council of Ministers should grasp this opportunity to arrange build-on activities and knowledge dissemination workshops with these projects so as to maximise Nordic uptake of the knowledge produced.

Produce Nordic guidelines for city development respecting the citizens right to clean air. The ongoing urbanisation in the Nordics demands continued expansion and/or densification of cities. These developments can take place in many ways, and not all of them are beneficial for air quality. However, there are inspirational Nordic examples of how to develop cities so as to enable good air quality even in cities. A

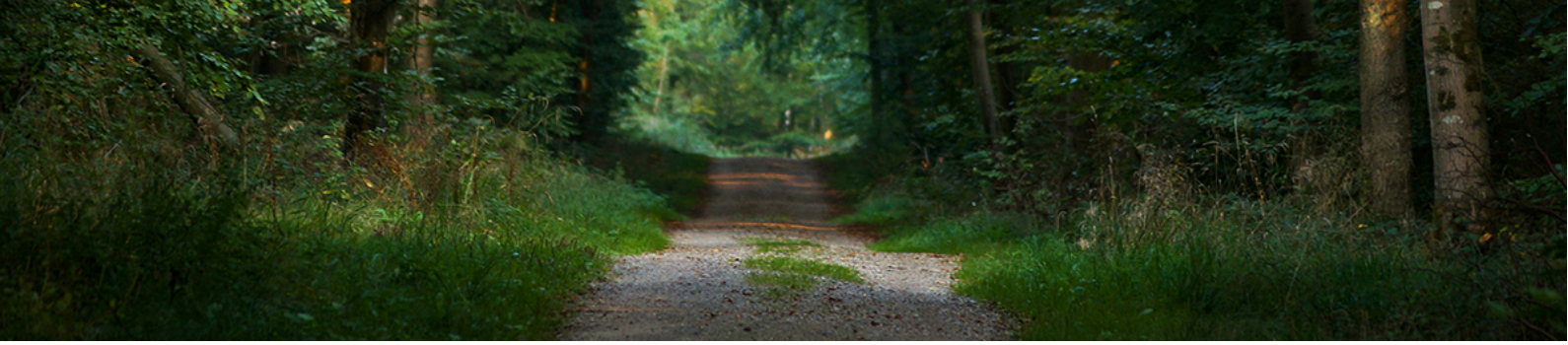
2. https://meteor-research.eu/

prominent example being the action taken by the city of Odense in Denmark. Production and dissemination of such Nordic guidelines to urban planners will help highlight the prerequisites for city planning enabling good air quality.

Clarify the economic value of air quality-related ecosystem services in cities. Many modern city planners utilize and highlight the importance of green areas in cities, sometimes with reference to their positive effect on air quality. However, this effect is contested, and most likely not as effective as specific emission reduction measures. But ecosystem services in cities have many benefits, not only for air quality. So, in order to help decision-making, it is important to show the economic benefits of various ecosystem services in cities, and also highlight which of the services that have best effects on Nordic air quality.

Wider thoughts on potential target groups

The discussions under the theme 'Clean Air – Cities and societies' were mainly aimed at developments in EU and in particular in the Nordic countries. However, many of the projects and initiatives presented above are applicable to several (other) arenas, such as the Air Convention (including FICAP) and various city networks.



Clean Air – Ecosystems and Climate

International action on air pollution was initially – in the 1970s and 1980s – motivated by damage to ecosystems, especially acidification of fresh water and wide-spread forest damage. Although the deposition of acidifying sulphur has significantly been reduced over the last 30–40 years, deposition of eutrophying nitrogen still exceeds the critical loads on approximately two thirds of EU ecosystems, and critical levels for ozone are exceeded over the majority of European forestry and agriculture land.

The scientific knowledge about air pollution impacts on ecosystems and biodiversity is solid and well-established. However, current policymaking often relies on economic cost-benefit analyses, and it has for many reasons proven difficult to achieve scientifically and economically robust monetary valuations to ecosystems and biodiversity. As a consequence, political acceptance of ecosystem-oriented cost-benefit analysis is yet to be achieved.

Moreover, there are complex interactions between air pollution, climate change, land-use change and other ongoing processes, which all affects ecosystems and biodiversity. While the evidence of air pollution causing damage to ecosystems and biodiversity is undeniable, further research is needed to deepen our understanding of the above-mentioned interactions. This work should be complemented by efforts to translate the complexities of these processes into clear and transparent facts to assist policymaking.

