Expert Group on Black Carbon and Methane

SUMMARY OF PROGRESS AND RECOMMENDATIONS
2019

ARCTIC COUNCIL

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Expert Group on Black Carbon and Methane Summary of Progress and Recommendations 2019

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Abbreviations

ACAP Arctic Council Working Group on Arctic Contaminants Action Program

AMAP Arctic Council Working Group on Arctic Monitoring and Assessment Programme

APG Associated Petroleum Gas

ARPA-E Advanced Research Projects Agency-Energy

AR5 Fifth Assessment Report

BAT Best Available Technology

BC Black Carbon

BLM Bureau of Land Management

BREF Best Available Technologies Reference Document

CAP Common Agricultural Policy (of the EU)

CIFFC Canadian Interagency Forest Fire Centre

CWFIS Canadian Wildland Fire Information System

CCAC Climate and Clean Air Coalition

CEIP Centre for Emission Inventories and Projections

CHP Combined Heat and Power

CH4 Chemical formula for Methane

CLRTAP Convention on Long-range Transboundary Air Pollution

CO Carbon Monoxide

COPERT Computer Programme to calculate Emissions from Road Transport

CO2 Carbon Dioxide

DEPA Danish Environmental Protection Agency

DERA Diesel Emissions Reduction Act

DPFs Diesel Particulate Filters

DOE Department of Energy

DOT Department of Transportation

EC Elemental Carbon, term used interchangeably with black carbon. [EC and BC are defined by their method of analyses where EC is analyzed thermally while BC is analyzed optically]

ECA Emission Control Areas

EEA European Economic Area

Expert Group Expert Group on Black Carbon and Methane

EU European Union

FEMP Fugitive Emission Management Program

Framework Enhanced Black Carbon and Methane Emissions Reductions: An Arctic Council Framework for Action

GHG Greenhouse Gas

GMI Global Methane Initiative

GWP Global Warming Potential

HFCs Hydrofluorocarbons

HFO Heavy Fuel Oil

IPCC Intergovernmental Panel om Climate Change

IMO International Maritime Organization

Kt/a kilo tons per year

LDAR leak detection and repair

LiDAR Light Detection and Ranging

LFG Landfill Gas

LMOP Landfill Methane Outreach Program

LULUCF - Land Use, Land-Use Change and Forestry

MaaS Mobility as a Service

MARPOL International Convention for the Prevention of Pollution from Ships

MEPC Marine Environment Protection Committee

MGO Marine Gas Oil

MMT Million Metric Tons

MONITOR Methane Observation Networks with Innovative Technology to Obtain Reductions

MSW Municipal Solid Waste

MWh Mega Watt hour

NCDC National Clean Diesel Campaign

NDC Nationally Determined Contributions (to reduce emissions according to the Paris Agreement)

NE Not Estimated

NOx Nitrogen Oxide

OA Organic Aerosol

OC Organic Carbon

OECD Organisation for Economic Co-operation and Development

OGC Organic Gaseous Compounds

OGCI Oil and Gas Carbon Initiative

OGMP Oil and Gas Methane Partnership

PAME Arctic Council Working Group on Protecting the Arctic Marine Environment

PM Particulate Matter

OA Primary Organic Aerosol

PPR Sub-committee on Pollution Prevent and Response

RED Radio Equipment Directive

SDWG Arctic Council Sustainable Development Working Group

SLCPs Short-Lived Climate Pollutants

SOA Secondary Organic Aerosol

Summary Report Summary of Progress and Recommendations

SYKE Finnish Environment Institute

USDA US Department of Agriculture

U.S. EPA United States Environmental Protection Agency

UNECE United Nations Economic Commission for Europe

UNFCCC United Nations Framework Convention on Climate Change

VOC Volatile Organic Compounds

ZRF 2030 Zero Routine Flaring by 2030 Initiative

Executive Summary

Black carbon and methane are air pollutants and short-lived climate pollutants. Exposure to fine particulate matter, including black carbon, has long been linked to premature deaths and a variety of other public health problems, including respiratory diseases. Based on the potential impact to human health and the environment, in April 2015 the Ministers of the Arctic Council adopted a framework titled "Enhanced Black Carbon and Methane Emissions Reductions: An Arctic Council Framework for Action" that outlined approaches for national and collective action to reduce black carbon and methane emissions. As a step towards this, Arctic States also decided to submit biennial national reports on existing and planned actions to reduce black carbon and methane emissions, on countries' national inventories of these pollutants and, if available, on projections of future emissions.

The Expert Group on Black Carbon and Methane (Expert Group) was established to review, analyze, and assess progress toward the common vision of the Framework based on a compilation of national reports, relevant output of Arctic Council Working Groups and other information. The Expert Group is to produce a "Summary of Progress and Recommendations" report, including conclusions and specific recommendations for further action.

At their 2017 meeting the Ministers of the Arctic Council member states adopted an expert group report that recommended a collective, aspirational goal to further reduce black carbon emissions by 25-33 percent relative to 2013 levels by 2025. Most Arctic countries still associate themselves with the goal.[1] As emissions of black carbon and methane outside of the Arctic also contribute to both Arctic and global warming, Observer States have been invited to join the Arctic States in efforts to reduce emissions of black carbon and methane and to submit similar reports on their progress.

This second Summary of Progress and Recommendations from the Expert Group provides an overview of the progress by Arctic States and Observer States to reduce emissions of black carbon and methane. The summary of progress is based on national information submitted in early 2018 and, where relevant, other available data.

In the 2017 report mobile diesel engines, oil and gas production and residential combustion were identified as priority areas for the reduction of black carbon. The actions that have been taken by countries so far have reduced emissions of black carbon since 2013.

For mobile diesel engines, new engine standards have contributed to decreased emissions from the transportation sector. In the oil and gas sector, regulations, technological progress and voluntary initiatives have reduced flaring per unit of production, though the reduction in the total volume of flared gas between 2013 and 2017 has been partially offset by increases in production volumes. In the residential combustion sector several countries have introduced regulations to ensure cleaner burning in new heating installations and incentives or regulations that contribute to the replacement of old installations.

1 Canada, the Kingdom of Denmark, Finland, Iceland, Norway, Russia and Sweden have affirmed their support of the collective goal. The United States does not associate itself with the collective aspirational goal, citing significant uncertainties and missing information with respect to the aggregate emission trajectory. The U.S. notes that particulate matter regulations are projected to roughly halve US black carbon emissions below 2013 levels by 2025 (US National Black Carbon and Methane Emissions, a Report to the Arctic Council, 2015).

Methane priority areas include emissions in the oil and gas sector and solid waste disposal. Overall methane emissions in the oil and gas sector appear to have remained stable since 2013, which may present opportunities to improve detection and reduce emissions. In solid waste management, significant reductions have been achieved in many countries, but waste management is still a challenge in many remote communities in the Arctic.

Many of the actions to reduce emissions of black carbon and methane will take effect gradually. Therefore, this report puts specific emphasis on tracking policy level actions that are likely to affect the trajectory of emissions until 2025. The goal is both better understanding of the actions, and the way in which they provide incentives for innovations that reduce emissions. Seven of the eight Arctic States have provided projections on anticipated reductions in black carbon emissions by 2025 based on current policies. Projected back carbon emissions in those states relative to 2013 provide estimated reductions of from 19% (Finland) to 48% (United States), with an average reduction level of 46%. Those seven countries already achieved a reduction of 16% by 2016. This suggests considerable progress has already been made, and significant further reductions are expected.

Russia has not provided projections of black carbon emissions, and it is therefore not possible to draw any definitive conclusions on overall reduction amounts expected to be achieved by Arctic States. This is especially true because Russia accounted for nearly half (49%) of the total reported 2013 emissions of black carbon.

The recommendations formulated by the Expert Group in 2017 were a collection of voluntary actions that countries may wish to apply in different combinations in efforts to reduce emissions. The Expert Group has concluded that the topics of the recommendations are still relevant in identifying possible courses of actions. Some recommendations have been modified as appropriate in the light of the experiences and policy changes. New recommendations have been provided on ways to deal with sources of emissions from agriculture and animal husbandry as well as wildfires.

The following recommendations developed by the Expert Group in 2019 describe actions that Member Countries and Observer States can consider in reducing black carbon and methane emissions. For some countries, these options would be primarily driven by the desire to reduce air pollution and thereby mitigate associated public health impacts. The recommendations are presented as a set of options to be considered in designing national and subnational policies, taking into account specific circumstances and needs. Some countries have already implemented many of these policies. The recommendations are grouped according to the priority areas identified by the Expert Group.

1. Mobile and stationary diesel-powered sources

The priority area concerning diesel engines has been expanded to cover stationary diesel engines, as these are important local sources of black carbon emissions in remote communities in the Arctic. Relevant recommendations to address emissions from these installations have been developed, including the switch to renewable energy sources.

Recommendation 1a: Reduce emissions from new diesel vehicles and engines by adopting and implementing world-class particulate matter exhaust emission standards and ensuring widespread availability of ultra-low sulphur fuels.

Recommendation 1b: Reduce emissions from legacy diesel vehicles and engines by adopting targeted policies and programs.

Recommendation 1c: Reduce black carbon by stimulating the shift to alternative vehicle technologies and modes of transportation, and through efficiency measures.

Recommendation 1d: Develop, as appropriate, and report on measures and best practices to reduce particulate matter and black carbon emissions from shipping.

Recommendation 1e: Reduce emissions from stationary diesel engines by adopting targeted policies and programs, including shift to new technologies and improved efficiency.

2. Oil and gas

The oil and gas sector is an important emitter of black carbon, in particular due to flaring. Methane is emitted in venting and from leaks. The recommendations underscore the actions already being taken in many parts of the oil and gas sector.

Recommendation 2a: Adopt and implement oil and gas methane emission reduction strategies.

Recommendation 2b: Encourage the adoption of best practices in reducing routine flaring and in improving gas capture.

Recommendation 2c: Urge firms to engage in international and domestic voluntary methane and black carbon emission reduction activities, including the implementation of methane management strategies.

Recommendation 2d: Promote targeted and cost-effective measures at large methane emission sources, where relevant.

3. Residential combustion

Residential combustion contributes to local air pollution and adverse health effects. The recommendations underline the importance of the renewal of technologies and addressing fuels used to heat residences.

Recommendation 3a: Reduce emissions from new solid fuel combustion appliances by accelerating deployment of cleaner and more efficient heating sources and by promoting proper operation and maintenance of appliances, including storage and treatment of fuels.

Recommendation 3b: Reduce emissions from legacy solid fuel combustion appliances by accelerating replacement with cleaner and more efficient new heating sources and promoting proper operation and maintenance of appliances, including storage and treatment of fuels.

Recommendation 3c: Reduce emissions by promoting enhanced energy efficiency in residential dwellings reducing the need for heating, especially in buildings heated with oil or solid fuels.

4. Solid waste

Many countries have made substantial progress in reducing emissions from solid waste treatment. The recommendations note that Arctic conditions may require specific designs for the waste treatment to deliver desired results.

Recommendation 4a: Avoid methane emissions by preventing food waste and the landfilling of organic waste. Improve resource efficiencies as appropriate for Arctic conditions, including new ways of reusing organic material based on more efficient sorting of waste, composting and biogas production.

Recommendation 4b: Adopt regulations or incentives for landfill gas capture and control.

Recommendation 4c: Promote best practices for waste management in northern and remote communities.

5. Agriculture and animal husbandry

Emissions from food production and consumption depend on the specific conditions of agriculture and animal husbandry. The recommendations identify approaches that can be part of actions tackling methane emissions and black carbon emissions from the agricultural sector. Changing agricultural practices to reduce open burning of agricultural waste is for health reasons a matter of high priority in countries where this is still common practice.

Recommendation 5a: Promote food consumption patterns that utilize Arctic food chains sustainably and efficiently, support the preservation of carbon sinks, and minimize life-cycle emissions of methane.

Recommendation 5b: Promote work on possibilities to reduce emissions of enteric methane under Arctic conditions, in co-operation with relevant organizations.

Recommendation 5c: Develop agricultural policies and practices to reduce open burning of agricultural waste. Encourage studies and piloting of innovative solutions that reduce the need for open burning.

6. Management of wildfires

Wildfires cause annually significant losses of natural resources and property in the Arctic and beyond. The recommendations reflect that management and mitigation of wildfires demand multiple actions that vary depending on specific regional circumstances such as ecosystem health, climate and weather patterns, access to wildfire sites, and proximity of people and infrastructure.

Recommendation 6a: Build and maintain international mutual aid and resource exchange arrangements amongst Arctic nations that have specialized experience in wildfire management, suppression, and monitoring.

Recommendation 6b: Develop region-specific public education campaigns on wildfire prevention and safety.

Recommendation 6c: Develop and implement regionally appropriate forest management practices that reduce the risk of severe wildfires.

Recommendation 6d: Use the best available science to develop prediction models that can be used to examine fire risks at daily to decadal scales, to support drafting of prevention and emergency response plans.

Context

The Arctic has warmed at twice the global average rate, and Arctic changes will affect regions well beyond the Arctic Circle. The overview report compiled by AMAP (2017)[2] documents climate related changes in the Arctic.

Black carbon is a short-lived climate pollutant (SLCP) of particular concern in the Arctic. In addition to its contribution to atmospheric warming, black carbon that falls on snow and ice accelerates the melting of these reflective surfaces and consequently intensifies the effects of global warming. Due to their proximity to the Arctic, Arctic States are uniquely positioned to slow Arctic warming caused by emissions of black carbon. Despite generating just ten percent of global black carbon emissions, Arctic States are responsible for 30 percent of black carbon's warming effects in the Arctic[3]. Other SLCPs include methane, ground-level ozone and HFCs (see info box). Black carbon and methane also contribute directly to air pollution that harms human health, in addition to the health impacts due to climate change itself[4]. Black carbon does so as a component of particulate matter (PM), while methane does so by contributing to the formation of ground-level ozone. Ground level ozone also impairs agricultural productivity.

Recognizing the significance of SLCPs, the Arctic States decided to implement a framework in 2015 to take "enhanced, ambitious, national and collective action to accelerate the decline in our overall black carbon emissions and to significantly reduce our overall methane emissions".[5] The actions are supported by the scientific assessments of the AMAP[6], specific pilot projects by ACAP, policy work related to shipping by PAME and policy synthesis by the Arctic Council Expert Group on Black Carbon and Methane (Expert Group).

At their 2017 meeting the Ministers of the Arctic Council member states adopted an expert group report that recommended a collective, aspirational goal to further reduce black carbon emissions by 25-33 percent relative to 2013 levels by 2025. Most Arctic countries still associate themselves with the goal.[7] For methane, no specific goal was set, noting that methane is part of the efforts to reduce greenhouse gas emissions under the UNFCCC. As the Arctic is affected by long-range transport of pollutants and their effects, Observer States also have been invited to join the Arctic States in the work to reduce emissions of black carbon and methane.

2 AMAP, 2017. Snow, Water, Ice and Permafrost in the Arctic (SWIPA). AMAP: Oslo, Norway. https://www.amap.no/documents/doc/Snow-Water-Ice-and-Permafrost-in-the-Arctic-SWIPA-2017/1610

3 AMAP. 2015. "AMAP Assessment 2015: Black carbon and ozone as Arctic climate forcers." Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. vii + 116 pp

4 Health effect of black carbon have been reported in Janssen, N.A.H., Gerlofs-Nijland, M.E., Lanki, T., Salonen, R.O., Cassee, F., Hoek, G., et al. (2012) Health Effects of Black Carbon. In: Bohr, R., Ed., WHO. http://www.euro.who.int/__data/assets/pdf_file/0004/162535/e96541.pdf

5 IQALUIT 2015 SAO Report to Ministers: Enhanced Black Carbon and Methane Emissions Reductions - An Arctic Council Framework for Action

6 AMAP. 2015. "Summary for Policymakers: Arctic Climate Issues 2015." Available at: http://www.amap.no/documents/doc/summary-for-policy-makers-arctic-climate-issues-2015/1196 and specific studies such as M. Sand, T.K. Berntsen, K. von Salzen, M.G. Flanner, J. Lagner, and D.G. Victor. 2016. "Responses of Arctic Temperatures to Changes in Emissions of Short-term Climate Forcers. Nature Climate Change 6: 286-289.

7 Canada, the Kingdom of Denmark, Finland, Iceland, Norway, Russia and Sweden have affirmed their support of the collective goal. The United States does not associate itself with the collective aspirational goal, citing significant uncertainties and missing information with respect to the aggregate emission trajectory. The U.S. notes that particulate matter regulations are projected to roughly halve US black carbon emissions below 2013 levels by 2025 (US National Black Carbon and Methane Emissions, a Report to the Arctic Council, 2015).

INFOBOX. Terminology of selected short-lived climate pollutants

Short-lived Climate Pollutants (SLCP)	A group of greenhouse gases and airborne particles that remain in the atmosphere for a few days to a decade and have warming effects on climate (AMAP SPM 2015). Often refers to black carbon, tropospheric ozone and methane, but for example the Climate and Clean Air Coalition (CCAC) also considers some Hydrofluorocarbon (HFC) compounds as SLCPs.
Black carbon (BC)	Qualitatively speaking, BC refers to strongly light-absorbing carbonaceous substances in the atmospheric aerosol, but in the scientific literature several specific definitions can be found, often dependent on the measurement principle. Bond et al. (2013) defined black carbon to be "a distinct type of carbonaceous material that is formed primarily in flames, is directly emitted to the atmosphere, and has a unique combination of physical properties. It strongly absorbs visible light, is refractory with a vaporization temperature near 4000K, exists as an aggregate of small spheres, and is insoluble in water and common organic solvents." This definition has been adopted by e.g. IMO.
Organic aerosol (OA), organic carbon (OC) and brown carbon	"Organic aerosol" (OA) is a broad term indicating carbon-containing compounds that contain hydrogen and, usually, oxygen. All sources that emit BC also emit primary organic aerosol (POA), as well as gases that may become secondary organic aerosol (SOA) in the atmosphere. In atmospheric chemistry, the combination of BC and OA is often called "carbonaceous aerosol. The term "organic carbon" (OC) refers to the carbon mass within OA, excluding the associated oxygen and hydrogen content. Brown carbon is a subset of OA lacking a formal analytical definition but with a weak light absorption. (Bond et al. 2013).
Soot	A lay term for black or dark dust or particulate matter with varying, but usually relatively high proportion of black carbon.
Aerosol	Solid or liquid particles suspended in air (or other gas)
Particulate matter (PM)	A term for a mixture of solid particles and liquid droplets found in the air. $PM_{2.5}$ are fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.[8]

Arctic States agreed in 2015 to submit biennial national reports on emissions and actions reducing emissions starting in 2015. Observer States were encouraged to submit similar national reports. This work complements work on SLCPs undertaken under other international fora. For instance, information on black carbon emissions is reported by parties to the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP) under the amended version of the Convention's Gothenburg Protocol (agreed in 2012), while methane emissions are reported under the United Nations Framework Convention on Climate Change (UNFCCC). Globally, some countries have included black carbon in their nationally determined contributions (NDC) and/or their long-term low greenhouse gas emission development strategies (i.e., mid-century strategies) under the Paris Agreement.

