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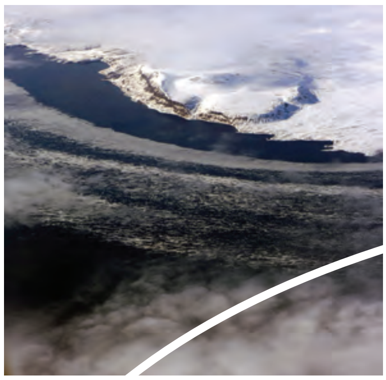
# Nordic workshop on action related to Short-lived Climate Forcers

Organised by the Nordic Council of Ministers Climate and Air Quality Group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*Hans Skotte Møller (Editor)*

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# Content

# Preface

*High concentrations of Short-lived Climate Forces such as black carbon may have a large impact on global warming, especially for the Arctic region. The good news, however, is that early reductions of such pollutants, could reduce the speed of global warming in the short term. Emission reductions will also have important health benefits.*

Emissions of air pollutants have long been known to have negative impacts on human health and ecosystems. Further, recent scientific findings have identified that certain air pollutants, like black carbon, methane and tropospheric ozone, might have a larger impact on global warming than earlier assessments indicated. As these substances are Short-lived Climate Forcers (SLCFs), abatement measures, especially for the Arctic, could reduce the speed of global warming in the shorter term (20–30 years).

During our meeting on Svalbard in March 2012, the environment ministers of Denmark, Finland, the Faroe Islands, Iceland, Norway, Sweden and Åland discussed what we could do to cut global and Nordic emissions of SLCFs, bearing in mind that the focus on SLCFs should not be at the expense of cuts in $CO_2$ emissions.

In order to direct future work, the ministers adopted the Svalbard Declaration on Short-lived Climate Forcers. Realising that global emissions of SLCFs can only be effectively abated through broad international, regional and national initiatives, we, among other priorities, agreed to improve the basis for national and joint Nordic initiatives. The ministers expressed willingness to further develop and strengthen national emissions inventories for SLCFs, to identify cost-effective initiatives to reduce emissions and to evaluate the need for national and Nordic action plans for the reduction of emissions. We will intensify our efforts and work more closely together in international fora to advocate more ambitious international regulation of emissions of greenhouse gases and SLCFs. To support the work initiated by the ministers, the Nordic Climate and Air Quality Group held a seminar in June 2012 at which scientists and policy-makers discussed recent scientific developments and ongoing activities related to SLCFs, as well as recommendations for future activities.

This report presents conclusions and recommendations which were the outcome of the meeting, e.g. nine specific "policy recommendations" by the Climate and Air Quality Group on immediate Nordic actions, Nordic campaigns and international actions. In addition, the workshop adopted a number of conclusions and recommendations on scientific research, monitoring and modelling underlining that particular emphasis should be directed towards the Arctic region, and the need to intensify collaboration with Russia.

The shaping of joint Nordic initiatives and actions to reduce the formation and emissions of SLCFs has been a major priority for Norway during our Presidency of the Nordic Council of Ministers in 2012. I know that my Swedish colleague who will take over the Presidency in 2013 will carefully follow up on the conclusions from the workshop and the policy recommendations by the Climate and Air Quality Group.

Oslo, 26 November 2012

*Bård Vegar Solhjell*
Minister of the Environment
Norway

# Summary

## Report from Nordic workshop on action related to Short-lived Climate Forcers

**Background**
Recent scientific findings have identified that short-lived air pollutants such as black carbon might have a larger impact on global warming than earlier assessments indicated, and that the abatement of Short-lived Climate Forcers (SLCFs), especially for the Arctic, could reduce the speed of global warming in the shorter time frame (20–30 years). The term Short-lived Climate Pollutants (SLCPs) was also used during the workshop as a synonym for SLCFs.

The Nordic Ministers of Environment adopted at their Svalbard meeting in March 2012 a declaration on SLCFs. The ministers also asked the Nordic Working Group on Climate and Air Quality (KoL) to convene a Nordic workshop to exchange information on the status of national inventories of short-lived climate pollutants and existing abatement strategies, identify cost-effective measures to reduce SLCF emissions and improve the basis for common but national action plans in the Nordic countries.

**Research findings**
To date, enough anthropogenic greenhouse gases may have been dumped into the atmosphere to warm the planet by more than 2°C. The 2°C warming can be delayed by three to four decades if we significantly reduce the global emissions of SLCFs, methane, HFCs and black carbon (BC). The growing atmospheric concentration of methane stabilised in the late 1990s, but has started to increase in recent years. Measures that abate emissions of SLCFs could improve the possibility of reducing the global temperature increase in the long run to below 2°C, but only if $CO_2$ and other long-lived greenhouse gases (GHGs) are aggressively addressed.

We should distinguish between Short-lived Climate Forcers that can have lifetime of 10–15 years (such as methane), and Very Short-lived Climate Forcers with a lifetime of days to weeks, such as air pollutants like nitrogen oxides ($NO_x$), volatile organic compounds (VOC) and carbon monoxide (CO), affect the global climate through photochemical reactions that produce tropospheric ozone. Ozone has a warming impact in the upper troposphere, while the ozone near ground level is negligible from a climate perspective. Methane and carbon monoxide are therefore the most important ozone precursors to abate in order to reduce radiative forcing of ozone, since these are the major precursors for ozone in the upper troposphere. The reduction of $NO_x$ will probably instead lead to increased warming since NOx emissions by reducing methane cool the atmosphere.

Black carbon, followed by methane, is probably the most important SLCF emission to contribute to global and regional Arctic warming. Emissions of black carbon from Nordic countries have a higher direct radiative forcing (warming) effect in the Arctic per unit of emission than BC emissions from other parts of the world. This is due to the proximity to the Arctic. BC from all sources in the world seems to have caused about 20% of Arctic warming and sea-ice loss over the last century. However, large interannual variability in the regional climate will make it very difficult to detect any climate-response signal in the mitigation of SLCFs.

Natural sources dominate carbonaceous aerosols in the atmosphere in Nordic countries during summer. Anthropogenic-originated organic and black carbon aerosols, as a share of total aerosols, increase substantially in winter. In summer, black carbon from fossil fuels dominates anthropogenic carbonaceous aerosols in the Nordic countries, while biomass fuels seem to be the dominant source in the winter period.

**Status of inventories and SLCF strategies in the Nordic countries**

The Nordic countries have all performed or are performing preliminary emission inventories of black carbon. The resources and methods utilised by the inventories differ, since there are no standard guidelines for black carbon inventory. An EMEP expert group is currently updating the EMEP/EEA Emission Inventory Guidebook on methodologies for black carbon emission inventory (ends 2012) under the Convention on Long-range Transboundary Air Pollution.

It is calculated that emissions of BC are dominated by residential heating by biomass in all Nordic countries. This feature is anticipated to be even more pronounced in the future due to the introduction of particulate filters on diesel vehicles and on diesel-fuelled off-road mobile sources. New particulate-emission standards in Europe will force the introduction of particulate filters.

In Denmark, BC from wood burning has increased by more than 100% since 1990, but it is calculated to decrease by 60% from 2007 to 2030, due to improved emission performance of stoves. Other major sources, such as road-traffic exhausts and off-road mobile sources, are calculated to decrease even further. The BC emissions for 2005 are calculated to have been 6.5–7 ktonnes. In total, the emissions are estimated to decrease by 30% from 1990–2030, based on the policy instruments currently in place.

The Finnish Regional Emission Scenario model (FRES) has been used to calculate BC emissions in Finland both for the year 2005 and for the 2020 projections. National characteristics for activities and emission factors have been used. Total BC emissions in 2005 are calculated to have been more than 7 ktonnes. The implementation of EU particulate legislation for vehicles and other mobile sources will decrease emissions by 2.5 ktonnes, while residential biomass heating will reach 60% of total BC emissions by 2020. A study has been launched by SYKE in order to estimate different options for reducing PM emissions from small-scale combustion in a 10–20-year timeframe. The National Climate Strategy will be reviewed later this year and will take SLCF measures into account.

In Norway, the Climate and Pollution Agency has been commissioned to develop an action plan for reducing emissions of SLCF. The action plan shall include recommendations for measures and instruments for emissions abatement up to 2030, and shall be submitted in April 2013. The assessment shall include not only climate effects, but also the health and environmental effects of air pollution. Currently, an emission inventory for BC – including emission measurements from the anticipated largest source, wood burning in residential stoves – is ongoing. Wood burning is calculated to contribute 70% of $PM_{2.5}$ emissions in 2010, but obtaining accurate wood-consumption data is a challenge.

The BC emissions in Sweden are estimated to be 5–6 ktonnes for 2005, a reduction of approximately 30% since 1990. It is planned that a new inventory will be performed after the EMEP Emission Inventory Guidebook is updated for black carbon. In 2020, emissions are projected to be around 3–3.5 ktonnes per year, 40% of which stems from residential heating by fuel wood. In relation to further reducing emissions, residential heating of houses emerges as the most important sources for abatement. Sweden is one of the parties to initiate the Climate and Clean Air Coalition to reduce SLCPs. In the Coalition's discussions, Sweden has identified residential/ small-scale fuel-wood heating (25% of current BC emissions) and diesel-fuelled off-road working machinery (10% of BC emissions) as the two sectors on which it will focus its future abatement activities.

**Discussions**

The workshop participants put forward vital parts of an action plan for how the Nordic countries could together enhance abatement of SLCF emissions, both in the Nordic context and internationally. The most urgent Nordic co-operation refers to supporting and strengthening the national action plans being drafted in the separate countries. The drafting of SLCF strategies would benefit from a Nordic expert network on abatement measures, and from workshops/seminars on:

- a clearer definition of black carbon (BC) and on the monitoring and harmonisation of BC emission factors
- measurements, monitoring and cost-effective abatement measures on BC emissions from wood burning, since this will be a dominant source of BC emissions in all Nordic countries in the future

A common Nordic publication describing national action plans, and their effects on the Arctic, could be embarked upon in 2013.

Active participation from Nordic members of the Climate and Clean Air Coalition was found to be instrumental and a catalogue on SLCF-abatement measures relevant for developing countries and for countries with economies in transition might be initiated through NDF and NEFCO.

To strengthen Nordic co-operation on research activities related to SLCFs, three key areas were identified: 1) definitions and metrics of BC; 2) monitoring; and 3) modelling.

There is an urgent need for definitions of "heating" aerosols (black carbon) that will work both for emission inventories and for atmosphere monitoring and modelling. The climate effects of SLCFs are presented in various ways, and there is a need to find common metrics for further use in scenarios and integrated assessments. In addition, some properties of aerosols over the Arctic are not well parameterised.

The monitoring networks should be extended to ensure that relevant air pollution parameters are properly monitored and co-ordinated. Measurements should include both advanced monitoring at a limited number of stations and wider networks, in order to ensure satisfying geographical coverage. In addition to scientific/technical contacts, initiatives at ministerial level might be taken to intensify collaboration with Russia, in order to widen the geographical coverage of the monitoring network.

Further development of climate modelling with respect to the impact of SLCFs on radiative forcing and climate, with an emphasis on the Arctic, should be supported, and regional climate trends/changes in relation to air pollution/SLCFs should be explored.

The l overall recommendations from the workshop to the Nordic Environment Ministers included that the Nordic countries should be active in the development of the EMEP/EEA Emission Inventory Guidebook within the framework of the LRTAP Convention , and improve the emission data regarding shipping and residential heating from wood burning. At national level, an increased focus on immediate measures to abate wood-stove emissions is needed, alongside more information about wood-stove performance, the Swan eco-label for stoves, and proper burning habits. New emission regulations for wood stoves and a common methodology for assessing cost-effective measures should also be developed. A Nordic network of experts on the development of cost-effective SLCP emission-abatement measures might support national abatement actions. At the regional level, the Gothenburg protocol could be an important instrument with which to control emissions of black carbon in the Northern Hemisphere, and co-operation with Russia on SLCFs should be intensified.

# 1. Policy recommendations by the Climate and Air Quality Group (KoL), based on discussions at the workshop

By the Nordic Council of Ministers' Climate and Air Quality Group

## 1.1 Nordic workshop related to action on Short-lived Climate Forcers (SLCFs), Gentofte, Denmark, 7–8 June 2012

Based on the Svalbard Declaration, as well as presentations and input from the Nordic countries during the workshop, the participants discussed ways to strengthen Nordic co-operation on SLCF action.

The Climate and Air Quality Group (KoL) recommends the following ways in which the Nordic countries together could enhance action on abating emissions and the formation of SLCFs, both in the Nordic context and internationally. The most important actions can be grouped into immediate Nordic actions, Nordic campaigns and international actions.

The Climate and Air Quality Group has offered to prepare actions to facilitate follow-up on the recommendations.

**Immediate Nordic actions**

- The most urgent action refers to supporting and strengthening the *national action plans* for emission reductions that are currently being prepared in several Nordic countries. Firstly, national plans would benefit from arranging a *Nordic workshop* covering *the whole cycle of black carbon (BC) issues* – from a standardised method for measuring and monitoring BC, to the harmonisation of emission factors and actions to abate emissions
- It is also considered essential that the Nordic countries participate actively in developing emission inventories for SLCFs through the work of the *Task Force on Emission Inventories and Projections (TFEIP)*, under the Convention on Long-range Transboundary Air Pollution (CLRTAP), for implementation into the *EMEP/EEA Emission Inventory Guidebook*. The Nordic countries should co-operate and

ensure that appropriate data and knowledge, incorporating, e.g. considerations of time and geographical variations, is made available

- Another crucial issue for Nordic countries is *wood burning*, which gives rise to 25–40% of the BC emissions in the Region. Also, for the purpose of identifying strategies to abate emissions of BC from wood burning, a *Nordic workshop* would be beneficial
- Co-operation should be enhanced among Nordic experts on the *evaluation of cost-effective emission-control measures and the valuation of effects achieved* using, i.a. Integrated Assessment Modelling. Further *development of climate modelling* to analyse the impact from SLCFs on radiative forcing and climate should be supported, and regional climate trends/changes in relation to air pollution/SLCFs should be explored. The focus here should be on the Arctic region

**Nordic campaigns**

- As several Nordic countries are in the process of developing emission inventories and evaluating cost-effective initiatives to reduce SLCFs, a *publication describing these efforts and their anticipated effects on the Arctic* could be embarked upon in 2013
- A project *to raise awareness on how to efficiently burn wood* in order to reduce BC emissions could be based on the experiences of the Nordic countries that have already carried out such campaigns

**International action**

- There is an increased international focus on the environmental effects of SLCFs, and Nordic countries are actively taking part in new forums with an SLCF focus. One such forum is *the Climate and Clean Air Coalition to Reduce Short-lived Climate Pollutants (CCAC)*, in which four Nordic countries are now partners. *An active role within the CCAC* is itself considered instrumental. The CCAC has listed several initiatives, such as domestic burning and action on methane, in which Nordic knowledge will play an important supporting role.
- In accordance with the Svalbard Declaration, the Nordic countries could intensify their efforts to reduce emissions of SLCFs at a global level and *work more closely together internationally to advocate more ambitious regulation* of such emissions. In their efforts to reduce emissions, there may also be benefits from closer Nordic co-operation in voluntary international initiatives like the CCAC
- Under the auspices of the Climate and Clean Air Coalition to Reduce Short-lived Climate Pollutants (CCAC), initiatives to identify possible measures to abate emissions of methane are underway. A *catalogue describing methane-emission abatement measures implemented in the Nordic countries* would provide good support to this process

- It is appreciated that the Nordic countries, through their bilateral and multilateral development projects, have gained a lot of experience on how to abate SLCF emissions in developing countries. Based on these experiences, a *catalogue presenting SLCF-abatement measures relevant for developing countries and countries with economies in transition* should be initiated, possibly through NEFCO

# 2. Conclusions and recommendations on scientific research and monitoring

*Peringe Grennfelt,* Swedish Environmental Research Institute*,* Stockholm, Sweden

## 2.1 Introduction

Scientific research and monitoring are of crucial importance for our understanding of the role of Short-lived Climate Pollutants (SLCPs) as both air pollutants and drivers of climate change. Even if there is a general consensus on sources and effects, the necessary understanding for setting priorities and developing cost-effective control approaches is still in its infancy. For some areas, e.g. the regional climate effect of SLCPs and the health effects of black carbon, the policy-relevant knowledge is at the cutting edge of today's research. Similarly, greater understanding is needed of the direct and indirect effects of aerosols' contribution to negative radiative forcing. The same can also be said with respect to monitoring, even if the recent establishment of advanced monitoring programmes directed at, e.g. atmospheric aerosols and emissions of SLCPs and their precursors, offers substantial improvements.

The Nordic countries are today well positioned within the area, with several strong research communities. Targeted support to key areas and Nordic collaboration will further strengthen this position and provide unique possibilities to support international and national policy development.

Nordic research is also contributing to the assessment of SLCPs with respect to policy development, e.g. the work under UNEP, CLRTAP, the Arctic Council and the European Union.

### *2.1.1 Ongoing research and monitoring*

Nordic Countries and Nordic research groups are involved in a large number of research, monitoring and scientific assessment activities of direct significance to SLCPs, such as:

- Monitoring and modelling work under CLRTAP. EMEP monitoring, activities under the Task Force on Hemispheric Transport of Air Pollution (TFHTAP) and the work under the Task Force on Health are of direct importance to SLCPs. Activities on ozone and its precursors have been a priority issue for EMEP for more than 20 years, and aerosols for more than a decade. This work has been of the utmost importance to our present understanding
- The Nordic Top-level Research Initiative, in which the two projects CRAICC and DEFROST are of direct relevance for SLCPs. Even though they do not directly support much new research, these projects are of crucial importance, since they support Nordic networking and also urge countries to contribute with national funds
- AMAP/ACAP supported activities
- Several EU projects (ECLIPSE, EUCAARI, ECLAIRE, ACTRIS, POLARCAT, etc.) are of direct or indirect importance to SLCPs
- Monitoring activities in relation to EU air-quality directives
- The new EU air-pollution strategy, to be launched in 2013
- Scientific assessments, including those of UNEP, IPCC and the Arctic Council

### *2.1.2 Recommendations*

At the workshop, three key areas were identified in which a strengthening of Nordic collaborative research would be particularly important:

- Definitions, metrics, etc.
  a) *Ensure proper definitions of SLCP-relevant parameters, in particular black carbon.* There is an urgent need for definitions of "heating" aerosols (black carbon) that will work both for emissions inventories and for atmosphere monitoring and modelling. Much of this work is already underway, within both EMEP and the Nordic Top Research Initiative CRAICC, but it needs to consolidated and expanded to other areas. There may also be a need for similar definitions of cooling aerosols. It is also of crucial importance that the definitions are communicated and commonly accepted. Action: EMEP, ACTRIS, WMO-GAW, CRAICC
  b) *Output metrics* for the assessment of the climate and air-pollution effect of SLCPs. The climate effects of SLCPs are presented in various ways, and there is a need to find common metrics for further use in scenarios and for integrated assessments. Appropriate parameters for health effects should also be considered. There is a need for harmonisation and for more appropriate definitions of output metrics that will work for policy development. The issue is considered under CLRTAP and in the EU project ECLIPSE. Action: TFHTAP, ECLIPSE, WHO-GAW, CRAICC.

c) *Parameterisation of basic properties* with respect to SLCPs. Some properties of, in particular, aerosols over the Arctic are not well parameterised. This is an issue for, i.a. the CRAICC research project. Action: Scientific Community

- Monitoring
  a) *Co-ordinate and extend the monitoring networks*. Ensure that relevant air-pollution parameters are properly monitored and co-ordinated. Measurements should include a wide variety of parameters, including various aerosol properties, ozone and ozone precursors and methane, as well as meteorological parameters. Measurements should include both advanced monitoring at a limited number of stations and wider networks, in order to satisfy geographical coverage. The EMEP monitoring strategy outlines a programme adequate to address SLCPs but there is still a need to engage countries that have not implemented the strategy. The EMEP requirements are fully harmonised with WMO-GAW (http://www.gaw-wdca.org/), and both programmes currently benefit from the ongoing activities in the ACTRIS project (www.actris.net)

  b) Nordic measurement activities of direct importance for SLCPs are directed towards both long-term trends and time-limited research projects. An inventory of these activities would improve possibilities for stronger collaboration and present options for a wider use of data, e.g. for validation of models and assessments of the role of SLCPs. A few networks (WMO-GAW, EMEP and national monitoring networks) have produced long-term data of particular importance to the evaluation of trends and decadal changes in the atmospheric composition of SLCPs. Some of these measurements are today questioned (e.g. due to the economic crisis or the assumption that the policy support is less important). NMR should:
     - initiate a project that includes both an inventory and a workshop. Action: the KoL group
     - ensure that ongoing long-term monitoring, including relevant parameters for assessing SLCPs, continues both in the Arctic and in the mid-latitude regions, in order to resolve regional transport issues. Action: Nordic countries

  c) *Intensify collaboration with Russia* in order to establish monitoring stations and thereby form a circumpolar network. A series of advanced, high-latitude monitoring stations has been established from Alaska to Svalbard. However, there is a lack of stations in the north of Russia, where the atmospheric influx to the Arctic is particularly large. In order to understand the transport patterns, improve the polar budget for SLCPs, and validate models and emission estimates, there is an urgent need for at least one advanced monitoring station along the Siberian north coast. The monitoring competence within the Nordic countries is ready to assist in this work. Initiatives should not only involve contacts on scientific/technical levels, but should be taken on ministerial levels and/or through the CACC. Action: Nordic Council, CACC, scientific communities.

d) *Make use of satellite data.* This issue was not further elaborated at the workshop due to a lack of experts in the area. However, all agreed that satellite data can give additional important information.