Abstracts of presentations

Filip Moldan, IVL Swedish Environmental Research Institute

Nitrogen emissions from agriculture, industry, and transport are decreasing only slowly, and nitrogen deposition still exceeds critical loads in 60–70% of Europe. Nitrogen negatively impacts the environment, human health, and contributes to global warming. Although nearly all reactive nitrogen (Nr) released into the environment is eventually converted back to nitrogen gas (N_2) through denitrification, it can undergo numerous reactions beforehand, causing a range of harmful effects on the atmosphere, hydrosphere, and biosphere. This process is often referred to as the nitrogen cascade. However, nitrogen is also an essential nutrient, and nearly half of the food produced for human consumption relies on nitrogen fertilizers derived from industrial nitrogen fixation.

Reactive nitrogen is present in all organic matter and many materials and products we depend on. The pathways and forms in which Nr leaks into the environment are diverse. To address the complexity of nitrogen cycling, the concept of the National Nitrogen Budget (NNB) was developed by the Air Convention's Task Force on Reactive Nitrogen (TFRN). This methodology divides national nitrogen budgets into eight key nitrogen pools and defines the major flows between them, proposing methods for quantifying these flows. NNB construction is based on national and international statistics, and where national data is unavailable – such as nitrogen content in certain products – typical values from published sources are synthesized. Sweden is close to completing its NNB using this methodology, while Denmark had already published an NNB before the TFRN approach was formalized. Finland and Norway have started their work on NNBs by focusing on forest nitrogen budgets through a joint project with Sweden and Denmark.

Nitrogen cycling in ecosystems is closely linked to carbon cycling. The size of carbon and nitrogen stocks in various pools depends on the balance between inputs and outputs. While measuring carbon inputs (photosynthesis) and outputs (microbial respiration and fires) is challenging, nitrogen inputs and outputs are easier to quantify. Since nitrogen and carbon are key components of organic matter, nitrogen budgets can help estimate changes in carbon stocks. The work of the TFRN on NNBs, therefore, has the potential to reduce uncertainties in national carbon budgets. This opens up opportunities for beneficial cooperation between the United Nations Framework Convention on Climate Change (UNFCCC) and the Air Convention.

Heleen de Wit, Norwegian Institute for Water Research (NIVA)

Surface water acidification remains an issue in the Nordic countries, which is reflected in continued exceedances of critical loads, monitoring data and also by significant annual spending on liming measures. The main culprit for surface water acidification in acid-sensitive (e.g., base-cation poor catchment soils) areas is elevated sulphate deposition along with long-term depletion of base cations from decades of mobilization and export of base cations from soils to surface waters. Natural acidity from dissolved organic matter (organic acidity) is beginning to be a more dominant driver of surface water acidity now that sulphate deposition has been strongly reduced.

Climate exerts a control on surface water acidification through enhanced soil base cation depletion and mobilization of organic acidity during high-precipitation events and long-term trends. Additionally, sea salt deposition associated with stormy weather can lead to episodic reacidification. Land use, especially in the form of forestry, can also lead to local acidification and to longer-term base cation depletion if all biomass is exported from the catchment. Long-term increases in biomass and longer growing seasons may lead to lower leaching of nitrate and thus oligotrophication of surface waters. Thus, surface water quality and acidity are controlled by multiple stressors.

It is difficult to assess to which status the ecosystems can be expected to return in an era of low air pollution but increasingly warmer and wetter climatic conditions. Especially estimation of biological status is fraught with uncertainty, since more factors than air pollution have changed since the onset of the industrial revolution. Very little is known about historical biological communities, and some populations may now be extinct. Thus, what may be expected in terms of a recovered ecosystem requires a solid understanding of species diversity and dynamics in healthy ecosystems, and predictive ability of changes in biogeochemical cycling.

Lise Marie Frohn, Aarhus University

In the perspective of the green transition and the biodiversity crisis, valuation of costs and benefits from changes in pressures to ecosystems is crucial. This presentation shows results from two NMR-funded projects revolving around this topic.

The project **Benefit Nature** has the goal to derive the methodology for a new Nature component to the EVA system, which previously has focused solely on human health effects and corresponding socioeconomic costs. The anthropogenic driver is reactive nitrogen deposition, the receptor is terrestrial sensitive ecosystems with biodiversity measured as similar plant species richness as the key metric, and the valuation of species loss/gain is based on Danish conditions.

The project **Nordic Nature & Nitrogen** has the goal to implement a more complex

(and more true to natural processes) dry deposition parameterisation in the three Nordic regional models DEHM, EMEP, and MATCH, and to evaluate the impact on reactive nitrogen deposition to sensitive terrestrial nature areas. The new parameterisation takes into account the saturation effects in plants, leaves, water and soil, which occur in high deposition regimes, which potentially redistributes the reactive nitrogen deposition with increased deposition further away from sources.

The results from the two (ongoing) research projects, will give recommendations for policy-relevant future research projects that can take advantage of existing data developed within the projects.

