

Project proposal: Reduction of Black Carbon emissions from Residential wood combustion

Submitted by Norway

1. Introduction

The topic of black carbon and other short-lived climate forcers was extensively discussed at the Ministerial Meetings of the Arctic Council in April 2009 in Tromsø, Norway and in Nuuk, Greenland in May 2011. The Ministers decided in their *Tromsø Declaration* to:

“Urge implementation of early actions where possible on methane and other short-lived climate forcers”

And in the Nuuk declaration the Ministers

“encourage Arctic states to implement, as appropriate in their national circumstances, relevant recommendations for reducing emissions of black carbon,”

In 2010 the ACAP Working Group under the Arctic Council established a Project Steering Group on black carbon and other short-lived climate forcers with the mandate to facilitate projects with an initial focus on activities that reduce emissions of black carbon that are transported to and deposited in the Arctic. The Terms of Reference for this Project Steering Group was approved by the Arctic Council Senior Arctic Officials (SAO) at their meeting in October 2010.

Norway hereby proposes a circumpolar project within the framework of this ACAP Project Steering Group, with a focus on the reduction of black carbon emissions from residential wood combustion in the Arctic.

Although wood is a renewable source of energy, the residential wood combustion is identified as a major source of emissions of black carbon, especially in the Nordic countries. This project will study the potential of different measures to reduce the emissions of black carbon from wood combustion.

2. Background

Black carbon is mainly composed of fine particles that are produced from incomplete combustion of fossil fuels, waste, wood, crop waste and other biomass.

Black carbon is one of the Short Lived Climate Forcers (SLCF). Tropospheric ozone and methane are other short lived compounds affecting climate. Common to all these compounds are their short residence time in the atmosphere compared to longer-lived greenhouse gases like CO₂. Black carbon has a lifetime of days to weeks, which implies that the location of the emission matters for the effect of BC in the Arctic.

Strong evidence indicates that black carbon contributes to climate change by warming the atmosphere and by darkening the surface when deposited on snow and ice (albedo effect), and thereby enhancing the melting further. In addition, fine particles, of which black carbon is one constituent, have well known and significant adverse impacts on human health.

Unlike long-lived greenhouse gases such as carbon dioxide, black carbon's warming effects are short-lived. Therefore reductions in emissions of black carbon will have the potential to slow the impact of climate change on a near-term basis, especially melting of ice and snow, and help mitigate Arctic warming. This reduction will complement long-term CO₂ mitigation. In addition, wood stove, fireplace and boiler emissions represent a significant risk to human health, especially in urban areas, as well as to indoor air quality and related health effects wherever they are used.

Although black carbon emission inventories are relatively uncertain, and pollution from sources outside the Arctic also impacts the Arctic, emissions of BC from incomplete combustion in the Arctic nations themselves represents by far the largest effect per unit of emission according to a recent AMAP study¹, as well as the UNEP/WMO Assessment² and other studies. The Project will take into account also other findings of the Arctic Council Task Force on Short Lived Climate Forcers (ACTFSLCF), the AMAP short lived climate forcer's expert group and UNECE LRTAP Convention, UNEP, work under the EU Ecodesign Directive (2009/125/EC) and other relevant bodies and activities.

The Arctic Council Task Force on Short Lived Climate Forcers (ACTFSLCF) have, in their report for the SAO meeting in October 2010, identified the following major sources of black carbon in the Arctic:

- 1) **transportation** (primarily on-road and off-road diesel vehicles)
- 2) **residential heating** (wood burning etc.)
- 3) **open burning** (both intentional in the agriculture and forestry sectors, and wildfires – the latter often spread from intentionally set fires)
- 4) **gas flaring**, a potential significant source with large uncertainties
- 5) **marine shipping**, a small but potentially significant source due to the proximity of Arctic shipping routes

With respect to residential heating, the ACTFSLCF further underlines in their Progress report and Recommendations for ministers of 12 May 2011 that;

Wood stoves and boilers have emerged as a leading target for black carbon mitigation strategies because they represent a major source of black carbon emissions in the Arctic. (...) Although planned stove replacement campaigns and particle emissions controls may reduce black carbon emissions in some areas, without new measures, overall emissions from this sector are projected to remain steady or increase by 2030. New technologies may enable highly effective mitigation measures to improve both health and climate. The following measures offer potential for reductions of black carbon emissions in this sector:

- *implementation of stringent black carbon emissions standards or stricter PM standards that maximize black carbon reductions, regulations, and inspection regimes for stoves and boilers;*

¹ AMAP (2011) *The Impact of Black Carbon on Arctic Climate* (AMAP Technical Report No 4)

² UNEP and WMO (2011) *Integrated assessment of black carbon and tropospheric ozone*

- *development of point-of-manufacture certification programs for stoves and boilers meeting emissions and performance standards;*
- *voluntary old stove/boiler change-out programs and incentives for newer models that emit less black carbon;*
- *increased combustion efficiency;*
- *boiler retrofits, for example, with accumulator tanks; and*
- *operator education campaigns (best fuels and burning techniques).*

3. Objective

The overall objective of this Project is to contribute to reduced emissions of black carbon from residential wood combustion used for heating (wood stoves and wood boilers) in the Arctic. This will be done by providing information and recommendations on possible measures to reduce emissions from residential wood combustion in the Arctic. The project may also demonstrate the effects of some of the recommended measures.

Emission reduction from residential wood combustion will contribute to the mitigation of climate change, whose impacts can be particularly significant in the Arctic, and include the melting of Arctic snow and ice, thawing of permafrost, etc.

4. Scope

The project is divided in two phases:

The geographical scope of the project phase 1, "identification of measures", is the territory of the eight Arctic countries (provided that all countries will participate with information), as well as relevant information from other countries. The time scope of phase 1 will be to look at emissions of black carbon from residential wood combustion in the time period from the 1990s and up until today. In phase 2, "pilot implementation of selected measures", the geographical scope will be considered.

Based on existing information provided by the participating Arctic countries, the project will:

1. Gather the existing information on emissions of black carbon from residential wood combustion, including review of:
 - a) existing information on emission factors
 - b) existing activity data
 - c) spatial distribution
 - d) technologies
 - e) operational practices

Uncertainties and possible gaps/missing information under item a-e should be pointed out, as well as a quantitatively or if not possible, a ranking of the importance of uncertainty for the emissions estimation and distribution results.

2. Gather information on existing and additional measures, technologies and approaches to reduce the emissions of black carbon from residential wood combustion, including their cost and effectiveness.
3. Based on information obtained in 1-2, the project will provide recommendations on cost-effective measures, technologies and approaches that can be implemented in the Arctic countries to reduce black carbon emissions³;
 - Provided input from other/separate projects become available, the recommendations will include reflections on how to overcome potential technical and social barriers to implementation.
 - Based on collected and assessed information and to the extent possible, the project will give AMAP the possibility to better quantify the current regional climate impacts and future mitigation possibilities.

The countries are encouraged to include in their contribution of national data and information, patterns and approaches to wood burning for heating in Arctic indigenous communities. This information should be elaborated in cooperation with indigenous communities, as appropriate.

The project may include a phase 2 in which implementation of relevant projects to demonstrate the effect of measures for reducing emission of black carbon from residential wood combustion in one or more of the Arctic countries will be conducted. Phase 2 may also include development of appropriate feasibility studies.

All results of the project will be open to the public and made available on internet.

5. Project implementation

The project is divided into two phases with subtasks and deliverables.

Phase 1: Desk study – emissions and measures for reduction of black carbon from residential wood combustion

Task 1 Emissions from residential wood combustion

Emission factors are, together with activity data, used to calculate the emissions. The emissions from residential wood combustion are strongly dependent on e.g. technology and firing techniques. Task 1 is divided into two subtasks;

a) Review of information on existing emission factors

³ Most of earlier work regarding reduced emissions from wood burning is based on emissions of PM2.5. Where data on black carbon emissions are missing, shares of BC in PM2.5 have been used to calculate the emissions of BC. The same method may be used in this project, although there is no well-established common conversion factor from PM2.5 to BC.

Black carbon is not well defined. There is no universal standardized measurement methodology (protocol) to quantify black carbon emissions or atmospheric concentrations from different sources. One consequence is that the measurements that exist worldwide for emissions from wood stoves and boilers differ considerably and are difficult to compare. No 1 a) will collect available information about the emissions measurement method applied in the different background studies and document relevant parameters (i.e. dilution, measurement of temperature, BC analyser applied). The consequences of the different methods to the emission factors will be discussed and compared. Other issues, such as lack of information about operational practice, type, dryness and other characteristics of the fuel (different wood species, wood pellets) also contribute to the uncertainty in emission factors and thus in national inventories. The influence of these on emission characteristics will be reviewed and discussed in task 1 a).