- Modelling
  a) *Promote further development of climate modelling* with respect to the impact of SLCPs on radiative forcing and climate. Particular emphasis should be directed towards the Arctic. This research involves cutting-edge knowledge. There are, however, strong research communities in Denmark, Finland, Norway and Sweden that, through close collaboration, would be able to further develop Nordic capabilities within the area. There is also still a strong need for further development of regional transport models to improve understanding of transport pathways at high latitudes. Action: The KoL Group, the Nordic Top-level Research Initiative.
  b) *Explore regional climate trends/changes* in relation to air pollution, and SLCPs in particular. Model development has reached a level where climate changes on a regional scale may be studied with respect to the role of, e.g. atmospheric pollutants. There have recently been published a couple of papers that assess the relationship between air pollution and climate. The area is of utmost importance for our ability to understand changes in climate patterns over recent decades and gain confidence in the efficiency of proposed SLCP-mitigation measures. Action: The KoL Group, the Nordic Top-level Research Initiative.
  c) *Develop a common set of scenarios for analyses of the outcome of SLCP measures and for integrated assessment modelling*. It is of utmost importance to develop and apply models that can serve both to estimate future climate and air-pollution impacts from control of SCLPs, but also to develop and apply integrated assessment models to support cost-effective strategies. Studies should include both climate effects and air-pollution effects on health and ecosystems (including ozone's impact on carbon sequestration). Suggested areas for further study are how present and future control of $NO_x$ over the Northern Hemisphere may affect methane and ozone, or how measures on wood burning would change aerosol forcing. Action: The KoL Group

# 3. Scientific developments regarding SLCFs

*Joakim Langner* Swedish Meteorological and Hydrological Institute and *H.C. Hansson*, Stockholm University, Sweden

## 3.1 What is meant by SLCFs and SLCPs?

The two acronyms SLCFs (Short-lived Climate Forcers) and SLCPs (Short-lived Climate Pollutants) have been introduced in recent years to represent chemical components that have relatively short lifetime in the atmosphere – a few days to a few decades – and tend to have a warming influence on climate. The focus is on agents that are warming, but strictly speaking, short-lived components include also cooling agents. This distinction is important when discussing the influence on climate by aerosols, since they can have both warming and cooling effects depending on chemical composition, size, distribution and other factors. The change in wording from "forcers" to "pollutants" reflects the importance of stressing the co-benefits of reducing short-lived components that are both air pollutants and "climate pollutants".

The main short-lived climate pollutants are black carbon, tropospheric ozone and methane, which, after $CO_2$, are the most important contributors to the human enhancement of the global greenhouse effect. These short-lived climate pollutants are also dangerous air pollutants, and have various detrimental impacts on human health, agriculture and ecosystems. SLCPs intercept incoming solar radiation and prevent it from reaching the Earth's surface, and at the same time heat up the atmosphere. Other short-lived climate pollutants include some hydrofluorocarbons (HFCs). While HFCs are currently present in small quantities in the atmosphere, their contribution to climate forcing is projected to climb to as much as 19% of global $CO_2$ emissions by 2050.

### 3.1.1 *State of knowledge regarding SLCFs/SLCPs in IPCC 2007*

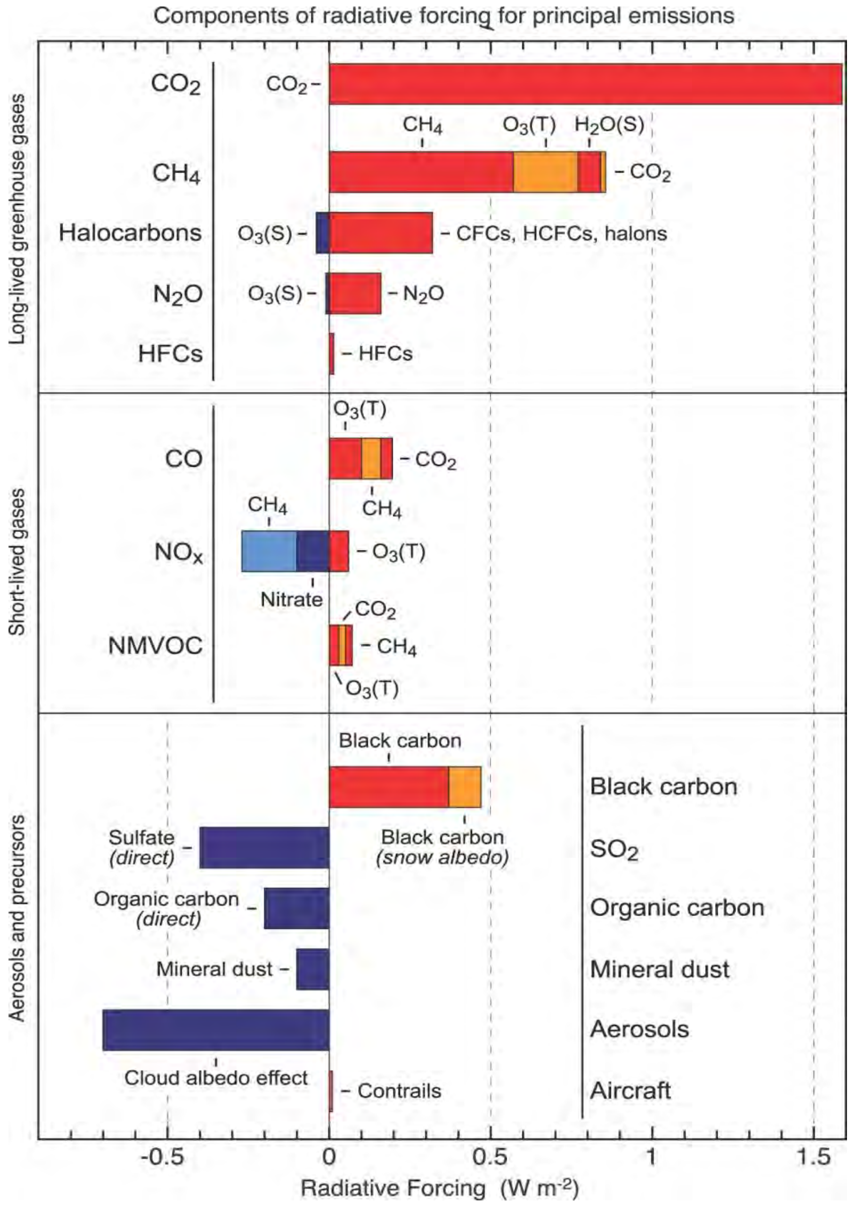
Figure 1 provides a good summary of the overall state of knowledge about both short- and long-lived climate forcers in the fourth IPCC assessment report (AR4, IPCC 2007). It gives the estimated contribution to radiative forcing (the change in radiation balance at the top of the atmosphere) from the anthropogenic emissions of different chemical components in the period 1750–2005.

From Figure 1, we can clearly delineate the importance of the different components included in the discussion on SLCPs. Next to $CO_2$, $CH_4$ is the most important greenhouse gas. Apart from direct emissions of $CH_4$, there are also contributions from oxidation of CO and non-methane volatile hydrocarbons (NMVOC). Note the negative impact of $NO_x$ emissions on $CH_4$. This is important to consider when designing control strategies for SLCPs.

Ozone is a secondary component formed from oxidation of hydrocarbons and CO in the presence of sufficient amounts of $NO_x$. It is the increase in the *tropospheric* concentration of $O_3$ that has a positive effect on radiative forcing, and in particular, on the concentration of $O_3$ in the upper troposphere. From Figure 1, it is clear that emissions of methane are most important for increased tropospheric $O_3$ concentrations, but also that emissions of CO are important. Again, this is important for control strategies.

The lower part of Figure 1 summarises the assessment in 2007 of the importance for the radiation balance of different aerosol forcings. As can be seen, there are warming effects related to the direct effect of black carbon emissions, as well as to deposits of black carbon on snow and ice and cooling effects from other aerosol components. Overall, the cooling effect was assessed as dominant. However, the level of scientific understanding attributed to the different aerosol forcings in AR4 was low for indirect (cloud-related) effects and medium-low for direct effects, while the level of understanding attributed to the effects of both short- and long-lived gases discussed above were medium-high. We discuss the current scientific understanding of the aerosol effects further in the next section.

***Figure 1. Change in radiative forcing 1750–2005 from anthropogenic emissions (IPCC 2007)***




## 3.1.2 *Current scientific understanding of aerosol effects on climate*

**Direct effect**

The direct aerosol impact on radiative forcing is caused by the scattering and absorption of sunlight. Both scattering and absorption are strongly dependent not only on particle size, but also composition. The total effect is estimated to about -0.5 ± 0.4 $Wm^{-2}$ (IPCC, 2007). The scattering is then estimated to about -0.7 $W/m^2$, while absorption from fossil fuel black carbon is estimated to +0.2 W/m². However, there has been a quite strong debate about the estimate of absorption. Ramanathan and Charmichael (2008) argue that absorption is underestimated and that a more accurate global estimate, due to soot aerosols, could be as large as about +0.9 W/m². Using several global models, Quaas et al. (2009) found the direct effect to be -0.4±0.2 W/m², and the EUCAARI project claimed to have narrowed the range further, to -0.2±0.1 W/m² (Kulmala et al., 2011). In an AEROCOM exercise involving nine different GCMs, the models gave a total direct forcing in the range -0.2±0.2 W/m², including a warming by BC in the range +0.2±0.15 W/m² (Schultz et al., 2006). All of these results seem to indicate that the direct effect is rather small. However, using satellite measurements, Quaas et al. (2008) derived an estimate of the direct effect of -0.9±0.4 Wm². They recognise the discrepancy, and suggest that it may partly be due to the fact that satellite retrievals of aerosols are not available over bright surfaces such as deserts, snow- or ice-covered surfaces, or low-level clouds, where the direct forcing may even be positive and suggest a reduction of 30–60% of the satellite-based estimate, which closes the gap between the results from observations and models.

An important source of uncertainty stems from relative humidity (rh), spatially and temporally, as atmospheric particles are hygroscopic, i.e. they absorb water and grow into droplets at sub-saturated conditions. In measurements of how the atmospheric aerosol increases in size with increasing humidity, it is usually found that a dominating number of particles is growing by about 30–50% in diameter, i.e. a factor of 2–3 in volume at 90% rh, and a scattering increase with a factor of around three compared with the dry particle. The growth is increasingly sensitive to rh – increasing rh, e.g. humidity, of 90–95% leads to an increase in scattering of roughly 30%.

When the air pollution spreads to the top of the boundary layer, rh usually increases and becomes quite high, whereas particles grow and scatter more light back to space. The increase in particle size, and therefore the increase in extinction, is not well captured in the models. Even though many models compare well with the aerosol optical depth (AOD) measured over the whole atmospheric column, errors due to erroneously calculated rh can be counteracted by errors in the emission and transport of different aerosol components.

**Indirect effects**

There are no less than six identified aerosol cloud interactions that indirectly affect climate. Here, the size as well as the chemical composition of the cloud condensation nuclei influence the radiative properties of the clouds formed on the aerosol. Table 2 gives an overview of the different processes discussed in the literature (Lohmann and Feichter, 2005), updated to include newer estimates from Lohmann et al. (2010).

**Table 1. Summary of different indirect aerosol effects on climate**

| Effect | Cloud type | Description | Forcing |
|---|---|---|---|
| First indirect aerosol effect (Twomey effect) | All clouds | The more numerous smaller cloud particles reflect more solar radiation | -0.9 +/- 0.4 |
| Second indirect aerosol effect (Albrecht affect) | All clouds | Smaller cloud particles decrease precipitation efficiency, prolonging cloud lifetime | Uncertain |
| Semi-direct effect | All clouds | Absorption of solar radiation by BC may cause evaporation of cloud particles | Uncertain |
| Glaciation indirect effect | Mixed ice and liquid clouds | More ice nuclei increase the precipitation efficiency | Uncertain |
| Thermodynamic effect | Mixed ice and liquid clouds | Smaller cloud droplets delay the onset of freezing | Uncertain |
| Riming indirect effect | Mixed ice and liquid clouds | Smaller cloud droplets decrease the riming efficiency | Uncertain |
| Total anthropogenic aerosol effect | All cloud types | Includes the above-mentioned indirect effects plus the direct aerosol effect | 0 to -1.8 |

The first indirect aerosol effect is on the cloud albedo, through the increase in number of CCN due to anthropogenic emissions. The most obvious evidence of the Twomey effect is ship tracks that are easily observable from space. These are white, narrow cloud streaks resulting from ship emissions. The best estimate of the global climate effect due to the first indirect effect is, according to IPCC (2007), about -0.7 W/m$^2$, with an uncertainty range of -0.3 W/m$^2$ to -1.8 W/m$^2$. Lohmann et al. (2010), suggest -0.9±0.4 W/m$^2$, which is close to the -0.7±0.5 W/m$^2$ proposed by Kulmala et al. (2011). Quaas et al. (2008) found that satellite measurements were considerably lower, giving an estimate of -0.2±0.1 W/m$^2$ for the first indirect effect. They recognise that this is considerably lower than most models, but argue that it is consistent with estimates from models constrained by satellite observations (Lohmann and Lesins, 2002; Quaas et al., 2006). However, Penner et al. (2011) argue that the satellite measurements underestimate the first indirect effect by a factor of 3–6, as they typically use the present-day relationship between observed cloud-drop number concentrations and aerosol optical depths, which are not valid for the preindustrial values of droplet numbers.

Other effects mentioned in Table 2 are suggested to affect the cloud lifetime. Clouds generally cool the climate due to a higher albedo than the surface of the Earth, and therefore a shorter lifetime warms the climate, while longer cloud lifetime will cool it. Similar to the Twomey effect, the second indirect aerosol effect, also called the Albrecht effect, is based on the fact that the number of cloud droplets rises with an increase in the number of available CCN, and concerns the processes that initiate the precipitation. The onset of precipitation is sensitive to the formation of a few big droplets, also referred to as precipitation embryos

(Albrecht, 1989). Ice nuclei are similar precipitation embryos, considered to be crucial for the onset of precipitation.

Soot is a strong light absorber. When enclosed in cloud droplets, it might cause evaporation and lead to the cloud dissipating prematurely, often referred to as the semi-direct effect. However, studies show that partial evaporation causes multiple effects, such as higher albedo due to smaller droplets and fewer giant droplets suppressing precipitation, both of which have a negative forcing effect on climate. Koch and Del Genio (2010) found in their review that the semi-direct effect most likely gives a slight negative forcing that might be large enough to eliminate the direct warming of soot.

The glaciation effect refers to formation of ice nuclei (IN) in cold clouds, i.e. clouds containing at least partially ice crystals or frozen droplets. In cold clouds, the formation of ice crystals is important for the formation of precipitation, as they enhance the precipitation. Anthropogenic emissions that enhance the number of good IN might then increase the probability of precipitation and thus decrease the cloud lifetime, leading to positive climate forcing. Some studies suggest that soot is a good IN, while others have concluded differently. Dust, however, is found to be an important IN. The fraction of dust of anthropogenic origin is, however, very difficult to estimate. Hoose et al. (2008) investigated the effect of assuming soot having favourable IN material properties, and found that the increase of IN from soot particles was counteracted by dust particles losing their IN capability due to a coating of anthropogenic inorganic salts. These findings stress the complexity in this area, and the need for better knowledge of IN properties and key processes that control the lifetime of clouds.

Other processes in mixed ice and liquid-water clouds are the thermodynamic effect and the riming effect connected to the competition in the cloud between condensing water into ice crystals and water droplets, which affects precipitation probability. However, none of these effects, as well as the glaciation effects, are investigated in detail, and the necessary experimental data or observations are largely missing.

In conclusion, the indirect climate effects of anthropogenic atmospheric aerosols are not well known, but although the estimates have an element of uncertainty, they are always quite large. The indirect climate effect therefore dominates the uncertainty in the total aerosol forcing.

### *3.1.3 The UNEP/WMO Integrated Assessment of Black Carbon and Tropospheric Ozone*

The UNEP Integrated Assessment of Black Carbon and Tropospheric Ozone (UNEP/WMO 2011) assessed the current state of knowledge regarding the climate and environmental impacts of SCLFs, with a particular focus on black carbon and tropospheric ozone. An important part of the assessment was the analysis of available abatement measures that could contribute to both a reduction of climate impacts and impacts on health and crop yields. Mitigation measures were ranked by the net GWP of their emission changes (considering CO, $CH_4$, BC, OC, $SO_2$, $NO_x$, NMVOCs, and $CO_2$). The top 16 measures out of ca. 2,000 were identified, giving both net climate and air-quality impacts, see Table 2. All of these measures were considered to be commonly available and possible to implement.

**Table 2. Measures that improve climate-change mitigation and air quality and have large emission-reduction potential (UNEP/WMO 2011)**

| Measure1 | Sector |
|---|---|
| **CH4 measures** | |
| Extended pre-mine degasification and recovery and oxidation of CH4 from ventilation air from coal mines<br>Extended recovery and utilisation, rather than venting, of associated gas and improved control of unintended fugitive emissions from the production of oil and natural gas<br>Reduced gas leakage from long-distance transmission pipelines | Extraction and transport of fossil fuel |
| Separation and treatment of biodegradable municipal waste through recycling, composting and anaerobic digestion, as well as landfill gas collection with combustion/utilisation<br>Upgrading primary wastewater treatment to secondary/tertiary treatment with gas recovery and overflow control | Waste management |
| Control of CH4 emissions from livestock, mainly through farm-scale anaerobic digestion of manure from cattle and pigs<br>Intermittent aeration of continuously flooded rice paddies | Agriculture |
| **BC measures (affecting BC and other co-emitted compounds)** | |
| Diesel particle filters for road and off-road vehicles<br>Elimination of high-emitting vehicles in road and off-road transport | Transport |
| Replacing coal with coal briquettes in cooking and heating stoves<br>Pellet stoves and boilers, using fuel made from recycled wood waste or sawdust, to replace current wood-burning technologies in the residential sector in industrialised countries<br>Introduction of clean-burning biomass stoves for cooking and heating in developing countries2, 3<br>Substitution of clean-burning cooking stoves using modern fuels for traditional biomass stoves in developing countries2, 3 | Residential |
| Replacing traditional brick kilns with vertical shaft kilns and Hoffman kilns<br>Replacing traditional coke ovens with modern recovery ovens, including industry improvement of end-of-pipe abatement measures in developing countries | Industry |
| Banning open field burning of agricultural waste2 | Agriculture |

[1] There are measures other than those identified in the table that could be implemented. For example, electric cars would have a similar impact to diesel particulate filters, but these have not yet been widely introduced. Forest fire controls could also be important, but are not included due to the difficulty in establishing the proportion of fires that are anthropogenic.
[2] Motivated in part by its effect on health and regional climate, including areas of ice and snow.
[3] Given their importance for BC emissions, two alternative measures are included for cooking stoves.