This report provides an overview of the progress by Arctic States and Observer States to reduce emissions of black carbon and methane since 2013, including information on new measures to reduce emissions introduced since publication of the 2017 Summary Report. The report has been prepared based on national submissions that have been synthesized in meetings of the Expert Group. The draft reports have been circulated among the States and organizations taking part in the work of the Expert Group for comments.

8 https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM

As many of the actions take effect only gradually, the report puts specific emphasis on identifying policy level actions that are likely to affect the emissions until 2025 and beyond. Data on emissions for the reference level of 2013 have also been updated and considered in the light of the most recently available data (2016 or 2017). The report provides a consolidated set of recommendations that are a set of options for Arctic States and Observer States to consider in designing their own specific policies, taking into account national circumstances and needs.

Emissions and projections

The emission data for black carbon and methane have been updated since the 2017 report. Not all countries have as yet been able to submit new emission data. The most recent publicly available data has been used, first, to check, and where relevant, to revise the 2013 reference year in the light of new data or better estimation methods. Second, the available data have been used to document the change in emissions over time. In some cases, new national projections have also become available. Additional country specific and sectoral emission data can be found in Appendix 2.

In the 2017 report, emissions and projections were reported by priority sectors in order to highlight practical steps that would most quickly reduce black carbon emissions.[9] These sectors covered oil and gas production, on-road and off-road diesel transport and residential and other stationary small-scale combustion.

Black carbon emissions and projections

This section compiles the most recent black carbon emission and projection data for both Arctic States and Observer States. Over a 20-year period, black carbon is estimated to be 3,200 times more potent a warming agent than CO_2[10]. Black carbon is of particular significance in the Arctic due to its additional warming effect when deposited onto ice or snow. Therefore, black carbon emitted near or within Arctic nations have a particularly significant impact on Arctic climate.

Arctic States

All Arctic Council States have submitted updated emissions data, with the exception of the Russian Federation[11]. The reference level of black carbon emissions for 2013 has remained at a similar level as estimated in the Expert Group 2017 Summary Report despite some new or modified data on emissions (Table 1). According to the available data many countries have already reduced their national emissions since 2013 and the estimate of the 2016 situation indicates a collective reduction of 16 % over a 3-year period (see Appendix 2) for the seven Arctic countries that have provided reported data.

Assuming no change in emissions of black carbon from the Russian Federation, current actions and policies would reduce total black carbon emissions by 23% in 2025, compared to 2013. An additional 12kt of reductions by Russia would result in an aggregate reduction level of 25% by 2025. Russia has not provided a 2025 projection, but a 12kt reduction would represent a reduction of Russian emissions by 3 % or more relative to 2013 by 2025.

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10 Bond et al. (2013) Journal of Geophysical Research: Atmospheres, Vol.118, 5380-5552, doi:10.1002/jgrd.50171.

11 The Russian Federation has not been able to update information on emissions and actions for the present report, but has undertaken efforts to develop its reporting so that new information will be available for the next progress report of the EGBCM.

Table 1. Inventories and projections of black carbon emissions as reported by Arctic States in 2015 and 2017 national reports or 2018 CLRTAP national submissions (kt/year). All numbers in this table were rounded to two significant digits: as a result, totals may not sum exactly.

	2013	2016	Change (%) in 2016 compared with 2013	Projection 2025	Change (%) in 2025 compared with 2013
Canada	43	35	-18%	31	-28%
Denmark	4.8	4.2	-12%	2.9	-40%
Finland	5.0	4.7	-6.0%	4.0	-19%
Iceland	0.23	0.20	-13 %	0.16	-30%
Norway	3.7	3.2	-14%	2.7	-28%
Russian Federation	360	NE		NE	
Sweden	3.4	2.9	-16%	2.1	-39%
US	310	260	-16%	160	-48%
Total	730	NE		NE	
Total without Russian Federation	*370*	*320*	*-16%*	*200*	*-46%*

NE = not estimated.

* Russian data from the 2015 national report;

** US emissions in the 2013 column are from the 2015 Summary of Progress and Recommendations, and represent 2011 emissions. Emissions reported here do not include prescribed burning or wildfire emissions. The 2025 projection is from the 2015 national report

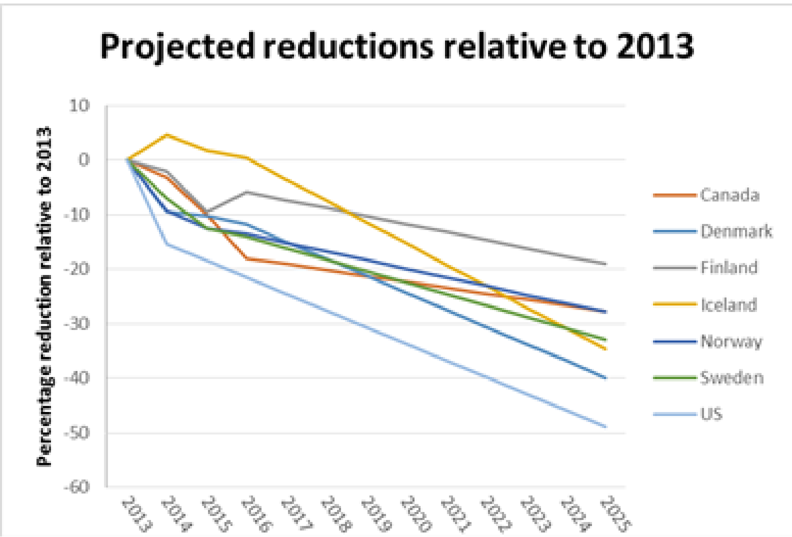

Figure 1 The documented and projected emission reductions relative to 2013 provided by seven Arctic Countries and the estimated linear trajectories until 2025.

Observer States

The inventories of black carbon emissions of Observer States that have submitted data suggest that most countries have been able to reduce their emissions in recent years (Fig. 2). So far three countries have provided specific black carbon projections for 2025 (Table 2). These same three countries plan to take further actions that also reduce emissions of black carbon. For example, the UK's recently published proposed clean air strategy 2018[12] sets a fine particulate matter ($PM_{2.5}$) emission reduction goal for 2030 that will reduce PM emissions by 46 % relative to the 2015 levels.

Table 2. Black carbon emissions in 2013 and 2016 and available projections of Observer States according to the 2017 national reports or 2018 CLRTAP national submissions (kt/year). All numbers in this table were rounded to two significant digits: as a result, totals may not sum exactly.

	Estimate for 2013	Estimate for 2016	Change (%) in 2016 relative to 2013	Projections for 2025	Change (%) in 2025 relative to 2013
France	39	31	-20%	NE	
Germany	17	14	-17%	9.0	-50 %
Italy	26	23	-12%	NE	
Japan*	17	17		NE	
Netherlands	4.1	3.2	-21%	NE	
Poland	21	21	+0.53%	NE	
Spain	39	36	-6.0%	NE	
South Korea**	13	13		NE	
Switzerland***	1.3	1.1	-17%	0.88	-32 %
United Kingdom***	21	18	-13%	18	-14 %
Total	200	180	-10%	NE	

NE = not estimated.
* 2012 emission data
** 2014 emission data
*** 2025 emission projection according to the "With Measures" (WM) scenario

12 https://consult.defra.gov.uk/environmental-quality/clean-air-strategy-consultation/supporting_documents/Clean%20Air%20Strategy%202018%20Consultation.pdf

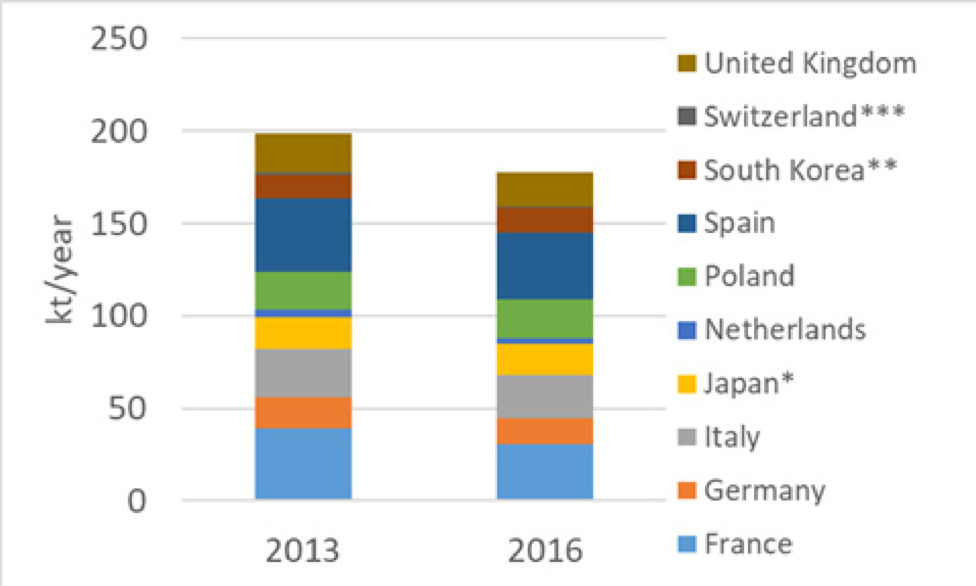

Figure 2. Black carbon emissions in 2013 and 2016 in the Observer States

Methane emissions and projections

This section compiles methane emission estimates from the 2017 national reports for the year 2016 as well as projections for both Arctic States and Observer States participating in the Expert Group. According to the IPCC AR5 assessment, the comparative warming effect of methane is 28-36 times greater than CO_2 (per kg) over a 100-year period. This warming will be concentrated in the first few decades after emission unlike CO_2 whose warming effect is spread out over the full 100-year period.

Arctic States

Table 3 compiles the national emission inventory data and available projections for the Arctic Council countries. The revised inventory of the Arctic Council 2016 emissions (Table 3) are five percent lower compared with the level reported for 2013 in the 2017 Summary Report. Countries that reported projection data expect a slight decline in methane emission between 2015 and 2030 (Figure 3).

Table 3. Methane emission estimates (kt/a) for 2016 and available projections for the Arctic States excluding LULUCF. All numbers in this table were rounded to three significant digits: as a result, totals may not sum exactly.

	Inventories	Projections	
	2016	**2020**	**2030**
Canada	3830	3840	3440
Denmark	280	261	266
Finland	189	180	153
Iceland	23	22	21
Norway	207	196	182
Russian Federation	34300	NE	NE
Sweden	182	162	137
United States	26300	NE	NE
Total	65300		

NE = not estimated.
Data: UNFCCC emission inventory Table 6(a) from and the biennial reports to the UNFCCC available in 2018.

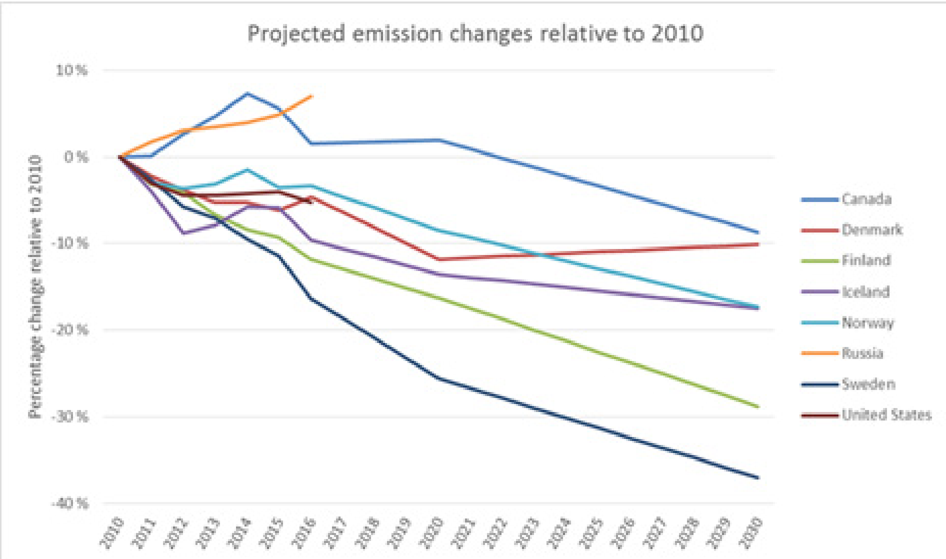

Figure 3. Methane emission estimates observed for 2010 to 2016 and available projections for the Arctic States.

Observer States

Table 4 compiles the national emission inventory data and available projections for the Arctic Council Observer States that submitted data to the Expert Group. During the 2017 national reporting data was received from 10 countries. Nine countries also provided projections. According to the data in Table 4 the emissions by Arctic Council Observer States that submitted data to the Expert Group are projected to decline by 4 and 10 percent, respectively by 2020 and 2030, compared with the 2016 emissions (Figure 4).

Table 4. Methane emission estimates (kt/a) for 2016 and available projections for the Observer States. All numbers in this table were rounded to three significant digits: as a result, totals may not sum exactly.

	Inventories	**Projections**	
	2016	**2020**	**2030**
France	2270	2290	2170
Germany	2180	2050	1870
Italy	1710	1620	1470
Japan	1230	1360	1260
Netherlands	744	723	667
Poland	1880	1820	1790
Spain	1490	1200	1140
South Korea	1070	NE	NE
Switzerland	196	198	194
United Kingdom	2080	1870	1650
Total*	14800	14200	13300

NE = not estimated.
Data: UNFCCC emission inventory and the biennial reports to the UNFCCC (2018 submissions); CH4 emission excluding LULUCF; *For 2020 and 2030 Total calculation South Korea 2014 emission value was used

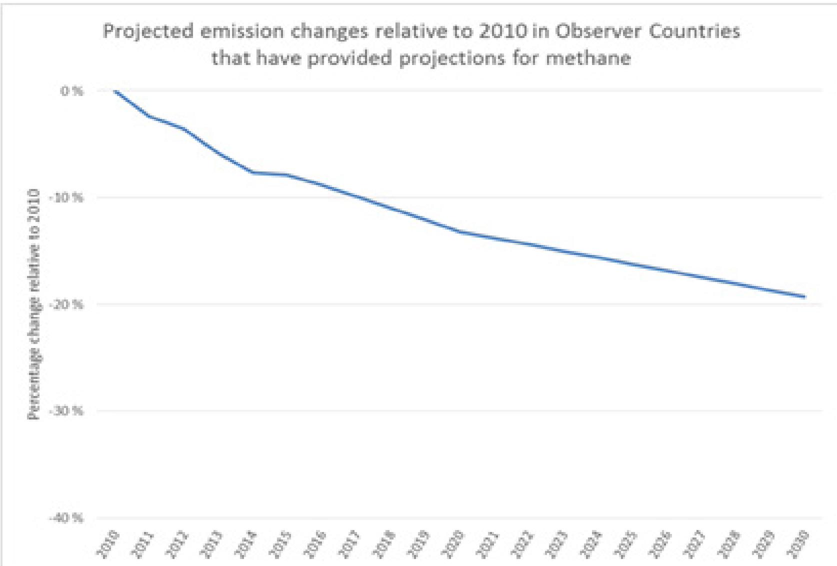

Figure 4. Methane emission estimates (observed for 2010 to 2016) and available projections for the Arctic Council Observer States participating in the Expert Group work

Assessment of progress and recommendations for enhanced action

In 2017 the Expert Group on Black Carbon and Methane summarized actions that states and the private sector had taken to reduce emissions. Based on the observations, a set of recommendations were provided for the Arctic Council Ministerial Meeting in 2017. These recommendations were a compilation of voluntary actions that states and the private sector could consider in order to reduce black carbon and methane emissions. The recommendations build upon the work by the Arctic Council Working Groups, including the Arctic Contaminants Action Program[13] (ACAP) and the Arctic Monitoring and Assessment Programme (AMAP)[14]. Additional details and background are available in documents published by these Working Groups.

Priority sources identified in 2017 included:

- Diesel-powered mobile sources (black carbon);
- Oil and gas production (both methane and black carbon);
- Residential biomass combustion appliances (black carbon); and
- Solid waste (methane).

The recommended actions that were provided in the 2017 report were intended as guidance on reducing emissions, noting also broad policy measures that may contribute to structural change such as modal shifts in transportation.

The Expert Group has, based on the submissions of the Arctic States and Observer States and other available sources of information, compiled information on progress in the fields of recommended action. In general, Arctic States and Observer States have made progress in implementing actions to reduce emissions, which have decreased overall between the 2013 and 2016 inventories.

The following overview follows the priority areas identified in the 2017 report, identifying lessons learned and examples of good practice. Details on how these practices have been implemented in each country can also be found in Appendix 1. Each section concludes with a set of recommendations for action from 2019 onwards.

