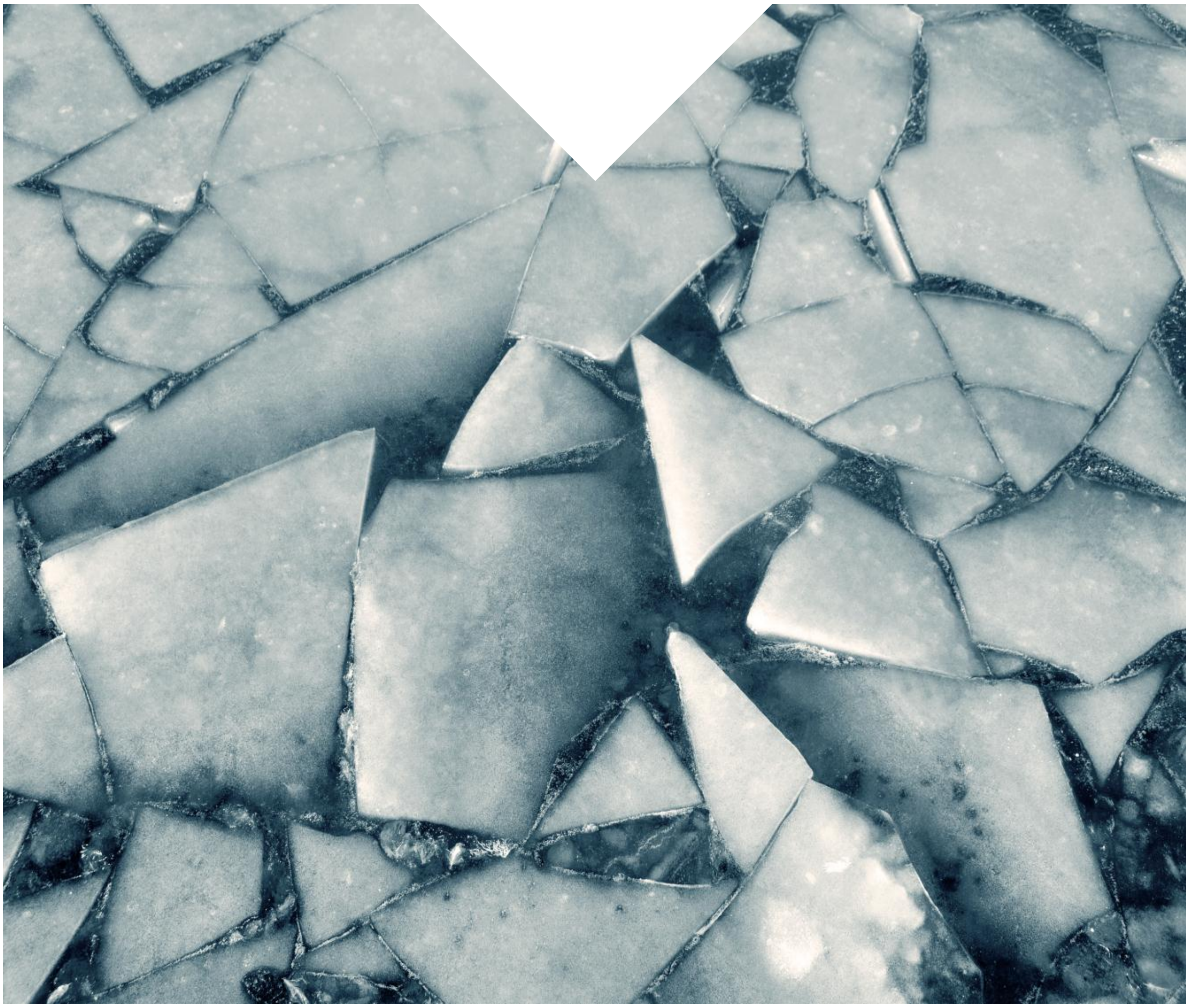
NORWEGIAN ENVIRONMENT AGENCY

REPORT

M-276 | 2014

Black carbon and methane in the Norwegian Barents region



COLOPHON

Executive institution

The Norwegian Environment Agency

Project manager for the contractor	Contact person in the Norwegian Environment Agency
Ingrid Lillehagen, The Ministry of Climate and Environment, section for polar affairs and the High North	Solrun Figenschau Skjellum

M-no	Year	Pages	Contract number
M-276	2014	15	

Publisher	The project is funded by
The Norwegian Environment Agency	The Norwegian Environment Agency