The impact on the global climate and air quality was investigated by using two different well-established global climate models: the ECHAM and GISS models. Besides the measures mentioned above, $CO_2$ abatement was assumed such that a maximum concentration of 450 ppm of $CO_2$ would be reached. This scenario is close to RCP 2.6, which assumes that the $CO_2$ emissions stagnate around 2020 and then decrease to zero by 2080.

The main findings can be summarised as follows:

- Broad implementation of 16 existing measures would reduce global warming by 0.5°C (range 0.2–0.7°C) by 2050 – half the warming projected – and would improve the chance of not exceeding the 2°C target, but only if $CO_2$ and the other long-lived greenhouse gases are also aggressively addressed
- Four million premature deaths due to outdoor air pollution, and a further 1.6 million deaths due to indoor air pollution, could be avoided globally each year
- Annual harvest losses of rice, maize, soya beans and wheat of 52 million tonnes per year could be avoided globally as a result of lower concentrations of ground-level ozone
- Regional benefits in the Arctic (2/3 reduction in temperature compared to reference) and Himalayas, and for the South Asian monsoon. Substantial health and crop benefits. Benefits strongly associated with emission regions
- The identified measures are all currently in use in different regions around the world, in order to achieve a variety of environment and development objectives

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# 4. Climate impacts of emissions of Short-Lived Climate Forcers (black carbon, methane and other ozone precursors) in the Nordic countries

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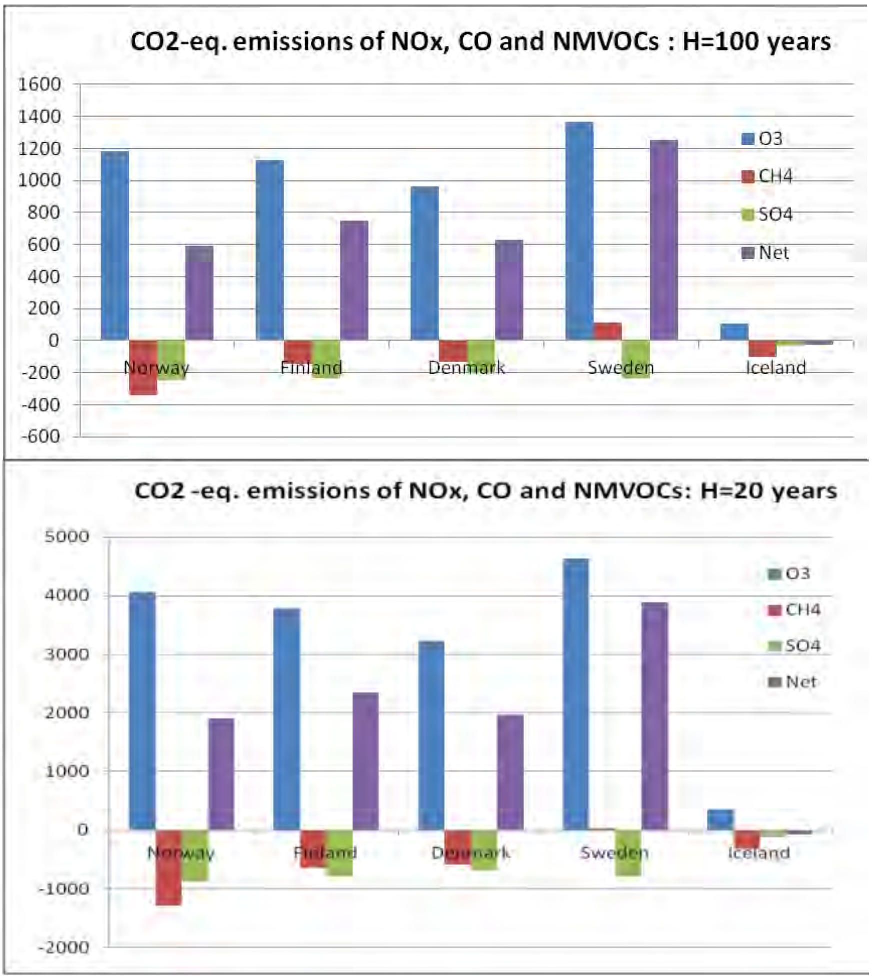
There is sometimes a bit of confusion about exactly what is meant by the term "short-lived". What should be the threshold for the lifetime of the emitted species (or an atmospheric product) to be called short-lived? This can refer to the lifetime being short compared to atmospheric mixing times, i.e. days/weeks, or that the lifetime is short compared to the timescales of climate-mitigation targets, i.e. decades (i.e. the 2°C target). The first definition would include ozone precursors ($NO_x$, CO and NMVOCs) and aerosols (e.g. black carbon (BC)), while gases like methane, HFC-134a and HFC-152a are excluded. In the following, I will use the term Very Short-Lived Climate Forcers (VSLCFs) for the first group of compounds, while SLCFs will also include methane, etc. VSLCFs have the ability to create a more spatially heterogeneous radiative forcing pattern, possibly with a more heterogeneous (regional) climate-response pattern. For the longer-lived gases (methane, HFC-134a, HFC-152a, etc.), the pattern of impact is similar to that of $CO_2$. However, mitigation is now more important for the rate of change (cf. UNFCCC, Art. 2) and, to a lesser extent, for the long-term stabilisation target.

Ideally, to quantify the impact of SLCF emissions from the Nordic countries on global climate, one would need to do separate model simulations for each component and country. While this has not been done, the HTAP project has carried out multi-model simulations of emissions from continental regions, including Europe. Using these results (Fry et al., 2012, calculating radiative forcings) as surrogates for true Nordic numbers and emission numbers (from http://www.ceip.at/overview-of-submissions-under-clrtap/2011-submissions/), I have estimated the $CO_2$-equivalent emissions for ozone precursors ($NO_x$, CO and NMVOCs) from the Nordic countries through formation of tropospheric ozone and changes in OH radicals, and thus methane. The results, using GWP-100 and GWP-20 as emission metrics, are given in Figure 1. $NO_x$ emissions lead to an increase in concentrations of OH radicals, which react with methane. As such, the net effect on methane is equivalent to negative $CO_2$-equivalent emissions.

***Figure 1. $CO_2$-equivalent emissions (Gg/yr) of combined $NO_x$, CO and NMVOCs from the Nordic countries. Effects through tropospheric ozone, methane lifetime and sulphur-cycle included***




To put these numbers in context, the $CO_2$-eq. emissions of BC from the Nordic countries are 30,000 and 110,000 Gg/yr for the 100- and 20-year time horizons respectively, while the $CO_2$ emissions themselves are about 200,000 Gg/yr.

However, the numbers presented above are based on a global perspective. An important question is whether the SLCFs emitted at high latitudes are particularly important for the climate response at high latitudes. To answer this question requires dedicated climate-model simulations. Until now, however, such simulations have not been based on results from mode-generalised studies (Fry et al., 2012; Shindell and Faluvegi, 2010), and therefore it is now possible to give a crude estimate of the regionality of the response in broad latitude bands to emissions from a region such as Europe. Figure 2 shows preliminary results (calculated by Bill Collins from the UK Met Office) of the warming/cooling per unit of emissions of BC and $SO_2$ in Europe.

***Figure 2. Steady state warming/cooling in different latitude bands per unit of emissions of BC and $SO_2$ in Europe***

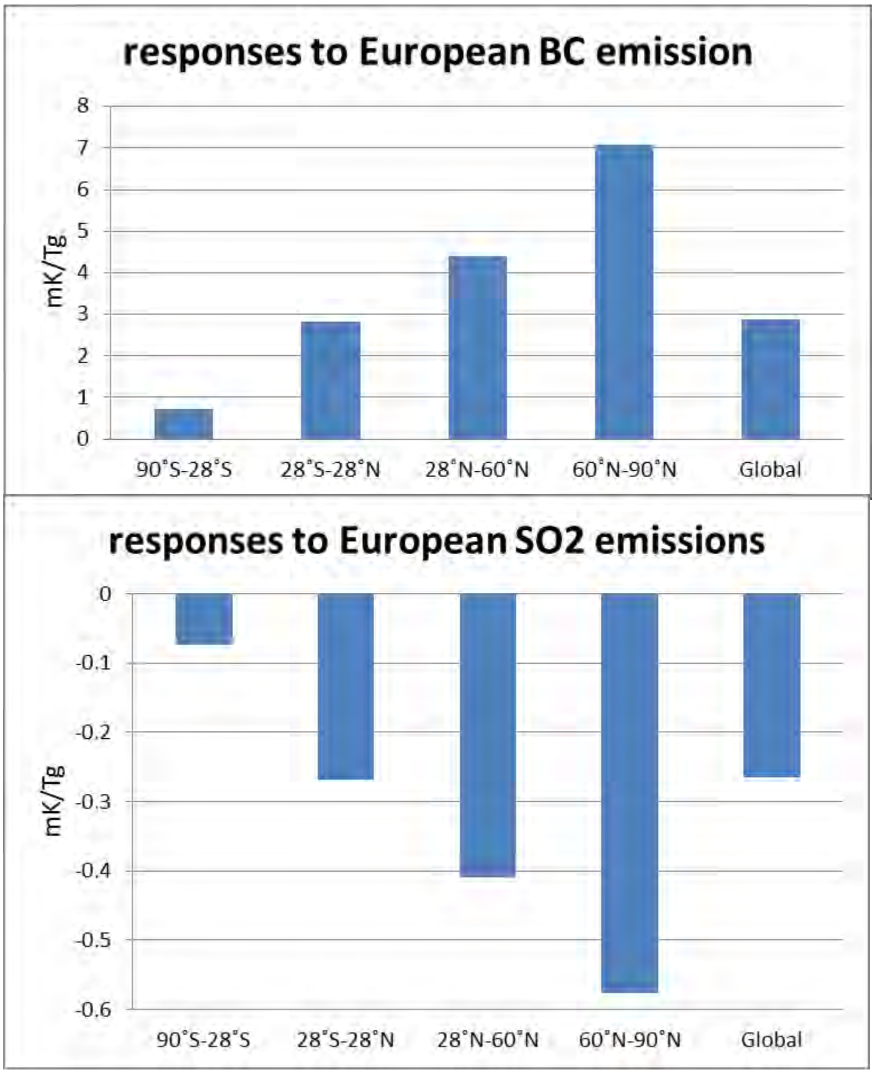



Figure 2 indicates that the high latitudes in the Northern Hemisphere are particularly sensitive to emissions of BC and $SO_2$ from Europe.

When focusing on SLCFs and responses in mid- and high latitudes, it is important to keep in mind that the main anthropogenic driver of climate change at all latitudes is the global accumulation of carbon dioxide. In addition, there is considerable natural variability, which increases with increasing latitude and decreasing regional area. Therefore, assuming that climate models can accurately calculate the regional impact of SLCFs, and that the substantial mitigation of SLCF emissions is carried out, it cannot be expected that it will be possible to identify effects on climate from observations with a reasonable statistical significance. However, this does not mean that there may be cost-effective mitigation options for SLCFs, which therefore should be implemented in a multi-component approach. It only means that one has to trust the models in these cases, and make sure that they are validated in terms of their general description of climate conditions.

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# 5. Sources of Nordic background aerosols – the SONORA project and beyond

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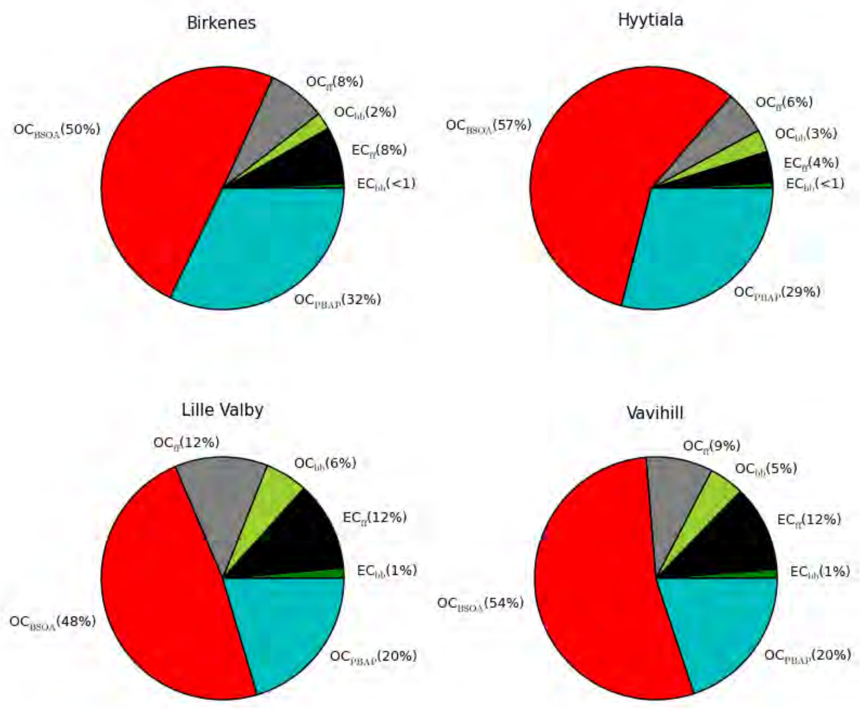
Atmospheric aerosols constitute the largest area of uncertainty in understanding perturbations in the climate system. In particular, there is a lack of knowledge about sources of organic and elemental carbon. Long-range transport is a major contributor to aerosols at most Nordic sites.

The project Sources to Nordic Background Aerosols (SONORA) was funded by NMR to investigate sources of carbonaceous aerosols at four Nordic rural background sites. Aerosol samples were collected during August 2009 and analysed for organic carbon (OC), elemental carbon (EC) and radiocarbon (C14), as well as a number of specific molecular tracers. The analysis results were used as input parameters for source apportionment, aided by statistical methods (Latin-hypercube sampling) (Yttri et al., 2011a).

The study showed that natural sources dominated total carbonaceous aerosols at all sites. Biogenic secondary organic aerosols (BSOA) contributed 48–57%, while primary biological aerosol particles (PBAP) contributed 20–32% of total particulate carbon (Yttri et al., 2011a). Elemental carbon, on the other hand, came primarily from the combustion of fossil fuels (Yttri et al., 2011a).

***Figure 1. Source contributions to total particulate carbon (PM$_{1.0}$) in Birkenes (Norway), Hyytiälä (Finland), Lille Valby (Denmark) and Vavihill (Sweden), August 2009 (Yttri et al., 2011a)***




The findings of the SONORA project are supported by other recent studies in the Nordic countries. In a one-year study, Genberg et al. (2011) observed considerable contributions from natural sources to carbonaceous aerosols at Vavihill, Sweden, during summer (80%). Yttri et al. (2011b) also found an 80% contribution from biogenic sources to particulate carbon at a rural background site and 50% at an urban background site in Norway during summer.

Recently, it has been discovered that anthropogenic pollutants may lead to the enhancement of BSOA (e.g. Hoyle et al., 2011), for example by catalysis of photochemical reactions through the influence of $NO_x$ or by acting as condensation nuclei for semi-volatile biogenic compounds. Whether this has any implications for the magnitude of the BSOA component identified in the SONORA study is not clear.

### *5.1.1 Conclusion*

The SONORA study was carried out in summer, when biogenic emissions generally peak. There is therefore a need to investigate sources of carbonaceous aerosols during winter in the Nordic countries. This would also contribute to an evaluation of the regional influence of emissions from residential wood combustion during winter.

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# 6. Soot and other SLCFs in the Arctic Atmosphere (AMAP)

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The rising global temperature is of increasing concern among scientist, politicians and the general public. In the Arctic, the temperature increase since the start of the last century has been twice as high as the increase in the global average temperature (www.noaa.gov). As a consequence, the polar sea ice has been retreating. Today, more than 40% of summer sea ice has disappeared, and the distribution between multiyear ice and seasonal ice has changed dramatically. This has significant consequences for the physical and chemical processes in the Arctic, and is also changing the living conditions [1].

Until now, about 50% of the temperature increase can be attributed to the increase in $CO_2$. The rest is caused by increasing concentrations of black carbon (BC), ozone and methane, as BC acts both directly in the atmosphere (absorbing outgoing heat from the ground) and indirectly after deposition on snow (by changing the surface albedo) [2;3]. BC is therefore currently the most important of the SLCFs.

Despite the importance of BC, the atmospheric transport model results have shown concentration differences of several orders between models, especially when looking vertically at the Arctic atmosphere. They also disagree with measured values [4]. The situation is even worse for climate models.

As a result, BC mass concentrations were determined using different methods at Station Nord (located at 81° 36' N; 16° 39' W, 25 m ASL), North Greenland. The BC mass concentrations were measured using a particle soot absorption photometer (PSAP), which took ambient air samples. Data were compared to elemental carbon (EC) and organic carbon (OC) concentrations determined from weekly aerosol samples

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collected at the station using a thermo-optical method. The results were compared to model estimates retrieved by the Danish Eulerian Hemispheric Model (DEHM), and excellent agreement was obtained [5].

As part of the Arctic Monitoring and Assessment Programme, an assessment group has been established to look into the state-of-the-art concerning SLCFs. Recently, a report on BC has been published [3]. A second assessment has also started. The following work plan has been decided: model simulations will be performed to determine the burden of particulate BC, OC and $SO_4^{2-}$ and tropospheric $O_3$ in the Arctic due to emissions from different source regions and source sectors. In addition, the radiative forcing and climate response to these emissions will be calculated. The work will involve data from measurement stations, and will utilise three different chemical transport models (EMEP, DEHM, OsloCTM2), as well as three different climate models (NorESM, CESM (NCAR), CanESM). Models will be run on the years 2008–2010, and will apply similar emission inventories and scenarios.

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# 7. International Policy Developments

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On the 4th of May 2012, a revised Gothenburg protocol was agreed under the *UNECE Convention for Long Range Transboundary Air Pollution* (CLRTAP). It contains new emission reduction commitments for 2020 for SO2, NOx, NMVOC and NH3, and a new commitment to reduce emissions of $PM_{2.5}$. Black carbon is a fraction of $PM_{2.5}$ and special consideration must be made of sources known to emit high amounts of BC when drawing up plans to meet the emission reduction commitment. The protocol also contains an option to review and strengthen the BC commitment when more scientific evidence is at hand.

This makes the revised Gothenburg protocol the first international environmental agreement to deal with emissions of BC. As a result of the inclusion of BC in the protocol and the agreed long-term strategy for the Convention, a large number of convention working groups are now pursuing the link between air and climate, which is growing in importance.

Within *the EU* intensive work on a comprehensive review of the EU air pollution policy is ongoing. The aim is to present a proposal for an updated Thematic strategy and an updated NEC Directive in autumn 2013. Possibly a revised Air Quality Directive will be proposed at a later stage. Work on BC and other SLCPs is expected to form part of the strategy and the new NEC Directive is expected to include a ceiling for $PM_{2.5}$, including BC. The support for work on SLCP from the EU countries is much stronger than during the Gbg protocol negotiations.

*The Climate and Clean Air Coalition* (CCAC) was launched in February 2012 by UNEP and six governments. The aim of the Coalition is to promote and accelerate actions to reduce Short-Lived Climate Pollutants (methane, black carbon, tropospheric ozone and short-lived HFCs) by raising awareness of impacts and mitigation strategies; enhancing and developing new national and regional actions; promoting best practices and showcasing successful efforts and improving scientific understanding. The Coalition is particularly keen to stress that the work on SLCPs does not replace, but complements and supplements, global action to reduce carbon dioxide.