Short overview of discussions

The complexity of valuing nature in economic terms was brought up as well as the intrinsic value of a thriving, healthy environment (clean air, clear water, productive soils, etc.). The latter could be set in contrast to the utilitarian view of "ecosystem services". Time of recovery, and the difference between chemical and biological recovery, were highlighted. Could "cost of restoration" be used as an alternative way of valuation? Which leads to the question of what recovered/restored ecosystems can we expect as a result? Links to the CBD, the EU's Nature Restoration Law and the impacts of climate change were also discussed.

Recommendations

Initiatives & Projects

The Nordic cooperation on air quality should aim to:

Ensure the continuity of ecosystems monitoring. Long-term data collection and analyses are essential for establishing the links between biodiversity and air pollution, and also needed for economic valuation of nature. Monitoring is of particular relevance for the protection of the vast and sensitive Nordic ecosystems.

Further develop exposure and valuation metrics for biodiversity. While exposure metrics already exist and are used for policy, there is still room for improvement of these, e.g. with respect to delay functions for exposure. Also, the implications of biodiversity metrics for science and policy advice need to be analysed qualitatively. In addition, research is needed for development of biodiversity valuation metrics. Promoting such developments and qualitative analyses will benefit Nordic countries that have vast ecosystem areas, many of which are stressed by air pollution, but not yet beyond rescue.

Promote better exchange of knowledge. Link Nordic scientific knowledge on air pollution (especially nitrogen) impacts on ecosystems, as well as Nordic work on

national nitrogen budgets, to relevant working groups supporting the Intergovernmental Panel on Climate Change (IPCC) and CBD.

Encourage integrated nitrogen-carbon management approaches. Nordic leadership in piloting integrated nitrogen-carbon strategies could set a model for broader international collaboration, creating a more coherent approach to managing nitrogen and carbon pollution, reducing overlap, improving both nitrogen and carbon emissions reporting, and thus improving policy outcomes both nationally and internationally.

Assess effects of ozone on (semi)natural ecosystems. Background ozone is still a threat to ecosystems and human health, and there is clear risk that ozone concentrations may increase if methane emissions increase. As ecosystem impacts of background ozone levels are not so well known, an assessment of current knowledge with respect to Northern ecosystems would be useful.

Clean Air – Emission Sectors

The session focused on three main emissions sectors - agriculture, residential wood-burning, and shipping. For these sectors, past emission reductions have generally been slower than in many other sectors, and future emission projections indicate similar patterns. Regarding agricultural emissions, the link to food and dietary issues was stressed in the discussions, as well as links to other policy initiatives that directly or indirectly will impact agricultural livestock production, a key emission source for ammonia and methane. Emissions from residential wood-burning is responsible for a growing share of PM-pollution in cities, but significant reductions could take place by changing to other types of heating systems. For shipping, there is an urgent need to investigate potential negative impacts of new/alternative fuels and propulsion systems, but there are also great opportunities to improve current legislation (e.g. the IMO NOx-standards) and to expand the emission control areas in Europe and in the Arctic.

Agriculture

Livestock production is the main source of ammonia emissions, and also a big source of methane emissions. Halving ammonia emissions in Europe is possible, but it would require dietary changes.

Abstracts of presentations

Rasmus Einarsson, Swedish University of Agricultural Sciences (SLU)

Nitrogen emitted from agriculture as ammonia, nitrate, and nitrous oxide affects air quality, biodiversity, and climate. An integrated perspective of these emissions is needed as they are causally connected and mitigation of one emission can have co-benefits or trade-offs with other emissions.

Agricultural emissions of ammonia and greenhouse gases share several common drivers. Broadly speaking, countries with high ammonia emissions tend to have

higher agricultural greenhouse gas emissions. Livestock production, including feed production, dominates agricultural emissions of ammonia and greenhouse gas emissions.

Food systems research shows that substantial mitigation of these emissions is possible. Technical and management improvements may enable emission reductions around 20-40% at current production volumes, given concentrated efforts in research and innovation, and with sustained policy support. To reach emission reductions around 40% or more, reduced primary production appears necessary. Strongly reduced primary production is possible without decreasing supply of food calories, protein, etc., if human diets shift towards more plant-based food and if non-food demand (e.g., biofuels and fibre) does not expand too far.

Among environmentally inclined food-systems researchers, a common sentiment is that basically "everything is known", in the sense that research has already quantified the technical, management, and consumption factors most important to mitigate emissions. The major gap, according to this sentiment, is not a knowledge gap, but an action gap.

The policies and agreements touching on these emissions are mostly focused on specific pollutants. They vary from specific and binding (e.g., EU NECD and EU Effort Sharing Regulation (ESR)) to more general and/or with weak enforcement (e.g., UN CBD, the UNFCCC Paris Agreement, and the Global Methane Pledge).