Author(s)

Maria Malene Kvalevåg, Vigdis Vestreng and Nina Holmengen

Title - Norwegian and English

Black carbon and methane in the Norwegian Barents Region Svart karbon og metan i den norske Barentsregionen

Summary - sammendrag

In 2011, land based emissions of black carbon and methane in the Norwegian Barents region were 400 tons and 23 700 tons, respectively. The largest emissions of black carbon originate from the transport sector and wood combustion in residential heating. For methane, the largest contributors to emissions are the agricultural sector and landfills. Different measures to reduce emissions from black carbon and methane can be implemented. Retrofitting of diesel particulate filters on light and heavy vehicles, tractors and construction machines will reduce black carbon emitted from the transport sector. Measures to reduce black carbon from residential heating are to accelerate the introduction of wood stoves with cleaner burning, improve burning techniques and inspect and maintain the wood stoves that are already in use. In the agricultural sector, methane emissions from food production can be reduced by using manure or food waste as raw material to biogas production. If the population reduce their waste of food or eat less red meat, the methane emissions from food production will also be reduced. Reducing emissions of black carbon and methane (as a precursor for ozone) will in addition have positive effects on human health, especially in more densely populated areas.

4 emneord	4 subject words
Svart karbon, metan, den norsk Barentsregionen, tiltak	Black carbon, methane, the Norwegian Barents region, mitigation

Front page photo

iStockphoto

Content

Summary

In 2011, land based emissions of black carbon and methane in the Norwegian Barents region were 400 tons and 23 700 tons, respectively. The largest emissions of black carbon originate from the transport sector and wood combustion in residential heating. For methane, the largest contributors to emissions are the agricultural sector and landfills.

The global climate effect of emissions of black carbon and methane in the Norwegian Barents Region is 75 % of the CO_2-emissions from the same region. Efforts to reduce black carbon, methane and CO_2 in this region will benefit the global climate. Reducing emissions of black carbon, and methane, as a precursor for ozone, will in addition have positive effects on human health, especially in more densely populated areas.

Different measures to reduce emissions from black carbon and methane can be implemented. Retrofitting of diesel particulate filters on light and heavy vehicles, tractors and construction machines will reduce black carbon emitted from the transport sector. Measures to reduce black carbon from residential heating are to accelerate the introduction of wood stoves with cleaner burning, improve burning techniques and inspect and maintain the wood stoves that are already in use. In the agricultural sector, methane emissions from food production can be reduced by using manure or food waste as raw material to biogas production. If the population reduce their waste of food or eat less red meat, the methane emissions from food production will also be reduced.

Efforts to mitigate short-lived climate pollutants should never replace measures to reduce CO_2. In order to limit global warming and prevent dangerous climate change in the long term, we need deep and persistent CO_2 reductions. Short-lived climate pollutants can help reduce the rate of warming in the short term and give additional positive effects on health and environment.

1. Background

This work is a response to the activity nr. 163 in the Norwegian Environment Agency assignment letter 2014:

"The Norwegian Environment Agency commissioned by the Ministry of Climate and Environment tasked to provide an overview of land-based emissions of black carbon and methane in the Norwegian Barents Region (Nordland, Troms and Finnmark). In addition, a list of options for reducing these emissions should be included. The report must be written in English."

1.1 An introduction to short-lived climate pollutants

Short-lived climate pollutants (SLCPs) are atmospheric compounds that have relatively short lifetime in the atmosphere - a few days to a decade - and an effect on climate predominantly in the near term after they have been emitted. The SLCP compounds contributing to a warming of the atmosphere includes methane, which is also a well-mixed greenhouse gas, as well as black carbon aerosols, tropospheric ozone (including the precursors) and some halogenated species. Some SLCPs are also dangerous air pollutants, with various damaging impacts on human health, agriculture and ecosystems. Human exposure to black carbon and ozone can cause effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death.

Limiting anthropogenic climate change and improving air quality are two of the most important environmental challenges facing humankind. Emission-reducing measures aimed at SLCPs could contribute to reduce global warming. But, the reduced rate of warming caused by a cut in SLCPs emissions would itself be short-lived. In order to prevent warming in the longer term, emissions of long-lived greenhouse gases such as CO_2 must be reduced. By implementing measures aimed at both short-lived climate pollutants and long-lived greenhouse gases, a more rapid climate benefit could be obtained, thereby increasing the chances of achieving the 2°C target that the world's leaders have set for preventing dangerous climate change. Abatement of SLCPs in the Barents region is of special interest because of its proximity to the Arctic region with large snow and ice cover. The warming in the Arctic is two times larger than the global average. The warming takes place due to heat transport from lower latitudes, but also due to emissions within the Arctic itself. Emissions of black carbon are of special importance because it warms the Arctic both by absorption of solar radiation in the atmosphere and by deposition on the white surfaces. When deposited, black carbon absorbs solar radiation and accelerates the melting of the snow and ice covered surface. The bare ground and ocean absorbs more heat than the reflective snow and ice covered surfaces thus black carbon deposition cause temperature rise in a positive feedback loop.