The CCAC is open to all governments and other stakeholders who are committed to taking action on SLCPs, both nationally and by supporting international action. Sweden was one of the six states to take the initiative, and Norway, Denmark and Finland have now joined as coalition partners.

Important work on SLCPs is also being done by the *Arctic Council* (see presentation by Håvard Toresen).

# 8. Why are snow and ice important to us? The Arctic Council and SLCFs

*Håvard Toresen*, The Ministry of the Environment, Oslo, Norway

## 8.1 Summary of Presentation to the Nordic Workshop onAction related to Short Lived Climate Forcers, Copenhagen 7 June 2012

"The Arctic is now experiencing some of the most rapid and severe climate change on Earth. Over the next 100 years, climate change is expected to accelerate, contributing to major physical, ecological, social and economic changes. Changes in the climate will also affect the rest of the world."

The above quote is from the Arctic Council report, "Arctic Climate Impact Assessment" (ACIA) from 2004. This was the first comprehensive assessment of research and observations of climate change covering the Arctic as a whole. The report gave a thorough documentation of the speed with which the Arctic climate was already changing: with temperature increasing by two times the global average; extensive melting of the Greenland ice sheet, and significant reduction in sea ice cover; and with a prospect for a continuation of these trends.

The ACIA indeed predicted what has occurred in the years since, and if anything, it was conservative in its estimates. Summer sea ice extent set record lows in 2007 (and again in 2012), and the extent of Greenland melt surprised even the most skeptical researchers through its increase in rate and speed. The 2010 *S*now, *W*ater, *I*ce and *P*ermafrost in the *A*rctic (SWIPA) report, launched in 2007 under the Norwegian chairmanship, provided extensive documentation of all these changes. The Arctic Council has continued its focused work with new and even more alarming reports about Arctic temperature increase, ice melting and reduced sea ice cover.

These changes are also important for the entire global climate system. As snow and ice melt in the Arctic, less of the sun's rays are reflected into space (the "albedo effect"), and the globe as a whole becomes warmer. Melting of the Greenland ice sheet also contributes to global sea level rise. The SWIPA report, taking into account the accelerating Greenland melting as well as other factors, raised the mean estimate for sea level rise by 2100 to over one meter, from previous estimates of one-third that amount. Finally, melting in the Arctic has the potential to release large amounts of methane from permafrost and the Arctic seabed, which could further speed global warming. Arctic climate change is therefore happening already today, faster than elsewhere and faster than we had expected; and it has global consequences.

While the Council has focused primarily on documenting the changes caused by climate change in the Arctic, it also works on mitigation, and that is how the Task Force on Short Lived Climate Forcers (SLCF TF) arose. The Arctic Monitoring and Assessment Program (AMAP) began studying these short-lived forcers – black carbon, methane and ozone – already in 2007 during the Norwegian chairmanship. As their potential for slowing warming in the Arctic became clear – especially, actions to reduce black carbon that could be taken by Arctic Council nations themselves – member countries agreed to form the SLCF Task Force.

Action on short-lived climate forcers was included in the Tromsø Ministerial Declaration of April 2009:

- Note the role that shorter-lived climate forcers such as black carbon, methane and tropospheric ozone precursors may play in Arctic climate change, and recognize that reductions of emissions have the potential to slow the rate of Arctic snow, sea ice and sheet ice melting in the near term
- Decide to establish a task force on short-lived climate forcers *to identify existing and new measures to reduce emissions of these forcers and recommend further immediate actions* that can be taken and to report on progress at the next Ministerial meeting (2011)

The AMAP work had demonstrated that together, black carbon, ozone and methane may account for half the warming that has occurred in the Arctic thus far. While action on CO2 remains the key focus of both global and Arctic-related efforts, action on short-lived forcers has the potential to slow the rate of Arctic warming *in the near-term*, and thus can serve as a powerful complement to action on CO2, where the full effect of emission reductions will occur after more than 100 years. Studies undertaken by UNEP in 2010–2011 indicate that intensive, efforts to reduce SLCF emissions at a global scale may reduce the global temperature increase by 0.5 degrees C by the mid of this century, and even more in the Arctic region. No other realistic action to reduce emissions of greenhouse gases will give such results in the short and medium term. A global effort to reduce SLCF emissions as illustrated by UNEP can help ensure that we manage to keep the increase in global average temperature below 2 degrees, at least in this century.

The Arctic Council Task Force initially focused on sources of black carbon, where the Nordic contribution is small in global terms. But in terms of impact per unit of emissions the contribution is greater than for any other region, because of its nearness to Arctic ice and snow. The most important sources of black carbon are domestic heating with wood, and diesel transport, both on-road and off-road. As noted in the March 2012 Svalbard Declaration, the Nordic countries will take responsibility for the effect of these emissions and contribute to emissions reductions where these are most effective.

In the Arctic nations as a whole, diesel transport is also an important source, but is, unlike wood burning, expected to decline as new regulations in the EEA and North America come into force. Agricultural burning is an extremely large source of black carbon emissions reaching the Arctic from Russia, and in lower amounts also from Canada and North America. Finally, oil and gas flaring is a potentially large source of black carbon reaching the Arctic from Russia, Alaska and the North Sea oil fields; and shipping emissions, while small today, are anticipated to increase. Both these sources are also close to the Arctic: potentially soon and ironically, even within the Arctic Circle itself, as shipping and oil & gas exploitation expand due to loss of sea ice. Thus, the per-unit impact also from these emissions is expected to be high. It is therefore important already today to establish norms that will limit the impact of in-Arctic emissions from these sources.

Methane, and to some extent ozone precursors, are more globally mixed gases, and their warming effect is anticipated to be less regional in nature. Nevertheless, Arctic and Nordic nations can do much to spearhead methane reductions globally, for example through development assistance, capacity building and financing schemes.

In conclusion, the Arctic and Nordic countries can and should do much, but we are facing a global problem that will require global solutions. We should act both regionally, and on the global stage to achieve these on the most urgent timeline – motivated by the rapid changes in the Arctic – and with the most effective short and medium term solutions available to us.


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# 9. Danish emissions of particulates and black carbon – historical estimates and projections

*Morten Winther* and *Ole-Kenneth Nielsen,* Department of Environmental Science, Aarhus University, Denmark

## 9.1 Introduction

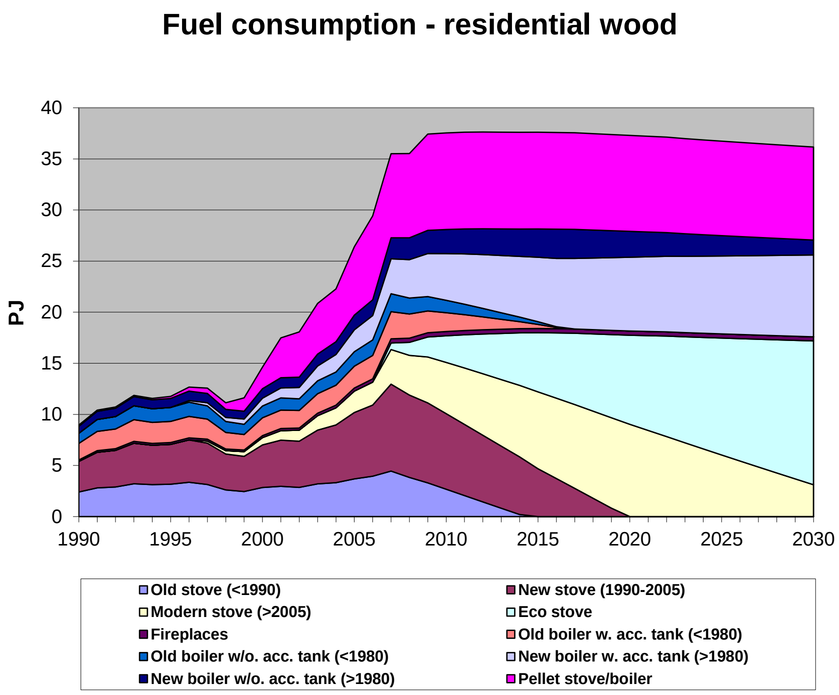
The primary carbonaceous aerosols emitted as part of the total particles (TSP) during fuel combustion are classified into black carbon (BC) and organic carbon (OC). BC is the light-absorbing part of the particles (soot). It has global-warming properties due to its ability to absorb light over reflective surfaces, and due to its darkening effect when deposited on snow and ice surfaces. BC is regarded as a Short-lived Climate Forcer (SLCF). Seen from a global-warming perspective, the short-term benefits of reducing BC are promising.

This presentation explains the TSP and BC emission inventory for Denmark from 1990–2030, covering all fuel-consumption sources. It is based on a technology-stratified inventory of TSP, as well as BC fractions of TSP (f-BC). The inventory was made by the Department of Environmental Science (ENVS)/Danish Centre for Environment and Energy (DCE), Aarhus University, under the project "BC emissions from Danish sources" (2010), supported by the Danish EPA (DANCEA programme). The BC results served as part of the Danish input for AMAP (Arctic Monitoring and Assessment Programme) in the Arctic Council. The full project also covers Greenland and the Faroe Islands and includes OC estimates.

## 9.2 Activity data

For stationary sources, the activity data comes from the Danish Energy Agency, and includes both historical and forecasted fuel consumption. The residential plant category covers stoves, boilers (oil/natural gas/straw) and fireplaces. Today, wood burning accounts for around 50% of residential fuel consumption. This share is expected to increase in the future, as the consumption of gas oil and natural gas drops. Large sources cover power plants, district-heating plants and refineries, whereas the remaining small combustion sources appear in the commercial-institutional, agricultural and manufacturing sectors.

***Figure 1. Fuel consumption for residential wood burning and diesel cars from 1990–2030***



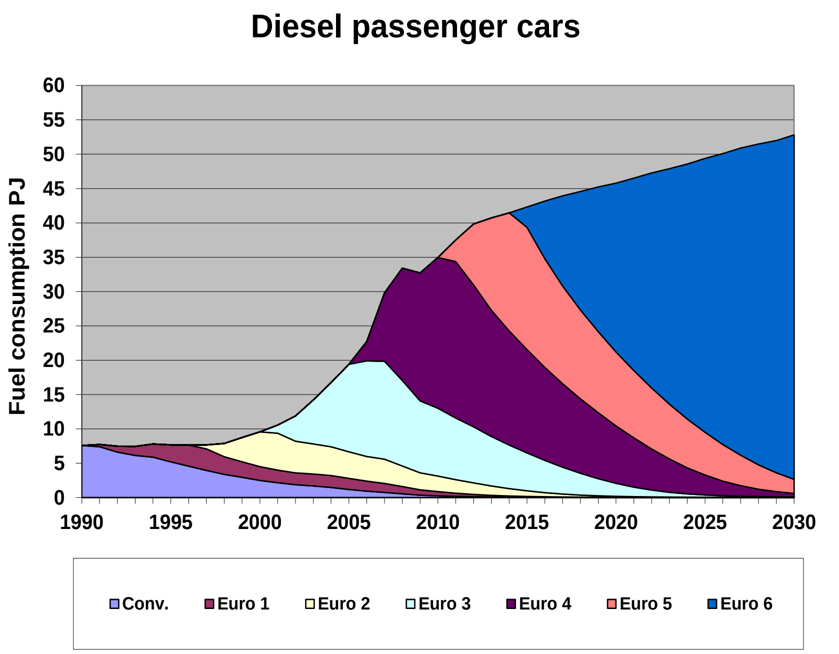



Figure 1 shows the wood consumption and fuel consumption for diesel cars (PJ), stratified into units/technologies. For wood consumption, a sharp increase is noted from 1999–2007 (>200%), due to an increase in prices for other fuels than wood, as well as popularity (cosiness). In the later years, the dieselification of the car fleet is very visible, and is expected to continue in the future.

### *9.2.1 Emission factors*

For residential wood burning and other stationary sources, the TSP emission factors in the Danish inventory are based on different studies (Nielsen et al. 2010), whereas f-BC data rely on the GAINS model. For road-transport exhaust and non-exhaust, the TSP emission factors and f-BC fractions are from COPERT IV. For the other mobile category, the Danish TSP emission factors come from different sources. f-BC data for railways, non-road and military are determined by expert judgement, based on road-transport engine analogies. Navigation f-BC data are derived from an extensive plume-measurement campaign, while aviation f-BC data are based on the GAINS model.

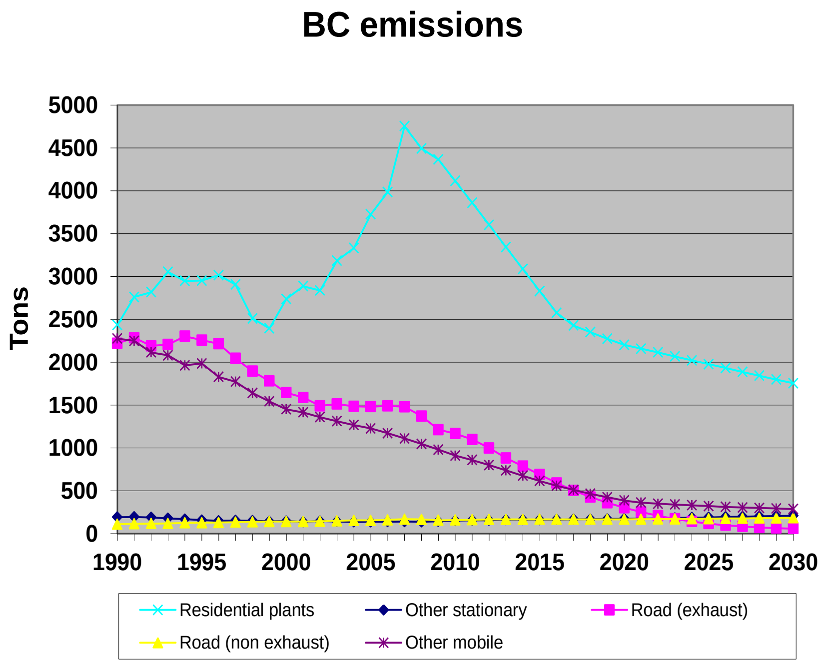
### *9.2.2 Results and conclusion*

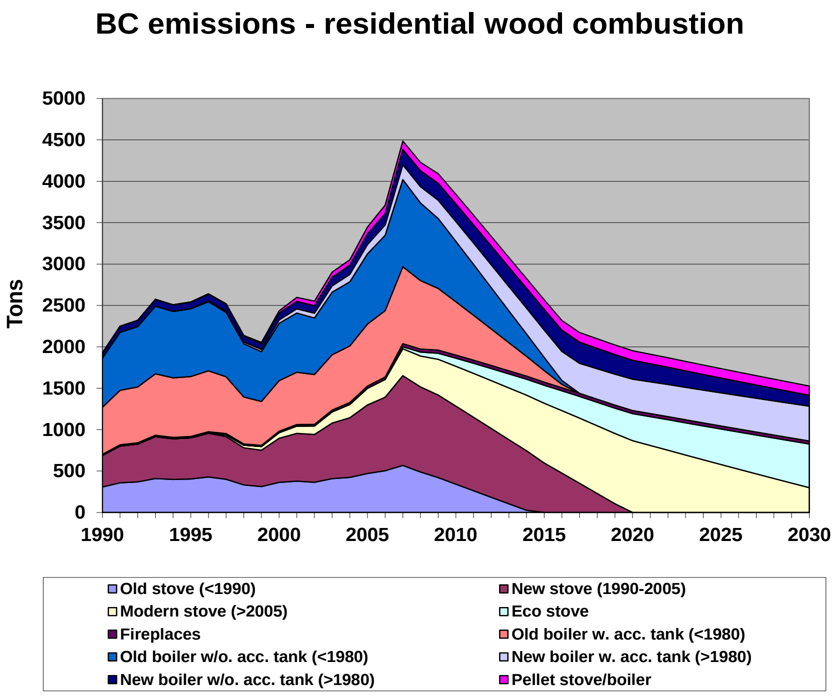
The BC emissions are calculated as the product of activity data (GJ), TSP emission factors (g/GJ) and BC fractions of TSP (f-BC), stratified into sectors/subsectors, fuel type and technologies. In 2008, residential plants are the largest emission source. TSP and BC emission shares were 70% and 62%, respectively. Wood burning alone accounts for 67% and 59% of the total Danish TSP and BC emissions.

The total emissions of TSP and BC decrease by 14% and 28%, respectively, from 1990–2030 (BC, Figure 2). For residential plants, the TSP and BC emissions drop by 16% and 28% from 1990–2030. The TSP and BC emission changes for smaller sources are (in brackets): road exhaust (-93%, -97%), other mobile (-84%, -87%), other stationary (-3%, +9%), road non-exhaust (+65%, +68%).

For the most important source, residential wood burning, BC emissions increase by 128% from 1999–2007 (Figure 2). From 2007–2030, the emissions are expected to decrease by 63% due to improved PM-emission performance (Danish EPA Executive Order no. 1432 and the Ecolabelling system for eco stoves). The PM emission limit for eco stoves (4g PM/kg wood) is tighter than the EPA limit (10g PM/kg wood). The Ecolabel limits are assessed every third year.

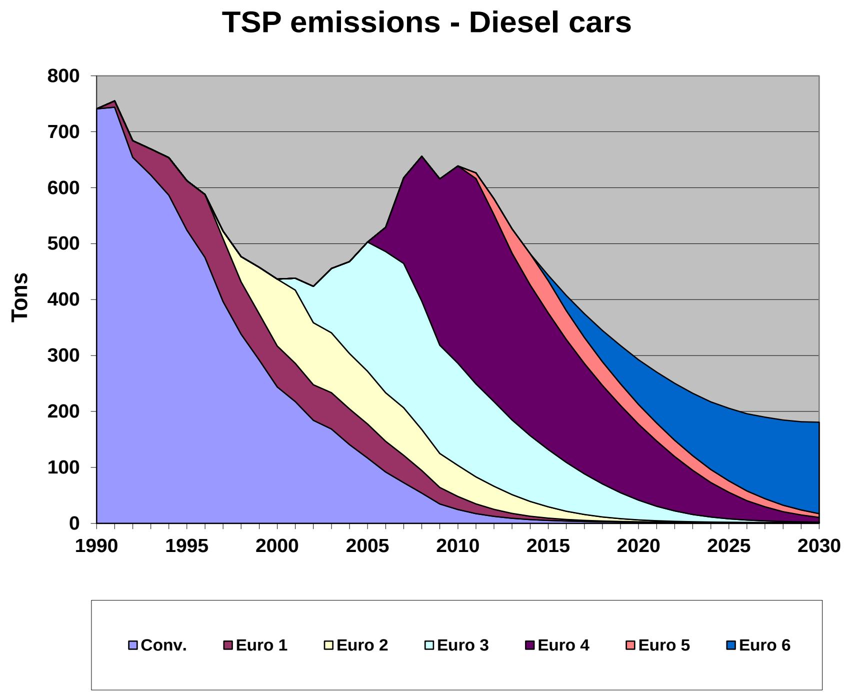
*Figure 2. BC emissions – Danish totals and detailed estimates for wood combustion (1990–2030)*

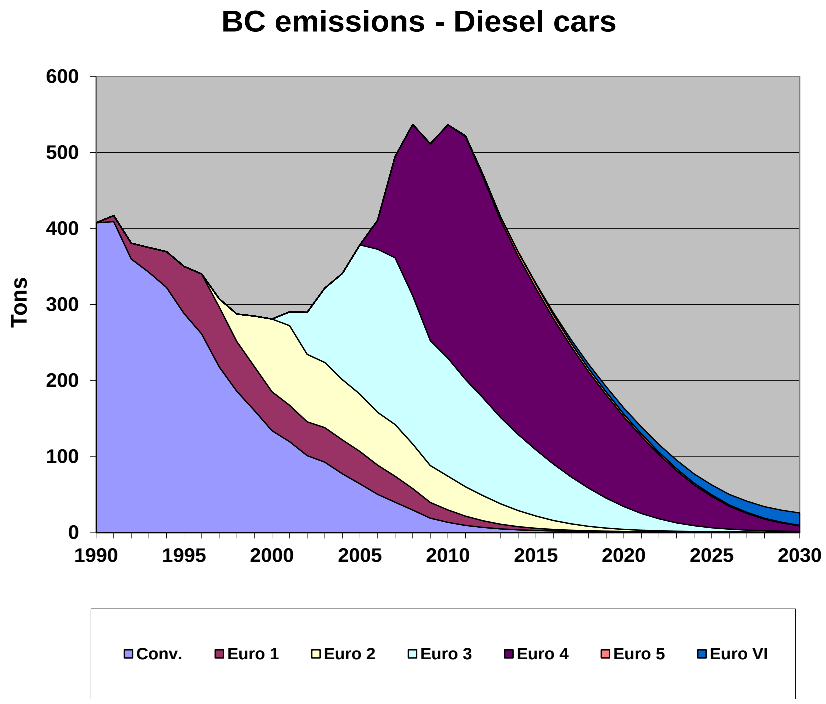



Euro 5 and 6 diesel cars and vans, and Euro VI trucks and buses must have filters installed in order to meet the EU requirements. Filters reduce the emissions of TSP from these vehicles, and even more efficiently remove the soot part of the particles (BC). For example, see Figure 3 – diesel cars.