As mentioned, these different emissions share common drivers (i.e., the intensity and scale of agricultural primary production), but the most stringent policies tend to focus on individual pollutants. It is therefore a common concern – at least among researchers – that policy is not sufficiently joined-up and systems-oriented, and that cost-benefit analyses of mitigation do not capture all the relevant benefits.

During this workshop, it would be interesting to reflect on the sufficiency of available cost-benefit analyses, available scientific knowledge and data, and the existing policy types/policy frameworks to address the challenges associated with agricultural emissions of nitrogen and greenhouse gases. More specifically, the following questions should be addressed:

- Are there major gaps in scientific knowledge or data limiting progress on air quality, biodiversity, climate?
- Imagine a total cost-benefit assessment of mitigation options for agricultural emissions. Would authorities and governments use it?
- Are pollutant-specific policies sufficient to address different types of nitrogen pollution, or is a more joined-up policy approach needed?

Short overview of discussions

The discussions focused mainly around how to better utilize the advice given by existing knowledge on agricultural emission control, and a main theme was how to convert knowledge to action. In addition, the workshop discussed whether Nordic cooperation could facilitate production of Nordic guideline documents to reduce emissions, improve coordination between policy domains affecting agricultural emissions, and whether it is desirable to drive a policy process towards mandating national nitrogen budgets in a revised NEC Directive.

Recommendations

Initiatives & Projects

The Nordic cooperation on air quality should aim to:

Strengthen nitrogen policies by including structural measures such as dietary change (for example reduced meat consumption). It is clear that the ammonia emission reductions needed to protect ecosystems and health, cannot be achieved by solely technical abatement measures. Nordic countries have good knowledge about and experience of nitrogen budgets. These could be further advanced and also spread to other countries. More Nordic research on future dietary needs and options and their role in reducing nitrogen emissions could be promoted. In this context, also climate aspects should also be taken into account.

Develop and improve knowledge sharing. Within the Nordic, there is a need to share knowledge and experiences on agricultural emission abatement measures, for example regarding the acidification of slurry. Such activities could also provide an opportunity to spread knowledge also to countries outside the Nordic to support further emission reductions.

Ensuring the application of integrated approaches to nitrogen management. These could focus on co-benefits to climate, water and biodiversity, both regarding specific measures and more general policies.

Residential heating

Heating residential buildings by burning solid fuels is the predominant source of several air pollutants in the EU. According to the EEA, the sector is responsible for 58% of PM2.5, 37% of black carbon, and 85% of benzo(a)pyrene (BaP) emitted in the EU. The majority of these emissions come from small wood-burning appliances.

Existing EU legislation, i.e. the Ecodesign Directive, will only deliver limited emission reductions over the next 5-10 years, meaning that additional (alternative) measures are needed.

Presentation abstract

Niko Karvosenoja, Finnish Environment Institute (SYKE)

Residential wood combustion (RWC) is the biggest source of $PM_{2.5}$ in all the continental Nordic countries: Finland, Sweden, Denmark and Norway (Paunu et al. 2022). The emissions are mainly caused by incomplete combustion in stoves that are relatively simple in structure and do not have advanced combustion control or flue gas aftertreatment systems (in contrast to other modern day combustion sources such as power plants, transport vehicles etc.). The amount of incomplete combustion depends – besides the stove structure and combustion technology – to a large extent on the combustion skills and habits of the stove user.

The only significant legislative measure in place to mitigate RWC emissions at the moment is the Ecodesign directive for solid fuel room heaters, which defines the emissions performance of new stoves and boilers that can be sold on the market. In the coming decades, the emissions are expected to decrease only slightly due to the slow turnover of stove stock. Correspondingly, RWC will remain the biggest source sector of $PM_{2.5}$ emissions, with even a higher share of total emissions than today.

Although wood use per household is typically highest in rural areas, stoves are common also in relatively densely populated suburban detached house areas of Nordic cities, where the emissions cause considerable population exposure and potentially negative health impacts. Therefore, mitigation of emissions would be beneficial to direct towards urban areas so that benefits like improved public health can be achieved.

In a technical sense, there is a considerable potential to mitigate emissions from RWC by:

1. Improving combustion technologies of stoves and small boilers in use so that there will be less incomplete combustion and thus less emissions.
2. Reducing the amount of incomplete combustion by sharing information about proper use of stoves.
3. Cleaning the flue gases after the combustion by, e.g., catalytic methods or particle filters on chimneys.
4. Restricting the use of stoves.