The work of the Expert Group has expanded to deal with wildfires, burning of agricultural waste and agricultural methane emissions, including enteric fermentation. These sources are considered as emerging areas of interest for the Expert Group. Narratives in these sections represent a preliminary exploration of these sources, and the Expert Group intends to follow up the topics in the coming years. They represent potential areas for additional reduction of black carbon and methane emissions. Wildfires and open biomass burning are globally important sources of black

13 ACAP. 2014. "Reduction of Black Carbon Emissions from Residential Wood Combustion in the Arctic – Black Carbon Inventory, Abatement Instruments and Measures." 164 pp

14 AMAP. 2015. "AMAP Assessment 2015: Black carbon and ozone as Arctic climate forcers." vii + 116 pp.

carbon emissions (approximately a quarter of the total global emissions)[15] and methane emissions from agriculture, including animal husbandry, are globally significant.[16]

The recommendations provided in this report for 2019 recognize and build on actions that are already in place in Arctic States and the lessons learned since 2017. As in the 2017 report these recommendations are provided as a menu of options for Arctic States and Arctic Council Observer States to consider in designing policies and initiating actions that reduce emissions of black carbon and methane as appropriate for the national context and circumstances. The Expert Group has formulated the recommendations to be broadly applicable. The identified actions are chosen with local benefits in mind, including benefits for human and ecosystem health.

15 Klimont, Z., Kupiainen, K., Heyes, C., Purohit, P., Cofala, J., Rafaj, P., Borken-Kleefeld, J., Schöpp, W. 2017. Global anthropogenic emissions of particulate matter including black carbon. Atmospheric Chemistry and Physics. https://doi.org/10.5194/acp-17-8681-2017

16 FAO, Reducing Enteric Methane for improving food security and livelihoods. http://globalresearchalliance.org/wp-content/uploads/2016/02/brochure_enteric-dtp3.pdf

1. Mobile and stationary diesel-powered sources

Overview of the current state of emissions and emission controls

Diesel exhaust emissions contain many gaseous and particulate compounds, including carbon monoxide, nitrogen oxides, fine particulate matter (including black carbon), ultrafine particles, polycyclic aromatic hydrocarbons and volatile organic compounds. Studies indicate that diesel exhaust is carcinogenic to humans, with a causal relationship demonstrated between diesel exhaust exposure and lung cancer. Evidence also suggests a causal link between diesel exhaust exposure and bladder cancer. Exposure to diesel exhaust has also been linked to adverse cardiovascular, immunological and respiratory health outcomes, and reproductive, developmental and central nervous system effects.

It is important to emphasize that diesel exhaust is a major contributor to ambient $PM_{2.5}$, a component of which is black carbon. However, diesel exhaust also contributes significantly to ambient concentrations of a variety of air pollutants. Thus, taking action to reduce emissions of black carbon from diesel-powered mobile sources and stationary diesel engines not only has positive impacts in terms of climate forcing, but also yields significant air quality and health benefits.[17]

Diesel-powered mobile sources include light- and heavy-duty vehicles, non-road equipment and engines, locomotives, and marine sources, including smaller crafts. Mobile sources continue to be the largest emitters of black carbon among Arctic States, accounting for 60% of overall estimated emissions of black carbon. While the 2017 Summary Report chapter on diesel engines focused exclusively on mobile sources of black carbon, this report expands the scope to include stationary diesel engines.

Stationary diesel engines are commonly used for electricity generation in remote communities and at off-grid resource exploitation sites in Canada, the United States, Russia and Greenland. These engines operate 24 hours a day for off-grid electricity generation, often in close proximity to homes and schools, affecting local air quality. At a national level, the total emissions from stationary diesel engines are estimated to be relatively small compared with emissions from mobile sources. However, emissions from stationary diesel engines are of concern in many Northern and remote communities, as they can lead to local air quality and climate forcing impacts. By introducing cleaner fuels and engines, as well as renewable energy sources and increased energy efficiency, hybrid solutions can be designed that reduce the run-time, emissions, and often the overall costs of power generation.[18]

Status of implementation of the 2017 recommended actions

In the 2017 Summary Report, the Expert Group recommended actions addressing diesel-powered mobile sources in a set of options that countries could consider in taking national and subnational policy action, taking into account specific circumstances and needs.

An overview of the implementation of the recommended actions among Arctic States and Observer States follows (for further details see Appendix 1).

17 Health Canada – Fuels Assessment Section. (2016) Human Health Risk Assessment for Diesel Exhaust. Ottawa: Health Canada http://publications.gc.ca/collections/collection_2016/sc-hc/H129-60-2016-eng.pdf

18 J.M. Hamilton, M. Negnevitsky, X. Wang, A. Tavakoli and M. Mueller-Stoffels. 2017. Utilization and Optimization of Diesel Generation for Maximum Renewable Energy Integration. In F.M.R. Islam et al. (eds.), Smart Energy Grid Design for Island Countries, Green Energy and Technology, DOI 10.1007/978-3-319-50197-0_2

Actions to reduce emissions from new diesel vehicles and engines[19]

Implementation of stringent emissions standards entails consideration of the following elements:

- Promotion and use of best available technologies (including the use of diesel particulate filters) where technically feasible;
- Promotion of lower carbon alternative fuels;
- Emissions standards for on-road vehicles and engines, non-road vehicles and engines, and recreational water crafts, and;
- Ensuring availability of ultra-low sulphur fuels.

Most Arctic States and Observer States have adopted or signaled the intent to adopt particulate matter exhaust emission standards and ensured availability of ultra-low sulphur fuels for mobile diesel-powered engines (See Appendix 1). Further improvement can be achieved by promoting emission-control and fuel standards in other multilateral fora, and by engaging in technical co-operation with other countries.

Arctic States and Observer States have increased the stringency of air quality standards and emissions regulations. For example, in Europe, EU emissions legislation has been effective at limiting black carbon emissions. European legislation on emissions from transport is covered by a series of amendments that have introduced increasingly stringent requirements for emissions of pollutants. In addition, in the EU, the Commission has introduced new more stringent carbon dioxide standards for light commercial vehicles and heavy-duty vehicles for post 2020 (COM/2018/284 and COM/2017/676). The regulations aim to promote manufacturers developing zero and low emission vehicles which in turn decrease black-carbon emissions. For heavy duty vehicles the new emission limits, based on Regulation (EC) 595/2009, are comparable in stringency to the US 2010 standards. The EU standards became effective in 2013 for new type approvals and for all registrations in 2014[20]. For light duty vehicles the Euro 6 standards apply to all sales of new cars and light commercial vehicles since September 2015 and not-to-exceed limits, applied as the Euro 6 emission limit multiplied by a conformity factor, applied starting in September 2017 (Regulation 715/2007). As the automotive industry works towards meeting these targets, average emissions are falling each year. The Republic of Korea has also introduced motor vehicle standards based on European standards in 2017, with a plan to increase the stringency of these standards beginning in 2020.

In 2017, amendments to Canada’s On-Road Vehicle and Engine Emission Regulations also came into effect, requiring stricter air pollution standards for new passenger cars, light-duty trucks and certain heavy-duty vehicles, in alignment with stringent U.S. Tier 3 standards. In 2018, Canada published amendments to its Heavy-Duty Vehicle and Engine Greenhouse Gas Emissions Regulations, which introduce more stringent GHG emissions standards that begin with the 2021 model year for on-road heavy-duty vehicles and engines. Further, the Amendments introduce new GHG emission standards that apply to trailers hauled by on-road transport tractors for which the manufacture is completed on or after January 1, 2020. In 2019, Canada also plans to propose air pollutant emission standards for mobile diesel engines that are to be used to provide a primary source of electricity in remote locations. To date, those engines have been excluded from the application of the existing Off-Road Compression-Ignition Engine Emission Regulations. Those standards would be in alignment with U.S. Tier 2 and Tier 3 emission standards for similar engines.

19 The headings in this report describing the actions are generalisations of the specific Recommended Actions provided in the Expert Group on Black Carbon and Methane (2017), ”Summary of Progress and Recommendations” Arctic Council Secretariat. Available at https://oaarchive.arctic-council.org/handle/11374/1936. This refers to Recommended action 1a from the 2017 Progress of Summary and Recommendation report: “*Reduce emissions from new diesel vehicles and engines, by adopting and implementing world-class particulate matter exhaust emission standards and ensuring wide-spread availability of ultra-low sulphur fuels*”.

20 https://www.transportpolicy.net/standard/eu-heavy-duty-emissions/

The mandatory vehicle emissions standards have had documented desirable impacts. For example, in the Netherlands, black carbon emissions from road transport have decreased by 83% between 1990 and 2015, mainly due to the introduction of increasingly stringent emissions standards for new road vehicles. In Denmark, black carbon emissions from road transport are expected to decline by 95% from 2016 to 2035 due to the introduction of diesel particulate filters for cars, vans, trucks, and buses.

Action to reduce emissions from legacy diesel vehicles and engines[21]

The following national and local-level policies have been considered in order to reduce emissions from legacy diesel vehicles and engines:

Flexible national grant programs, including options for certified retrofitting, engine replacement, refueling or scrappage. Grant programs can be applied for on-road, non-road, rail, and marine engines (including recreational crafts), and should address other pollutants and greenhouse gases, including particulate matter (PM) and nitrogen oxide.

Fiscal measures linked to emissions performance, which can take the form of extra taxes on diesel engines without particle traps, carbon taxes for fossil fuels, and annual vehicle taxes. Such measures shorten the payback time for consumers retrofitting with filters and/or offer an incentive for trading in their old vehicle.

Regulations targeting emissions of legacy engines, requiring all engines of a certain type to be fitted with a filter, or decommissioned by a certain date. Regulations can be very effective, especially when paired with a grant program to incentivize early compliance.

Adoption of policies and programs to reduce emissions from legacy diesel vehicles can be challenging as the service life of the legacy fleet must be considered. Furthermore, many options available for limiting emissions from legacy diesel vehicles and engines rely on consumer incentives, and are therefore costly to implement. Nonetheless, several countries have implemented measures that address emissions from legacy diesel vehicles. Sweden and Denmark have in place taxes for emissions-intensive vehicles, while Iceland has in place a carbon tax that applies to all liquid and gaseous fossil fuels. The U.S. has a Natural Resources Conservation Service program for engine replacement, and EPA's Diesel Emissions Reduction Act (DERA) program supports efforts to address legacy diesel engines. Canada is implementing a pan-Canadian approach to pricing carbon pollution which will establish carbon pollution pricing throughout Canada with increasing stringency over time, which will help drive fuel switching and technology advances. Further, Canada's framework also sets out several other complementary actions to reduce emissions from the transportation sector such as actions to develop new requirements for heavy-duty trucks to install fuel-saving devices like aerodynamic add-ons and regulations to reduce the lifecycle carbon emissions (carbon intensity) from diesel fuel and other fossil fuels produced and imported into Canada (Clean Fuel Standard). As of 2018 German cities can restrict the entry of diesel vehicles with high emission levels.[22]

Norway and Finland have passenger vehicle scrappage programs, with Norway's program recently expanded to include motorcycles, mopeds, campers and caravans. The Republic of Korea is also conducting a scoping study to determine the cost of subsidizing the scrappage of old trucks in support of its plan to strengthen exhaust emissions standards in 2018. Although the Canadian in-use diesel fleet is still dominated by engines pre-dating the most recent emissions standards, some sub-national jurisdictions have undertaken inspection and maintenance, retrofit and/or scrappage programs.

21 Recommended action 1b from the 2017 Progress of Summary and Recommendation report: *Reduce emissions from legacy diesel vehicles and engines by adopting targeted policies and programs*

22 https://www.reuters.com/article/us-germany-emissions-factbox/factbox-german-cities-ban-older-diesel-cars-idUSKCN1NK28L

Actions related to the reduction of black carbon by alternative vehicle technologies, modes of transportation and increased efficiency[23]

States have a variety of options at their disposal to encourage a shift from diesel passenger vehicles to non-diesel transport modes. Measures have varied from country to country, but generally include some mix of the following measures:

- Electric vehicle subsidy programs for personal vehicles and transition of public transit systems;
- Creation of low emissions zones, where only vehicles that meet certain standards are allowed to be driven;
- Vehicle taxes based on emissions levels;
- Tax exemptions for electric vehicles;
- Free parking for electric vehicles;
- Free charging at public charging stations;
- Shore power for ships;
- Access to bus lanes for electric vehicles;
- No charge on toll roads for electric vehicles;
- Reduced rates on ferries for electric vehicles;
- Information campaigns encouraging cycling and walking;
- Investments in public transport;
- Electrification of railways.

Stimulating a shift to alternative vehicles has been enthusiastically embraced by Scandinavian countries, with many of these measures being undertaken in Denmark, Norway, Sweden, Iceland and Finland. Norway now has the highest rate of electric vehicles in the world. In 2017 approximately 20% of new passenger cars sold were zero emission cars and approximately 30% were hybrid cars. Moreover, by 2025 the aim is that all new passenger cars and light vans will be zero-emission vehicles. Improvements in technological maturity, in a way that zero emission vehicles will be competitive compared to conventional vehicles is a precondition for the targets. Denmark is undertaking the electrification of its railways. In Greenland, the number of electric and hybrid cars has increased from almost zero to about 200 in the past seven years out of a total car fleet of about 4000.[24]During 2018, Sweden has offered a subsidy for private individuals purchasing electric bicycles and motorbikes by up to 25 percent. This was later in 2018 expanded to also include electric outboard motors for boats.

An innovative approach to public transit is being pioneered by Finland. “Mobility as a Service” (MaaS) aims to convert transportation into a service package along the lines of the communications sector. This concept aims to link transport service chains together more seamlessly; supported by the MaaS information-based emerging instrument, mobility will to a greater extent become a service in which physical mobility and digital services merge into a high-quality door-to-door service that better meets users’ needs. This will reduce the need to own a car, existing cars will operate more efficiently, and public transit will become more attractive. Finland is currently reorganizing its traffic regulations to allow new companies and concepts to enter the transportation business.

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23 Recommended action 1c from the 2017 Progress of Summary and Recommendation report: *Reduce black carbon by stimulating the shift to alternative vehicle technologies and modes of transportation, and through transportation efficiency measures.*

24 Statistics Greenland, Greenland in Figures 2017

Canada is also committed to stimulating a shift to alternative vehicles and has committed to developing a Canada-wide strategy to promote the deployment of zero-emission vehicles. The Government of Canada is also investing in electric vehicle and alternative fuel transportation infrastructure. The Clean Fuel Standard regulations currently under development will require reductions in the lifecycle carbon emissions (carbon intensity) of fossil fuels, including gasoline and diesel. Displacing these fossil transportation fuels with low carbon fuels, or electric vehicles, will be one way that these regulations can be complied with. This will further support the shift to electric and alternative vehicles.

Actions to accelerate efforts under the International Maritime Organization to mitigate black carbon from international shipping[25]

A work plan to assess the impacts of black carbon emissions from ships on the Arctic environment is under discussion at the International Maritime Organization (IMO). A recent meeting of the technical sub-committee under IMO's environmental protection committee (MEPC) in February 2018 identified three appropriate methods for measuring black carbon from shipping for the purposes of data collection: Filter Smoke Number, Photo-acoustic Spectroscopy, and Laser Induced Incandescence. The sub-committee discussed black carbon reduction measures at its February 2019 meeting and will report outcomes of its discussions to MEPC in May 2019.

The Protection of the Arctic Marine Environment Working Group (PAME) has been closely involved with the work at IMO related to Arctic shipping, including consideration of the impact of emissions of black carbon and development of measures to reduce risks associated with the use of heavy fuel oil (HFO) as fuel in Arctic shipping. Combustion of HFOs emits high levels of air pollutants, often including black carbon. However, while recent research has shown some differences in black carbon emissions from switching from HFO to distillates such as marine gasoil (MGO), the impacts are subject to research.[26]

A related issue is that of the sulphur content in marine fuels, which is covered by regulation 14 of annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). Sulphur is a naturally occurring component of crude oil. Emissions of sulphur oxides (SOx) are correlated directly with emissions of secondary particulate matter. Any reduction in fuel sulphur immediately also reduces emissions of secondary particulate matter. While regulation 14 explicitly aims to reduce particulate matter, as opposed to black carbon, low sulphur fuels allow for the use of advanced control technologies, such as particulate filters, to be used on diesel engines. These control measures reduce black carbon effectively.

Arctic waters are becoming more navigable for longer periods of time, which presents economic opportunities as well as challenges. There is some uncertainty about the potential growth in Arctic shipping activity. It appears that ship traffic is moving farther north as Arctic sea ice recedes. There are many recent signs of growth in Arctic shipping activity, including increasing numbers of transits of the Bering Strait, the advent of liquefied natural gas (LNG) shipping from the Yamal Peninsula of Russia to Norway, to other European destinations, and to China, and Maersk Line's 2018 test of a container ship in the Northern Sea Route. However, a number of factors other than sea ice extent/thickness will influence growth in Arctic shipping activity. Shipping contributes only up to about 2% of global black carbon emissions. However, absent further emission reduction measures, exposures to pollutants in coastal communities are expected to increase as shipping intensifies, as is the local radiative forcing and the local surface temperature. Increases

25 Recommended action 1d from the 2017 Progress of Summary and Recommendation report: *Work to accelerate efforts under the International Maritime Organization to mitigate black carbon from international shipping*.

26 A recent literature review by Dan Lack on the effectiveness of switching from HFO to distillate fuels (submitted to IMO at PPR5, PPR5/INF.7), found that on average this switch leads to a 33% reduction in black carbon emissions. A recent ICCT technical workshop to identify appropriate black carbon control measures confirmed this switch as appropriate and will be recommending this at PPR6 (paper to be submitted to PPR6 in Feb 2019).

in black carbon may also damage sensitive ecosystems.[27]

Arctic States and Observers, industry and NGO partners are developing, through the PAME Working Group, a variety of measures meant to prevent and minimize environmental impacts from Arctic shipping. These measures include the consideration of low-impact shipping corridors, assessment of the impact of possible HFO controls, the establishment of an Arctic shipping traffic activity database, and an exchange of Arctic shipping best practices.