*Figure 3. TSP and BC emissions for diesel cars, stratified into Euro layers (1990–2030)*



### *9.2.3 Related work*

An EU-commissioned project by DCE is currently underway: "Services to support the update of the EMEP/EEA Emission Inventory Guidebook, in particular on methodologies for black carbon emissions" (project ends 2012). The updated BC-emission data supports emission inventories for the CLRTAP convention. DCE is also carrying out the project "Emissions from ships in the Arctic", funded by the Danish EPA (DANCEA). Its output is a spatial distribution of the emission and deposition of SLCFs from ships in the Arctic for 2011 and the forecast years 2020, 2030, 2040 and 2050. The results can be used by AMAP and other researchers.

# 10. SLCPs – Emission inventories and preparation of policy measures in Finland

*Seppo Sarkkinen*, Ministry of the Environment, Helsinki, Finland

The main content of the presentation was emissions and main sources of SLCPs, earlier research on fine particulates, and national measures on black carbon, methane, tropospheric ozone and F-gases. Issues related to emission inventory were presented with help of material from SYKE (Kaarle Kupiainen, Niko Karvosenoja).

Emissions of black carbon and organic carbon by sector for the year 2005, as well as two projections for year 2020, were calculated using the FRES model and published in the technical report of the Arctic Council TF in May 2011. The total emissions of black carbon have been more than 7 Gg, the major sources of which were transport and other engines. Further implementation of EU legislation will decrease this part of the emissions by 2.5 Gg. The share of domestic combustion is likely to reach 60% of total BC emissions. The main sources of methane are waste and wastewater management (50%), agriculture (30%) and small-scale combustion (10%). The methane emissions are slightly reduced by the measures of the present National Climate Strategy.

During the last decade, several research programmes and individual projects on fine particulates and their health effects have created ground for the development of policies on black carbon. SYKE, FMI, VTT, THL and the Universities of Helsinki and Eastern Finland have participated in many of these studies. These institutes have also participated in international or EU-wide projects, such as MACEB.

The Ministry of the Environment has gradually supported the development of the Finnish Regional Emission Scenario (FRES) model in SYKE. The effect module of this integrated assessment model includes critical load exceedances and health effects. The SLCFs module, including radiative forcing of Finnish emissions, will be completed in 2012. It should be possible to compare the effects of carbon dioxide and black carbon measures during the review of the National Climate Strategy later this year.

Black carbon emissions are reduced as a part of particulate-emission measures. The major motivation to reduce particulates has been the health risks caused by fine particulates. Measures for new vehicles have become gradually more stringent due to EU emission regulations. It is possible to, at national level, encourage the use of modern bio fuels, and, locally, to take smaller emissions into account in procurement systems related to bus services. A study has been launched in SYKE to estimate different possibilities to reduce PM emissions from small-scale combustion in a 10–20-year perspective. Potential emission-reduction measures, such as product standards, information campaigns and add-on technologies are studied, and the health effects, as well as the effects of SLCPs and other greenhouse gases, are compared.

Some measures on tropospheric ozone, methane and HFCs are already in place in the present National Climate Strategy. Further measures are considered in the ongoing review of the Strategy. Regarding HFCs, we are preparing to influence the forthcoming revision of EU legislation and to study the use of voluntary economic instruments.

# 11. Status Norway – emission inventories and action plan to cut Norwegian SLCF emissions

*Vigdis Vestreng* and *Solrun Figenschau Skjellum*, Climate and Pollution Agency (Klif), Oslo, Norway

The Norwegian Ministry of the Environment has mandated the Climate and Pollution Agency (Klif) to develop an action plan for reducing emissions of Short-lived Climate Forcers (SLCF). The action plan shall include recommendations for measures and instruments for cutting emissions up to 2030.

No fixed emission-reduction or effects targets for SLCFs are given at project initiation. Klif has been asked to perform an integrated assessment of air pollution and climate change, as most SLCFs, in addition to being climate forcers, have an adverse effect on health and environment. They may also have regional effects. The work to establish the action plan is organised as a project with a core team of 10–15 people from the Climate and Pollution Agency. Several external experts will also be contracted. The deadline for the action plan is 10 June 2013.

The scope of the action plan is to assess the SLCFs $CH_4$, $O_3$, HFC 134a and 152a and BC, together with co-emitted cooling emissions of $SO_2$, $NH_3$ and OC. We will estimate the emission reductions and costs of measures and instruments by 2030 and, to the extent possible, model the effect of reductions. The definitions we plan to apply are as follows: climate effect = radiative forcing; health effect = premature deaths; environmental effect = effects on crops, (forests). We will try to consider the valuation of health and environment, and possibly climate. If possible, we also aim to compare the effects of SLCF reductions with $CO_2$.

SLCFs may be considered “known suspects in a new perspective”, as many of them are air pollutants in addition to climate forcers. All of the SLCFs in Norway are, to some extent, regulated through protocols, as shown in Table 1.

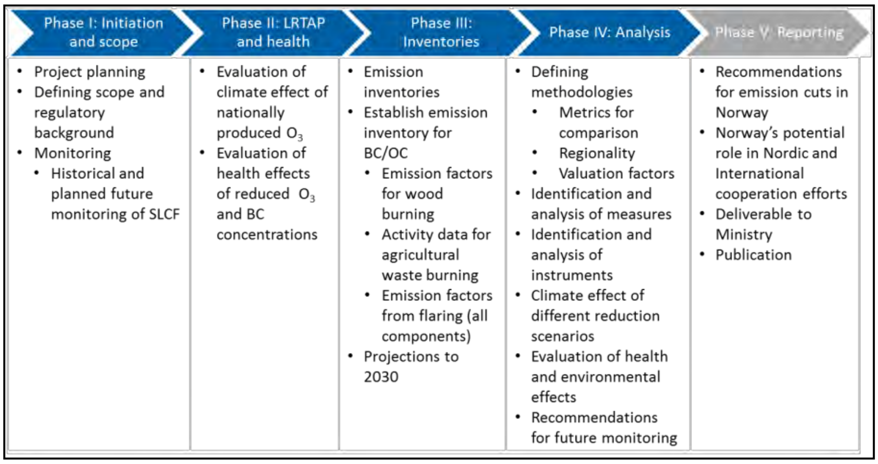
**Table 1. SLCF characteristics and regulations**

| SLCF | Type of component | Regulation mechanism |
|---|---|---|
| $CH_4$ | Greenhouse gas | Kyoto Protocol |
| Ground based/Tropospheric $O_3$ ($NO_x$, nmVOC, $CH_4$, CO) | Greenhouse gas / Air pollution | Gothenburg protocol |
| Black carbon (BC) | Part of fine particles | (Gothenburg protocol) |
| Hydrofluorocarbons (HFC), HFC 134a and 152a | Substitute stratospheric $O_3$-reducing CFC | Kyoto Protocol |

$CH_4$, $O_3$ and HCF 134a and 152a were assessed in the project "Climate Cure 2020". The action plan will take on board methodology and assessments from this study, but updates are needed in order to complete the plan.

Much less work has previously been done on black carbon (BC). Norway is working on developing an emissions inventory for BC, including the measurement of emissions from the anticipated largest source, wood burning in residential stoves. This source contributed 70% of $PM_{2.5}$ in 2010. It is challenging to obtain accurate wood-consumption data for this source, since much of the wood is self-cut and not commercially sold. Surveys are conducted in order to obtain the best possible data. The only current measure for wood burning is the 1998 regulation limiting emissions to 10 g PM/kg for new stoves. This regulation has led to a slow but continuous decrease in the emissions from wood burning in Norway, as the share of new stoves increases at the expense of old stoves.

***Figure 1. The content of the Norwegian action plan project***




The Norwegian action plan project is divided into five phases, as shown in Figure 1. Klif has already initiated work in four of the five phases, but there is much work to do and several challenges to overcome before the action plan is completed.

So far, we have experienced that the action plan is a complex project with a tight timeframe. Some challenges are listed below:

- Many internal and external sub-projects are interdependent and interlinked
- It is demanding to conduct multidisciplinary work and challenging to perform a holistic analysis for emissions reduction and measures/instruments
- It is important to agree on definitions of key terms and the scope of the project
- SLCFs may have different key sources, and some SLCFs affect the formation of other SLCFs
- Measures may act simultaneously or have drawbacks in relation to several SLCFs and/or CO2
- Measures might affect health, environment and climate
- The effect of measures to reduce SLCFs is not directly comparable with the effect of CO2 measures – we need to define a methodology in order to be able to carry out sound comparisons
- It is time-consuming to get an overview of all relevant existing knowledge and ongoing processes
- It is important to establish high-quality input data, e.g. for emission inventories, in particular black carbon
- It is time consuming and costly to call for tenders and to engage consultants
- It is challenging to scope modelling and analysis: metrics/comparison, regionality, valuation
- We risk reaching the limits of analysis tools (e.g. our tool for measures, costs and benefits, "Klimatall"), and in certain areas we are close to exceeding current scientific understanding
- There are many uncertainties involved

In order to move towards meeting the expectations of the Svalbard Declaration, we propose the following actions for discussion:

- Active participation in ACTFSLCF, AMAP EG SLCF, and the ACAP project on residential wood stoves
- Implementation of measures to fulfil the Gothenburg protocol
- Compilation/overview of individual Nordic emissions (ACTFSLCF)
- Possible Nordic co-operation efforts:
  a) Emission inventories
     - Harmonisation of emission-factor measurements
     - Knowledge transfer with respect to the surveys undertaken to define wood consumption
  b) Measures and costs
  c) Metrics
  d) Valuation factors
  e) Monitoring efforts

- Agreement on measurement standards to put forward internationally
- Nordic countries could act jointly in different international forums
- Agreement on voluntary reporting of BC and OC emissions to the LRTAP convention
- Assess the feasibility, pros and cons of a Nordic action plan.

# 12. SLCF status in Sweden – carbon and methane emissions (inventories and policy aspects)

*Reino Abrahamsson* (Swedish Environmental Protection Agency) and *Caroline Dickson* (Ministry of the Environment) Stockholm, Sweden

Research on short-lived air pollutants with a climate impact has identified emissions of black carbon and methane as the most important pollutants with a warming effect on the climate.[2] Black carbon (BC) has a special effect on the Arctic climate due to its character of absorbing solar irradiance, and thereby melting snow and ice. Only a preliminary inventory has been performed on BC emissions in Sweden, while methane emissions are inventoried every year in accordance with the Climate Convention. This presentation gives an overview of the calculated trends of BC and methane emissions in Sweden from 1990 to 2010, projected emissions to 2020/2030 and policy aspects.

## 12.1 Emissions of black carbon

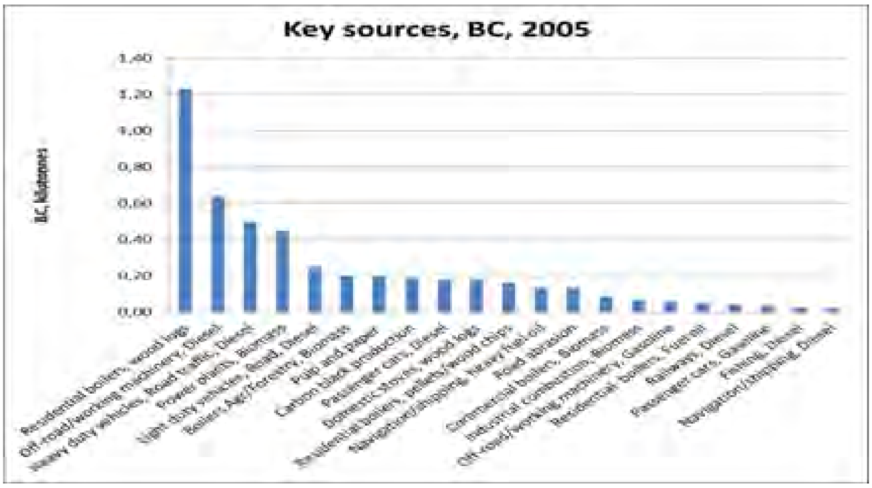
Inventoried emissions of $PM_{2.5}$ from BC-emitting sources have been used as a proxy to estimate black carbon emissions. BC fractions of the $PM_{2.5}$ emissions from different activities and fuel emissions (calculated by IIASA) were used to establish emission factors for BC. The identified key sources are residential heating by fuel wood, off-road diesel mobile sources, heavy-duty diesel trucks and biomass-fuelled power plants.[3] Overall, Swedish BC emissions are estimated at 5–6 ktonnes in 2005, which is a reduction of approximately 30% since 1990, mainly due to lower emissions from diesel-fuelled heavy-duty trucks and off-road mobile sources. A new inventory will apply when the Emission Inventory Guide-

[2] UNEP (2011), Integrated assessment on black carbon and tropospheric ozone.

[3] ITM/IVL (2011), Black carbon – Possibilities to reduce emissions and potential effects, ITM Report 202.

book, under the Convention on Long Range Transport of Air Pollutants, is updated for black carbon. This work is planned to be finished in 2013.

***Figure 1. Estimated key sources of black carbon emissions in Sweden, 2005 (ktonnes)***




Due to the introduction of more stringent particulate-emission standards for diesel-fuelled mobile sources (new ones will be introduced in 2012 and 2016), it is anticipated that BC emissions from these sources will be reduced by 60–80% by 2020. However, emissions from residential heating will continue at the same level without new policy instruments. In 2020, emissions are projected to be around 3–3.5 ktonnes per year, of which 40% stems from residential heating by fuel wood.

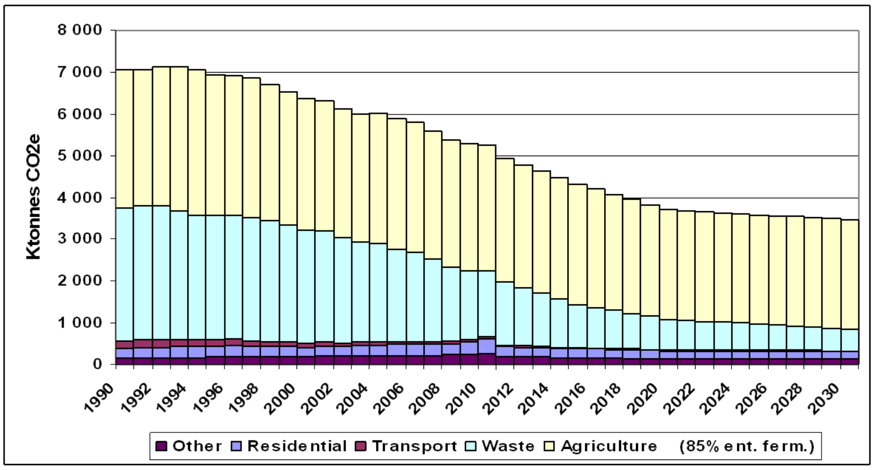
Regarding further reducing emissions in Sweden, residential heating is the most important source for abatement. These emissions occur during winter, when the BC climate impact is most severe. Traffic and the use of off-road mobile machinery occur all year round, but are most intense during summer. To focus further abatement, residential heating is also well motivated from a health perspective.

## 12.2 Emissions of methane

Inventories of methane emissions are performed every year and submitted to the United Nations Climate Convention. Projections are made every second year, in accordance with European Union requirements. Emissions of methane ($CH_4$) in Sweden arise mainly from agriculture and landfill sites, and are for the year 2010 estimated at 5.3 million tonnes of CO2-equivalents. Since 1990, emissions have decreased by around 25%, primarily due to measures implemented in the waste sector and in agriculture.

From 2010 to 2030, it is anticipated that emissions will continuously fall, and will be halved compared to 1990. Landfilling is taxed and organic waste cannot be deposited. Household and other combustible waste is mainly burned, with energy recovery in district-heating plants. The collection of landfill gas was introduced in 1995–2000 with governmental grants. The ban on depositing organic waste is calculated to reduce emissions from landfills from 3 Mtonnes CO2e in 1990 to 0.2 Mtonnes in 2030. In 2030, the agricultural sector is anticipated to be the sole remaining source, with a significant amount of emissions. Emissions from enteric fermentation will dominate and are currently regarded to have limited ability to abate.

***Figure 2. Trends and projections of methane emissions in Sweden 1990–2030. Inventoried emissions for 1990–2010 (Mtonnes CO2e)***




The main measure for further abating methane emissions in agriculture production is regarded as anaerobic digestion of manure for biogas production. This is currently supported via information and advice to farmers on biogas-production systems, together with investment grants. The Swedish Agricultural Board has proposed to increase the current work and investment support from 2014 to 2016. Increased farming productivity will, in the long run, be important for reducing emissions from enteric fermentation. Reduced meat consumption will have a pronounced impact on methane levels.

## 12.3 Policy aspects of Short-lived Climate Pollutants in Sweden

After the Climate Conference in Copenhagen in 2009, it was obvious that the negotiations would not yield the results for global GHG reductions that we had hoped for in the short term. At the UNEP Governing Council in Nairobi in 2010, ministers met and listened to a presentation of the report "Integrated Assessment of Black Carbon and Tropospheric Ozone". The report identifies 16 measures that would produce important climate, health and crop-yield benefits. The Swedish and Mexican ministers, together with the Minister of the Environment in Bangladesh, decided to initiate action on Short-lived Climate Pollutants. This discussion was the starting point that has now resulted in the international "Climate and Clean Air Coalition to Reduce SLCPs". In the Coalition's discussions, the Swedish Minister of the Environment has strived for all countries to commit themselves to take action in their own countries. This is also written in the Coalition statute. Sweden has identified residential/small-scale fuel-wood heating (currently 25% of our BC emissions) and diesel-fuelled off-road working machinery (10% of our BC emissions) as the two sectors on which Sweden shall focus its future abatement activities.

In addition to the Climate Coalition, Sweden plans to launch discussions in the Arctic Council on a possible treaty on SLCPs, and to prepare a proposition for a common Nordic Council of Ministers project on domestic biomass burning.

# 13. Concluding remarks

*Annika Rosing*, Department for Growth and Climate, Nordic Council of Ministers Secretariat

## 13.1 Nordic workshop on action related to Short-Lived Climate Forcers

Ladies, Gentlemen and Dear Participants,

First of all, I would like to thank you for giving me the opportunity to make the concluding remarks to this workshop.

A workshop with experts on Short-lived Climate Forcers is very timely, not only in the Nordic countries but also in the Arctic and internationally, given the importance of SLCFs for global climate development.

In March 2012, the Nordic Ministers of Environment met at Svalbard to discuss environmental issues and climate change.

The main focus at the meeting was how to reduce emissions of SLCFs locally in the Nordic Region, as well as globally.

Reducing emissions of SLCFs will, apart from the beneficial effects in terms of combating climate change, also have positive effects on the environment – and, not least, on human health.