Task 1 a) will describe the existing emission factors of black carbon from residential wood combustion in the Arctic countries, including indigenous communities, based on current available data. This will include specific emission factors for the most common residential wood stoves and boilers in use in each country, together with data on stove age and type and firing pattern. The review of emission factors will also cover other substances co-emitted with black carbon, such as organic carbon (OC) and primary particulate matter. Where data is available, information about other co-emitting substances will also be collected (dioxin, PAH, CH₄ etc). Based on results of the review of task 1 a) there should be made recommendations for a selection of technology specific emission factors for the Arctic Council countries that may be further used in estimating the emissions to support work in task 2). The report will point out possible gaps or weaknesses in the methods of calculating and assigning emission factors, including assessments of uncertainty.

The information will be gathered by a consultant based on input provided by the identified contact persons in each country (participants in the project expert group). The contact persons in each country will later have to verify the content of the consultant report.

b) Review of existing activity data, spatial distribution and technologies

In addition to emission factors, activity data, such as the amount of wood consumption, is essential to make an inventory for black carbon emission from residential wood combustion. It is also essential to know the location of the emissions from residential wood combustion. This is important from both climate (north-south gradient / proximity to the Arctic) and health (urban/non-urban activities / proximity to population) perspectives when implementation of measures is considered. Heating activities are also seasonally concentrated to winter months. Task 1 b) will review and compile the existing data on seasonality, i.e. monthly distribution of activities.

Task 1 b) will compare the existing usage of wood stoves and boilers, based on information from each of the Arctic countries, including indigenous communities. This task should gather existing information on:

- the number of different stoves and boilers and their average lifetime,
- the amount of wood and wood pellet used in different kinds of stoves and boilers,
- the amount of energy delivered by the installations and
- the spatial distribution of wood stoves and boilers in each country.

Where such data are not readily available, information gaps should be identified. The work will also review the methodologies with which such information has been compiled in individual countries.

When the country's energy balance for residential heating includes a significant share of other solid fuels, available data on also such installations and fuel consumption should be compiled.

The information in task 1 a) and b) will be gathered and reviewed by the consultant based on input provided by the identified contact persons in each country (participants in the project expert group). Uncertainties and possible gaps/missing information should be pointed out. If quantifying the uncertainty is not possible, a ranking of the importance of various input data to the uncertainty of emissions estimation and distribution results should be given.

The contact persons in each country will later have to verify the content of the consultant report.

The report will be delivered to ACAP WG for them to consider forwarding it to SAO and present in one of their meetings. Task 1 will be a basis for discussions of possible measures in task 2.

Task 2 Review of existing and additional measures, technologies and approaches and their costs

The technical report from the Arctic Council Task Force on short-lived climate forcers has summarized policies and measures already taken in several of the Arctic countries. In addition, both technical and non-technical measures and policy instruments have been tested and/or implemented in different countries worldwide to reduce the emission of particles from residential wood combustion for health reasons. The identification of possible new technologies will also be relevant.

The task 2 will collect information on a selection of relevant measures in each of the Arctic countries and, to the extent possible, measures outside the Arctic with relevance to the Arctic countries. Information on the cost and the expected effectiveness/potential reduction of the measures will also be collected. The information will include:

- Overview of measures planned or already implemented to reduce the emissions of PM and/or black carbon from residential wood combustion in each of the Arctic countries.
- Overview of possible new measures/technology with potential to reduce black carbon emissions from residential wood combustion. Quantification of reduction potential from each identified measure.
- Information on cost and benefits from the identified measures.

The task 2 will result in a consultant report which summaries possible cost-effective measures, technologies and approaches in each of the Arctic countries, and highlight the most promising actions to be considered by the countries based on the review undertaken in task 2.

The information will be gathered by the consultant based on input provided by the identified contact persons in each country (participants in the project expert group). The consultant will,

based on the received information, estimate costs and benefits from a selection of the identified measures, including estimation of health⁴ benefits, and, where possible, regional climate benefits.

The contact persons in each country will later have to review the content of the consultant report to make sure that information is correct.

The report will be delivered to ACAP WG for them to consider forwarding it to SAO and present in one of their meetings.

Summary report Phase 1

A Summary report of phase 1, based on the reports from task 1 and 2, will be produced by the countries.