This report is an analysis of black carbon and methane emissions in the Norwegian Barents region and how these emissions can be reduced in order to benefit the climate, health and environment.

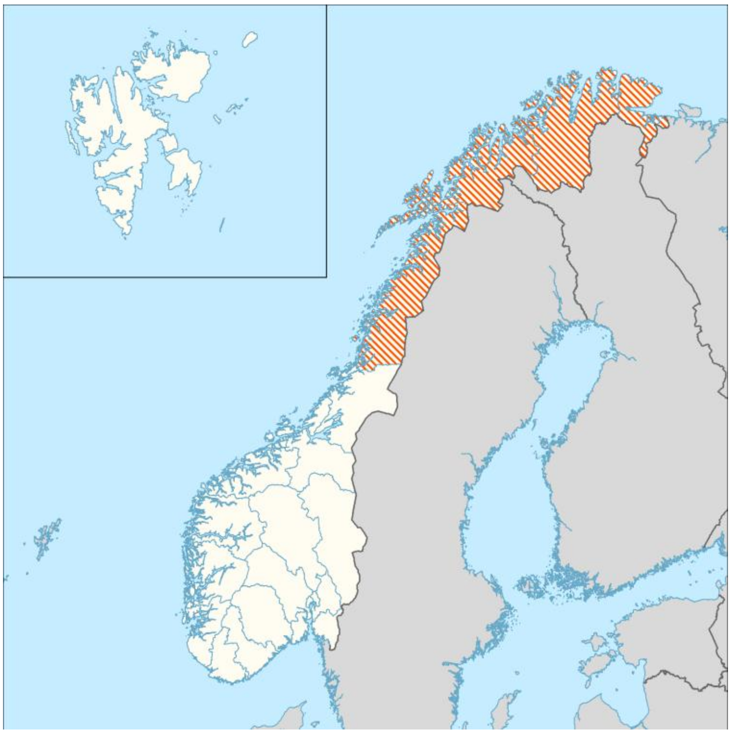


Figure 1: The Norwegian Barents region in red. Source: Miljødirektoratet

2. Scope

The Barents region is a geographical region located in the Arctic including parts of four different countries. About 5.5 million people live in this region and the population density is on average 3.5 inhabitants per square kilometer. The largest city in the Barents Region is Arkhangelsk (Russia) with its 350.000 inhabitants.

The surface area of the Barents Region is 1.755.800 km^2. This Euro-Arctic region is also characterized by its harsh climate and long distances. But no other part of Europe and indeed few places on earth are equally rich in forests, fish, minerals, oil and gas. The Barents Euro-Arctic Region includes the following 13 territories which also are members of the Barents Regional Council:

Norway: Finnmark, Troms and Nordland
Russia: Murmansk, Arkhangelsk, Nenets, Komi and Karelia
Finland: Lappland, Oulu and Kainuu
Sweden: Norbotten and Västerbotten

The three Norwegian counties included in the Norwegian Barents region are shown in Figure 1. The land area covered by these counties is approximately 98 000 km^2, which is 33 % of the area of Norway. The population in the Norwegian Barents region is about 470 000, 9 % of the total Norwegian population. Settlement and economic activity is especially based on the exploitation of natural resources. Agriculture and fisheries are important sectors in this region. Although primary industries have declined substantially during the last decades, they are still of great importance in many municipalities. The service industries have employed an increasing share of the economic activity in these counties in parallel with the decline in primary industries and other industries.

The largest sources of black carbon and methane in this region are from wood combustion for residential heating in households, diesel consumption in the transport sector and industrial processes from a few industries. The greatest point source of both black carbon and methane emissions in the Norwegian Barents region is Melkøya in Hammerfest in Finnmark county. Melkøya is an industrial facility for receiving and processing natural gas from the Snøhvit gas field in the Barents Sea. Annual emission from this point source is 2000-3000 tons of methane per year. Estimated emissions of black carbon from point sources are not available. However, combustion and flaring at Melkøya also produce black carbon particles.