Lessons learned and best practices

Arctic Council States and Observer States continue to implement a combination of approaches to reduce black carbon emissions from mobile sources.

In general, enforceable measures – such as fuel standards, and regulations on engines (including mandatory use of diesel particulate filters) – have the largest impact on emissions. In particular, mandatory standards to reduce sulphur levels in fuels have been effective because they (1) enable the use of best available control technologies (such as diesel particulate filters); and (2) reduce emissions across all diesel-powered engines, including on-road and off-road vehicles, marine and rail engines, and stationary diesel engines. Other measures including inspection programs, mandatory labelling of equipment, and incentives for early compliance, are important complements for the achievement of emissions reductions.

Recommendations for action 2019

Based on the experiences gained and further deliberations on the set of options that countries can consider in drafting national and subnational policies, taking into account specific circumstances and needs, the Expert Group provides the following recommendations.

Recommendation 1a: Reduce emissions from new diesel vehicles and engines by adopting and implementing world-class particulate matter exhaust emission standards and ensuring widespread availability of ultra-low sulphur fuels.

Recommendation 1b: Reduce emissions from legacy diesel vehicles and engines by adopting targeted policies and programs.

Recommendation 1c: Reduce black carbon by stimulating the shift to alternative vehicle technologies and modes of transportation, and through efficiency measures.

Recommendation 1d: Develop, as appropriate, and report on measures and best practices to reduce particulate matter and black carbon emissions from shipping.

Recommendation 1e: Reduce emissions from stationary diesel engines by adopting targeted policies and programs, including shift to new technologies and improved efficiency.

Recommendations 1a, 1b, and 1c are carried over from the 2017 report and are deemed to still be relevant. It should be noted that recommendations 1a and 1b are applicable both to land vehicles and small vessels and crafts that do not come under IMO regulations.

Action to accelerate work under the IMO was the subject of a recommended action in 2017. The recommendation has been broadened to encompass a broader set of potential activities and measures to be considered by Arctic States, which may, as appropriate, include other international work to characterize particulate matter and black carbon emissions from shipping and identify options for emissions reductions.

Another notable change to the recommendations is an explicit recognition of stationary diesels in recommendation 1e. Similar to diesel-powered mobile engines, alternative technologies are increasingly available to replace or supplement the use of stationary diesel power generation in remote communities. While it is recognized that in some communities economically viable

27 AMAP Assessment 2015: Black carbon and ozone as Arctic climate forcers, pg 30

options for transitioning away from diesel may be limited, opportunities for minimizing emissions exist, starting with measures to improve the efficiency of all electricity users.

- Where appropriate, communities should endeavour to link to the electricity grid.
- Viable local renewable energy options for power generation, including solar, wind and hydropower may allow partial or total elimination of diesel generators, particularly in sites lacking connection to the electricity grid. Their introduction will reduce reliance on diesel in remote areas (which often is quite expensive) and thereby limit associated diesel exhaust emissions, and also increase energy security.
- Use of biomass may also be considered. However, caution should be taken to ensure that emissions from biomass combustion are carefully managed and do not "outweigh" emissions reductions from transitioning away from diesel.

Projects to reduce the reliance on diesel of remote communities are taking place across the Arctic. During the past several decades it has been a priority within Greenland to expand the use of renewable energy. Several of Greenland's larger towns have well developed district heating networks using heat generated from hydropower, heat waste from diesel power generators, and heat from waste incineration. Today, about 18% of the total energy consumption is from renewable sources, and approximately 70% of the national energy supply of heat and electricity is based on renewable energy. Concurrently, potential opportunities for solar energy and wind energy are being explored. Greenland's official goal is that "renewable energy sources shall cover the country's public energy supply as much as possible by 2030". The government is implementing a comprehensive plan for public energy supply, which includes a push to increase energy efficiency in the energy sector, and realizing industrial-scale hydropower to connect parts of the West Coast to the grid. In addition to emissions reductions, this shift is associated with reduced dependence on imported fossil fuels, and improved self-sufficiency for Northern communities.

There are approximately 200 remote communities and industrial sites across Canada that rely on diesel fuel for electricity generation and heat. Many of these communities, which are not connected to the continental grid, are indigenous or have significant indigenous populations. While diesel generation is a well-known reliable source of energy in these communities, it comes with many environmental, social and economic disadvantages. Canada is investing in the deployment of clean energy infrastructure and renewable power, support for capacity-building, and upgrades to fossil fuel-based energy systems in northern and remote communities through various federal programs and initiatives. Canada has committed $220 million over six years to support clean energy infrastructure projects that reduce reliance on diesel in off-grid, rural and remote communities, and industrial sites across Canada; and $53 million over 10 years for the deployment of renewable energy projects in northern communities to reduce their reliance on diesel for heating and electricity through the use of local renewable energy sources and energy efficiency[28].

In the United States, grants through the DERA program can cover a number of project types – from school bus replacement to railroad engines. The State of Alaska uses DERA funds exclusively to replace prime power diesel engines in rural Alaska. These engines typically run 24 hours a day, 7 days a week and make the largest impact on air quality for a rural community. The Alaska Energy Authority (AEA) selects communities for engine replacement through the DERA program based on current engine condition, redundancy, engine eligibility, available data on current engine condition, number of operational engines, reported generation efficiency and factors affecting the eligibility of engines. AEA then works with the individual utilities to ensure their interest

28 https://www.canada.ca/en/services/environment/weather/climatechange/climate-action/actions-reduce-emissions/reducing-reliance-diesel.html

in participating in the program and determine the full scope of the project.

The Arctic Contaminants Action Program (ACAP) has developed a Black Carbon Case Studies Platform to showcase projects that reduce emissions of black carbon across the circumpolar Arctic. This platform currently features a sampling of almost 100 projects in Alaska, the Canadian Arctic, Scandinavia and Russia. All Arctic States and Observer States are encouraged to work through ACAP to include projects from their countries on this platform, and to scale up ACAP projects to reduce black carbon emissions.

A combination of regulatory and program approaches, addressing both new and existing sources, can be effective in reducing emissions from stationary diesel engines. Similar to the recommendations for diesel-powered mobile sources, measures could address new or legacy appliances, and could involve adoption of regulations, as well as grants programs to incentivize the change-out of old and inefficient engines.

In Canada, regulations are being developed to set air pollution emission standards for new stationary diesel engines, and consultation with stakeholders has been conducted. The proposed regulations will complement the federal funding programs by ensuring that, when new diesel engines cannot be avoided or are needed to provide back-up power to renewable energy systems, clean, efficient engines are used. The proposed regulations, planned for publication in 2019, would set standards to reduce emissions of pollutants including carbon monoxide, volatile organic compounds, nitrogen oxides and particulate matter (including black carbon). The standards in the proposed regulations would be similar to U.S. standards (in place since 2006), and would require Tier 4 standards to be met, while allowing some flexibilities (Tier 2 or 3 standards) for engines destined for backup use, and for use in remote locations.

2. Oil and gas sector

Overview of the current state of emissions

There are four Arctic States with appreciable oil and gas production – Canada, Norway, the Russian Federation, and the United States. Although uncertainty remains high on the actual magnitude of oil and gas sector black carbon and methane emissions[29], they account for a significant portion of SLCP emissions in Arctic States. Differences in applied methodological approaches and underlying activity data and emissions factors for certain emission sources cause uncertainties in the estimates. Discrepancies have been noted, for example, between official statistics and satellite information for both the US and Russia. Nevertheless, the Arctic Council Monitoring and Assessment Programme (AMAP) has indicated that flaring is the second largest source of black carbon emissions from Arctic States.[30]

According to satellite data more than half of the flaring occurs in the Russian Federation (Table 5). The northern location of large parts of the black carbon emissions strengthens the climate impact of the emissions. For methane, approximately 32% of emissions from the Arctic States is from oil and gas installations.[31]

Generally, public and private sector attention to flaring and methane emissions remains high. The extent to which this has had impacts on emission levels is not yet clear. For example, governments, oil companies and development institutions around the world have been encouraged to commit to the World Bank's Zero Routine Flaring by 2030 Initiative.

Table 5. Development of flaring volumes in billion cubic meters (bcm) based on satellite data http://pubdocs.worldbank.org/en/965611531840923687/Gas-flaring-data-2013-17.pdf

Country	2013	2014	2015	2016	2017
Canada	1.5	2.1	1.8	1.3	1.3
Denmark	0.10	0.12	0.11	0.13	0.11
Norway	0.43	0.34	0.34	0.36	0.22
Russian Federation	19.9	18.3	19.6	22.4	19.9
United States	9.2	11.3	11.9	8.9	9.5
Total	31.13	32.16	33.75	33.09	31.03

29 http://carbonlimits.no/wp-content/uploads/2016/03/Arctic-SLCPs_report_final_public.pdf

30 AMAP Assessment 2015: Black carbon and ozone as Arctic climate forcers

31 Value for 2015. Based on the National inventory submissions 2017 to the UNFCCC. Methane emissions from the oil and gas sector included are those reported under NFR category 1.B.2 – fugitive emissions and emissions from venting and flaring in the oil and gas sector.

Flaring intensity (flaring volume/production of hydrocarbons) has gone down somewhat since 2013, but no major reductions can yet be documented in the countries with the largest flaring volumes.[32] The Norwegian company Equinor has set a flaring intensity target of a maximum 2 tons of gas flared per 1000 tons of hydrocarbons produced by 2020.[33] If all Arctic oil producers were to achieve similar low levels, flaring volumes would drop significantly.

Methane emissions from oil and gas operations from the 4 major oil producing Arctic States have been relatively stable (changes of 10% or less) over the 2013-2016 time period (Table 6)

Table 6. Methane emissions from oil and gas operations (Mt)

Country	2013	2014	2015	2016
Canada	1.89	2.01	1.94	1.77
Denmark	0.0043	0.0043	0.0041	0.0040
Norway	0.028		0.030	0.031
Russian Federation	25.3		25.3	
United States	8.02	8.12	8.18	8.08

Status of implementation of the 2017 recommended actions

The 2017 Summary Report focused on reducing emissions from oil and gas production, reductions of flaring and the adoption of voluntary actions. An overview of the relevant actions follows. For further details see Appendix 1.

Actions to adopt and implement oil and gas methane emission reduction strategies[34]

A number of laws and regulations in the Arctic States already exist to address emissions to air, including methane, from petroleum operations.

Emissions to air from the Norwegian offshore and onshore oil and gas sector are regulated through several acts; the Pollution Control Act and The Greenhouse Gas Emission Trading Act, the CO2 Tax Act (offshore) and the Sales Tax Act. Pursuant to the Pollution Control Act, a number of special regulations have been issued. Specific emission limit values are set on a case to case basis in individual permits, based on best available techniques (BAT) as defined nationally or in the EU. In addition, local factors are taken into account when the emission limits are set (ambient air quality guidelines). BAT is defined in the EU Directive 2010/75/EU on industrial emissions.

New regulations specifically for methane from the oil and gas industry are also being introduced by a number of countries. Building on existing measures at the provincial and territorial level, in 2018 Canada issued Federal Methane and VOC Regulations which set specific operating and maintenance requirements to reduce methane emissions from oil and gas facilities by about 40% from 2012 levels by 2025.[35] The new rules mandate companies to undertake leak detection and repair (LDAR) programs and set emission limits for certain emission sources.

In the US a number of initiatives are currently being discussed/developed and might lead to further methane emission reductions. In addition, the Department of Interior's Bureau of Land Management (BLM) finalized a "waste prevention" rule to reduce the venting and flaring of natural gas, which is primarily methane, from oil and gas wells in November 2018.

Russia is planning a pilot transition to BAT for 300 companies from 2019, which will help, among

32 http://pubdocs.worldbank.org/en/543961531836926475/GGFR-5.pdf

33 https://www.seforall.org/hio_phase-out-of-gas-flaring-from-oil-production

34 Recommended action 2a from the 2017 Progress of Summary and Recommendation report: *Adopt and implement oil and gas methane emission reduction strategies*

35 https://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=FF677357-1&offset=2&toc=hide

other things, reduce emissions from oil and gas sector. A number of BAT approaches covering methane emissions are included in the sector guidance documents – vapour recovery from reservoir parks, increased durability of pipelines, compressor station optimization, etc.[36]

Although regulations and other efforts exist that control emissions of methane and, to a certain extent, limit them in the main oil producing Arctic States, further progress can be made in developing methane reduction strategies that would unify existing efforts and help not only limit, but reduce methane emissions from the sector. So far methane emissions appear to have remained rather constant (see Table 6).

Actions related to reducing flaring[37]

Canada, Denmark, Norway, and the Russian Federation have endorsed the Zero Routine Flaring by 2030 initiative (ZRF 2030)[38]. If the target of the initiative is met, black carbon emissions will be significantly reduced. Countries and companies who have signed on to ZRF 2030 are obliged to publicly report their flaring and progress towards the Initiative on an annual basis. Data on flare volumes have been submitted to the World Bank, which manages ZRF 2030.

Canada, Russia and Norway all have regulations in place that limit the amount of flaring that is permitted. For instance, in Norway flaring of natural gas is only permitted when necessary for safety reasons. The Russian Federation has scaled up its flare reduction efforts with higher economic penalties for flaring above allowed norms.[39] A special multiplier for the pollution charges for flaring was introduced in 2013 (equal to 12) and was increased twofold the following year[40]. Flare volumes have dropped by some 42% from 2012 to 2015 according to national statistics[41], but satellite data suggest an increase of flaring in Russia from 2013 until 2016, with a reduction after 2017 (Table 5).[42] The national goal is to achieve a 95% utilization rate for all associated petroleum gas (set in 2012). As reported by the Federal State Statistics Service, 88% of associated petroleum gas (APG) was utilized in 2016[43]. Russia is also in the process of implementing best available technology (BAT) standards which will help reduce black carbon emissions from flares. Four specific BAT documents for the oil and gas industry have been published[44]. They take into account the EU Best Available Technologies Reference document (BREF[45]) as well as local conditions of the Russian oil and gas sector.

Actions urging firms to engage in multilateral fora and domestic programs promoting voluntary methane and black carbon emission reductions[46]

Oil and gas companies in all Arctic States are increasingly taking active part in voluntary partnerships to address their emissions. The Global Methane Initiative (GMI), the Global Gas Flaring Reduction Partnership, and the Oil and Gas Methane Partnership of the Climate and Clean Air

36 http://old.gost.ru/wps/portal/pages/directions?WCM_GLOBAL_CONTEXT=/gost/GOSTRU/directions/ndt/ndt/sprav_NDT_2017 (in Russian)

37 Recommended action 2b from the 2017 Progress of Summary and Recommendation report: *Develop implementation plans for the Zero Routine Flaring by 2030 Initiative and report on progress and best practices to the Arctic Council*

38 http://www.worldbank.org/en/programs/zero-routine-flaring-by-2030#4

39 https://new.wwf.ru/upload/iblock/84a/png_2017_web.pdf (in Russian)

40 http://pravo.gov.ru/proxy/ips/?docbody=&nd=102160640&rdk=&backlink=1 (in Russian)

41 NIR 2018 https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018

42 https://www.worldbank.org/en/news/press-release/2018/07/17/new-satellite-data-reveals-progress-global-gas-flaring-declined-in-2017

43 http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/economydevelopment/#

44 http://old.gost.ru/wps/portal/pages/directions?WCM_GLOBAL_CONTEXT=/gost/GOSTRU/directions/ndt/ndt/sprav_NDT_2017

45 http://eippcb.jrc.ec.europa.eu/reference/

46 Recommended action 2c from the 2017 Progress of Summary and Recommendation report: *Urge firms to engage in multilateral fora and domestic programs aimed at promoting voluntary methane and black carbon emission reductions*

Coalition are examples. As the current co-chair of the GMI Oil and Gas sub-committee, Canada assists in facilitating collaboration among delegates from Partner Countries and Project Networks members, which are a growing community of private-sector entities, financial institutions, and other governmental and non-governmental organizations with an interest in methane abatement, recovery and use projects. More specifically, the sub-committee helps to develop strategies and markets and removes technical and non-technical barriers to oil and gas sector methane mitigation project development.

Firms operating offshore Norway are encouraged to engage in voluntary fora and programs. In November 2017, guiding principles to reduce methane emissions across the natural gas value chain were collaboratively developed and undersigned by a coalition of major industry players (including Shell, Equinor, Eni, ExxonMobil, Total, Repsol & Wintershall) in a concerted industry response to increase focus on the reduction of methane emissions[47]. In March 2018, Gazprom joined this group of companies and also signed the principles. In addition, there is now a large number of international fora where industry take part and share knowledge of experiences on methane mitigation, both industry associations[48] and public–private partnerships[49].

Another voluntary partnership, The Natural Gas STAR Program, launched by the U.S EPA in 1993, is a flexible, voluntary partnership that encourages oil and natural gas companies—both domestically and abroad—to adopt cost-effective technologies and practices that improve operational efficiency and reduce emissions of methane. These voluntary activities include nearly 50 technologies and practices and have resulted in cumulative domestic methane emissions reductions of over 39bcm from 1993 to 2016. These methane emissions reductions have cross-cutting benefits on domestic energy supply, industrial efficiency, revenue generation, and greenhouse gas emissions reductions. The 2016 emissions reductions alone achieved through the program are equivalent to the additional revenue of approximately $155 million in natural gas sales.

In 2016, U.S. EPA launched an expanded voluntary effort, the Natural Gas STAR Methane Challenge. The Methane Challenge Program provides incentives and opportunities for partner companies to undertake and be recognized for ambitious and transparent voluntary methane emissions reductions, principally from existing methane sources.

Many actors – including state and provincial governments, industry, and non-governmental organizations – are developing programs to advance methane measurement and mitigation efforts. An example of a recent proposal[50] from 2018 is the North American Methane Reduction Framework to coordinate regulations, voluntary industry actions and scientific developments in methane estimation and mitigation.