The Ecodesign directive aims to improve stove technologies. However, it does not bring such strict requirements to stove manufacturers that it would drastically change the technologies used. Furthermore, it regulates only new appliances on the market. Stoves and boilers are often long lived, i.e. the turnover of appliance stock is slow, and the emissions from the stock decrease slowly. There have been

attempts to accelerate the pace of the modernization by e.g. financial support or demands to purchase a new stove when moving to a new address. According to a Finnish survey and modelling study, financial support for new stove purchases does not appear to be effective policy. It is not a cost-efficient way to reduce emissions, nor a cost-effective way to improve public health (manuscript in preparation). This is supported by the results from a Norwegian study (Lopez-Aparicio & Grythe 2020). Sauna stoves, not covered by the Ecodesign directive now, are in the process to be added to the directive in the future. This could potentially reduce RWC emissions in Finland, depending on the requirements in the future legislation.

Information campaigns about proper combustion practices to reduce emissions have been carried out regularly in several Nordic cities. These have been shown to be a cost-efficient and immediate measure, although efficacy and permanence of the change are uncertain (Savolahti et al. 2016).

Aftertreatment of flue gases in RWC is not commonly used anywhere in the Nordic countries. There are several technologies in development or on the market (e.g. www.tassuesp.com, www.noeton.fi). However, the characteristics of RWC flue gases with discontinuous and variable composition and high amounts of organics make the removal challenging, and there are issues of price and need for maintenance of the appliances, which do not make the purchase tempting for stove users. It is not foreseeable that these technologies will become mainstream, unless technology- or emission-specific regulations are introduced and enforced.

There have been isolated cases of restricting RWC at certain times or technologies, e.g. ban on the use of old stoves in Bergen, Norway. As more wide-ranging mitigation efforts, bans or other prohibitive measures might be politically challenging to implement due to foreseeable resistance from the citizens. A "softer" option to try to mitigate RWC could be information sharing about the negative impacts of wood smokes on vulnerable people in the neighbourhood, e.g. targeted to urban areas during winter inversions.

Additional factors to take into consideration when assessing the feasibility and applicability of various measures to mitigate RWC emissions:

- Stove technologies, use types and geographical locations vary a lot. Considerable amounts of stoves are used only occasionally and/or in sparsely populated areas. It is important to avoid measures that would heavily impact citizens or targets that are not causing considerable negative impacts.
- There are differences in stoves and other characteristics between the Nordic countries, which are important to consider when, e.g., assessing common Nordic mitigation measures. For instance, radiative iron stoves, typical especially in Norway and Denmark, are lighter and easier to replace with new stoves than masonry heaters which is the most common stove type in Finland.

- RWC is important from an energy security point of view. Stoves are the only heat source that does not require electricity. Power cuts are quite common, and especially in rural areas they can sometimes last tens of hours. This is important to keep in mind if considering banning stoves.

Short overview of discussions

The discussions on how Nordic cooperation can reduce emissions from residential heating circled mainly around which policy instruments that can be effective as well as cost-effective. The policy instruments discussed included potential establishment of (temporal) bans on wood burning in urban areas, faster implementation of - or stricter rules for - Ecodesign stoves in Nordic countries, as well as experiences from information on clean burning.

Recommendations

Initiatives & Projects

The Nordic cooperation on air quality should aim to:

Clarify opportunities and challenges with (temporal) bans on residential wood-burning in cities. To achieve satisfactory air pollution levels in cities, residential wood-burning in cities needs to be stopped, or completely new zero- or near-zero emission technologies for small-scale combustion developed. In cities, alternative heating options, such as district heating or various types of heat-pumps are readily available. There are several Nordic and European examples of local temporal and/or conditional bans. A Nordic project could investigate options for various measures, including bans, local regulations, and information campaigns promoting voluntary actions.

Promote Nordic information-sharing on tried and tested ways to reduce emissions from residential wood-burning.

Improve the knowledge on regional and time-dependent factors affecting health effects from residential wood combustion. Just as discussed during the session Clean Air – Cities and Societies, improved scientific understanding of effects from RWC would enable better policy advice from science. One issue that needs better clarification includes exposure-response functions for exposure periods shorter than one year but longer than a couple of days. Given that RWC in the Nordics is mainly an autumn/winter activity, the use of annual average ERF can lead to estimation errors in impact assessments. Another issue that needs clarification, or at least clear recognition, is the differences between urban and rural regions with respect to health effects, energy security, etc.

Clarify to what extent residential wood combustion affects BaP emissions. Even if Nordic $PM_{2.5}$ concentrations are relatively close to WHO guideline values and Nordic Environmental Quality Objectives, the same cannot be said for BaP. RWC is a key source also for BaP, and it is therefore important to increase the knowledge and attention to BaP emissions from RWC and how much these can be reduced through emission control measures.

Shipping

As shipping largely is an international business, it is logical to try and bring about global agreements for control of its air pollutant emissions, and since the early 1990s such work has been ongoing within the Marine Environment Protection Committee (MEPC) of the UN International Maritime Organization (IMO). Here, Nordic countries have been front-runners by proposing and establishing Emission Control Areas in the Baltic Sea and the North Sea through HELCOM and OSPAR with strong Nordic voice in both conventions.