Offshore emissions in the Norwegian Barents region are related to shipping and petroleum activity on the coastal areas of these three counties. Offshore emissions of methane are not distributed to county levels (see chapter 3 on method) and not available for analysis, but black carbon emissions from shipping is estimated to be approximately 190 tons. Even though offshore emissions are not included in this report, it is important to note that shipping and petroleum industry offshore in this part of Norway is also relevant in this context and will possibly increase in activity in the nearest decades and should not be omitted from a multi-effect analysis of how to mitigate SLCPs in this region.

3. Method for emission calculations at the regional level

The emissions of black carbon and methane in Norway are initially calculated at the national level, and then distributed to counties based on information relevant to the specific emission sources. The approach for calculating county emissions for black carbon and methane are based on the same information, but the approach is somewhat different.

3.1 Calculation of black carbon emissions

For geographical distribution of the black carbon emissions, information from the reporting under the Convention on Long-range transboundary air pollutants (CLRTAP) forms the basis. Gridded black carbon emissions have not been reported to the CLRTAP, and the national black carbon emissions have been geographically distributed based on information on the allocation of particle emissions (PM2.5).

For the reporting under the CLRTAP, emissions of acidifying substances, particles, heavy metals and persistent organic pollutants (POPs) are distributed in a 50X50 km grid. For Norway, this distribution is partly made using information on the location of point sources (mainly industrial plants and installations in the oil and gas industry). In addition, different types of information are used as "allocation keys" to allocate emissions that cannot be directly placed at a location. The allocation key will often be the distribution of some of the activity data used for emission calculations at the national level. This is for instance the case for road transport and agriculture. Relevant allocation keys here are traffic counts and number of livestock of different types in different counties. Emissions are also distributed based on population data.

The gridding is performed on a more aggregated level than the reporting of emissions by emission source categories. While the national emission figures reported are distributed on 109 emission source categories, the gridded emissions are spread on 17 different categories. This for instance means that most of the oil and gas industry and combustion in manufacturing industries are placed in the same grid category.

As mentioned, the geographical distribution of black carbon is based on information from the gridding of particles. This implies that the distribution of PM2.5 and black carbon are the same, but the magnitude of black carbon emissions for each emission source category and geographical unit is based on national black carbon emission levels.

3.2 Calculation of methane emissions

County specific methane emissions are gathered from the official statistics on emissions to air, published by Statistics Norway (Statistics Norway, 2014). The national emission figures forms the basis for the county specific emissions. The same approach as for calculation of gridded emission figures under the CLRTAP is used, utilizing the best available information on emission point sources and distribution of activity data.

There are some emission source categories that are included in national emissions, but not in the statistics on methane emissions by county. This includes emissions that cannot be allocated to a specific county, such as emissions from oil and gas installations off-shore, airspace and seas. Some sources are omitted due to lack of sufficient information to distribute emissions regionally. It applies to for instance shipping.

3.3 Correspondence between county specific black carbon and methane emissions

The distribution of both the black carbon and methane emissions is based on the best available information on location of emissions, and generally the same information sources are used for allocation for both substances. In this respect, the two approaches give comparable results.

The gridding reported under the CLRTAP convention (used for black carbon) and the statistics on emissions to air from Statistics Norway (used for methane) have a somewhat different classification. For instance, as mentioned previously, combustion emissions from oil and gas industries and manufacturing industries are placed in the same emission source category for the CLRTAP, while they are different emission sources in the statistics on emissions to air by counties. The two classifications are made comparable in this study by redistributing the methane emissions from the statistics to the classification of the CLRTAP gridding.

The gridding reported under the CLRTAP convention (used for black carbon) and the statistics on emissions to air from Statistics Norway (used for methane) also have somewhat different delimitation. For instance, emissions from aviation and shipping are excluded in the methane emissions, while they are included for black carbon.

3.4 Uncertainties in geographically distributed emissions

Due to limitations in the data at the county level, the geographically distributed emission figures will often be more uncertain than the national emission figures. Differences in uncertainties are primarily dependent on the quality of the information about where the emissions take place. For black carbon there is the additional uncertainty in using the allocation keys developed for PM2.5.

Even if a reduction in emissions as a result of measures is captured in the national emission estimates, the reduction will not always be properly distributed to counties. This will for instance occur if the allocation key does not capture the measures and the measures at the same time vary between counties.