If possible, the report will give country-specific recommendations on possible measures, technologies and approaches to reduce black carbon from residential wood combustion.

In the report, the countries will also recommend further work for Phase 2, including possible feasibility studies and demonstration project(s) on testing potential measures. This may also include identification of need for further research, development and demonstration activities (R&D&D-activities).

The report will be delivered to ACAP WG for them to follow up and consider forwarding it to SAO and present in one of their meetings.

Phase 2. Implementation of proposed recommendation

Based on the conclusions and recommendations from Phase 1, and guidance from ACAP WG, the project group will decide on how to proceed into Phase 2. This could be develop and undertake, appropriate feasibility studies and implement projects to demonstrate the effect of measures.. If appropriate, the feasibility studies and implementation of cost-effective demonstration projects can take place in parallel.

The details of the demonstration project(s) will have to be developed later, when the findings and conclusions are made. Phase 2 depend on a new decision for funding.

The Phase 2 will result in a report including

- a summary of the findings
- discussions
- recommendations for if and how to implement the measure(s)

The report will be delivered to ACAP WG for them to forward to SAO and present in one of their meetings.

⁴ The SLCF TF underlines in their report that measures aimed at decreasing black carbon emissions have positive health effects and that this should be taken into account when evaluating possible measures

7. Output

The project will start with desk studies by a consultant. Some of the tasks of the project may be carried out in parallel. The project will be conducted in two phases with subtasks.

Progress reports will be presented to the ACAP WG at their meetings.

A summary report from Phase 1 with recommendations on relevant measures to reduce emission of black carbon from residential wood combustion in the Arctic will be written by the participating countries, and is expected to be submitted to the ACAP WG in 2013. A final report from the Phase 2 of the project, with results from demonstration project(s) implementing measures to reduce emission of black carbon from residential wood combustion in the Arctic, could be submitted to the ACAP WG in 2014 or 2015, depending on when a decision for undertaking Phase 2 is taken. The reports will include results and recommendations.

8. Budget

There will be a need for external expertise in this project phase 1 estimated to the order of (excl. VAT) 1 250 000 NOK (210 000 USD). Norway is prepared to contribute with a substantial amount of the necessary funding for the project phase 1 but may also seek co-financing from other sources. If relevant, the project will also seek funding from PSI for phase 1. In addition each of the Arctic countries is expected to provide in-kind participation through the participation of national experts.

For phase 2 (implementation of proposed recommendation) a new decision for funding will have to be made. If relevant, the project will seek funding from PSI.

9. Project risks

A separate document on project risks will be prepared, if relevant.

10. Evaluation

When the project has been finalized an evaluation will be made.

Based on the above, the ACAP WG will be asked to:

- Approve the project proposal on reduction of black carbon emissions from residential wood combustion.
- Submit the project to the SAOs for their approval of the project as an Arctic Council project.

ANNEX I.

6. Project organization

Norway is the lead country of the project, and the Norwegian Climate and Pollution Agency (Klif) will be the project manager. Finland has offered to be co-lead of the project.

Norway will contribute with funding of Phase 1. The participating countries will contribute with experts and country-specific information in-kind.

The project will require experts with competence on emission factors, emission inventories, wood stove technology, competence on retrofitting wood stoves and heating systems with new technology, competence on regulatory measures to reduce emission of black carbon from wood combustion, and other related topics. The project will mainly be conducted by consultants, but will also require information, comments and review from the nominated experts from the Arctic countries.

The project will report through the ACAP Short Lived Climate Forcers and Contaminants Project Steering Group to the ACAP Working Group, as appropriate (status reports, preliminary reports, final report).

Arctic Council member states, Permanent Participants and Observers have been invited to participate in the project with experts and funding. Representatives from the AMAP expert group on black carbon and the Arctic Council Task Force on Short Lived Climate Forcers have also been invited to participate in the project.

The mode of work will be through e-mail, tele- or videoconferences, meetings and workshops.

Some of the project activities may be carried out in parallel. The first phase of the project will be carried out during 2012 and 2013, given the necessary approval of the project. Phase 2 is expected to be carried out during 2013 through 2015, depending on the results of phase 1.

Participation

There are three levels of participation in the project:

- **Core participation/Project lead or co-lead**

Participants in the lead of the project are the nominated experts that will be responsible for active and close follow up and implementing of the project together with Norway. This will include the finalizing of the project proposal document, preparing the tendering for a consultant, preparing the work plan, oversee the output from the project etc.