As mentioned before, in their meeting, the Nordic Ministers agreed on – in addition to supporting EU initiatives and the international climate negotiations, of course – the following actions:

- Further developing and supporting national emissions budgets, including data on emissions of black carbon
- Assessing cost-efficient possibilities for reducing emissions of SLCFs, and assessing the need for national plans for this
- Assessing the need for a common Nordic plan to stimulate and support an efficient implementation of national plans to reduce emissions of SLCFs
- And, last but not least, supporting this work by arranging a Nordic seminar (which is why we are here today) to exchange experiences on national emissions accounts, identification of efficient initiatives and the establishment of national plans

Maybe we need to discuss the three first points more…

At the meeting, the Secretary General of the Nordic Council of Ministers highlighted the possibility of using the Nordic initiative on SLCFs as a tool in relation to the implementation of political priorities, e.g. in the Nordic Arctic Co-operation Programme.

This is therefore, as you know, relevant in many different forums.

It is also planned that initiatives on SLCFs will be taken over the next six years as part of our new Nordic Environmental Action Plan.

Now, having mentioned some of the work that is done on SLCFs in the Nordic Region, we must not forget the initiatives taken outside of the Nordic countries. As you probably know all too well, there are a lot of these – so we are not working alone.

But there's still a lot to be done:

- We need to continue our work within the public sector, but also involve the private sector, as well as NGOs
- We have to raise awareness of this issue among Nordic citizens
- We have to increase co-operation between sectors and the Nordic countries
- We also need to build bridges between research and politics!

I am only a humble bureaucrat. You are the experts on this matter. But I strongly believe that in order to achieve change we need to find steps that are easily understood and can be efficiently implemented. We always want to know more, but we also need to act, to make it possible for our politicians to make the right decision. We have momentum now!

To change our societies in a sustainable way is difficult. Hopefully, this work will lead to stronger co-operation between our countries and fruitful achievements – with the Nordic countries leading the way, of course.

And with this in mind, I would like to thank the organisers for taking this step on the road and making this gathering possible. And thanks to you all for participating in this workshop with such interest and engagement.

I hope you have had some fruitful discussions, made contact with new and old colleagues, and added value to your work on SLCFs.

Thank you all, and have a safe trip home.
8 June 2012

# 14. Sammendrag

## 14.1 Rapport fra nordisk workshop om tiltak vedrørende kortlivede klimadrivere

**Bakgrunn**
Nyere forskning har fastslått at kortlivede luftforurensende stoffer som for eksempel svart karbon kan ha større innvirkning på global oppvarming enn tidligere antatt, og at en reduksjon av kortlivede klimadrivere (SLCF), spesielt for Arktis, vil kunne redusere den globale oppvarmingshastigheten på kort sikt (20–30 år). På workshopen ble begrepet kortlivede klimaforurensende stoffer (SLCP) også brukt, synonymt med SLCF.

Nordisk ministerråd vedtok en erklæring om SLCF på sitt møte på Svalbard i mars 2012. Ministrene ba også den nordiske Klima- og luftgruppen (KoL) om å arrangere en nordisk workshop for å utveksle informasjon om statusen for arbeidet med nasjonale utslippsregnskap for kortlivede klimaforurensende stoffer og eksisterende reduksjonsstrategier, identifisere kostnadseffektive tiltak for å redusere utslipp av SLCF og skape et bedre grunnlag for felles, men nasjonale handlingsplaner i de nordiske landene.

**Forskningsfunn**
Til nå kan det være sluppet ut nok antropogene drivhusgasser i atmosfæren til å varme opp planeten mer enn 2 °C. Oppvarmingen på 2 °C kan utsettes med 30 til 40 år hvis vi sørger for en drastisk reduksjon av de globale utslippene av SLCF: metan, HFC-er og svart karbon (BC). Den voksende konsentrasjonen av metan i atmosfæren stabiliserte seg på slutten av 1990-tallet, men har begynt å øke igjen de senere årene. Tiltak som reduserer utslippene av SLCF vil i det lange løp kunne styrke mulighetene for å redusere den globale temperaturstigningen til under 2 °C, men bare dersom det iverksettes offensive tiltak mot utslipp av $CO2$ og andre langlivede drivhusgasser (GHG).

Vi må skille mellom kortlivede klimadrivere som kan ha en levetid på 10–15 år (som for eksempel metan), og svært kortlivede klimadrivere med en levetid fra noen dager til uker, som for eksempel forurensende stoffer som nitrogenoksider (NOx), flyktige organiske forbindelser (VOC) og karbonmonoksid (CO), som påvirker det globale klimaet gjennom fotokjemiske reaksjoner som danner troposfærisk ozon. Ozon har en oppvarmende virkning i den øvre troposfæren, mens ozonet nær bakken er uvesentlig i et klimaperspektiv. Derfor er det viktigst å redusere utslippene av metan og karbonmonoksid for å dempe strålingspådrivet fra ozon, siden disse er de viktigste forløperne for ozon i den øvre troposfæren. Reduksjon av NOx vil derimot sannsynligvis føre til økt oppvarming, siden utslipp av NOx avkjøler atmosfæren ved å redusere mengden metan.

Svart karbon, etterfulgt av metan, står sannsynligvis for de viktigste SLCF-utslippene som bidrar til global og regional arktisk oppvarming. Utslipp av svart karbon fra de nordiske landene har høyere direkte strålingspådrivende (oppvarmende) effekt i Arktis per utslippsenhet enn utslipp av svart karbon fra andre deler av verden. Dette skyldes nærheten til Arktis. Svart karbon fra alle kilder i verden ser ut til å ha forårsaket rundt 20 % av oppvarmingen og tapet av havis i Arktis i løpet av forrige århundre. Men stor variasjon i det regionale klimaet fra år til år vil gjøre det svært vanskelig å påvise eventuelle tegn til klimarespons på reduksjon av SLCF.

Naturlige kilder dominerer de karbonholdige aerosolene i atmosfæren i de nordiske landene om sommeren. Andelen av aerosolene som består av svart karbon og organiske aerosoler med antropogen opprinnelse, øker kraftig om vinteren. Om sommeren domineres de antropogene karbonholdige aerosolene i de nordiske landene av svart karbon fra fossilt brennstoff, mens biomassebrennstoff ser ut til å være den dominerende kilden om vinteren.

**Status for utslippsregnskap og SLCF-strategier i de nordiske landene**

Alle de nordiske landene har utarbeidet eller er i ferd med å utarbeide foreløpige utslippsregnskap for svart karbon. Det er ulike ressurser og metoder som tas i bruk, ettersom det ikke finnes noen standard retningslinjer for estimering av utslippene av svart karbon. En ekspertgruppe under EMEP er i ferd med å oppdatere EMEP EEA Emission Inventory Guidebook om metoder for å utarbeide utslippsregnskap for svart karbon (ferdig 2012) under Konvensjonen om langtransportert grenseoverskridende luftforurensning (CLRTAP).

Det er beregnet at utslippene av svart karbon domineres av boligoppvarming med biomasse i alle de nordiske landene. Dette trekket antas å bli enda mer markant i framtiden ettersom det skal innføres partikkelfiltre for dieselkjøretøyer og dieseldrevne ikke-veigående mobile kilder. Nye standarder for partikkelutslipp i Europa vil tvinge fram innføring av partikkelfiltre.

I Danmark har svart karbon fra vedfyring økt med mer enn 100 % siden 1990, men beregnes å gå ned med 60 % fra 2007 til 2030 fordi ovnene har fått bedre utslippsegenskaper. Andre viktige kilder som eksos fra veitrafikk og ikke-veigående mobile kilder er beregnet å minke enda mer. Utslippene av svart karbon for 2005 er beregnet å ha vært på 6 500–7 000 tonn. Totalt beregnes utslippene å bli redusert med 30 % fra 1990 til 2030, basert på nåværende virkemiddelbruk.

Den finske regionale utslippsscenariomodellen (Finnish Regional Emission Scenario Model, FRES) er brukt til å beregne fremskrivninger av utslipp av svart karbon i Finland for årene 2005 og 2020. Det er brukt nasjonale karakteristika for aktiviteter og utslippsfaktorer. De totale utslippene av svart karbon for 2005 er beregnet å ha vært på mer enn 7 000 tonn. Implementering av EUs partikkellovgivning for kjøretøyer og andre mobile kilder vil redusere utslippene med 2 500 tonn, mens boligoppvarming med biomasse vil komme opp i 60 % av de totale utslippene av svart karbon i 2020. SYKE har iverksatt en undersøkelse for å vurdere ulike alternativer for å redusere utslipp av partikler fra småskalaforbrenning i et 10–20-årsperspektiv. Den nasjonale klimastrategien vil bli evaluert senere i år og vil ta SLCF-tiltak med i beregningen.

I Norge har Klima- og forurensningsdirektoratet fått i oppdrag å utvikle en handlingsplan for reduserte utslipp av SLCF. Handlingsplanen skal omfatte anbefalinger om tiltak og virkemidler for utslippsreduksjon fram til 2030, og skal legges fram i april 2013. Vurderingen skal omfatte ikke bare klimaeffekter, men også helse- og miljøeffektene av luftforurensning. For øyeblikket pågår det en kartlegging av utslipp av svart karbon som omfatter måling av utslipp fra den antatt største kilden: vedfyring i boliger. Vedfyring er beregnet å stå for 70 % av $PM_{2.5}$-utslipp i 2010, men det er en utfordring å framskaffe nøyaktige tall for forbruket av ved.

Utslippene av svart karbon i Sverige er beregnet til 5 000–6 000 tonn for 2005, en reduksjon på rundt 30 % siden 1990. Man har planer om å gjennomføre en ny kartlegging når EMEPs Emission Inventory Guidebook er oppdatert for svart karbon. I 2020 er utslippene anslått å være på rundt 3 000–3 500 tonn per år, med 40 % fra vedfyring i boliger. Oppvarming av boliger blir den viktigste kilden til ytterligere reduksjoner. Sverige er en av partene som tok initiativ til Climate and Clean Air Coalition to reduce SLCPs. I diskusjoner i koalisjonen har Sverige utpekt vedfyring i boliger (25 % av de nåværende utslippene av svart karbon) og dieseldrevne ikkeveigående maskiner (10 % av utslippene av svart karbon) som de to sektorene der landet skal konsentrere sine reduksjonsaktiviteter.

**Diskusjoner**

Deltakerne i workshopen la fram vesentlige deler av en handlingsplan for hvordan de nordiske landene i fellesskap kan styrke reduksjonen av SLCF både i en nordisk sammenheng og internasjonalt. Det viktigste nordiske samarbeidet innebærer å støtte og styrke de nasjonale handlingsplanene som skal utarbeides i hvert enkelt land. Ved utarbeidelse av SLCF-strategier ville det være nyttig med et nordisk nettverk av eksperter på reduksjonstiltak og med workshoper/seminarer om

- en klarere definisjon av svart karbon (BC) og om overvåking og harmonisering av utslippsfaktorer for svart karbon
- målinger, overvåking og kostnadseffektive reduksjonstiltak mot utslipp av svart karbon fra vedfyring, siden dette vil være en dominerende kilde til utslipp av svart karbon i alle de nordiske landene i framtiden

En felles nordisk publikasjon som beskriver nasjonale handlingsplaner og disses effekt på Arktis, vil kunne bli påbegynt i 2013.

Aktiv deltakelse fra nordiske medlemmer i Climate and Clean Air Coalition ble ansett som formålstjenlig, og en katalog over tiltak for SLCF-reduksjon som er relevante for utviklingsland og land med overgangsøkonomi, kan initieres via NDF og NEFCO.

For å styrke det nordiske samarbeidet om forskningsaktiviteter i tilknytning til SLCF, ble det pekt ut tre nøkkelområder: 1) Definisjoner og måleparametre for svart karbon, 2) overvåking og 3) modellering.

Det er et presserende behov for definisjoner av «oppvarmende» aerosoler (svart karbon) som kan fungere både for utslippsregnskaper og for atmosfæreovervåking og modellering. Klimaeffektene av SLCF blir presentert på ulike måter, og det er behov for å finne felles måleparametre for videre bruk i scenarier og for integrerte vurderinger. Dessuten er enkelte trekk ved aerosolene over Arktis ikke tilfredsstillende parameterisert.

Overvåkingsnettverkene bør utvides for å sikre at relevante luftforurensningsparametre blir overvåket og koordinert på en ordentlig måte. Målingene bør omfatte både avansert overvåking ved et begrenset antall stasjoner og større nettverk for å sikre tilfredsstillende geografisk dekning. I tillegg til vitenskapelige/tekniske kontakter kan det tas initiativer på ministernivå for å intensivere samarbeidet med Russland i den hensikt å øke overvåkingsnettverkets geografiske dekning.

En bør støtte ytterligere utvikling av klimamodellering med henblikk på virkningen av SLCF på strålingspådriv og klima, med vekt på virkningene i Arktis, og utforske regionale klimatrender/-forandringer relatert til luftforurensning/SLCF.

Av de generelle anbefalingene fra workshopen til de nordiske miljøministrene kan nevnes at de nordiske landene bør delta aktivt i utviklingen av EMEP/EEA Emission Inventory Guidebook innenfor rammen av LRTAP-konvensjonen, og forbedre utslippsdataene for sjøfart og for vedfyring i boliger. På nasjonalt plan er det nødvendig å fokusere ytterligere på umiddelbare tiltak for å redusere utslipp fra vedfyring, og å informere befolkningen om vedovners yteevne, Svanemerket for vedovner og riktige fyringsvaner. Det bør også utvikles nye utslippsreguleringer for vedovner og en felles metode for å vurdere kostnadseffektive tiltak. Et nordisk nettverk av eksperter på utvikling av kostnadseffektive tiltak for å redusere utslipp av SLCP kan støtte nasjonale reduksjonstiltak. På regionalt plan kan Göteborg-protokollen være et viktig middel for å kontrollere utslipp av svart karbon på den nordlige halvkule, og samarbeidet med Russland om SLCF bør intensiveres.

# 15. Yhteenveto

## 15.1 Raportti lyhytikäisiä ilmastoon vaikuttavia yhdisteitä käsitelleestä työpajasta

**Tausta**

Tieteellisissä tutkimuksissa on äskettäin havaittu, että lyhytikäisillä ilmansaasteilla kuten mustahiilellä on arvioitua suurempi vaikutus ilmaston lämpenemiseen ja että lyhytikäisten ilmastoon vaikuttavien yhdisteiden (Short Lived Climate Forcers, SLCF) vähentäminen voisi varsinkin arktisella alueella hidastaa globaalia lämpenemistä lyhyellä aikavälillä eli seuraavan 20–30 vuoden aikana. Termiä Short Lived Climate Pollutants (SLCP) käytettiin työpajassa SLCF:n synonyymina.

Pohjoismaiden ympäristöministerit hyväksyivät Huippuvuorilla maaliskuussa 2012 pidetyssä kokouksessaan ministerijulistuksen SLCF-päästöistä. Ministerit pyysivät myös pohjoismaista ilmasto- ja ilmaryhmää (KoL) järjestämään aihetta käsittelevän pohjoismaisen työpajan. Tavoitteena oli vaihtaa tietoa lyhytikäisten ilmastoon vaikuttavien yhdisteiden kansallisista päästöinventaarioista ja nykyisistä vähennysstrategioista, löytää kustannustehokkaita toimia SLCF-päästöjen vähentämiseksi sekä luoda parempi pohja kansallisille ja yhteispohjoismaisille toimintasuunnitelmille.

**Tutkimustuloksia**

Ihmisen toiminnasta on tähän mennessä aiheutunut kasvihuonekaasupitoisuuksien lisääntymistä ilmakehässä niin paljon, että maapallon lämpötila nousee yli 2 celsiusastetta, vaikka koko maailman hiilidioksidipäästöt olisivat 50 prosenttia pienemmät vuonna 2050 kuin vuonna 1990. Kahden celsiusasteen lämpötilan nousu on erittäin todennäköinen vuoteen 2050 mennessä, jos nykyinen päästösuuntaus jatkuu. Kahden celsiusasteen lämpötilan nousua voidaan viivyttää 30–40 vuodella vähentämällä merkittävästi lyhytikäisten ilmastoon vaikuttavien yhdisteiden kuten metaanin, alailmakehän otsonin, fluorihiilivetyjen ja mustahiilen (BC) päästöjä. Metaanin määrän lisääntyminen ilmakehässä saatiin taitettua 1990-luvun lopulla, mutta viime vuosina ilmakehän metaanipitoisuus on alkanut kasvaa. Ihmisen toiminnan aiheuttamien aerosolipäästöjen suoran ja epäsuoran säteilypakotteen viilentävän vaikutuksen lasketaan olevan 1 Watt/m2, mutta mustahiiliaerosolien lämmittävän vaikutuksen arvioidaan olevan lähes 0,5 Watt/m2. SLCF-päästöjä vähentävät toimet voisivat parantaa mahdollisuuksia rajoittaa maailmanlaajuinen lämpötilan nousu alle kahden celsiusasteen pitkällä aikavälillä.

Tämä on kuitenkin mahdollista vain, jos hiilidioksidia ja muita pitkäikäisiä kasvihuonekaasuja vähennetään määrätietoisesti.

Meidän pitäisi erottaa toisistaan lyhytikäiset ilmastoon vaikuttavat yhdisteet, joiden elinikä on 10–15 vuotta (kuten metaani), ja erittäin lyhytikäiset ilmastoon vaikuttavat yhdisteet kuten typen oksidit (NOx), haihtuvat orgaaniset yhdisteet (VOC) ja hiilimonoksidi (CO), jotka vaikuttavat maapallon ilmastoon muodostamalla otsonia (elinikä muutamasta päivästä viikkoihin) alailmakehässä valokemiallisten reaktioiden tuloksena. Otsonilla on lämmittävä vaikutus alailmakehän yläosassa, kun taas lähellä maan pintaa olevalla otsonilla ei ole merkitystä ilmastonäkökulmasta. Metaani ja hiilimonoksidi ovatkin tärkeimmät otsonia alailmakehän yläosassa muodostavat yhdisteet ja siitä syystä niiden määrää tulee alentaa otsonin lämmitysvaikutuksen vähentämiseksi. Typen oksidien vähentäminen sen sijaan todennäköisesti lisää lämpenemistä.

Mustahiili ja metaani ovat todennäköisesti tärkeimmät maailmanlaajuista ja arktisen alueen lämpenemistä edistävät SLCF-päästöt. Pohjoismaiden mustahiilipäästöillä on suurempi suora lämmitysvaikutus arktisella alueella päästöyksikköä kohti kuin muualta tulevilla mustahiilipäästöillä. Tämä johtuu arktisen alueen läheisyydestä. Kaikista maailman lähteistä tulevat mustahiilipäästöt ovat todennäköisesti aiheuttaneet noin 20 prosenttia arktisen alueen lämpenemisestä ja jääpeitteen häviämisestä viime vuosisadan aikana. Koska alueen ilmasto vaihtelee paljon vuodenajoista johtuen, on erittäin vaikeaa havaita signaaleja ilmaston reagoimisesta SLCF-päästöjen alentamiseen.

Kesäaikana ilmakehän hiilipitoiset aerosolit tulevat Pohjoismaissa pääasiallisesti luonnollisista lähteistä. Talvikautena ihmisen toiminnasta aiheutuvien orgaanisten ja mustahiilihiukkasten osuus kaikista aerosoleista lisääntyy. Kesäisin fossiilisista polttoaineista syntyvä mustahiili on vallitseva ihmisen toiminnan aiheuttama hiilipitoinen aerosoli Pohjoismaissa, kun taas biomassapolttoaineet näyttävät olevan hallitseva lähde talvikautena.

**Päästöinventaarioiden tilanne ja SLCF-strategiat Pohjoismaissa**

Pohjoismaat ovat kaikki tehneet tai ovat parhaillaan laatimassa alustavia mustahiilipäästöjen inventaarioita. Inventaariotyössä käytetyt resurssit ja menetelmät eroavat toisistaan, koska mustahiilen inventaariolle ei ole olemassa yleisiä ohjeita. EMEP-asiantintijaryhmä on saanut tehtäväksi päivittää EMEP/EEA-ohjekirjaa mustahiilipäästöjen inventaariomenetelmien osalta (työ päättyy 2012) valtiosta toiseen tapahtuvan ilman epäpuhtauksien kaukokulkeutumista koskevan yleissopimukseen puitteissa.