4. Emissions of black carbon and methane

4.1 Black carbon

Black carbon is the highly absorbing part of fine particulate matter (PM2.5). It is a major component of soot and is produced by incomplete combustion of fossil fuel, biofuel and biomass. It is emitted from various anthropogenic and natural sources including diesel cars and trucks, residential wood burning stoves, forest fires, agricultural open burning and some industrial facilities. Its resident time in the atmosphere (the lifetime) varies from a few days to a few weeks. Black carbon aerosols causes both atmospheric warming and, when deposited on ice and snow, an increase of the melting rate. It also influences cloud formation and properties, and impacts regional circulation and rainfall patterns. In addition, black carbon impacts human health. It is a primary component of particulate matter in air pollution that is the major environmental cause of premature death globally[1].

4.1.1 Black Carbon emissions in Norway

The total emissions of black carbon in Norway in 2011 were 5 100 tons. This includes land based emissions and offshore emissions from shipping and petroleum activity. The largest source of black carbon emissions nationally is diesel vehicles. On-road and off-road transport

---

[1] - See more at: http://www.unep.org/ccac/Short-LivedClimatePollutants/Definitions/tabid/130285/Default.aspx#sthash.TLwLcUbj.dpuf

accounted for 40 % of the national emissions. Wood combustion for residential heating was responsible for 23 % of the total emissions in 2011. Emissions of black carbon rose by 2 % in the period 1990-2011. Emissions have remained relatively constant despite increased activity due to implementation of strict air pollution control policies, especially in the transport, industry and power plant sectors as well as cleaning measures, changes in production procedures and lower activity in some industries. In addition, a larger share of the wood is burned in stoves with new technology.

4.1.2 Black Carbon emissions in the Norwegian Barents Region

Land based emissions of black carbon in the Norwegian Barents region was approximately 400 tons in 2011 and corresponds to 8 % of the national emissions. Figure 2 shows the different sources of black carbon in this region. The largest contributor is the transport sector, with 60 % of the emissions. The second largest contribution originates from wood combustion in residential heating (31 %).

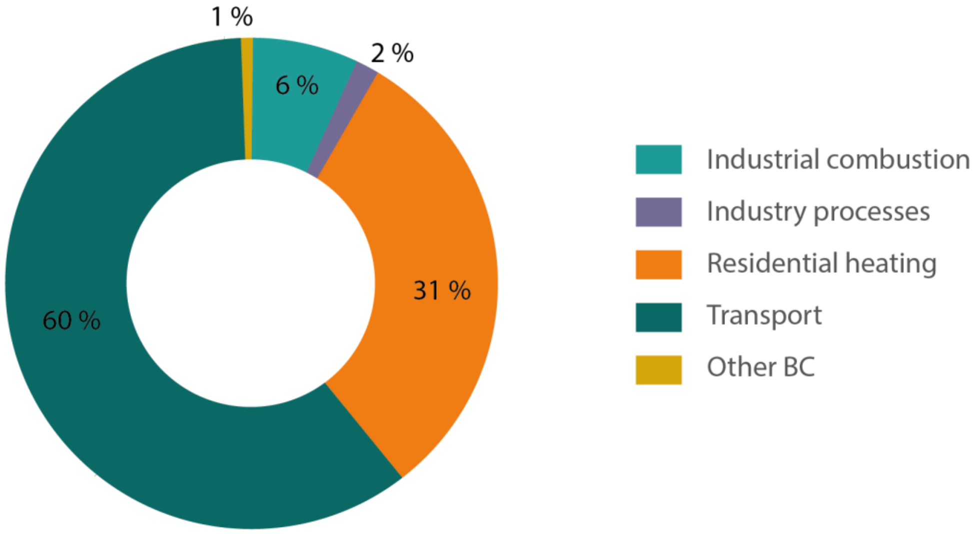


Figure 2: Land based Black carbon (BC) emissions in the Norwegian Barents region in 2011.Source: Aasestad et al. (2013).

4.2 Methane

Methane (CH_4) is a greenhouse gas that is over 20 times more potent than CO_2, and has an atmospheric lifetime of about 12 years. It is produced through natural processes (i.e. the decomposition of plant and animal waste), but is also emitted from many man-made sources, including coal mines, natural gas and oil systems, and landfills. Methane directly influences the climate system and also has indirect impacts on human health and ecosystems, in particular through its role as a precursor of tropospheric ozone[2].