Norway is the Lead Country and Project Owner of this project. Norway has nominated Ingunn Lindeman (ingunn.lindeman@klif.no) and Bente Anfinnsen (bente.anfinnsen@klif.no), both from the Norwegian Climate and Pollution Agency, to be the leaders of the project.

Finland is co-lead of the project and has nominated the following person for this:

- Finland – Kaarle Kupiainen, Finnish Environment Institute, kupiain@iiasa.ac.at, kaarle.kupiainen@ymparisto.fi
- **Project expert group/Data input and review**

One nominated expert per Arctic Council state and relevant PPs, observers and stakeholders who can help coordinating relevant national input to the consultants in the project. The nominated experts are also expected to contribute to reviewing the consultant report. The following persons have been nominated to this group:

 - Denmark – to be confirmed
 - USA – Amanda Aldridge, Larry Brockman and Gil Wood, US EPA.
 - Canada - David Niemi, Environment Canada,
 - Sweden- Titus Kyrklund, Swedish Environmental Protection Agency,
 - Finland- Niko Karvosenoja and Mikko Savolahti , Finnish Environment Institute,
 - Norway- Bente Anfinnsen, Climate and Pollution Agency,
- **Technical expert/reference group**

A group of invited/nominated experts, resource persons, producers of wood stoves, technology to reduce black carbon emissions etc. to participate in a technical reference group to give input to the project regarding measures (task 2) to make sure it is on the right track covering the best available technology.

 - Pam Pearson, International Cryosphere Climate Initiative (ICCI)
 - More nominations to come

ANNEX II.

Work plan (tentative)

- **June 2012** – Norway and co-chair Finland sends out 2nd draft of project proposal to members of SLCFC PSG under ACAP
- **20th of August 2012** – Deadline for comments to the 2nd draft, including information on about availability of data, to Norway
- **August 2012** – Status report to ACAP WG about the project proposal,
- **First week of September 2012** – Teleconference and finalization of project proposal (by participants in the project),
- **September 2012**- agreed project proposal submitted from SLCFC PSG to ACAP WG for inter-sessional approval,
- **October/November 2012** – (inter-sessional) approval of project proposal by the ACAP WG?
- **Autumn 2012** – The identified project partners come to agreement on a detailed work plan and the distribution of tasks and follow-ups, including time line for collection of data. Pending on approval of the project,
- **February 2013** – status report submitted to ACAP WG for spring meeting,
- **Early 2013** – Workshop on black carbon from residential wood combustion,
- **Spring 2013** – ACAP WG submits the (ACAP-approved) project proposal to SAOs for endorsement of the project as an Arctic Council project,
- **Autumn 2013** – Consultant delivery of draft report to the project group,
- **Winter 2013** – Work on Summary report of phase 1,
- **February 2014** – Delivery of Phase 1 report and summary report on residential wood combustion to ACAP WG
- **Spring 2014 and 2015** – Planning and conduction of phase 2,
- **2015** – Delivery of phase 2 report to ACAP WG
- **2015** – Dissemination of results
- **2015** – Evaluation of the project

ANNEX III.

Literature

Nordic Council of Ministers, Copenhagen 2004: [Particulate matter emissions and abatement options in residential wood burning in the Nordic countries](#)

The Finnish Environment 46/2006: [Fine particle emissions, emission reduction potential and reduction costs in Finland in 2020](#)

Technologie- und Förderzentrum (TFZ) im Kompetenzzentrum für Nachwachsende Rohstoffe, 2010: [Bewertung kostengünstiger Staubabscheider für Einzelfeuerstätten und Zentralheizungskessel](#)

Thomas Nussbaumer, 2008: [Feinstaub-Emissionsfaktoren von Holzheizungen: Übersicht aus Ländern der Internationalen Energie Agentur – Bioenergy Combustion Task](#)

UNECE Convention on Long-range Transboundary Air Pollution, June 2010: [Options for limit values for emissions of dust from small combustion installations < 50 MWth](#)

AMAP report (2011): [The Impact of Black Carbon on Arctic Climate. AMAP Technical Report No. 4](#)

United States Environmental Protection Agency, March 2012: [Report to Congress on Black Carbon.](#)

UNECE Convention on Long-range Transboundary Air Pollution, Sept 2010: [Report by the Co-Chairs of the Ad Hoc Expert Group on Black Carbon](#)