In Canada, industry, governments and other stakeholders are undertaking research projects in support of methane emissions reductions from the oil and gas industry:

- Advanced Methane Measurements using Ground-based and UAV-based Sensors
- Development of a Highly Repeatable and Auditable, Cost-effective Monitoring System to Locate and Quantify Emissions via Small Unmanned Aerial Systems (sUASs)
- Airborne 3D Gas Imager Aerial Verification
- Aerial Emissions Detection and Mapping
- Mobile Methane Sensing Analytics for Emissions Reduction

47 http://ccacoalition.org/en/resources/reducing-methane-emissions-across-natural-gas-value-chain-guiding-principles

48 For example: International Petroleum Industry Environmental Conservation Association (IPIECA), the International Association of Oil and Gas Producers (IOGP) and Gas Exporting Countries Forum (GECF).

49 Such as Climate & Clean Air Coalition's Oil and Gas Methane Partnership (CCAC/OGMP), Global Methane Forum (GMI), United Nations Economic Commission for Europe (UN ECE).

50 https://www.tandfonline.com/doi/full/10.1080/14693062.2018.1427538

- Verification of Quantitative Optical Gas Imaging System
- Pilot Measurements Study for Quantifying Methane Emissions at Upstream and Midstream Oil and Gas Facilities
- Fugitive Emission Management Program (FEMP) Effectiveness Assessment

Another example of such collaboration across organizations and companies is the U.S Government Advanced Research Projects Agency-Energy (ARPA-E) MONITOR (Methane Observation Networks with Innovative Technology to Obtain Reductions) program that is aimed to advance methane-sensing technologies. This $30 million program[51] provides funding for 11 new projects that are each developing low-cost, highly sensitive systems that detect and measure methane associated with the production and transportation of oil and natural gas. Finally, the U.S. Department of Energy (DOE) supports the Natural Gas Infrastructure Modernization Partnership, which provides technical assistance to states on model regulatory practices to enhance transmission and distribution pipeline reliability and cost-effective methane control technologies to mitigate methane emissions.

Such collaborative approaches can bridge the divide between science and policy, and drive new research that in turn can support better policies when governments are ready to act.

Lessons learned and best practices

Black carbon emissions from flaring can in broad terms be addressed in three ways:

i. By reducing volume of gas going to flare stacks,

ii. By use of flaring technology and practices which minimize emissions of particulates,

iii. By separating the heavier components of associated gas prior to flaring.

From a policy and regulatory perspective, the main focus has been on controlling total flare volumes. All oil and gas producing Arctic States have explicit regulations for flaring of associated gas, with emphasis on routine flaring. Approaches being applied vary between the Arctic States. In the Russian Federation, pollution charges on emissions from flare quantities above permissible levels are a key policy instrument, although it remains to be seen how effective the pollution charges have been at changing behavior.

Other economic instruments have also been used to limit flare volumes in Arctic States. For example, in Norway a high CO_2 tax (imposed in 1991 and currently at approximately US$60 per ton), together with a general flare prohibition has resulted in the elimination of all routine flaring. Canada and the United States have applied a mixture of emission limits, technical standards and economic instruments to regulate flaring.

In cases where it is technically and economically difficult to eliminate flaring, substantial reductions in black carbon emissions can still be achieved through the recovery of high value and readily condensable liquids from vented or flared volatile organic compound (VOC) rich associated gas. In Canada, there is a particular emphasis towards recovering hydrocarbon liquids and bringing them into existing liquids processing and transportation infrastructure.[52]

Regarding methane emissions from oil and gas installations, more information about the scale and characteristics of emissions is needed for effective and cost-efficient action in some of the Arctic states. The situation is now improving as oil companies, national governments and a large number of international initiatives are increasingly paying attention to this problem. While gathering additional information, actions implementing existing options could yield near term

51 http://arpa-e.energy.gov/?q=news-item/department-energy-announces-22-new-projects-enable-emissions-reductions-and-improve-energy

52 https://www.bcogc.ca/node/5916/download

benefits.[53]

There are a number of reasons why there are negative cost opportunities that have not yet been implemented by oil and gas companies. Lack of knowledge, awareness and motivation are important factors. There are also regulatory, institutional and financial barriers.

Currently three sets of responses are being made to enhance efforts:

1. **Action taken directly by the oil and gas industry**. These are unilateral voluntary measures or coordinated actions taken as part of broader international initiatives. For example Oil and Gas Carbon Initiative (OGCI) comprising 13 of the largest international oil companies have jointly committed to a 25% reduction in the upstream methane emissions intensity by 2025, and with a further ambition to achieve a 33% reduction by the same year[54].

2. **Regulatory measures by national governments.** National authorities have several options for imposing policies and regulations to reduce oil and gas sector methane emissions, including emissions and technology standards, economic instruments and agreements made with industry. Creating standards for practices and equipment are currently the most common measures.

3. **Cooperation between national authorities and industry**. Increasingly there appears to be a dialogue between national authorities and oil and gas companies on how to improve quantification of methane emissions, and on negotiated or voluntary targets and measures to reduce emissions. This reflects the increased attention this issue now has on the policy agenda and at the corporate level in the industry.

Recommendations for action 2019

The oil and gas sector is an important emitter of black carbon, in particular due to flaring. Methane is emitted in venting and from leaks. The recommendations underscore the actions already being taken in many parts of the oil and gas sector.

The following recommendations are based on lessons learnt and recent developments, as described above. The recommendations are presented as a set of options to be considered in designing national and subnational policies, taking into account specific circumstances and needs.

Recommendation 2a: Adopt and implement oil and gas methane emissions reduction strategies.

Recommendation 2b: Encourage the adoption of best practices in reducing routine flaring and in improving gas capture.

Recommendation 2c: Urge firms to engage in international and domestic voluntary methane and black carbon emissions reduction activities, including the implementation of methane management strategies.

Recommendation 2d: Promote targeted and cost-effective measures at large methane emission sources, where relevant.

Recommendation 2a is carried over from the 2017 Summary Report and is deemed to still be relevant. Recommendation 2b and 2c are also carried over from the 2017 Summary Report with slightly modified wording. Recommendation 2d is a new addition to the Summary of Progress and Recommendations.

Given the ample evidence that methane emissions reductions from oil and gas companies are, in many instances, some of the lowest cost GHG emissions reductions, industry should develop strategies and operational plans to reduce emissions. This could include preparation of company inventories of emissions, as well as reduction goals with a justification based on technical feasi-

53 The International Energy Agency has estimated that 50% of global methane emissions from the oil and gas sector can be reduced at zero or negative abatement costs.

54 https://oilandgasclimateinitiative.com/oil-and-gas-climate-initiative-sets-first-collective-methane-target-for-member-companies/

bility and financial viability. In addition, companies should be encouraged to take part in international initiatives which are focused on methane mitigation and sharing of knowledge.

As alternatives or complementary to voluntary action, national regulations could be considered regarding targeted regulatory measures so as to spur effective and cost-efficient methane emissions reductions measures. New regulatory measures may be useful if and when companies are not adequately making cost-efficient reduction measures. Regulatory measures may include mandatory leak detection and repair programs with emphasis on addressing prioritized emission sources (so-called super-emitters[55]). Standards for equipment and practices, particularly for emission vents (engineered/intended emissions), should also be considered, for example by integrating strict standards as part of broader BAT schemes.

55 Alvarez, R.A., Zavala-Araiza, D., Lyon, D.R., Allen, D.T., Barkley, Z.R., Brandt, A.R., Davis, K.J., Herndon, S.C., Jacob, D.J., Karion, A., Kort, E.A., Lamb, B.K., Lauvaux, T., Maasakkers, J.D., Marchese, A.J., Omara, M., Pacala, S.W., Peischl, J., Robinson, A.L., Shepson, P.B., Sweeney, C., Townsend-Small, A., Wofsy, S.C., Hamburg, S.P., 2018. Assessment of methane emissions from the U.S. oil and gas supply chain. Science eaar7204. https://doi.org/10.1126/science.aar7204

3. Residential combustion

Overview of the current state of emissions and emission controls

Residential biomass combustion appliances, boilers and space heaters (i.e. stoves, furnaces, fireplaces, etc.), emit particulate matter, including black carbon, and a smaller amount of methane as a result of incomplete combustion. The quantity of black carbon emitted varies depending on factors such as the type of combustion appliance, the moisture content of the fuel, heat load, and end-user practices. This section focuses on heating devices for biomass since biomass is the most commonly used fuel in the residential sector in the Arctic States[56].

According to the 2013 inventories submitted by Arctic States, residential biomass combustion represents 13 percent of black carbon emissions by Arctic States, though this figure is subject to considerable uncertainty. This figure does not include emissions from the Russian Federation due to incomparable sectoral aggregation. AMAP (2015) estimated that the residential sector accounts for about 20% of black carbon emissions in the Arctic States. The contribution from residential biomass combustion to the total emissions of black carbon varies between the Arctic States. In Finland the sector contributes about two thirds of the total black carbon emissions, in Denmark about half and in Canada, Norway and Sweden about one third of the total black carbon emissions, while in the US the contribution is about 9 percent. Black carbon is formed in the flame and is inert after formation. Since black carbon is a component of PM, the emissions inventories may, in the absence of specific emissions factors, rely on black carbon percentages of $PM_{2.5}$. However, $PM_{2.5}$ emissions factors are sensitive to how condensable particles are taken into account which then also affects black carbon emissions. As countries use different methods for estimating emissions, comparisons across countries are uncertain.

Measures to reduce PM emissions from residential biomass combustion can result in important benefits for public health[57,58,59,60], especially by reducing emissions in urban areas with poor air quality.

A recent study commissioned by the Nordic Council of Ministers[61] showed that both for boilers and stoves the black carbon (in the study measured as elemental carbon, EC)[62] emissions did not correlate with the emissions of $PM_{2.5}$. Black carbon emissions were less affected than most of the other pollutants by moist fuel and burning at less than full effect. The study showed that emissions were about four times higher from traditional log wood boilers than from modern ones. Emissions from pellet and wood-chip boilers were in the same range as modern log boilers. This indicates that specific emissions factors for each burning technology are needed to reflect the emissions of black carbon correctly and that measures to reduce $PM_{2.5}$ do not necessarily reduce emissions of black carbon from residential combustion.

Government policies and programs to reduce emissions from residential biomass combustion in Arctic States and Arctic Council Observer States generally consist of the following measures:

56 ACAP, 2014, Reduction of Black Carbon Emissions from Residential Wood Combustion in the Arctic – Black Carbon Inventory, Abatement Instruments and Measures. Arctic Contaminants Action Program (ACAP).

57 Oudin A, Segersson D, Adolfsson R, Forsberg B (2018) Association between air pollution from residential wood burning and dementia incidence in a longitudinal study in Northern Sweden. PLoS ONE 13(6): e0198283. https://doi.org/10.1371/journal.pone.0198283POLS one web

58 Magalhaes, S., Baumgartner, J., Weichenthal, S., 2018. Impacts of exposure to black carbon, elemental carbon, and ultrafine particles from indoor and outdoor sources on blood pressure in adults: A review of epidemiological evidence. Environmental Research 161, 345–353. https://doi.org/10.1016/j.envres.2017.11.030

59 Weichenthal, S., Kulka, R., Lavigne, E., van Rijswijk, D., Brauer, M., Villeneuve, P.J., Stieb, D., Joseph, L., Burnett, R.T. (2017) Epidemiology, 28(3):329-337.

60 Naeher, L.P., Brauer, M., Lipsett, M., Zelikoff, J.T., Simpson, C.D., Koenig, J.Q., and Smith, K.R. (2010) Woodsmoke Health Effects: A Review. Inhalation Toxicology, 19:1, 67-106, DOI: 10.1080/08958370600985875

61 Emission factors for SLCP emissions from residential wood combustion in the Nordic Countries, TemaNord 2017:570

62 Elemental carbon (EC) is often used interchangeably with Black carbon (BC) in development of emission factors. EC and BC are defined by their method of analyses where EC is analyzed thermally while B is analyzed optically.

- Environmental performance standards, emission limits, appliance certification, and eco-labels for new biomass combustion appliances;
- Change-out programs to replace inefficient existing biomass-burning appliances, especially in urban areas with poor air quality;
- Education campaigns for operators on biomass combustion practices and stove maintenance;
- Improving energy efficiency of buildings to reduce the need for heating; and
- Banning biomass burning in high pollutant combustion appliances on a temporary basis due to poor air quality, with the exception of households where biomass burning is the household's dominant source of heating.

Status of the implementation of the 2017 recommended actions

The 2017 Summary Report focused on reducing emissions from residential combustion by focusing on the burning processes and the need for heating through more efficient insulation of dwellings. The following provide a brief overview of relevant actions. For further details see Appendix 1.

Actions to reduce emissions from new biomass combustion appliances[63]

Actions that reduce emissions include the following

- Develop and adopt, where possible, a standardized testing protocol for black carbon emissions for new heating appliances;
- Promote energy efficiency standards – voluntary or regulatory – for new heating appliances and other clean sources of space heating. Appliances that produce heat more efficiently generally use less fuel and generate fewer emissions of PM;
- Promote emission performance standards for new residential wood combustion appliances;
- Cooperate with manufacturers to promote and bring to market affordable designs and technologies that improve biomass combustion appliance use, reduce operator error and thereby reduce black carbon emissions;
- Develop, test and deploy effective education campaigns to improve consumer use of all biomass combusting appliances.

Several countries have introduced measures that accelerate change towards new boilers. Standardized testing protocols help to ensure quality of new appliances. Co-operation with manufacturers has been initiated. Awareness raising campaigns have also been initiated.

Appliances that produce heat more efficiently generally use less fuel and generate fewer emissions of PM. For example, the US EPA's new wood heater performance standards require reporting on standardized efficiency by manufacturers. The requirements apply to outdoor and indoor wood-fired boilers (also known as hydronic heaters), indoor wood-fired forced air furnaces and single burn-rate woodstoves. The European Union's Eco-design directive also contains minimum required energy efficiency for solid fuel boilers and space heaters[64].

The European Union's Eco-design directive is phasing in emission standards for PM, CO, OGC and NOX for boilers from 2020 and for space heaters from 2022. Current requirements for wood

63 Recommended action 3a from the 2017 Progress of Summary and Recommendation report: *Reduce emissions from new biomass combustion appliances by accelerating deployment of cleaner and more efficient new heating sources when installing or reinstalling appliances and promoting proper operation and maintenance*.

64 EU regulation 2015/1186 and 2015/1187

stoves in Norway are 10 PM g/kg dry wood, and in Denmark 4 g PM/kg dry wood. Eco-design requires 5 g PM /kg dry wood. Many countries have not set up national requirements for room heaters and boilers, therefore these regulations are expected to reduce particle emissions from these sources by more than 50 percent by 2030[65].

Several Canadian provinces, territories and municipalities have also enhanced efforts to reduce emissions from residential wood-burning. For instance, the City of Montreal has put in place stringent standards for wood-burning stoves and fireplaces; wood-burning stoves in Montreal must now be certified to show they emit no more than 2.5 grams of $PM_{2.5}$ per hour, and cannot be used on smog days. Further, all new wood burning appliances sold in British Columbia must now be certified to meet particulate matter emissions standards set by the US EPA in 2015, or equivalent standards.

Actions to reduce emissions from legacy biomass combustion appliances[66]

Actions that reduce emissions from legacy appliances include the following

- Incentivize the replacement of older biomass combustion appliances with cleaner and more efficient alternatives, including cleaner biomass combustion appliances, while adopting policies to keep legacy heating appliances from reaching the second-hand market;
- As with new stoves, developing, testing and deploying effective education campaigns to improve consumer use of biomass combustion appliances is necessary to reduce emissions associated with operator error.

Legacy appliances remain a particular challenge. Because residential biomass combustion appliances have a typical lifetime of two to three decades, new-stove standards and relevant PM regulations take effect only gradually. Although several Arctic States have sought to address this issue through changeout programs, it has proven difficult to find sufficient, sustained funding for, and the appropriate level of incentives to substantially accelerate replacement. Experiences show that offsetting funds for administration is also important. The incentive level to get a wood burning appliance owner to invest in a cleaner appliance may vary by location, year, economic and regulatory measures in place, the weather, the price of alternative fuels and new appliances, etc. Experience in US programs suggests that providing 30 percent of the entire project cost is a good starting figure to incentivize replacement, unless the program focuses on lower income households, in which case incentives near full replacement cost are needed. Experience in Danish scrapping schemes suggests that a grant of about 300 Euro to scrap your old wood stove is enough to nudge an increased scrapping-rate of old wood stoves.

Public education and so-called nudging initiatives[67] may be useful in promoting appliance replacement and better usage, but more data are needed to assess and enhance their effectiveness, particularly over time. Several Arctic States have used information campaigns as a means to reduce emissions from residential biomass combustion, but evaluations of their effects are lacking. To improve the design of educational programs, Arctic States would benefit from data that links evaluation of outreach strategies and program design with monitoring of household-level emissions. For example, 42 percent of participants in a Danish public information campaign ("smokestop guide for wood stoves") reported intended behavioral change. Canada found that a small, targeted "Burn It Smart" workshop stimulated reported behavioral change among 62

65 Commission Staff Working Document Impact Assessment of the Commission Regulation implementing Directive 2009/125/EC SWD (2015) 90 final.

66 Recommended action 3b from the 2017 Progress of Summary and Recommendation report: *Reduce emissions from legacy (i.e., old technology) biomass combustion appliances by accelerating replacement with cleaner and more efficient new heating sources and promoting proper stove operation and maintenance.*

67 https://behavioralpolicy.org/what-is-nudging/

percent of participants[68].

Actions to reduce emissions by promoting enhanced home heating efficiency[69]

Specific actions may include the following

- Adopt mandatory or voluntary standards for building energy efficiency;
- Offer financial incentives for building energy efficiency such as tax credits, rebates, or financing for high-usage stoves.