[2] - See more at: http://www.unep.org/ccac/Short-LivedClimatePollutants/Definitions/tabid/130285/Default.aspx#sthash.TLwLcUbj.dpuf

4.2.1 Methane emissions in Norway

The national emissions of methane in 2011 was 209 400 tons (NIR, 2013), which corresponds to 4.4 million tons CO_2-equivalents[3]. This is approximately 8 % of total Norwegian greenhouse gas emissions. These numbers include emissions from land based, offshore and shipping activities in Norway. About 46 % of the national methane emissions in 2011 originated from agriculture, and 24 % originated from solid waste disposal on landfills. Methane emissions from agriculture are dominated by releases from enteric fermentation. Offshore emissions from combustion and evaporation/leakage in the oil and gas industry accounted for approximately 12 % of the total methane emissions in 2011, the largest fraction of which is releases of methane (venting) during the loading and unloading operations of petroleum products. Other sources include emissions from petrol cars, residential heating, coal mining, shipping and oil refineries. During the period 1990-2011 the total CH_4 emissions decreased by almost 13 %. This decrease is primarily due to decreased emissions from waste treatment, which more than compensated for the growth in emissions from the oil- and gas industry.

4.2.2 Methane emissions in the Norwegian Barents region

Land based emissions of methane in the Norwegian Barents region was 23 700 tons in 2011, this corresponds to 11 % of the national methane emissions. Figure 3 shows that the largest contributors of methane in this region are the agricultural sector (60 %) and waste treatment (solid waste disposal, 23 %). Methane from industrial combustion accounted for 13 %, residential heating for 3 % of the emissions.

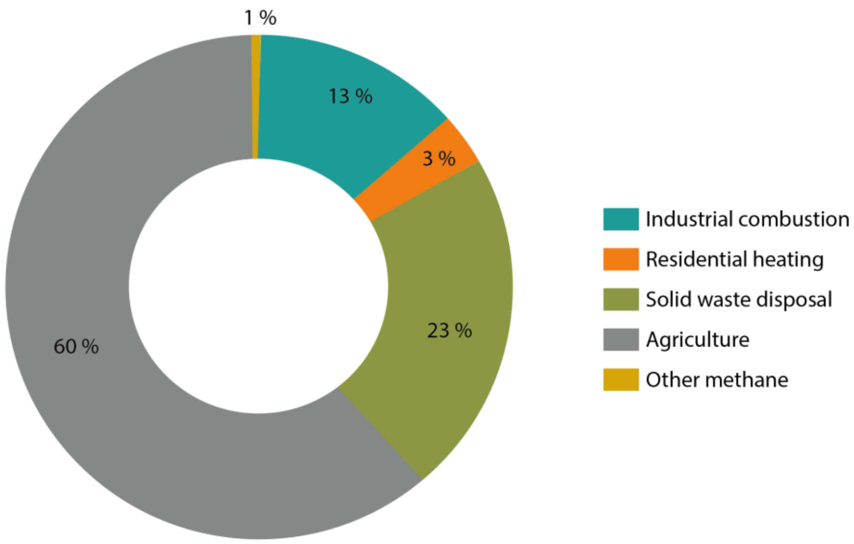


Figure 3: Land based methane emissions in the Norwegian Barents region in 2011.Source: Statistic Norway (2014).

[3] The GWP100 for methane is 21 (IPCC,1995) and is used to convert methane emissions into CO_2-equivalents in order to compare different green house gas emissions.

5. Climate effect of black carbon and methane emissions

The climate effects of the black carbon and methane emissions can only be compared to each other and summarized after conversion into so-called CO_2 equivalents. This can be done by multiplying emissions in tons by a factor that represents the climate effect per ton of the component we are interested in relative to the climate effect of a ton of CO_2 with certain given assumptions. The three key assumptions are 1) the method for calculating the climate effect, typically global warming potential (GWP) or global temperature change potential (GTP); 2) the period of time over which the climate effect is calculated; and 3) the geographical region where the emissions occur. This factor is called an emission metric.

Emission metrics for estimating the global climate effect of national and regional emissions of different short lived climate pollutants were developed for the work with the proposed Norwegian action plan (Hodnebrog et al. 2013). For instance, the metric named "GTP10, Norway" can be used for calculating the Global Temperature Potential[4] 10 years after the emission occurred in Norway. In the same study, a similar metric was estimated for emissions occurring in Northern Norway ($GTP_{10,\ \text{Northern Norway}}$) as shown in Table 1. The effect on climate from black carbon is separated into 1) the direct effect from atmospheric absorption of solar radiation, and 2) the albedo effect when black carbon is deposited on snow and ice. This shows that one ton of black carbon has 2944 times higher effect on climate than one ton of CO_2 when this metric is applied. The effect of emitting one ton of methane in the Norwegian Barents region is 86 times higher than the climate effect of emitting one ton of CO_2 when $GTP_{10,\ \text{Northern Norway}}$ is applied. By multiplying the emissions (column 1 in Table 1) with the metric (column 2 in Table 1), the climate effect of all emissions (column 3 in Table 1) can be calculated.