While there is an EU-directive regulating the sulphur content of marine fuels, there are currently no EU standards for NOx or PM emissions from sea-going ships, although such standards exist for inland waterway vessels. NOx-emissions from international shipping are regulated through the IMO's NOx technical code which defines NOx emission standards for vessels according to their key-lay date. The Baltic Sea, the North Sea and the English Channel have been designated as Emission Control Areas, with mandatory Tier III NOx-standard for all new ships built from 2021.

As regards national initiatives to cut air pollution from shipping, Nordic countries have shown leadership by, for example, introducing and applying economic instruments (e.g. the Norwegian NOx-tax and the Swedish environmentally differentiated port and fairway dues) and onshore power.

Abstracts of presentations

Jana Moldanova, IVL Swedish Environmental Research Institute

Despite decades of focus on reducing air pollutants from the shipping sector, significant challenges remain, especially with the addition of greenhouse gas reduction targets. Recent regulations have reduced sulphur oxide (SOx) emissions, particularly in Sulphur Emission Control Areas (SECAs). But outside these zones, such as in the Mediterranean and Atlantic, potential for further reductions remains. Parts of this potential will be fulfilled through the designation of the Mediterranean Sea as a SECA by 2025. However, using high-sulphur fuel with Exhaust Gas Cleaning Systems (EGCS, i.e. scrubbers) has introduced new environmental

concerns. Scrubbers emit metals and other contaminants into the sea, posing an apparent risk of having serious impact on populations of key species of marine food webs. Further, scrubbers imply higher concentrations of $PM_{2.5}$ in ambient air compared to mitigation of SOx emissions through low-sulphur fuels. A study from the EMERGE project showed a 30% increase in $PM_{2.5}$-related health effects due to high scrubber use compared to scenarios with alternative fuels.

With respect to nitrogen oxides (NOx), the shipping sector's contribution has increased, and in 2020 ship NOx emissions in European seas was equal to around 50% of total EU land-based emissions. Despite the introduction of Nitrogen Emission Control Areas (NECAs) in the Baltic and North Seas in 2021, NOx emissions remain high due to the long lifetime of ships. In addition, underperformance of both Tier II and new Tier III vessels, especially at low engine loads, has been observed and due to these two facts, high NOx emissions from shipping risk continuing for a long time. Projections suggest that NOx emissions will significantly decrease by 2040 in NECA regions. However, non-compliance could hinder this progress, leading to 50% higher emissions and contributions to ambient NO_2 levels compared to the compliant scenario. Ozone formation from shipping emissions is particularly problematic in the Mediterranean, where conditions favour ozone production. Implementation of Mediterranean NECAs could reduce shipping's impact on ozone, but non-compliance could offset these gains.

Liquefied natural gas (LNG) is being promoted as a cleaner fuel option with a 100% increase in use between 2018 and 2022. However, LNG, particularly from 4-stroke engines, emits more methane than previously estimated, especially under low-load conditions. Being a potent greenhouse gas, these emissions have significant impact on climate.

The greatest challenge for shipping is decarbonization. The IMO aims for net-zero greenhouse gas (GHG) emissions by 2050, with interim targets for 2030. Promising low-carbon fuels, like ammonia, methanol, and hydrogen, come with new risks. For example, ammonia poses toxicity risks, its slip would contribute to PM formation and all alternative fuels have the potential to produce emerging pollutants, such as aldehydes, amines and nitro-PAHs, which requires further research.

Short overview of discussions

The fact that NOx emissions from ships in real-life driving conditions are higher than the emission standards result in higher health and environmental impacts, but also has add-on effects on policy analyses because emission inventories assume compliance with emission standards. Consequently, there is an urgent need to improve legislation.

New, so-called low-carbon shipping fuels and other GHG abatement measures for ships need to be scrutinised by full life-cycle assessments, to ensure that they bring real GHG-reductions and that they do not result in increased pollutant emissions either to the air or to the marine environment.

Recommendations

Initiatives & Projects

The Nordic cooperation on air quality should aim to:

Promote Nordic collaboration on alternative fuels and propulsion systems. Increased knowledge about potential negative well-to-wake impacts of alternative (zero- or low-GHG) fuels and propulsion systems are urgently needed, in order to avoid (yet unforeseen) environmental damage and sunk investments.

Provide Nordic leadership on ship emissions abatement. The Nordic countries have long shipping experience, academia, many ports, shipping companies, emission control manufacturers, etc. They have also been frontrunners for several "cleaner shipping" initiatives (e.g. ECAs, economic instruments, onshore power, alternative fuels and propulsion systems). Consequently, the NCM should promote Nordic cooperation to further this leadership.