As a complement to actions aimed at directly reducing emissions from heating sources, measures that transform the residential heating sector can virtually eliminate emissions over the longer term. Measures can aim to enhance the overall energy performance of the building envelope through use of proper insulation, air sealing, and energy-efficient windows and doors, thereby reducing heating demand and corresponding emissions from biomass consumption. Such programs are most effective in reducing black carbon when targeted at areas with high usage of small-scale biomass for heating (as distinguished from occasional use of biomass combustion wood-burning appliances for aesthetic reasons).

Lessons learned and best practices

While measures to reduce total fine particulate emissions will result in lower black carbon emissions, there is a need to identify further measures that reduce black carbon emissions effectively. Measuring black carbon emissions from heating sources, especially biomass combustion appliances, can be quite complicated due to differences in appliance and fuel type and how appliances are used. At present, manufacturers generally do not report on black carbon emissions and there is no standardized and accepted protocol for doing so. Standardizing black carbon emissions test methods would generate the data necessary for voluntary labelling or regulatory approaches for new appliances. Such data would also help to identify appliances eligible for incentives through a change-out program.

Germany introduced stricter regulation for small scale burning of solid fuels in boilers and room heaters in 2010. The date when legacy boilers and room heaters shall comply with the emission standards from 2010 depend on the age of the equipment. If the equipment does not comply with the standards it must be retrofitted or shut down. Chimney sweepers have an important role in controlling emissions through measurements and in setting transition periods for legacy equipment.[70]

Changing fuels can achieve additional emissions reductions. In Poland, the city of Krakow has offered subsidies to the poorest households as a part of the social care system. Compensation has been provided to cover higher fuel cost caused by the use of less polluting fuels.[71]

Addressing operator error and maintenance is important in reducing emissions. For example, research suggests that putting excessive amounts of wood in the stove can increase black carbon (and $PM_{2.5}$) emissions by a factor of three.[72] Proper regulation of airflow to the combustion chamber is critical to efficient biomass combustion. Advances in design that reduce the potential for user error would help in this regard. New technologies may optimize stove operation,

68 Canadian Council of Ministers of the Environment. 2004. "Feasibility Assessment of a Change-out / Education Program for Residential Wood Combustion. Available at: https://www.ccme.ca/files/Resources/air/wood_burning/rwc_final_report.pdf

69 Recommended action 3c from the 2017 Progress of Summary and Recommendation report: *Reduce emissions by promoting enhanced home heating efficiency for residential dwellings, especially those heated with biomass.*

70 https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/heating_with_wood_heizen_mit_holz._komplett_klein.pdf

71 https://www.unece.org/index.php?id=45535

72 U.S. EPA. 2012. Report to Congress on Black Carbon. Available at https://www3.epa.gov/airquality/blackcarbon/2012report/fullreport.pdf

such as devices for automatically regulating air intake into the combustion chamber and digital phone apps that make it easier for stove operators to monitor temperature and oxygen levels and prompt users when they should add more air and/or fuel.[73] A higher degree of automation of devices results in lower emissions[74]. End of pipe solutions such as electrostatic precipitators may also be used when viable products become available for households.[75]

Maintenance of biomass combustion appliances to prevent leakage is also important. For example, laboratory tests carried out in Norway found that when the seal gasket around a stove's door was completely removed, elemental carbon emission factors (often used as a proxy for black carbon in emission inventories) were two to four times higher than under normal conditions.[76]

Recommendations for action 2019

Residential combustion contributes to local air pollution and health effects. The following recommendations underline the importance of addressing technologies and fuels used to heat residences. A combination of actions is needed to promote new, cleaner and efficient heating appliances or systems and accelerate the replacement of legacy biomass combustion appliances. The recommendations are presented as a set of options to be considered in designing national and subnational policies, taking into account specific circumstances and needs.

Recommendation 3a: Reduce emissions from new solid fuel combustion appliances by accelerating deployment of cleaner and more efficient heating sources and by promoting proper operation and maintenance of appliances, including storage and treatment of fuels.

Recommendation 3b: Reduce emissions from legacy solid fuel combustion appliances by accelerating replacement with cleaner and more efficient new heating sources and promoting proper operation and maintenance of appliances, including storage and treatment of fuels.

Recommendation 3c: Reduce emissions by promoting enhanced energy efficiency in residential dwellings reducing the need for heating, especially in buildings heated with oil or solid fuels.

All three recommendations are carried over from the 2017 Summary Report but have been amended slightly.

To achieve a more rapid transition to cleaner combustion technologies, key policies and programs should accelerate deployment of new and cleaner sources of space heating. This includes both non-combustion sources such as district heating or heat pumps and cleaner new biomass combustion appliances, for example pellet-fueled appliances, where necessary or desirable.

Biomass combustion appliances typically have long lifetimes. Moreover, how appliances are used significantly affects the level of black carbon emissions produced. Accordingly, reducing emissions from legacy heating appliances can be achieved through a two-pronged approach that on one hand provides incentives to replace old appliances with new low emitting appliances and on the other hand educates users to minimize emissions. Good practices include encouraging not only proper stove operation and maintenance, but also proper drying and storage of fuel. This is especially relevant for pellets and briquettes that are subject to regulated fuel standards.

Overall increases in the energy efficiency of buildings allows a reduction of the consumption of fuel in general, which is naturally conducive to reductions in black carbon emissions.

73 SINTEF/Norsk Energi has assessed BC reductions from better regulation of the air inlet by installation of a flu gas fan for newer woodstoves, and reported a reduction of BC of about 15%. Reference was made to a study in Denmark (http://mst.dk/service/publikationer/publikationsarkiv/2015/dec/publikation-om-forprojekt-om-rensning-af-braenderoeg-for-partikler/)

74 Deutsche Umwelthilfe et al.: Clean Heat - Residential wood burning. Environmental impact and sustainable solutions

75 see for example https://www.sccer-biosweet.ch/wp-content/uploads/Flue-Gas-Treatment.pdf, Miljøprojekt nr 1705, 2015, Miljøministeriet, Miljøstyrelsen http://mst.dk/service/publikationer/publikationsarkiv/2015/dec/publikation-om-forprojekt-om-rensning-af-braenderoeg-for-partikler/) and http://www.tfz.bayern.de/mam/cms08/festbrennstoffe/dateien/23_bericht.pdf

76 http://www.miljodirektoratet.no/no/Publikasjoner/2016/Mars-2016/Effect-of-maintenance-on-particulate-emissions-from-residential-woodstoves/

4. Solid waste disposal

Overview of the current state of emissions and emission controls

Solid waste disposal, specifically, landfilling, is a significant source of methane emissions. Alternative waste disposal methods, such as composting, anaerobic digestion, recycling, and energy-from-waste, not only help reduce methane emissions, but are also important in improving resource efficiency. In some regions where waste disposal infrastructure is unavailable, open burning of waste also contributes to black carbon emissions.

Arctic States currently emit nearly 70 000 kt of methane each year, 12% of which is generated from solid waste disposal. Data from Observer States that have provided data show that approximately 20 % of methane emissions are due to solid waste.

There are two main strategies for reducing emissions from waste: prevention of future methane emissions by diverting organic material from landfills, and mitigation of the emissions that will be released by waste already landfilled. Waste disposed in a landfill will decompose over 30-50 years. Therefore, waste already landfilled over the past several decades will continue to emit methane. The capture and control of landfill gas is essential to mitigate the current effects of historical management practices, while efforts to divert future waste from landfill will have positive future impacts.

Status of the implementation of the 2017 recommended actions

The 2017 Summary Report focused on reducing emissions from waste management through the prevention of landfilling of organic waste and though the collection of landfill gas where it is still being generated. Further details of the efforts to reduce emissions from solid waste disposal are provided in Appendix 1.

Actions to avoid methane emissions by preventing the landfilling of organic waste[77]

Specific actions include the following

- Minimize generation of food waste and other organic waste;
- Enhance waste diversion and alternative treatment;
- Incentivize or adopt bans on landfilling organics at the appropriate jurisdictional level.

The actions to avoid methane emissions by preventing the landfilling of organic waste follow a general trend in the development of legislation for solid waste disposal in many countries. The 2018 Circular Economy Package of the EU[78] emphasizes the appropriate treatment of organic waste and thus the Arctic States and Observer States that follow EU legislation have continued and strengthened regulations to reduce and eventually ban landfilling of organic waste. Similar initiatives have also been taken in other Arctic States. For example, in Canada, Nova Scotia and Prince Edward Island have province-wide bans on organics going to landfill since 2007 and 2002, respectively. The Ontario Ministry of the Environment and Climate Change has published a policy statement on addressing food and organic waste in Ontario[79], referring to a Strategy for a Waste-Free Ontario that includes a commitment to a possible disposal ban on food waste by 2022. Metro Vancouver banned organic materials from area landfills in 2015. In the United States EPA's Waste Reduction Model can be used to help municipalities, states, and other organizations make decisions on waste management depending on their own priorities. Some states in the United States have implemented legislation to ban landfilling of organic waste.[80]

77 Recommended action 4a from the 2017 Progress of Summary and Recommendation report: *Avoid methane emissions by preventing the landfilling of organic waste*

78 http://ec.europa.eu/environment/circular-economy/

79 https://www.ontario.ca/page/food-and-organic-waste-policy-statement

80 https://www.biocycle.net/2016/11/10/fresh-look-organics-bans-waste-recycling-laws/

Actions adopting regulations or incentives for landfill gas capture and control[81]

Possible actions include

- The formulation of specific regulations on actions that ensure proper operation of landfills;
- The development of technical cooperation programs and provision of financial incentives for addressing landfill gas.

Actions to improve landfill gas recapture and control is being implemented through regulations of landfills. For Arctic Council States and Observer States that follow EU legislation, the Annex I of the Landfill Directive requires appropriate measures to be taken in order to control the accumulation and migration of landfill gas; to collect gas from all landfills receiving biodegradable waste; and to treat and use the gas[82]. Also, other countries are actively supporting landfill gas recovery, but mainly through information campaigns and voluntary guidance. For example, the US EPA's Landfill Methane Outreach Program (LMOP) reduces methane emissions at municipal solid waste (MSW) landfills by supporting the voluntary recovery and use of landfill gas for energy. In 2016, there were 648 operational landfill gas energy projects in the United States, of which LMOP assisted more than 550. LMOP's efforts reduced methane emissions from landfills and avoided CO_2 emissions totaling approximately 42.5 MMT CO_2e in 2016. Nearly 650 LMOP-assisted landfill gas energy projects have collectively reduced and avoided over 427 MMT CO_{2e} since the program began in 1994.[83]

Lessons learned and best practices

The management of solid waste is intimately linked with improving resource efficiency and striving towards an overall reduction of waste. In countries where action has been taken to sort waste and to improve the separate treatment of biodegradable waste, methane emissions from the waste sector and landfills in particular have dropped significantly. Addressing the full circle of production and consumption of biomass, including food, and developing a 'circular bioeconomy' in which as much as possible of organic material is used and circulated before conversion to energy, can lead to further lowering of emissions.

The two main approaches to reduce emissions from landfills have different requirements for success. The implementation of an organics ban in municipal waste needs citizen participation, education campaigns and collection bins for waste separation. Cities need collection infrastructure. There are many examples where programs dealing with organic waste did not initially achieve the expected success, since citizens were unaware of why and how to participate, while in other regions, education and outreach programs have resulted in great success.

The collection of land fill gas is targeted at landfills themselves and require investment in infrastructure at private and/or public facilities. Feasibility studies are needed to determine how much additional landfill gas could be captured.

A particular challenge is to manage waste in remote regions of the Arctic, such as in Canada, Russia and Alaska.[84] Thus, few if any landfill gas capture projects exist in Canada's Arctic, and the feasibility of such projects in remote areas is uncertain. Currently the focus in remote regions of Canada is on storing hazardous waste in a safe way, closing unlined "dumps", and eliminating open burning.[85] Composting is one option that has been developed in some Arctic communi-

81 Recommended action 4b from the 2017 Progress of Summary and Recommendation report: *Adopt regulations or incentives for landfill gas capture and control*

82 http://ec.europa.eu/environment/waste/landfill/legislation.htm

83 https://www.epa.gov/lmop/landfill-gas-energy-project-data

84 https://www.sdwg.org/activities/sdwg-projects-2017-2019/solid-waste-management-in-small-arctic-communities/

85 ECCC's Report on Solid Waste Management for Northern and Remote Communities, 2017

ties and can be developed further.[86] The Cities of Yellowknife[87] in the Northwest Territories and Whitehorse[88] and the City of Dawson[89] in Yukon Territory operate municipal composting facilities and have implemented programs to increase the diversion of organic waste from their landfills. A composting operation is planned as part of a new waste management system recently funded for Iqaluit in Nunavut[90].

Recommendations for action 2019

Many States have made substantial progress in reducing emissions from solid waste treatment. The recommendations note that Arctic conditions may require specific designs for the waste treatment to deliver desired results. The recommendations are presented as a set of options to be considered in designing national and subnational policies, taking into account specific circumstances and needs.

Recommendation 4a: Avoid methane emissions by preventing food waste and the landfilling of organic waste. Improve resource efficiencies as appropriate for Arctic conditions, including new ways of reusing organic material based on more efficient sorting of waste, composting and biogas production.

Recommendation 4b: Adopt regulations or incentives for landfill gas capture and control.

Recommendation 4c: Promote best practices for waste management in Northern and remote communities.

Recommendations 4a and 4b are carried over from the 2017 Summary Report and are deemed to still be relevant. Recommendation 4c is a new addition to the 2019 Summary of Progress and Recommendations.

Biogas production and composting in Arctic conditions require specific solutions due to the varying conditions, including composition and volumes of the waste. Therefore, solutions developed for lower latitudes cannot be transferred as such. Piloting and sharing of experiences is needed, for example through ACAP.

The recommendation 4c underlines the need for specific solutions that fit with Artic conditions. Such work is on-going.[91] The Arctic provides several challenges with respect to waste management. Volumes are often small and logistics are difficult. Thus, there is a need to develop solutions that are implementable in diverse Arctic conditions, also recognizing that the seasonal variation of the waste load can pose specific challenges for waste management, for example in Arctic tourist destinations.

The Sustainable Development Working Group (SDWG) in cooperation with the Arctic Contaminants Action Program (ACAP) is currently undertaking a scoping study on solid waste management in the Arctic. This study aims to scope small and remote Arctic community waste management practices and provide a preliminary slate of best practice options from which communities may draw. Preliminary results indicate that best practices include:

- Safer waste burning policies and strict procedures;
- Landfill access control, mandatory collection programs;
- Landfill and equipment maintenance;

86 https://congress.uarctic.org/program/science-section/sessions/1-environmental-protection/session-36076/abstract-38695/
87 https://www.yellowknife.ca/en/living-here/Green-Cart-Program.asp
88 http://www.whitehorse.ca/departments/environmental-sustainability/waste-diversion/additional-information/organics
89 http://www.cityofdawson.ca/landfill-and-recycling
90 https://www.gov.nu.ca/sites/default/files/01_-_nr_-_iqaluit_solid_waste_facilities_-_final_-_en.pdf
91 https://www.sdwg.org/activities/sdwg-projects-2017-2019/solid-waste-management-in-small-arctic-communities/

- Safe handling of hazardous and other harmful wastes;
- Use of available regional special waste facilities and programs; and,
- Program design based on community behavior and values (including enforcement, education and setup).

Additionally, internally controllable human drivers can broaden a community's best practice options. For instance, a motivated and trained landfill officer can override a facility's inadequacies. A local champion can convince residents and local officials to improve financial contributions, disposal habits, enforcement, and more. An engaged and informed community will contribute to meeting the financial and behavioral responsibilities associated with potentially reducing and detoxifying the waste stream. Finally, local government leadership that prioritizes a health-protective waste management system, and develops and supports the system's legal, infrastructural, and financial obligations is important to improved waste management in remote communities.

5. Emissions from agriculture and animal husbandry

Overview of the current state of emissions and emission controls

Agriculture and animal husbandry contribute to emissions of both methane and black carbon.

Methane emissions from agriculture and animal husbandry are dominated by enteric fermentation. Enteric methane from ruminant livestock accounts for 35% of global anthropogenic methane, which is 5.5% of total global anthropogenic greenhouse gas emissions, based on a 100-year measure of global warming potential (GWP).[92] Methane emissions from animal husbandry may also arise in the treatment of manure. While the amount of methane generated by agriculture and animal husbandry within the Arctic region is modest, methane is a well-mixed gas, so reducing global emissions will benefit the Arctic.

Large scale burning of agricultural waste after harvest is a seasonal source of air pollution and may cause significant emissions of black carbon that cause local health hazards.

Inventory of methane and black carbon emissions from agriculture and animal husbandry

Most of the national reports provide "methane from agriculture" and do not break out methane from enteric fermentation. The amount of a specific country's enteric methane emissions depends on its population of ruminant animals - primarily cattle, but also buffalo, sheep and goats --and other factors, such as the type and quality of feed, but there is need for better data in order to make detailed assessments.

Enteric fermentation is significant as a source of emissions[93]. For example, in the United States, methane emissions from enteric fermentation represent 26% of total US methane emissions, second only to the natural gas and petroleum sector (31%).[94] The United States has the highest emissions of enteric methane among Arctic States. Observer States that have large cattle populations include EU member states and India. Although US emissions of enteric methane are higher, the animals are higher producing, whether it be meat or milk, such that emissions per unit of animal product is lower than in many other states.

Black carbon emissions from open biomass burning in agriculture are small in Arctic States compared with the emissions from wildfires and prescribed burning. For example, in the United States agricultural open biomass burning accounts for approximately 6 % of the total emissions of open biomass burning. Among Arctic EU member states the proportion is even lower. However, in some Observer States the open burning of agricultural waste is still a significant source of emissions of black carbon.