Mustahiilipäästöt syntyvät Pohjoismaissa pääasiassa biopolttoaineen käytöstä asuinrakennusten lämmityksessä. Tulevaisuudessa tämä piirre korostuu entisestään, koska dieselpolttoainetta käyttävissä ajoneuvoissa ja työkoneissa otetaan käyttöön hiukkassuodattimet. Euroopan yhteisön uudet hiukkaspäästömääräykset johtavat hiukkassuodattimien käyttöönottoon.

Tanskassa puun pienpoltosta aiheutuva mustahiili on lisääntynyt yli 100 prosenttia vuodesta 1990, mutta sen lasketaan vähenevän 60 prosenttia vuosina 2007–2030 johtuen tulisijojen paremmasta päästöjen hallinnasta. Muiden pääasiallisten päästölähteiden kuten ajoneuvojen ja työkoneiden arvioidaan vähenevän vielä enemmän. Vuoden 2005 mustahiilipäästöjen arvioidaan olleen 6,5–7 tuhatta tonnia. Nykyisillä politiikan välineillä kokonaispäästöjen arvioidaan laskevan yhteensä 30 prosenttia vuosina 1990–2030.

Suomen alueellista päästöskenaariomallia (Finnish Regional Emission Scenario, FRES) käytettiin mustahiilipäästöjen laskennassa vuonna 2005 ja vuoden 2020 ennusteen laadinnassa. Työssä käytettiin kansallisia tietoja aktiviteeteista ja päästökertoimista. Vuoden 2005 mustahiilipäästöjen arvioidaan olleen yli 7 tuhatta tonnia. Ajoneuvojen ja työkoneiden hiukkaspäästöjä koskevan EU-lainsäädännön täytäntöönpano vähentää päästöjä 2,5 tuhannella tonnilla ja asuinrakennuksissa käytettävän biomassalämmityksen osuus nousee 60 prosenttiin mustahiilen kokonaispäästöistä vuonna 2020. Suomen ympäristökeskus SYKE on käynnistänyt tutkimuksen, jonka tavoitteena on arvioida eri mahdollisuuksia vähentää pienpoltosta aiheutuvia pienhiukkaspäästöjä 10–20 vuoden aikavälillä. Kansallista ilmastostrategiaa tarkistetaan myöhemmin tänä vuonna ja SLCF-toimet otetaan tässä huomioon.

Norjassa ilmasto- ja saastevirasto (Klif) on saanut tehtäväksi laatia toimintasuunnitelman SLCF-päästöjen vähentämiseksi. Toimintasuunnitelman tulee sisältää suosituksia toimenpiteistä ja keinoista päästöjen vähentämiseksi vuoteen 2030 mennessä ja sen odotetaan valmistuvan huhtikuussa 2013. Arviointi ei sisällä pelkästään ilmansaasteiden vaikutuksia ilmastoon vaan myös terveyteen ja ympäristöön. Päästöinventaario mustahiilen osalta on parhaillaan käynnissä ja se sisältää päästömittauksia oletettavasti suurimmasta lähteestä eli puunpoltosta asuinrakennusten tulisijoissa. Puunpolton osuuden arvioidaan olevan 70 prosenttia $PM_{2.5}$-päästöistä vuonna 2010, ja tarkkojen tietojen saaminen puun kulutuksesta on haastava tehtävä.

Ruotsin mustahiilipäästöjen arvioidaan olleen 5–6 tuhatta tonnia vuonna 2005, mikä on noin 30 prosenttia vähemmän kuin 1990. Uutta inventaariota suunnitellaan tehtäväksi sen jälkeen, kun Euroopan yhteistyöohjelman (EMEP) ohjekirja on päivitetty mustahiilipäästöjen osalta. Vuonna 2020 päästöjen arvioidaan olevan noin 3–3,5 tuhatta tonnia vuodessa, josta 40 prosenttia aiheutuu asuinrakennusten lämmityksessä käytettävästä polttopuusta. Päästöjen supistamiseksi entisestään tärkeintä on vähentää asuntojen lämmityksestä aiheutuvia päästöjä. Ruotsi on yksi SLCP-päästöjen vähentämiseen tähtäävän Climate and Clean Air Coalition -aloitteen käynnistäjistä. Aloitteeseen liittyvissä keskusteluissa Ruotsi on todennut, että puun pienpoltto lämmitystarkoituksessa (25 prosenttia nykyisistä mustahiilipäästöistä) ja dieselkäyttöiset työkoneet (10 prosenttia mustahiilipäästöistä) ovat kaksi sektoria, joihin Ruotsi keskittyy tulevissa vähennystoimissaan.

**Keskustelut**
Työpajan osanottajat tekivät tärkeitä ehdotuksia toimintasuunnitelmaksi siitä, kuinka Pohjoismaat voivat yhdessä edistää SLCF-päästöjen vähentämistä sekä Pohjoismaissa että kansainvälisesti. Kiireellisintä pohjoismaisessa yhteistyössä on eri maissa parhaillaan laadittavien kansallisten toimintasuunnitelmien tukeminen ja vahvistaminen. SLCF-strategioiden laatimisessa olisi hyötyä vähennystoimia käsittelevästä pohjoismaisesta asiantuntijaverkostosta ja työpajoista tai seminaareista, joiden aiheena olisi

- selkeämpi mustahiilen määritelmä ja mustahiilen päästökertoimien seuranta ja harmonisointi,
- 2. puun pienpoltosta aiheutuviin mustahiilipäästöihin liittyvät mittaukset, seuranta ja kustannustehokkaat toimet, koska puun pienpoltto on hallitseva mustahiilipäästöjen lähde kaikissa Pohjoismaissa tulevaisuudessa.

Kansallisia toimintasuunnitelmia ja niiden vaikutuksia arktiseen alueeseen esittelevän yhteispohjoismaisen julkaisun valmistelu voitaisiin aloittaa vuonna 2013.

Kansainvälisten toimien osalta esitettiin, että Pohjoismainen ilmasto- ja ilmaryhmä muodostaisi alaryhmän, jonka tehtävänä olisi pohtia ja koordinoida Pohjoismaiden kansainvälistä toimintaa. Climate and Clean Air Coalition -aloitteen pohjoismaisten jäsenten aktiivista osallistumista pidettiin tärkeänä. Lisäksi Pohjoismaisen kehitysrahaston ja Pohjoismaiden ympäristörahoitusyhtiön (NEFCO) kautta tulee käynnistää työ tärkeimpiä vähennystoimia sisältävän luettelon laatimiseksi kehitysmaille ja siirtymätalousmaille.

SLCP-päästöjä koskevan pohjoismaisen tutkimusyhteistyön vahvistamiseksi rajattiin kolme avainaluetta: 1) mustahiileen liittyvät määritelmät, 2) seuranta ja 3) mallinnus.

Lämmityksessä syntyville aerosoleille (mustahiilelle) tarvitaan kiireellisesti määritelmiä, jotka toimivat sekä päästöinventaarioissa että ilmakehän seurannassa ja mallinnuksessa. SLCF-päästöjen ilmastovaikutuksia esitellään eri tavoin ja nyt tarvitaan yhteistä metriikkaa skenaarioita ja yhdennettyjä arviointimallituksia varten. Lisäksi joidenkin arktisen alueen yläpuolella olevia aerosolien ominaisuuksia ei ole parametrisoitu riittävän hyvin.

Seurantaverkostoja pitäisi laajentaa tärkeiden ilmansaasteparametrien asianmukaisen seurannan ja koordinoinnin varmistamiseksi. Mittauksiin pitäisi sisältyä sekä suppealla määrällä asemia tapahtuva tehoseuranta että laajempi verkosto riittävän maantieteellisen peittävyyden takaamiseksi. Tieteellisten ja teknisten yhteyksien lisäksi ministeritasolla pitäisi tehdä aloitteita ja tehostaa yhteistyötä Venäjän kanssa seuranta-asemien perustamiseksi.

Tärkeää olisi tukea ilmastomallinnuksen edelleen kehittämistä SLCF-päästöjen säteilypakotteen ja ilmastovaikutuksen selvittämiseksi erityisesti arktisella alueella sekä tutkia alueellisia ilmastotrendejä ja -muutosta suhteessa ilmansaasteisiin ja SLCF-päästöihin.

Työpajan Pohjoismaiden ympäristöministereille antamissa yleissuosituksissa todettiin, että Pohjoismaiden pitäisi olla aktiivisia päästöinventaarioita koskevan EMEP/EEA-ohjekirjan laatimisessa CLRTAP-työryhmän puitteissa sekä parantaa lämmitystarkoituksessa tapahtuvan puun pienpolton ja laivaliikenteen päästötietoja. Kansallisella tasolla on tärkeää käynnistää välittömiä toimia puun pienpoltosta aiheutuvien päästöjen vähentämiseksi ja antaa tietoa tulisijojen suorituskyvystä. Lisäksi tarvitaan Joutsenmerkki tulisijoille ja oikeita puunpolttotapoja. Puukäyttöisille tulisijoille on luotava uudet päästösäännökset ja kehitettävä yhteinen metodiikka kustannustehokkaiden menetelmien arvioimiseksi. SLCF-päästöjen vähennysmenetelmiä ja metodologiaa kehittävä pohjoismainen asiantuntijaverkosto tukisi kansallisia päästövähennystoimia. Aluetasolla Göteborgin pöytäkirja voisi toimia tärkeänä välineenä mustahiilipäästöjen sääntelyssä pohjoisella pallonpuoliskolla, ja Venäjän kanssa tehtävää yhteistyötä SLCF-päästöistä tulisi tehostaa.

# 16. Útdráttur

## 16.1 Skýrsla um Norræna námstefnu um aðgerðir vegna skammlífra loftslagsáhrifavalda

**Forsaga**

Nýlegar rannsóknaniðurstöður hafa leitt í ljós að skammlífir loftslagsáhrifavaldar á borð við sót (svart kolefni – Black Carbon – BC) geta haft meiri áhrif á hnattræna hlýnun en áður var álitið. Það gæti því dregið úr hraða hnattrænnar hlýnunar til skemmri tíma litið (20–30 ára) að minnka áhrif skammlífra loftslagsáhrifavalda (SLCF), einkum á Norðurskautssvæðinu. Hugtakið skammlífir loftslagsáhrifavaldar var notað á námstefnunni sem samheiti SLCF (Short Lived Climate Pollutants).

Norrænir ráðherrar umhverfismála samþykktu yfirlýsingu um skammlífa loftslagsáhrifavalda á fundi sínum á Svalbarða í mars 2012. Ráðherrarnir báðu einnig norræna loftslags- og lofthópinn (Klima- og luftgruppen – KoL) um að standa að norrænum fundi með það fyrir augum að skiptast á upplýsingum um stöðu yfirlita á landsvísu yfir skammlífa loftslagsáhrifavalda og þær aðgerðir sem beitt er til þess að draga úr þeim, benda á skilvirkar lausnir til þess að draga úr losun skammlífra loftslagsáhrifavalda og að styrkja grundvöll sameiginlegra aðgerðaáætlana á Norðurlöndunum öllum.

**Rannsóknaniðurstöður**

Menn hafa fram til þessa dags losað það mikið af gróðurhúsalofttegundum í andrúmsloftið að það mun hafa hitað jörðina um rúmlega 2 °C á heimsvísu árið 2050 miðað við árið 1990, jafnvel þótt dregið verði úr losun koltvísýrings um 50%. Hlýnun hefur að öllum líkindum náð 2 °C árið 2050, haldi núverandi þróun áfram. Hægt yrði að fresta þessari 2 °C hlýnun um þrjá til fjóra áratugi, verði dregið umtalsvert úr losun skammlífra loftslagsáhrifavalda á borð við metan, óson í veðrahvolfinu, aðrar gróðurhúsalofttegundir og sót. Metanþéttni náði jafnvægi síðla á tíunda áratug síðustu aldar eftir að hafa aukist lengi en fer nú vaxandi á ný. Reiknað er með því að bein og óbein loftslagsáhrif (Radiative Forcing – geislunarálag) af heildarlosun manngerðra svifeinda hafi kælandi áhrif sem nemur 1 Watt/$m^2$ en það er metið svo að sótsvifeindir hiti jörðina um nær því 0,5 Watt/$m^2$. Aðgerðir til þess að draga úr losun skammlífra loftslagsáhrifavalda gætu aukið líkur á því að hægt sé að draga úr hækkun hitastigs á heimsvísu til lengri tíma litið og undir 2 °C, en því aðeins að tekið sé af krafti á losun koltvísýrings og annarra langlífra gróðurhúsalofttegunda.

Við ættum að greina á milli skammlífra loftslagsáhrifavalda sem eru virkir í 10–15 ár (t.d. metan) og mjög skammlífra loftslagsáhrifavalda á borð við loftmengun eins og glaðloft (NOx), rokgjörn lífræn efnasambönd (VOC) og kolsýring (CO) sem hafa áhrif á hnattrænt loftslag með myndun ósons í veðrahvolfi (með nokkurra daga til vikna líftíma) með ljósefnafræðilegum efnahvörfum. Óson hefur hitandi áhrif á efri hluta veðrahvolfsins en óson nálægt jörðu skiptir nær engu máli hvað loftslag varðar. Þess vegna eru metan og kolsýringur mikilvægustu undanfarar ósons sem draga þarf úr til þess að draga úr geislunarálagi ósons því þau eru helstu undanfarar ósons í efri lögum veðrahvolfsins. Verði dregið úr losun glaðlofts, mun það hins vegar leiða til aukinnar hlýnunar.

Að öllum líkindum eru sót og svo metan þeir skammlífu loftslagsáhrifavaldar sem mest áhrif hafa á bæði hnattræna og staðbundna hlýnun á Norðurskautssvæðinu. Losun sóts frá Norðurlöndum veldur hærra beinu geislunarálagi (hlýnun) á Norðurskautssvæðinu á hverja losaða einingu en losun sóts frá öðrum heimshlutum. Ástæðan er nálægð við Norðurskautssvæðið. Sót alls staðar að úr heiminum virðist hafa valdið um 20% hlýnunar á Norðurskautssvæðinu og bráðnunar hafíss á síðustu öld. Þó veldur mikill breytileiki svæðisbundin loftslags á milli ára því að mjög erfitt er að greina loftslagsviðbrögð, þótt dregið verði úr áhrifum skammlífra loftslagsáhrifavalda.

Mestan hluta kolsvifeinda í loftslagi Norðurskautssvæðisins að sumarlagi má rekja til náttúrulegra orsaka. Hlutfall lífrænna svifeinda og sótagna af mannavöldum í heildarmagni svifeinda eykst umtalsvert að vetrarlagi. Sót frá jarðefnaeldsneyti er langmestur hluti kolsvifeinda á Norðurlöndum að sumarlagi en lífmassaeldsneyti virðist vera helsta orsökin að vetrarlagi.

### Staða magntöku og aðgerða í tengslum við skammlífa loftslagsáhrifavalda á Norðurlöndum

Öll norrænu ríkin hafa annað hvort magntekið losun sóts í viðkomandi landi eða vinna að því. Úrræði og aðferðir eru ekki alveg eins vegna þess að enginn leiðbeinandi staðall er til um magntöku sóts. Nýlega var tilnefndur EMEP-sérfræðingahópur til þess að uppfæra leiðbeiningahandbók EMEP EEA um aðferðafræði við magntöku sótlosunar (lýkur 2012) samkvæmt samningnum um loftmengun sem berst langar leiðir.

Reiknað er með því að losun sóts megi fyrst og fremst rekja til hitunar íbúðarhúsnæðis með lífmassa á Norðurlöndunum öllum. Gert er ráð fyrir að þetta einkenni verði enn meira áberandi til framtíðar litið vegna þess að skylda menn á til þess að nota sótagnasíur í dísilbílum og í öðrum vélum sem ganga fyrir dísilolíu. Nýir staðlar um losun sótagna í Evrópu krefjast notkunar sótagnasía.

Í Danmörku hefur sót frá eldiviði aukist um rúmlega 100% frá því árið 1990 en reiknað er með því að úr því dragi um 60% frá 2007 til 2030 vegna þess að ofnar verða stöðugt betri hvað losun varðar. Reiknað er með því að jafnvel enn meira dragi úr annarri mikilvægri losun, til dæmis frá akstri bíla og öðrum tækjum en ökutækjum. Reiknað hefur verið út að árið 2005 hafi verið losuð 6.500 til 7.000 tonn af sóti. Alls er reiknað með því að það dragi úr losun sóts sem nemur 30% frá 1990 til 2030, verði núverandi stefnumörkun áfram við lýði.

Finnska svæðisbundna losunaraðstæðnalíkanið (FRES) hefur verið notað til þess að meta sótlosun í Finnlandi fyrir árið 2005 og spá fyrir um árið 2020. Tekið hefur verið tillit til ríkjandi hefða og starfsemi og útblástursþátta við útreikninginn. Reiknað var út að heildarlosun sóts hafi verið rúm 7.000 tonn á árinu 2005.

Þegar löggjöf ESB um agnalosun bifreiða og annarra farartækja tekur gildi, dregur úr losun sem nemur 2.500 tonnum og þá verður hægt að rekja allt að 60% sótlosunar til lífmassabruna til húsakyndingar. Rannsókn er hafin á vegum SYKE til þess að meta mismunandi möguleika á að draga úr sótagnalosun lítilla brunahreyfla næstu tíu til 20 árin. Stefna á landsvísu í loftslagsmálum verður endurskoðuð síðar í ár og þá með tilliti til skammlífra lofslagsáhrifavalda.

Loftslags- og mengunarstofnun Noregs hefur fengið það verkefni að þróa aðgerðaáætlun um að draga úr losun skammlífra loftslagsáhrifavalda. Í aðgerðaáætluninni verður að finna tilmæli um aðgerðir og tæki til að mæla hvernig dregið skuli úr losun fram til 2030 en hún verður lögð fram í apríl 2013. Matið snýst ekki aðeins um loftslagsáhrif heldur líka um heilbrigðis- og umhverfisáhrif loftmengunar.

Um þessar mundir er unnið að magntöku sótlosunar, þar með taldar mælingar á losun þess sem talið er stærsti mengunarvaldurinn, brennslu eldiviðar í íbúðarhúsnæði. Gert er ráð fyrir því að viðarbrennsla hafi valdið um 70% 2,5 svifrykeinda (PM) árið 2010 og það er snúið verkefni að afla sér nákvæmra talna um meðalnotkun á eldiviði.

Það er metið svo að losun sóts í Svíþjóð hafi verið 5.000–6.000 tonn árið 2005 en það er u.þ.b. 30% minnkun síðan 1990. Gert er ráð fyrir nýrri magntöku í framhaldi af uppfærslu á leiðbeiningahandbók EMEP um magntöku losunar á sóti. Gert er ráð fyrir því að árið 2020 verði losun á bilinu 3.000–3.500 tonn á ári og að 40% hennar stafi frá hitun íbúðarhúsnæðis með eldiviði. Eigi að draga enn frekar úr losun, eru að öllum líkindum mestir möguleikar til þess við hitun húsnæðis. Svíþjóð er eitt þeirra ríkja sem stóðu fyrir stofnun bandalags um loftslagsmál og hreint loft (Climate and Clean Air Coalition) til þess að draga úr skammlífum loftslagsáhrifavöldum. Í umræðum bandalagsins hafa Svíar bent á hitun íbúðarhúsnæðis/í litlu magni með eldiviði (nú 25% allrar sótlosunar) og dísilvélar aðrar en bílvélar (10% allrar sótlosunar) sem þá tvo þætti sem Svíar munu einkum beina sjónum að við að draga úr losun.