The global climate effect in the short term of black carbon and methane emissions in 2011 in the Norwegian Barents region is 3 215 200 tons $CO_{2eq(GTP10,\ \text{Northern Norway})}$. In comparison, the land based emissions of CO_2 in the Norwegian Barents region were 4 283 000 tons in 2011. This means that the global climate effect of emissions of black carbon and methane corresponds to 75 % of the CO_2-emissions from this region in the short-term. This highlights the stronger effect on global climate in the short term of reducing black carbon and methane along with CO_2. In addition, reducing black carbon in cities and densely populated areas will also give cleaner air and have a positive effect on human health.

[4]Read more about metrics and Global Temperature Potential in IPCC (2013) working group 1 Chapter 8.7

Emissions, metrics and climate effects in the Norwegian Barents Region			
	Emissions in the Norwegian Barents Region (tons)	GTP10,Northern Norway[5]	Climate effect (tons $CO_{2eq(GTP10, Nothern Norway)}$)
Black carbon (direct effect)	*400*	*1370*	*548 000*
Black carbon (albedo effect)	*400*	*1574*	*629 600*
Black carbon	**400**	**2944**	**1 177 600**
Methane	**23 700**	**86**	**2 038 200**
Total			**3 215 200**
CO_2	**4 283 000**	**1**	**4 283 000**

Table 1: Emissions (in tons), emission metric (GTP10, Northern Norway) and climate effect (tons CO_2-equivalents) of black carbon and methane in the Norwegian Barents region.

6. Options for emission reductions in the Norwegian Barents region

Table 2 shows possible mitigation options for reducing land based black carbon and methane emissions in the Norwegian Barents region. Emission reductions potentials and costs have not been calculated for this region separately, but the national emission reduction potentials and costs for these measures are estimated in the proposed action plan for Norwegian emissions on SLCPs (NEA, 2013).

[5] http://www.miljodirektoratet.no/Global/dokumenter/tema/klima/19092014(CICERO_metrics_English_final).pdf

Black carbon measures
Transport (Diesel particulate Filters (DPFs)):
Retrofitting DPFs on light vehicles
Retrofitting DPFs on heavy duty vehicles
Retrofitting DPFs on tractors
Retrofitting DPFs on construction machines
Residential Heating (Wood Combustion):
Accelerated introduction of new stoves and pellet burners
Improved combustion practices, inspection and maintenance

Methane measures
Agriculture:
Phasing in biogas from manure or food waste on buses[6]
Reduced food waste
Transition from red to white meat

Table 2: Possible mitigation options for reducing emissions of black carbon and methane in the Norwegian Barents region.

6.1 Black Carbon measures

Diesel particulate filters (DPFs) are devices that can be installed on older cars (retrofitting) into the exhaust system of a diesel engine to reduce the portion of black carbon particles of combustion from light vehicles, heavy duty vehicles, tractors and construction machines. However, it is argued that DPFs increase concentrations of NO_2 which can be harmful for human beings and cause health problems. Retrofit DPF applications may also cause fuel penalties and increase CO_2-emissions from higher fuel consumption. More research and testing is therefore needed before implementing DPFs on Norwegian cars.

An introduction of new stoves with cleaner combustion or pellet burners, in addition to the replacement that is expected to take place anyway, will reduce emissions of black carbon from residential heating. Improved burning practices (light from the top etc.) together with inspection and maintenance of wood stoves to reduce leakage and improve combustion, result in less emissions of black carbon.

[6] Phasing in biogas on buses will also reduce emissions of black carbon from combustion in the transport sector

6.2 Methane measures

Methane emissions in the agricultural sector can be reduced by producing biogas from manure or food waste. The produced biogas can replace fossil fuel in other sectors and give additional reductions of black carbon. Emissions from meat production, and in particular red meat, can be reduced if the population eats less red meat and reduce their waste of food. Methane emissions from landfills are controlled by waste regulations and will be reduced accordingly. No measures on waste management in landfills have therefor been suggested.