Policies/regulations and voluntary mechanisms to address methane and black carbon emissions from agriculture and animal husbandry

Measures to address methane from agriculture and animal husbandry are detailed in Appendix 3. The US Dairy Industry, for example, has included enteric methane in its emissions-reduction goal for 2020. Several Arctic States have introduced measures that include support for R&D and innovation that may help mitigate methane emissions from enteric fermentation and other sources. Although methane emissions from enteric fermentation exceed those from manure management, the opportunities for reducing emissions from enteric fermentation are not well

92 FAO, Reducing Enteric Methane for improving food security and livelihoods. http://globalresearchalliance.org/wp-content/uploads/2016/02/brochure_enteric-dtp3.pdf

93 Van Dingenen, R., Crippa, M., Maenhout, G., Guizzardi, D., Dentener, F., Global trends of methane emissions and their impacts on ozone concentrations, EUR 29394 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-96550-0, doi:10.2760/820175, JRC113210 https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/global-trends-methane-emissions-and-their-impacts-ozone-concentrations

94 EPA's Inventory of Greenhouse Gas Emissions and Sinks: 1990-2016 Report (Table ES-2)

understood. For that reason, mitigation options for agriculture often focus primarily on those applicable to manure management through the use of anaerobic digestion techniques. However, opportunities also exist to reduce enteric methane ($CH4$) and other greenhouse gas (GHG) emissions per unit of product from ruminant livestock.[95]

Emissions due to burning of agricultural waste have been reduced in several Arctic countries through a combination of awareness campaigns and regulations. In Denmark, one of the measures - a ban on burning of straw residues on fields - was introduced in 1989 taking effect from 1990. The ban has resulted in reductions in emissions of black carbon and a greater return of carbon to the soil, and therefore increased carbon storage in the soil, as well as increased use of straw as a fuel. The measure was implemented in the form of a statutory order under the Environmental Protection Act. A ban on field burning is currently part of cross compliance under EU Common Agricultural Policy thus affecting all Arctic States and Observer States following EU law.

Lessons learned and best practices

Work on enteric methane is relatively new and still fragmented, and according to the UN Food and Agriculture Organization, ongoing research may provide new opportunities for action. Countries within the Global Research Alliance collaborated on a global rumen census, completed fall 2015, which showed similar methanogen species in all rumens. Several studies[96] suggest that further work on enteric fermentation is likely to provide some progress in reducing emissions.

Developing agricultural practices to reduce open burning of agricultural waste and, where feasible, to use the organic material in a more sustainable way, offers opportunities to reduce both air pollution and improve the carbon balance of soils. Several states have shown that such shifts in agricultural practices are achievable using a combination of regulations and information campaigns.

Recommendations for action 2019

Further studies on ways to reduce emissions from enteric fermentation and additional efforts to reduce methane emissions generally from agriculture can open up possibilities for specific actions. As food consumption indirectly influences the methane emissions from the agricultural sector, consumption patterns should therefore also be considered.

Changes in agricultural practice to reduce open burning contributes to resource efficiency and may also improve soil carbon balance. The recommendations are presented as a set of options to be considered in designing national and subnational policies, taking into account specific circumstances and needs.

Recommendation 5a: Promote food consumption patterns that utilize Arctic food chains sustainably and efficiently, support the preservation of carbon sinks, and minimize life-cycle emissions of methane.

Recommendation 5b: Promote work on possibilities to reduce emissions of enteric methane under Arctic conditions, in co-operation with relevant organizations.

Recommendation 5c: Develop agricultural policies and practices to reduce open burning of agricultural waste. Encourage studies and piloting of innovative solutions that reduce the need for open burning.

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95 Knapp, J.R., Laur, G.L., Vadas, P.A., Weiss, W.P., Tricarico, J.M., 2014. Invited review: Enteric methane in dairy cattle production: Quantifying the opportunities and impact of reducing emissions. Journal of Dairy Science 97, 3231–3261. https://doi.org/10.3168/jds.2013-7234

96 Global Research Alliance, Livestock Research Group newsletter. http://globalresearchalliance.org/wp-content/uploads/2015/10/2015_10_Oct_Newsletter.pdf ; Knapp, J.R., Laur, G.L., Vadas, P.A., Weiss, W.P., Tricarico, J.M., 2014. Invited review: Enteric methane in dairy cattle production: Quantifying the opportunities and impact of reducing emissions. Journal of Dairy Science 97, 3231–3261. https://doi.org/10.3168/jds.2013-7234; Hristov, et al. Proceedings of the National Academy of Sciences, US. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4553761/ ;

6. Management of wildfires

Overview of the current state of emissions and emerging concerns

Countries across the globe are experiencing longer and more intense wildfire seasons[97]. For example, the 2017 and 2018 wildfire seasons in Europe and California were the most destructive on record. Over 1.2 million ha burned in Europe and 126 were killed by fires, while 405000 ha were burned and 106 fatalities occurred in California. Central and northern Europe (Sweden) experienced an uncharacteristically active fire season, which saw forest fires extend as far north as the Arctic Circle. Climate change has had a considerable impact on this trend; increased temperatures contribute to decreased soil moisture and arid conditions that create large forest fuel loads ready to combust. Furthermore, as human activity continues to expand into wilderness areas, the accidental ignition of wildfires is increasingly common. For example, approximately half of all wildfires in Canada are human-caused[98], while nearly 95% of fires in Europe are also human caused. Exposure to wildfire smoke is a serious health concern, particularly for small children, pregnant women, the elderly, and those with lung or heart conditions. It is estimated that 339 000 premature deaths worldwide are attributed to exposure to wildfire smoke each year.[99]

Increased wildfire activity is not only a symptom of a changing climate; wildfires can also influence climate change through emissions of SLCPs, especially black carbon. High intensity forest fires release large amounts of black carbon high into the atmosphere, thus enabling an efficient pathway for long-range transport of emissions[100],[101]. The Arctic is particularly sensitive to these emissions, as black carbon emissions from mid-to-high-latitude fires can be transported and deposited on Arctic ice and snow in great quantities. For example, a recent study sourced black carbon deposited over Greenland ice sheets in 2013 to wildfires in Canada's boreal forest[102].

The complete elimination of these emissions is not possible. Fire is an integral component of the boreal ecosystem. However, action can be taken to reduce the occurrence of high-intensity forest fires, thus mitigating the magnitude of black carbon emissions in the future. Frequent, low intensity fires reduce forest fuel loads, thus preventing larger, more intense fires in the future. Lower intensity fires also likely produce less black carbon per area burned and are far less likely to inject black carbon into the stratosphere where it is more easily transported to the Arctic. The extreme fires occurring in the last decade are the result of the effect of a changing climate and the fire-exclusion policies that were implemented in most countries, leading to the accumulation of fuels that resulted in high intensity fires, with dramatic effects to the environment and to the population [103].

Fires that affect boreal peatlands are a particular concern in Arctic States. These peatlands, which are found across circumpolar forests, store 30% of the world's terrestrial carbon. However, draining of wetlands and accelerated climate change is shifting the fire regime of this ecosystem. Instead of acting as a carbon sink, increased fire activity can turn peatlands into a net source of carbon dioxide. Furthermore, peatland wildfires tend to smolder, which produces higher methane and particulate matter emissions compared to flaming combustion[104]. Finally, peatland fires

97 Jolly et al. 2015. Climate-induced variations in global wildfire danger from 1979 to 2013. *Nature Communication,* 6:7537.

98 Canadian Council of Forest Ministers. 2016. Canadian wildland fire strategy: A 10-year review and renewed call to action.

99 Johnston et al. 2012. Estimated global mortality attributable to smoke from landscape fires. *Environmental Health Perspectives* 120:5.

100 AMAP. 2011. The Impact of black carbon on arctic climate.

101 AMAP. 2015. AMAP assessment 2015: Black carbon and ozone as arctic climate forcers.

102 Thomas et al. 2017. Quantifying black carbon deposition over the Greenland ice sheet from forest fires in Canada.

103 International Union of Forest Research Organizations, 2018. Global Fire Challenges in a Warming World. Robinne F.-N., Burns J., Kant P., de Groot B., Flannigan M.D., Kleine M., Wotton D. M. (eds.). Occasional Paper No. 32. IUFRO, Vienna, 2018.

104 Kohlenberg et al. 2017. Control on boreal peat combustion and resulting emissions of carbon and mercury. *Environmental Research Letters*, 13:035005

can be very difficult to extinguish. These fires can smolder for months, even under the snow layer where incomplete combustion results in large black carbon emissions that can immediately settle on ice and snow.

Wildfire activities are often concentrated spatially and seasonally depending on co-occurrence of dry litter and ignition sources. Furthermore, variations in climate and weather on short and long-term scales directly influence the variability of wildfire risk and occurrence[105]. As a result, it can be very difficult to predict where, when, and to what extent wildfire activity will occur. Technology will continue to play an important role in predicting fire activity, and response resources must be able to adapt to constantly changing wildfire scenarios. Table 8 compiles available information about mitigation measures for wildfires.

Table 8. National actions, national action plans, or mitigation strategies concerning black carbon emissions from biomass burning (agricultural or wildfires)

Country	Examples of national mitigation measures
USA	Prescribed burning is a key wildland management practice for reducing risk of uncontrolled wildfire, thus helping limit overall fire-related emissions of black carbon. Uncontrolled wildfires loft black carbon emissions much higher in the atmosphere where long-range transport is much more likely than when prescribed fires are conducted and emission impacts are less in volume and more localized. USDA is increasing use of prescribed fire, forest and range-related practices such as forest stand improvement and active timber management in order to significantly reduce wildfire risk and severity, thereby greatly reducing black carbon emissions. In 2019 Smokey Bear celebrates his 75th Birthday as the internationally recognized symbol for wildfire prevention. In 2017, approximately 88 percent of the wildfires in the United States were human-caused therefore an extensive publicity campaign is planned to emphasize the need to prevent these unwanted human-caused wildfires. The human health impacts of wildfire smoke are now being recognized in the United States and addressed through interagency efforts led by USDA resulting in greater messaging to the public to reduce exposure to smoke. In 2011, 51 percent of black carbon emissions from open biomass burning were from wildfires, 43 percent from prescribed burning
Canada	The Canadian Wildland Fire Information System (CWFIS) is a computer-based fire management information system that monitors fire danger across Canada. Provincial/territorial governments manage wildfire response and prevention; however, resources are coordinated across Canada though the Canada Interagency Forest Fire Centre (CIFFC). CIFFC also coordinates resources sharing with the United States and other countries. While not included in the national inventory, emissions from wildfires are quantified using the Government of Canada's FireWork system; an air quality prediction system that indicates how smoke from wildfires is expected to move across North America. Training and educational material for communities, industry partners, and firefighting professionals is made available through FireSmart Canada.
Finland	Efficient approaches for monitoring and informing the public of risks of wildfires have been developed and preparedness for forest fires is efficiently maintained.

105 AMAP 2011. The impact of black carbon on arctic climate.

Norway	Controlled fires are not common in Norway. The area subject to wild land and forest fires varies considerably from year to year due to natural factors (e.g. variations in precipitation). Norway experienced two of the most intensive wildfires in 2006 and 2008, when areas burned corresponded to around 3800 and 3200 hectares, respectively. Emissions of CO_2, CH_4 and N_2O from wildfires are estimated in the national emissions inventory. Emissions of black carbon are not estimated. Local authorities are responsible for managing wildfire response and prevention. In the case of high-intensity wildfires, additional resources such as helicopters are provided by national authorities. The Norwegian Meteorological Institute has developed a wildfire hazard index for 100 locations in Norway. Monitoring is also done using aircraft and satellites to detect wildfires at an early stage.
Sweden	Guidelines for risk management of forest fires in forestry. Common guidelines for Swedish Forestry Agency, Swedish Civil Contingencies Agency, Fire and Rescue Services and the largest forest owners in Sweden. https://www.skogforsk.se/contentassets/6c848836ec104a4ea436c11051b3d9f2/riskhantering-avseende-brand.pdf Municipalities and County Governments can issue fire bans due to for example dry and hot weather conditions. https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2003789-om-skydd-mot-olyckor_sfs-2003-789 Municipalities may also specify regulations for burning of straw on crop land. https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-1998899-om-miljofarlig-verksamhet_sfs-1998-899
EU	The European Forest Fire Information System (EFFIS) provides early warning for forest fires, often evidenced by fire danger anomalies, and monitors wildfire regimes and impact in EU and the pan-European region .[106] http://effis.jrc.ec.europa.eu A Global Wildfire Information System (GWIS) is currently under development, which aims at providing information on wildfire regimes and impacts at the global scale. Each system provides estimates of wildfire emissions in Europe and at the global scale, respectively. GWIS, developed in close cooperation with the Group on Earth Observations (GEO)[107] and the United State's National Aeronautics and Space Administration (NASA) will soon allow for a comprehensive assessment of wildfire impacts at the global scale.

106 San-Miguel-Ayanz et al. 2018. Forest Fires in Europe, Middle East and North Africa 2017, EUR 29318 EN, ISBN 978-92-79-92831-4, doi: 10.2760/663443

107 https://www.earthobservations.org/activity.php?id=126

Lessons learned and best practices

SLCP emissions from wildfires will always be a reality. However, reductions could be achieved through prevention of wildfires caused by humans and landscape-level fuel reduction measures, primarily the management of low-intensity wildfire without full suppression. Therefore, a holistic, risk-based approach to wildfire management is recommended.

Public education is critical to preventing fires caused by humans and mitigating the risk to human health and infrastructure in the event of a wildfire. For instance, Canada's FireSmart campaign aims to educate the public, industry, and government organizations on preventing, managing and living with wildfire. It is a successful program that can be adopted by regional governments to address specific community needs, such as best practices for property owners on clearing debris around buildings to reduce risk of damage in the event of a wildfire. FireSmart is an excellent resource for training and education materials.

Prevention of high-intensity fires can also be achieved by promoting healthy forest ecosystems. Forests impacted by disease and drought are more prone to intense burning and large releases of SLCPs. For example, forest and wetland drainage may affect fire risks. Large peatland systems should be managed as intact ecosystems or actively reclaimed when disturbed in order to minimize the risk of large-scale peat carbon loss and SLCP emissions.

When reacting to a wildfire event, a risk-based approach is recommended, whereby fires that pose a risk to life, infrastructure and/or resources are suppressed, while low-risk fires are allowed to burn. In Canada, all significant wildfires are monitored by airborne and satellite platforms, even if no suppression action is taken. Wildfire monitoring and growth projection tools are continuously updated to allow for the managed spread of low-intensity fire away from values and resources, thereby mitigating large, intense fires in the future.

In regions like Europe, where a large number of neighboring countries experience wildfires, the sharing of firefighting resources is essential. However, for a sound assessment of wildfire risk in the region, harmonized information on wildfires risk is required. In the context of the European Forest Fire Information System (see Table 8) basic criteria for the assessment of wildfire risk in the pan-European region[108] have recently been developed. Additionally, countries in the EU have already established protocols for the sharing of resources under the Union Civil Protection Mechanism[109], which will be further strengthened by forthcoming EU legislation.[110]

When firefighting action is required, it is vital to ensure that resources are efficiently mobilized. While individual countries and regions should have resource-sharing arrangements in place to deploy workers and equipment where and when they are needed, international aid has been increasingly required to deal with emergency wildfire situations. Therefore, it is important to have mutual agreements in place across nations affected by forest fires such that international aid can be exchanged. Advance planning of possible actions in case of fire is crucial.

The conditions for the occurrence, spread and control of wildfires differ greatly among the Arctic States and Observer States. In countries with large poorly accessible forest areas, prevention and fire-fighting are difficult compared with countries in which access to forests is facilitated through networks of roads. The growth of inhabitation at the wildland urban interface has created problems for fire prevention as well as for wildfire suppression efforts. All share the need for effective protection of especially inhabited regions and also means to prevent and contain wildfires.

Continued research and development among Arctic countries will aid in wildfire risk assessment

108 San-Miguel-Ayanz et al. 2018. Basic criteria to assess wildfire risk at the Pan-European level. EUR 29500 EN, ISBN 978-92-79-98200-2, doi:10.2760/052345.

109 Decision No 1313/2013/EU of the European Parliament and of the Council of 17 December 2013 on a Union Civil Protection Mechanism Text with EEA relevance, OJ L 347, 20.12.2013, p. 924–947

110 European Commission, 2017. Communication from the Commission to the European Parliament, the Council and the Committee of the Regions: Strengthening EU Disaster Management: rescEU Solidarity and Responsibility, COM(2017) 773 final.

and management. For example, the development of Arctic meteorological cooperation and novel systems of remote sensing such as LiDAR (Light Detection and Ranging), offer possibilities for both risk assessment and fire control.

Recommendations for action 2019

The recommendations are presented as a set of options to be considered in designing national and subnational policies, taking into account specific circumstances and needs.

Recommendation 6a: Build and maintain international mutual aid and resource exchange arrangements amongst Arctic nations that have specialized experience in wildfire management, suppression, and monitoring in boreal forests.

Recommendation 6b: Develop region-specific public education campaigns on wildfire prevention and safety.

Recommendation 6c: Develop and implement regionally appropriate forest management practices that reduce the risk of severe wildfires.

Recommendation 6d: Use the best available science to develop prediction models that can be used to examine fire risks at daily to decadal scales to support drafting of prevention and emergency response plans.

Future progress

The black carbon inventories and biennial reports on black carbon and methane are important for implementing the Framework endorsed by Arctic States.

The work of the Expert Group remains relevant, and there are many strategic and policy-relevant directions that future work may take. For instance, there are still significant uncertainties with respect to the emissions and especially the projections of emissions until 2025 and beyond. Additional work to improve the data that is used to track progress and to justify further actions is one option for future work. Such work could be undertaken in cooperation with AMAP and their work on short-lived climate pollutants. In addition, there are opportunities to more systematically document the policies and measures and their immediate effects on the actions that cause or reduce emissions of black carbon and methane. Of particular interest are the incentives and actions that support the emergence of innovations and commercially viable solutions that achieve both emission reductions and transformations of current business models in, for example, energy production, transport, domestic heating or agriculture and animal husbandry.