**Umræður**

Þátttakendur á námstefnunni fjölluðu um mikilvæga þætti aðgerðaáætlunar um hvernig Norðurlöndin geta í sameiningu dregið enn frekar úr losun skammlífra loftslagsáhrifavalda, bæði í norrænu samhengi og á hnattræna vísu. Mest áríðandi er að norræna samstarfið snúist um að styðja við og styrkja aðgerðaáætlanir á landsvísu sem mótaðar verði í hverju landi fyrir sig. Mótun áætlana um aðgerðir gegn skammlífum loftslagsáhrifavöldum myndu njóta góðs af norrænu sérfræðinganeti um aðgerðir til minnkunar og af námstefnum/námskeiðum um

- skýrari skilgreiningu á því hvað sót (Black Carbon – BC) er og á eftirlit og samræmingu á losunarþáttum sóts
- mælingar, eftirlit og skilvirkar aðgerðir gegn sótlosun frá eldiviði þar sem þar er um að ræða helstu ástæðu sótlosunar á Norðurlöndum til framtíðar litið

Hægt væri að hefjast handa árið 2013 um útgáfu sameiginlegs norræns rit þar sem upplýsingar væru gefnar um aðgerðaáætlanir í hverju landi fyrir sig og áhrif þeirra á Norðurskautssvæðið.

Lagt var til hvað varðar fjölþjóðlegar aðgerðir að norræni loftslags- og lofthópurinn (KoL) myndi kalla saman undirnefnd til þess að ræða fjölþjóðlegar norrænar aðgerðir og samhæfa þær. Fram kom að virk þátttaka norrænu þjóðanna í bandalaginu um loftslagsmál og hreint loft væri afar mikilvæg og að standa ætti, með aðkomu NDF og NEFCO, að gerð skrár um aðgerðir til þess að draga úr áhrifum skammlífra loftslagsáhrifavalda fyrir þróunarlönd og ný iðnvædd lönd (economies in transition).

Tilgreind voru þrjú svið þar sem styrkja þyrfti norrænt samstarf um vísindarannsóknir á þremur helstu áhrifasviðum skammlífra loftslagsáhrifavalda: 1) skilgreiningar og mælingar á sóti, 2) eftirlit og 3) líkanagerð.

Mikil þörf er fyrir skilgreiningar á „hitandi“ svifeindum (svörtu kolefni) sem nýtast bæði við gagnasöfnun um losun og eftirlit með loftslagi og gerð líkana um það. Áhrif skammlífra loftslagsáhrifavalda á loftslagið eru sett fram á mismunandi hátt og það þarf að finna sameiginlegar mælingaaðferðir til þess að nota við skoðun sviðsettra aðstæðna og við samþætt mat og ákveðna eiginleika svifeinda á Norðurskautssvæðinu sem ekki hafa verið vel stikaðar.

Víkka þyrfti eftirlitsnetið út til þess að tryggja að fullnægjandi eftirlit sé með viðeigandi loftmengunarbreytum og að það sé samhæft. Mælingar ættu að fela í sér bæði mjög ýtarlegt eftirlit í takmörkuðum fjölda stöðva og víðtækari samstarfsnet til þess að tryggja fullnægjandi landfræðilegt umfang eftirlitsins. Á vettvangi ráðuneyta þyrfti einnig, auk vísindalegra/tæknilegra samskipta, að grípa til aðgerða til að auka samstarf við Rússland með það fyrir augum að koma upp eftirlitsstöðvum.

Styðja ætti við frekari þróun á gerð loftslagslíkana með tilliti til áhrifa skammlífra loftslagsáhrifavalda á geislunarálag og loftslag með sérstöku tilliti til Norðurskautssvæðisins og kanna svæðisbundnar tilhneigingar í/breytingar á loftslagi með tillit til loftmengunar skammlífra loftslagsáhrifavalda.

Í endanlegum heildartillögum námstefnunnar til norrænu umhverfisráðherranna er það einnig lagt til að Norðurlönd taki virkan þátt í gerð leiðbeiningahandbókar EMEP EEA um aðferðafræði við magntöku innan ramma CLRTAP-starfshópsins, að bæta gæði gagna um losun vegna hitunar á íbúðarhúsnæði með eldiviði og vegna flutninga. Hvert land fyrir sig er hvatt til þess að beina sjónum sérstaklega að tafarlausum aðgerðum til þess að draga úr losun frá viðarofnum, auk þess sem fræða þarf fólk um afköst viðarofna, Svansmerkingu ofna og réttar aðferðir við notkun þeirra. Móta ætti nýjar reglugerðir til að draga úr losun frá viðarofnum og um sameiginlega aðferðafræði til þess að meta skilvirkar aðgerðir. Norrænt samstarfsnet sérfræðinga um aðferðir til þess að draga úr losun skammlífra loftslagsáhrifavalda og skyld aðferðafræði myndi styrkja við aðgerðir hvers lands um að draga úr losun. Gautaborgarbókunin gæti orðið mikilvægt verkfæri til þess að stýra losun á sóti á svæðisvísu á norðurhelmingi jarðar og efla þarf samstarf við Rússland um skammlífa loftslagsáhrifavalda.

# 17. Appendices

## 17.1 Annex i. Ministers Svalbard Declaration, 28th March 2012

### *17.1.1 Svalbard Declaration on Short-lived Climate Forcers:*

**Emissions of short-lived climate forcers must be reduced**
We, the environment ministers of Denmark, Finland, the Faroe Islands, Iceland, Norway, Sweden and Åland, discussed what we can do to cut global and Nordic emissions of short-lived climate forcers, such as black carbon and methane, at our meeting on Svalbard, 26–27 March 2012.

Cuts of this nature will help to slow the rise in temperature, which has been particularly rapid in the Arctic where it has caused a significant reduction in the volume of ice in the last 30 years.

The cuts will also have important health and environmental benefits, and act as a supplement to an active climate policy designed to reduce emissions of other greenhouse gases in line with our international obligations.

As emissions of short-lived climate forcers (SLCFs) have a negative impact on both the climate and human health, there is a need to regulate them as part of the range of international environmental agreements. However, it will take a long time before such agreements have a sufficient effect.

While waiting for international regulation to be implemented, there is a great need for rapid reductions in emissions of SLCFs such as black carbon, methane and tropospheric ozone. Such initiatives need to be taken in both the industrialised and developing countries.

Based on our close co-operation and shared values, we, the Nordic environment ministers, will intensify our efforts to reduce emissions of SLCFs at national, regional and global level.

We will act as a driving force and work more closely together in international fora to advocate more ambitious international regulation of emissions of greenhouse gases and SLCFs.

However, focus on SLCFs should not be at the expense of cuts in CO2 emissions. We will actively strive to:

- promote a global climate agreement under the UNFCCC, which will ensure that the two-degree target is achieved
- continue the knowledge-building and co-operation initiatives under the Arctic Council, and follow up on any agreement to reduce carbon in the Arctic

- develop national measures to reduce emissions from transport and from the inefficient use of wood heating, which will also have positive regional effects on health and the climate
- strengthen co-operation under the auspices of the Nordic Council of Ministers
- work with projects that reduce emissions of SLCFs at regional level through the Nordic Environment Finance Corporation (NEFCO)
- develop activities under the auspices of Barents co-operation
- support the work of the UN Environment Programme (UNEP) to implement effective measures to curb SLCFs, which will have positive health and environmental effects
- evaluate participation in various UNEP-supported initiatives, including the newly created "Climate and Clean Air Coalition to Reduce Short-lived Climate Pollutants"
- continue international work to promote cost-effective reduction measures and international regulation, including prioritisation of measures to reduce emissions of carbon by regulating national particle emissions under the Convention on Long-range Transboundary Air Pollution (CLRTAP)

To improve the basis for national and joint Nordic initiatives, we will:

- further develop and strengthen national emissions accounts for SLCFs, alongside separate accounts for black carbon
- identify cost-effective initiatives to reduce emissions and evaluate the need for national action plans for emission reductions
- evaluate the need to draw up a Nordic action plan, based on the proposed national plans, which will help ensure that initiatives are implemented effectively and that the Nordic countries optimise the use of the available instruments

To support this work, we will hold a Nordic seminar, 7–8 June 2012. The agenda will include national experiences with emissions accounts, identification of cost-effective measures to cut emissions and drawing up national action plans.

## 17.2 Annex ii. Ministers Article, May 2012

### *17.2.1 Arctic in need of first aid. Emissions of carbon and methane must be cut now (www.norden.org)*

**Debate article written jointly by the environment and climate ministers of Denmark, Finland, the Faroe Islands, Iceland, Norway, Sweden and Åland**

The Arctic ice is melting fast. The main culprit is the rise in global emissions of long-lived greenhouse gases, in particular CO2, which contribute to rising air and ocean temperatures. Less well known is the fact that emissions of carbon also speed up the melting process. Carbon may have a short lifetime in the atmosphere but it still has a substantial impact on the climate.

Sea ice is an important component of the Arctic ecosystem. The lives of several species, including seals and polar bears, revolve around it. The ice also has an important cooling effect on the climate, so melting it exacerbates global warming and destabilises the climate, not just in the Arctic, but over large swathes of the northern hemisphere.

Significant reductions in emissions of long-lived greenhouse gases such as CO2 are the key to putting a stop to global warming and the melting of the Arctic ice. However, because these gases have such a long life in the atmosphere, no matter how much we cut emissions of them today, the slow pace at which the climate recuperates means that it will take about a century before the full impact of any reduction is felt.

The Arctic needs urgent first aid in order to slow down the rapid melting of the ice. Any measures implemented need to make an immediate impact. At the Svalbard meeting and in other contexts, the Nordic environmental ministers have taken the initiative for international, regional and national reductions in emissions of particles and gases such as carbon, methane and tropospheric ozone. These gases, known as short-lived climate forcers (SLCFs), have both a warming effect and a short atmospheric life span. This work complements Nordic efforts to reduce emissions of CO2 and other long-lived greenhouse gases.

Pending international regulation, there is an urgent need for rapid reductions in emissions of SLCFs. Initiatives with a positive effect on health and the environment need to be taken in both the industrialised and developing countries. Based on our close co-operation and shared values, we agreed at the Svalbard meeting to intensify our efforts to reduce emissions of SLCFs at national, regional and global level.

We also agreed to work more closely together in international fora to advocate a more ambitious international regulation of SLCF emissions. By working together to advocate better regulation and by their own national efforts, the Nordic countries intend to be a driving force in this work at international level.

SLCFs such as carbon and methane are estimated to cause 30–40% of the temperature rise in the Arctic. Along with CO2, they are one of the reasons why the ice in the Arctic Ocean is melting. Since carbon and methane have a much shorter atmospheric lifetime than CO2, reductions in these emissions would have a far faster climate effect than cuts in CO2 emissions.

Measures to reduce emissions of carbon and methane will also reduce air pollution and have positive local health benefits. Carbon emissions stem from the incomplete burning of fossil fuels, inefficient wood-heating, straw burning, forest fires and methane emissions from energy production, gas transport, rubbish tips and agriculture. In other words, there is plenty of potential for regulating emissions of SLCFs at local level.

Ice cover in the Arctic Ocean in the summer has already been reduced by 30% since the late 1970s. In areas where previous scientific surveys found four metres of multi-year ice, it has now disappeared completely or is down to 1–2 metres. Less ice and snow as a result of rising temperatures leads to more open water and patches of bare ground, both of which absorb far more solar heat than ice and snow. This reinforces the warming effect, which in turn causes more ice to melt. It is a vicious circle and one of the main reasons why the temperature in the Arctic is rising twice as fast as the global average.

Carbon landing on snow and ice in the Arctic is thought to have an additional effect that is three to four times greater than the warming effect of carbon in the atmosphere. Due to its relative proximity, the likelihood of Nordic carbon emissions ending up in the Arctic is higher than for emissions from many other parts of the world. It is therefore important that we reduce our national emissions of carbon and encourage other Arctic nations to follow suit.

However, about 90% of global emissions of carbon and methane come from outside the Arctic. Significant reductions in emissions will require wide-ranging measures both in other industrialised nations and in the developing world. At the same time, we must not be lured into thinking that greater efforts to curb carbon and methane mean that we can postpone the difficult measures needed to deal with emissions of other greenhouse gases. How quickly we reduce emissions of greenhouse gases in the coming decades will still be crucial to the climate after 2050. We have to work on both types of emissions at the same time.

Reducing emissions of SLCFs will not only cut global warming, it will also have a positive health effect. UNEP analyses of the environmental and health effects of SLCFs show where the effect of mitigating measures will be greatest.

The UNEP has proposed a package of measures to reduce global methane emissions by 38% and carbon emissions by 77%. According to its data, the social benefits of approximately half of the measures needed will exceed the costs of implementing them. In developing countries, cutting carbon emissions will have major health benefits, particularly for women who cook over open fires in enclosed spaces.

Measures to reduce outdoor pollution caused by the incomplete burning of fossil fuels could reduce premature deaths by 2.4 million a year, mainly in Asia and Africa. The effect of measures to reduce indoor particle pollution is estimated to be of at least the same magnitude.

Since SLCFs have negative effects on both health and the climate, emissions ought to be regulated at both global and regional level. Carbon emissions are not covered by the UNFCCC, but will be covered by the Convention on Long-range Transboundary Air Pollution.

A first step is for countries to publish their own emissions accounts for carbon. This will generate the data needed for future regulation. Countries and groups of countries also need to work together to devise voluntary schemes to promote rapid reductions in carbon emissions. As Nordic ministers, we will take the initiative to speed up these processes. We will act as a driving force to encourage tangible national measures and to make sure that regulation is implemented.

In our own region, the Nordic countries will work more closely together on the problem, including within the framework of the Arctic Council, which is currently chaired by Sweden. The Arctic Council will contribute by studying and implementing cost-effective measures to reduce carbon emissions in and near the Arctic.

Under the Norwegian chair of the Nordic Council of Ministers for the Environment in 2012, we will promote emissions accounts and the potential of action plans to reduce emissions. The Nordic Environment Finance Corporation (NEFCO) will also implement emission reduction projects in our partner countries.

- Minister for the Environment, Ida Auken (Denmark)
- Minister for Climate, Energy and Building, Martin Lidegaard (Denmark)
- Minister of the Environment, Ville Niinistö (Finland)
- Minister of the Interior, Kári Páll Hojgaard (The Faroe Islands)
- Minister for the Environment, Svandís Svavarsdóttir (Iceland)
- Minister of the Environment, Bård Vegar Solhjell (Norway)
- Minister for the Environment, Lena Ek (Sweden)
- Minister of Social Affairs and Environment, Carina Aaltonen (Åland)

## 17.3 Annex iii. Programme for workshop 7th–8th June 2012

### 17.3.1 *Nordic workshop on action related to Short-lived Climate Forcers*

Organized by the Nordic Council of Ministers' Climate and Air Quality Group (KOL),Copenhagen, 7–8 June 2012, Agenda (as of 6 June 2012)

**Thursday 7th June**

| | |
|---|---|
| **12.00–13.00** | **Lunch** |
| **Chair: Carsten Møberg Larsen, Danish EPA** | |
| 13.00–13.10 | Opening of Workshop<br>*Eli Marie Åsen, Chair of the Climate and Air Quality Group* |
| 13.10–13.50 | Recent scientific developments and ongoing activities on SLCFs, including a brief summary of the meeting held in Stockholm 15 November 2011<br>*Joakim Langner, Swedish Meteorological and Hydrological Institute (SMHI)* |
| 13.50–14.20 | Climate impacts of emissions of SLCFs (black carbon, methane and other ozone precursors) in the Nordic countries<br>*Terje Berntsen, CICERO/University of Oslo* |
| 14.20–15.10 | Presentations of SLCF related KOL-projects -Sources to Nordic background aerosol (SONORA)<br>*Marianne Glasius, Aarhus University, Denmark*<br>Effects of soot and other SLCFs on melting of ice in the Arctic (AMAP)<br>*Henrik Skov, Aarhus University, Denmark* |
| **15.10–15.40** | **Coffee** |
| 15.40–16.00 | International Policy developments (CLRTAP, Arctic Council, The Climate and Clean Air Coalition) to reduce Short-Lived Climate Pollutants and others<br>*Anna Engleryd, Swedish Environment Protection Agency* |
| 16.00–16.30 | Arctic Council's work on SLCFs<br>*Håvard Toresen, Norwegian Ministry of the Environment* |
| 16.30–17.30 | Recent international developments and status in the Nordic countries concerning emission inventories, abatement analysis, and development of action plans, with focus on achievements after the Stockholm workshop in November 2011 (to be continued on Day 2)<br>Danish emissions of particulates and black carbon – historical estimates and projections<br>*Morten Winther, Aarhus University, Denmark*<br>Status for Finland – emission inventories and preparation of policy measures<br>*Seppo Sarkkinen, Ministry of the Environment, Finland* |
| **18.00** | **End of day 1** |
| **19.00** | **Dinner** |

## Friday 8th June

| | |
|---|---|
| **Chair: Anna Engleryd, Swedish Environmental Protection Agency** | |
| 09.00–10.00 | Status in the Nordic countries concerning emission inventories, abatement analysis, and development of action plans, continued from Day 1<br>Status for Norway – emission inventories and action plans<br>*Vigdis Vestreng, Climate and Pollution Agency, Norway*<br>Status for Sweden – emission inventories and action plans<br>*Caroline Dickson, Ministry of Environment, Sweden* |
| 10.00–11.30 | How should Nordic cooperation on emission inventories and action plans be strengthened? If so, how should it be achieved?<br>*Discussion led by Alec Estlander, Finnish Environment Institute (SYKE)* |
| **11.30–12.00** | **Coffee** |
| 12.00–13.00 | Strengthening Nordic cooperation on research activities related to SLCFs<br>*Discussion led by Per-Inge Grennfelt, IVL Swedish Environmental Research Institute* |
| **13.00–14.00** | **Lunch** |
| 14.00–14.45 | Recommendations from the workshop to the Nordic Environment Ministers<br>*Discussion led by Eli Marie Åsen, Norwegian Ministry of the Environment* |
| 14.45–15.00 | Concluding remarks<br>*Annika Rosing, Nordic Council of Ministers Secretariat* |
| **15.00** | **Closing of workshop** |

## Venue

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Denmark
Phone: +45 39 77 28 00
E-mail: info@schaeffergaarden.dk
http://www.schaeffergaarden.dk/

## Regristration

To register, send an email including name, organization, email and any special request to *hsm@nst.dk*. Deadline for registration is *25th May 2012*.

Please, inform whether you want to stay overnight between June 7th and 8th at Hotel Schæffergården (single rooms are pre-booked).

Visit the seminar's webpage in order to find links to other relevant information.

- http://www.norden.org/en/nordic-council-of-ministers/councils-of-ministers/nordic-council-of-ministers-for-the-environment-mr-m/institutes-co-operative-bodies-and-working-groups/working-groups/climate-and-air-quality-group-kol/events/nordic-seminar-on-action-related-to-short-lived-climate-forcers-slcfs

If you have questions or wish to get further information, please contact Hans Skotte Møller, e-mail: *hsm@nst.dk*; phone: +45 27 54 48 58

Participation is free of charge. The number of participants at the seminar is limited.

## 17.4 Annex iv. List of participants

**Nordic workshop on action related to Short-lived Climate Forcers**
Hotel Schæffergården, Gentofte, Danmark 7.–8. juni 2012

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TemaNord 2012:567

## Nordic workshop on action related to Short-lived Climate Forcers

Nordic Ministers of Environment adopted in March 2012 the "Svalbard Declaration" with decisions to reduce the negative impacts of the climate changes and air pollution caused by the emission of the so-called Short-lived Climate Forcers (SLCFs) such as black carbon (soot) and methane. Along with CO2, they are the main reasons why the ice in the Arctic now is melting rapidly.

At a workshop organised by the Nordic Group on Climate and Air Quality in June 2012 researchers and policy-makers discussed the recent scientific findings, the national experiences with emission inventories, identification of cost-effective measures to cut emissions and the drawing up of national action plans as well as the development in the field of international co-operation on SLCFs.

The report presents policy recommendations, conclusions and recommendations on scientific research and monitoring.

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