Support the expansion of Emission Control Areas to all sea areas around Europe. Despite the effect of existing Emission Control Areas, shipping emissions still cause air pollution problems in Europe. Through an expansion of the ECAs, shipping emissions can be reduced. This would benefit most countries in Europe as well as reducing the input of BC to the Arctic.

Support a revision of the IMO's NOx standards for ships. A fast introduction of revised NOx standards is needed to ensure that ships certified to the Tier II and Tier III standards perform according to the standards, not only at the time of certification but also in real-world driving. Ship emissions contribute significantly to nitrogen deposition in Nordic countries, and also to elevated NO_2-levels in Nordic port cities and coastal areas.

Clean Air – Efficient Communication

Todays' society is characterised by a very competitive information landscape and there are several environmental problems that are getting worse. In contrast, air pollution in Europe and the Nordics is improving (although not fast enough). Correspondingly, it is difficult for air pollution policy makers and scientists to reach out with messages on the importance and benefits of reducing air pollution further. Nordic cooperation and coordination can be a way to breach through this dense information competition.

Abstracts of presentations

Daniel Lissoni, European Environmental Bureau (EEB)

Daniel Lissoni addressed the critical need for improved communication about clean air and outlined ideas to elevate the importance of clean air issues in the public's mind. Clean air is vital not only for public health but also for economic and environmental sustainability. However, despite the availability of data and technical solutions, public awareness and prioritisation of clean air remain low. The presentation aimed to bridge that gap by exploring effective communication strategies.

The presentation began by outlining the current state of play with air pollution communication in Europe, focusing on the major challenges and barriers that prevent effective public engagement. While the science behind air quality is robust, clean air issues often seem abstract or are perceived as a secondary concern compared to more visible environmental issues. The presentation discussed the importance of framing air quality messages in ways that resonate personally, such as highlighting health impacts on vulnerable groups like children.

The presentation provided specific recommendations to improve clean air communication, including leveraging digital platforms, storytelling, and emotional engagement. It was demonstrated how public campaigns can make air pollution's

impact more tangible, encouraging public support for policy changes. Additionally, emphasis was on the potential for citizen science initiatives to foster a sense of ownership and understanding among communities.

The goal of the presentation was to inspire coordinated action that places clean air at the forefront of public and policy agendas, ultimately leading to tangible improvements in both air quality and public health across the region.

Line Merete Karlsoen, Norwegian Environment Agency

Line Merete Karlsoen informed about a Norwegian governmental Air Quality Collaboration Group consisting of the Norwegian Meteorological Institute (Met), the Norwegian Public Roads Administration, the Norwegian Institute of Public Health, the Norwegian Directorate of Health and the Norwegian Environment Agency.

Together these governmental bodies have created an air quality forecast service for the whole of Norway. The public, including vulnerable groups, and the municipalities, which are local authorities for air quality, are the main target groups. The intention is also to encourage the media to use the forecast actively.

In addition, the cooperation has created a service with historical air quality data, like concentration maps and maps for land-use planning, population exposure and source apportionment. And a mitigation calculator. The target groups are the municipalities and others working with air quality. Fine scale emission data are used, which are also available through a database. The model used is urban EMEP (uEMEP) developed by Met.no.

This collaboration has made it possible to provide these services and is an example of a valuable interdisciplinary cooperation. The goal is to offer relevant information about air quality and to raise awareness and knowledge about air pollution, primarily to municipalities and others working with air quality in their work for securing good air quality. The services are also valuable in the government's own work.

The Air Quality Collaboration Group has had good experience with:

- Involving the users actively to ensure that the features offered are useful and relevant, and that they trust and rely in the services. Both the public, and especially the municipalities, since they are local authorities.
- Using an already existing platform, the weather service Yr, to reach out with the forecast.
- Formalizing the structure of our cooperation with yearly goals for communication and dissemination work, making it clear who is responsible for each goal and reporting results in an annual report.

There have also been a couple of challenging experiences:

- Reaching out to everyone that could benefit from the services, including in within the governmental organizations included in the cooperation.
- Reaching out with the health advice in the forecast.
- Communicating uncertainty, i.e. why there can be differences between monitoring data and modelled data.

In Norway there is also a package to support the municipalities in their transition to a low emission society, including several communication products. The package includes: 1. A financial support scheme for climate measures ("Klimasats"). 2. Guidance on climate planning and measures. 3. Webinars, i.e. about how to include climate and nature into land-use planning. 4. Podcast with inspiring examples. 5. Climate emission inventory for municipalities and county municipalities. 6. Templates for calculating effects of climate measures. 7. Guidance on how to include climate in public procurement. 8. Facebook-group for "local climate work".