6.3 Organic carbon and SO_2

Organic carbon particles are produced by burning of biofuel and fossil fuel. These particles reflect solar radiation and contribute to cooling and have a negative climate effect. Since organic carbon always is emitted from the same source and at the same time as black carbon, organic carbon should always be included when calculating climate effects of measures that reduce black carbon.

Sulphur dioxide (SO_2) is generated by burning substances containing sulfur, mainly oil and coal, as well as by a number of industrial processes. SO_2 is also sometimes co-emitted with other short-lived climate pollutants and should also be taken into account when analyzing the effects of a measure. These particles have a cooling effect when present in the atmosphere (a removal will contribute to warming) and can cause to counteract the climate effect from reducing SLCPs.

The net climate effect of a measure depends on the ratio of reduced warming and cooling particles. But a reduction of all these particles will always have a positive health effect.

6.4 Other measures

There might be other and better measures than described in Table 2 that could be implemented in the Norwegian Barents region. For instance, we have not looked at measures aimed specifically to reduce CO_2-emissions because that was outside the scope for the proposed action plan on Norwegian emissions of SLCPs (NEA, 2013). Many measures, for instance traffic reducing initiatives and energy efficiency, reduce both CO_2 and SLCPs. The uncertainty in the black carbon inventory is large, and may have limited our ability to identify all possible mitigation options.

7. Uncertainties

In addition to the uncertainty related to the distribution of emissions and uncertainties that arise from the regional resolution of this study (chapter 3), there are uncertainties associated with the emission estimates and the calculation of the climate effect. According to NIR (2013) the uncertainty in the national methane emissions data is 14 %. The uncertainty in the black carbon emissions is not quantified but is considerably higher (NEA, 2013). The uncertainty in the black carbon emissions is mostly related to lack of reliable country and technology specific emissions factors. There are also uncertainties related to the climate effect as a result of uncertainty in the modeling. The choice of metric has to be considered carefully, in order to fit with the purpose of the analysis. Sensitivity analyses with various metrics indicate that the climate effect of measures is generally reduced if the time horizon is increased from 10 years (short term) to 100 years (long term).

8. References

Aasestad et al., 2013, Emissions of black carbon and organic carbon in Norway 1990-2011, Document 13/2013

Hodnebrog et al. (2013), Climate impact of Norwegian emissions of short-lived climate forcers http://www.miljodirektoratet.no/Global/dokumenter/tema/klima/19092014(CICERO_metrics_English_final).pdf

IPCC (1995), Houghton, J.T.; Meira Filho, L.G.; Callander, B.A.; Harris, N.; Kattenberg, A., and Maskell, K., ed., Climate Change 1995: The Science of Climate Change, Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324

NEA- Norwegian Environment Agency (2013), Proposed Action Plan for Norwegian Emissions of Short Lived Climate Pollutants, M89
http://www.miljodirektoratet.no/no/Publikasjoner/2014/Mars-20141/Summary-of-proposed-action-plan-for-Norwegian-emissions-of-shortlived-climate-pollutants/

NIR – National Inventory Report (2013), Greenhouse Gas Emissions 1990-2011, NEA, TA3030
http://www.miljodirektoratet.no/no/Publikasjoner/Publikasjoner/2013/April/National_Inventory_Report_Greenhouse_Gas_Emissions_1990_2011/

Statistics Norway (2014): Fylkestall for utslipp av klimagasser [Emissions of greenhouse gases by counties]. http://www.ssb.no/natur-og-miljo/artikler-og-publikasjoner/fylkestall-for-utslipp-av-klimagasser (In Norwegian only)

Norwegian Environment Agency
Telephone: +47 73 58 05 00 | Fax: +47 73 58 05 01
E-mail: post@miljodir.no
Web: www.environmentagency.no
Postal address: Postboks 5672 Sluppen, N-7485 Trondheim
Visiting address Trondheim: Brattørkaia 15, 7010 Trondheim
Visiting address Oslo: Strømsveien 96, 0602 Oslo

The Norwegian Environment Agency's primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature, and prevent pollution.

We are under the Ministry of Climate and Environment and have over 700 employees at our two offices in Trondheim and Oslo and at the Norwegian Nature Inspectorate's more than sixty local offices.

Our principal functions include monitoring the state of the environment, conveying environment-related information, exercising authority, overseeing and guiding regional and municipal authorities, cooperating with relevant industry authorities, acting as an expert advisor, and assisting in international environmental efforts.