Short overview of discussions

Even though there is much data and information on air pollution/air quality readily available, public awareness and political prioritisation remain relatively low. Improved and intensified communication activities, directed to the general public as well as to policymakers, require additional funding.

The fact that air pollution is a threat not only to human health but also to nature and biodiversity needs to be highlighted. Methods to better visualise the damage caused by air pollution should be explored.

As policy debates linked to air pollution control action often tend to focus on the costs of proposed measures, it is important to communicate also the benefits to health and the environment in both quantitative and qualitative terms.

Recommendations

Initiatives & Projects

The Nordic cooperation on air quality should aim to:

Ensure better access to reliable air quality forecasts for Nordic municipalities and citizens. That this is feasible is shown e.g. by a project run by the Norwegian Air Quality Collaboration Group. Nordic countries would benefit from cooperating and sharing experiences on this topic.

Link air quality forecasts with well-thought out 'action advice' for citizens. To expand the numbers of receivers (and to avoid misunderstandings and/or confusion regarding the advice) it is useful to link forecasts with commercially available apps. Nordic health experts could develop templates on recommended "action advice" to be used by such apps.

Clarify that air quality has improved over time, but that more needs to be done. There appears to be a fairly widespread view among the general public that air quality is deteriorating. To motivate additional action to reduce emissions, it is important to show that the various actions taken over the last 30–40 years have been successful in reducing emissions and improving air quality, and moreover they have also been very cost-effective. Nordic ex-post analyses would be useful to further this argument.

Raise the profile of nature protection. While nature protection was the main driver for international action to cut air pollutant emissions in the 1970s and 1980s, nowadays air quality policies are primarily focused on lowering negative health impacts. Communicating the importance of a healthy nature and functioning ecosystems is important. Joint Nordic initiatives could be developed to find effective ways to communicate the importance of healthy nature and functioning ecosystems.

Ensure better public information on air quality. On top of the voluntary informative air quality forecasts mentioned above, Annex IX of the new AAQD contains a number of requirements for member states regarding information to the public, including information on impacts on health and vegetation, and timely information about actual or predicted exceedances of alert thresholds, and any information threshold. Nordic countries would benefit from cooperating and sharing experiences on how best to implement these requirements.

Workshop programme and participants

7 October

11.30–12.00	Arrival and lunch sandwiches
12.00–12.30	Welcome and introduction from the NCM (Katja Asmussen) and the moderators (Stefan Åström and Christer Ågren)
12.30–13.45	**Session 1: Clean Air – Regionally and Globally** • *Setting the scene* (moderators) • *Nordic involvement in CLRTAP & EU processes* (Anna Engleryd – presented by Christer Ågren) • *CBD & Critical loads for biodiversity* (Jesper Bak) • Discussion
13.45–14.00	Break
14.00–15.15	**Session 2: Clean Air – for Cities and Societies** • *Implementation of the current and the new EU Air Quality Directive in the Nordic countries* (Thomas Ellermann) • *Current health impacts in the Nordic, and exceedance of the WHO air quality guidelines* (Leo Stockfelt) • *Valuing health effects* (Lise Marie Frohn)
15.15–15.30	Break
15.30–17.15	**Session 3: Clean Air – Ecosystems and Climate** • *Nitrogen budgets and nitrogen sequestration in Scandinavian forest ecosystems* (Filip Moldan) • *Effects of air pollution, climate and land use on aquatic ecosystems* (Heleen de Wit) • *Valuation of environmental cost and effects* (Lise Marie Frohn)
17.15–17.30	Wrap up (moderators)

8 October

09.00–09.30	Recap from day 1 (moderators)
09.30–10.45	**Session 4: Clean Air – Emission Sectors** • *How can agriculture be adjusted to benefit both biodiversity, air and climate?* (Rasmus Einarsson) • *Residential heating: User study and what can be done to cut emissions* (Niko Karvosenoja) • *Emission challenges in international shipping* (Jana Moldanova) • Discussion
10.45–11.05	Break
11.05–12.20	**Session 5: Clean Air – Efficient Communication** • *Improving clean air communication* (Daniel Lissoni) • *Information about air quality for residents an administrations: Air cooperation in Norway* (Line Merete Karlsøen) • Discussion
12.20–13.20	Lunch
13.20–14.00	Conclusions and next steps (moderators)

List of participants

Pål Amdal Magnusson, Klima- og miljødepartementet, Norway
Katja Asmussen, Miljøministeriet, Danmark
Jesper Bak, Aarhus University, Denmark
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Rasmus Einarsson, SLU, Sweden
Thomas Ellermann, Aarhus University, Denmark
Martin Forsius, SYKE, Finland
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Heleen de Wit, NIVA, Norway
Christer Ågren, moderator
Stefan Åström, Anthesis, moderator

About this publication

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