The mutual learning between the Arctic States and Observer States provides opportunities for significant and rapid progress in reducing emissions, which ultimately may lead to greater reductions of emissions than the currently endorsed goals. Further, while policy action in certain sectors is well-developed, less is known about some other emissions sources, and there remains ample opportunity for enhanced action on emissions from these (i.e. wildfires and enteric fermentation). In addition to the sections described in the Framework for Enhanced Action on Black Carbon and Methane, future editions of the Summary of Progress and Recommendations could involve a focus on such sources, including in-depth discussion of the state of knowledge, the relative importance of the source, and the opportunities and impediments to mitigation.

The economic aspects of the emissions reductions have been identified as a major topic of interest. The work initiated with the OECD will contribute to further discussions on finding cost-efficient solutions and to the consequences of inaction. By highlighting regional aspects, the work will provide a base for further reflection on how to best achieve emission reductions that at the same time also provide short- and medium-term economic benefits.

Wild fires and open biomass burning have received increasing attention in the past two years. They are important from the point of view of health, resource management and emergency preparedness and response, in addition to their contributors of black carbon emissions. The complexity of the issues means that the actions to deal with wildfires and other open biomass burning should be carried out as a joint effort supported by several Arctic Council working groups and a broad range of experts.

The work of the Expert Group has shown that there is still a need to strengthen also the basic knowledge of black carbon and methane emissions. This is best done in co-operation with other international organizations working on related matters. The Convention on Long-Range Transboundary Air Pollution is of particular significance.

The Expert Group should also in the future continue to follow widely used guidelines and comprehensive methodologies, when developing black carbon inventories and projections. A continuous dialogue should be maintained with the work under the Convention on Long-Range Transboundary Air Pollution to propagate best practices for black carbon inventories, including the specification of source categories. The Expert Group should also follow closely the discussions in the IPCC on methodology for estimating short lived climate pollutants.

Appendix 1

Mobile and stationary diesel-powered sources

Table A1: Status of recommended actions 2017 related to the reduction of emissions from diesel engines

Actions to reduce emissions from new diesel vehicles and engines[111]

COUNTRY	STATUS
Canada	• On-Road Vehicle and Engine Emission Regulations • Off-Road Compression-Ignition Engine Emission Regulations • Off-Road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations (in development) • Sulphur in Diesel Fuel Regulations
Kingdom of Denmark	Denmark has participated actively in the EU work on setting standards for emissions for on-road vehicles and non-road mobile machinery. The most efficient action on diesel engines to reduce diesel soot has been setting an EU-wide particle number (PN) emission limit. These are in force for many on-road vehicles and for non-road engines from 2019. From 2020 the Government proposes to strengthen the zones. When fully implemented only Euro 6 diesel truck, busses and vans will be allowed or the vehicle has to be fitted with a particulate filter. That will further reduce the particulate exhaust with 25 % in 2022. For older diesel passenger cars the scrap premium will be doubled.
Finland	Finland has adopted and implemented the most recent EURO-regulation and their amendments for light passenger and commercial vehicles, heavy duty vehicles, off-road vehicles and machinery. The amounts of sulphur in gasoline and diesel have been limited to 10 mg/liter (1206/2010) and 0.1 weight-% for ship traffic on Baltic Sea control area.

111 2017 Recommended Action 1a: *Reduce emissions from new diesel vehicles and engines, by adopting and implementing world-class particulate matter exhaust emission standards and ensuring wide-spread availability of ultra-low sulphur fuels.*

Iceland	CO_2-neutral in 2050 action plan: Iceland´s government has put together an action plan to become CO_2-neutral by 2050. There, one of the aims is to reduce emissions from transport of 35% before 2030 (compared to 2005 levels). Additionally, there is a target of a 45% reduction of emissions from off-road transport compared to 2005 levels. This will lead to reduced use of fossil fuels and therefore reduce both BC and CH_4 emissions. Also, Iceland has implemented COPERT, the EU standard vehicle emissions calculator, to improve emission estimates and calculations for black carbon and methane emissions from the transport sector – which is the main source of black carbon in Iceland. Iceland has adopted and implemented relevant Directives of the European Parliament and of the Council; Directive 2004/107/EC and 2008/50/EC on ambient air quality and cleaner air for Europe. Also, work is underway by the Icelandic government to evaluate and incorporate the new National Emissions Ceiling Directive (2016/2284) into the EEA agreement. It is expected that the implementation of the Directive will lead to reduced PM emissions and thereby, reduced BC emissions. In Iceland the sulphur content of fuel is limited in both ships and vehicles on land according to the fuel quality directive and the sulphur directive. Only fuels that meet the requirements set in those directives are put on the market. Low sulphur gas fuel oil is the most imported type of ship fuel in Iceland. Finally, Iceland has adopted carbon tax system that applies to all liquid and gaseous fossil fuels.
Norway	Norway has adopted and implemented relevant Directives of the European Parliament and of the Council; Directive 2004/107/EC and 2008/50/EC on ambient air quality and cleaner air for Europe as the most significant. In addition, set out national goals for NO_2, PM_{10}, SO_2 and benzene. This national goal provides an even more ambitious target standard than the obligations derived from the Directives. The Norwegian Government has decided to put forward an action plan for fossil-free construction sites in the transport sector. Norway aims for a rapid transition to electric mobility towards zero emission standard. Norway provides user incentives, including substantial tax breaks, free parking, access to bus lanes in urban areas, and exemptions from road tolls and car ferry charges. The sale of electric vehicles has increased considerably over the last six years. In recent years, emissions have decreased causing a gradual and substantial improvement of the air quality in Norway
Russian Federation	Specific information not submitted
Sweden	Sweden has implemented the Euro 6 standards for passenger cars, light duty vehicles and heavy-duty vehicles. Standards are continuously tightened as for example RED-requirements are implemented. For working machinery step 5 will be implemented from January 1st 2019 for almost all categories. Engines in stock may be sold under a transition period of 2 years.

USA	In the United States, stringent PM emissions standards for new mobile source engines are being phased in across different sectors between 2007 and 2020. In most cases, the most stringent standards result in the use of DPFs on new engines. In the United States, regulations require the use of ultra-low sulphur diesel (ULSD) fuel (15 ppm sulphur) in diesel engines.
EU	Real Driving Emissions regulatory acts: 4 acts have been decided to ensure real driving emission tests of new vehicles as well as of vehicles in circulation. New regulation of non-road mobile machineries (September 2016), which defines emission limits for Non-Road Mobile Machinery engines for different power ranges and applications. It also lays down the procedures engine manufacturers have to follow in order to obtain type-approval of their engines – which is a prerequisite for placing their engines on the EU market.

Actions to reduce emissions from legacy diesel vehicles and engines[112]

COUNTRY	STATUS
Canada	• Sulphur in Diesel Fuel Regulations • Metro Vancouver Non-Road Diesel Engine Emission Regulation Bylaw • Shore Power Technology for Ports Program • Pan-Canadian Approach to Pricing Carbon Pollution • Pan-Canadian Framework on Clean Growth and Climate Change • Clean Fuel Standard • Provincial-Territorial Pan-Canadian Task Force on Reducing Diesel Use on Off-Grid Communities • Clean Energy for Rural and Remote Communities Program (NRCan) ◦ Bioheat, Demonstration & Deployment Program StreamCapacity Building Stream
Kingdom of Denmark	The existing vehicle fleet is regulated by low emission zones, which target heavy duty vehicles not fitted with a particle filter. Those have been in force since 2008 in Denmark. In 2014, 300 busses, in Copenhagen were fitted with both particulate filter and NOx-after treatment systems. We have also additional yearly tax for all light duty vehicles not fitted with a particulate filter. With the new climate and air proposal "Together for a greener future", the Government proposes the following: —Phase out the sale of new petrol and diesel cars in 2030. —Zero carbon emissions and zero air pollution from busses in Denmark's cities by 2030.—Clean air in big cities through stricter environmental zones.
Finland	Finland has introduced two scrappage scheme (2015 and 2018) to promote the renewal of the passenger car fleet and adoption of alternative fuels and electric vehicles.

112 2017 Recommended Action 1b: *Reduce emissions from legacy diesel vehicles and engines by adopting targeted policies and programs*

Iceland	CO_2-neutral in 2050 action plan: Iceland´s government has put together an action plan to become CO_2-neutral by 2050. There, one of the aims is to reduce emissions from transport of 35% before 2030 (compared to 2005 levels). Additionally, there is a target of a 45% reduction of emissions from off-road transport compared to 2005 levels. This will lead to reduced use of fossil fuels and therefore reduce both BC and CH_4 emissions. Also, Iceland has implemented COPERT, the EU standard vehicle emissions calculator, to improve emission estimates and calculations for black carbon and methane emissions from the transport sector – which is the main source of black carbon in Iceland. Iceland has implemented a national air quality action plan which is set forth to promote air quality and a healthy environment in Iceland by reducing ambient air pollution concentrations. The main objectives are to decrease yearly premature deaths attributable to $PM_{2.5}$ as well as to reduce daily exceedances of traffic related PM10. These actions inevitably reduce emissions from BC. The fuel quality directive is implemented in Iceland which has limits on the sulphur content of diesel fuel. Concentrations of parameters in the directive are measured every year in imported fuel and results are reported.
Norway	From 2018 cash payment was introduced for scrapping motorcycles, mopeds, campers and caravans. Scrapyards gets operational support for receiving these vehicles. There is already cash payment in place for scrapping recreational boats and passenger cars.
Russian Federation	Specific information not submitted
Sweden	Regional public transport agencies are eligible to apply for an electrical bus premium as of 30 July 2016 (SFS2016:836). The size of the premium depends on the number of passengers and whether the bus runs on electricity only or is a hybrid. In total, SEK 330 million has been allocated for 2016-2019. A bonus-malus–system for the purchase of new light vehicles came into effect 1 July 2018. Vehicles with low emissions of carbon dioxide qualify for a bonus at purchase, while vehicles with high emissions of carbon dioxide are taxed at a higher rate for the first three years. The system replaced the tax exemption for environmentally friendly vehicles and super-green car rebate. Individual municipalities have the right to restrict traffic in areas with poor air quality. From 2018 this applies to both heavy traffic, light duty vehicles and passenger cars. The Congestion Tax Act (2004:629) introduced congestion tax in order to reduce traffic during peak hours and thus improve air quality. The law is designed so that it can be applied in urban areas throughout Sweden. Heavy traffic is charged with a toll under the Tolls for Certain Heavy Vehicles act (1997:1137). The size of the toll is partly based on the vehicle's emissions class. The Swedish Transport Administration and the metropolitan municipalities of Gothenburg, Stockholm and Malmö jointly apply procurement requirements on fuel, age, exhaust emissions and emission control on equipment such as lorries and other non-road mobile machinery.

USA	The National Clean Diesel Campaign (NCDC) and the SmartWay Transport Partnership Program are the U.S. EPA's two primary programs responsible for reducing emissions from in-use, legacy diesel vehicles and equipment. These programs support the testing and deployment of numerous technologies and strategies to reduce emissions, including black carbon, from in-use diesel engines and can provide immediate reductions. The NCDC administers the DERA grant and rebate programs, which is the only Federal government program addressing these legacy engines (model year 2007 and older) as its sole mission to reduce in-use emissions.

Actions related to the reduction of black carbon by alternative vehicle technologies, modes of transportation and increase efficiency[113]

COUNTRY	STATUS
Canada	• SmartWay Transport Partnership • Commitment to develop a Canada-wide strategy to promote the deployment of zero-emission vehicles. • Commitment to invest in alternative fuel transportation hubs and ports • Sustainable Transportation Strategy (Nova Scotia) • Drive Electric Program (Quebec) • Joined the International Zero Emission Vehicle Alliance (British Columbia and Quebec) • Transportation Electrification Action Plan (Quebec) • The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area (Ontario) • GreenTRiP (Alberta) • Ecocamionnage program (Quebec) • Light Duty vehicles GHG emissions standards for the light duty vehicle model years 2011-2025. Heavy duty vehicles GHG emissions standards for the heavy duty vehicle model years 2014-2018 and 2021-2027 and trailers
Kingdom of Denmark	Energy efficient and low emission vehicles are promoted through incentives in the taxation of vehicles (see Chapter 4.3.3.1.2 in Denmark's 7th National Communication under the UNFCCC: https://unfccc.int/sites/default/files/resource/8057126_Denmark-NC7-BR3-2-NC7-DNK-Denmarks-NC7-and-BR3_1January2018-12MB.pdf) With the new climate and air proposal "Together for a greener future", the Government also takes steps towards a Denmark where the air is clean, and where we will eventually reduce our negative climate impact to zero. The proposal includes: - From 2020, all new busses must be climate friendly powered by e.g. electricity, hydrogen, biogas or biofuels. -From 2030, city busses and taxis may not be powered by fossil fuels, but by e.g. electricity or hydrogen. - Stop on the sale of new petrol and diesel cars in 2030, and plug-in hybrid cars in 2035
Finland	Government programs and strategies aim at steady increase of the share of biofuels and electric cars. A number of measures are in force to encourage people to buy as energy efficient and environmental friendly vehicles as possible: taxation (2018), scrappage scheme (2018) and lowered parking fees and allowing the use of bus lanes (city level decision). Finland also has a compulsory training on economic driving style in driving schools. In addition, Finland has taken measures to increase the use of public transport and encourage of walking and cycling at the city and municipal levels. Finally, promotes MaaS (Mobility as a Service) approach

113 2017 Recommended Action 1c: *Reduce black carbon by stimulating the shift to alternative vehicle technologies and modes of transportation, and through transportation efficiency measures*

Iceland	Energy efficient and low emission vehicles are promoted through incentives in the taxation of vehicles. Governmental support of public transport and construction of bike and walking paths. In June 2012 the Icelandic Parliament passed a new law on climate change (Act No 70/2012). The objectives of the Act are the following: - To reduce greenhouse gas emissions efficiently and effectively, - To increase carbon sequestration from the atmosphere, - To promote mitigation to the consequences of climate change, and - To create conditions for the government fulfil its international obligations regarding climate change. CO_2-neutral in 2050 action plan: Iceland´s government has put together an action plan to become CO_2-neutral by 2050. There, one of the aims is to reduce emissions from transport of 35% before 2030 (compared to 2005 levels). This will lead to reduced use of fossil fuels and therefore reduce both BC and CH_4 emissions.
Norway	The Norwegian government puts emphasis on policies to achieve a decarbonised transport sector. Especially taxes and fiscal incentives are important to incentivize consumers to choose electric vehicles. In 2018, 31.2 per cent of new passenger cars were zero emission vehicles. A third of all car ferries are expected to be electric by 2022, much thanks to requirements in public procurement processes. These policies do not put requirements in diesel or diesel engines per se, but have great effects as they limit the use of diesel. Before the summer of 2019, the government will present an action plan for fossil free public transport by 2025, an action plan for green shipping and an action plan for infrastructure for alternative fuels in the transport sector. The strategy to ensure a rapid transition to electric mobility also includes several efforts to improve charging infrastructure. The Norwegian Ministry for Transport and Communication is working on an updated plan of action for the provision of infrastructure for so called alternative fuels – which includes electricity and hydrogen. The Norwegian Government is working on an action plan for making public transport fossil-free by 2025.
Russian Federation	Specific information not submitted
Sweden	To decrease emissions incurred by commuting and transportation, the Swedish Parliament allocated 395 million SEK for 2018 to subsidize the cost of electric vehicles such as electric bicycles, motorbikes and mopeds. A new “Charge at home” support scheme was introduced in the beginning of 2018. Through the scheme private individuals have been able to apply for financial support up to 50% of the cost of installing electric car charging stations. The Climate Leap supports charging stations for electrical vehicles in tenants and has granted support to over 3200 projects including ca 30 000 charging points for plug-in electric vehicles.
USA	In addition to the U.S. EPA programs to reduce emissions from existing vehicles, the U.S. Department of Transportation has several programs that help to reduce emissions. These include funding for projects that reduce air emissions of criteria pollutants, such as PM, through the Congestion Mitigation and Air Quality Program, as well as overall efforts to improve system efficiency, strengthen transportation planning, and encourage low emissions transportation choices.

EU	3 mobility packages in 2017-18, including focus on clean mobility and connected & automated mobility. Clean mobility measures are focusing on alternative fuels, new technologies and smart road charging. EU collaborates with Gwich'in Council International as part of the external stakeholder group for the Arctic Sustainable Energy Futures Toolkit and sharing Guidelines for Sustainable Action Plans under the Covenant of Mayors initiative.

Actions to accelerate efforts under the International Maritime Organization to mitigate black carbon from international shipping[114]

COUNTRY	STATUS
Canada	• Providing expert technical support, policy advice and emissions testing expertise relating to air pollutant and greenhouse gas emissions from ships, as well as input relating to fugitive VOCs from tankers (ECCC) • Led the correspondence group on development of reporting protocol for voluntary measurement studies to collect black carbon data (Transport Canada) • Leading the correspondence group on investigation of appropriate control measures to reduce the impact on the Arctic of black carbon emissions from international shipping (Transport Canada)
Kingdom of Denmark	Denmark has participated actively in the work in IMO on black carbon. We have contributed by collecting information from Danish companies on technical measures to reduce black carbon and passed the information on to the technical sub-committee. Further, the Danish Eco-innovation program (MUDP) has co-financed projects aiming at reduction and measurement of black carbon from ships.
Finland	Finland is following closely the IMO's work on black carbon emissions from shipping in the Arctic and has contributed to IMO's sixth PPR meeting held in February 2019 (PPR 6/INF.15 and PPR 6/7/2) by providing research-based information on measurement methods as well as influence of fuel and engine characteristics on black carbon emissions.
Iceland	Iceland has adopted and implemented relevant Directives of the European Parliament and of the Council; Directive 2004/107/EC and 2008/50/EC on ambient air quality and cleaner air for Europe. Also, Iceland will enforce the coming ban on ships using fuels that have sulphur content above 0,5% from the 1st of January 2020 which is expected to positively affect the emission of black carbon.
Norway	Norway works actively at IMO to get regulations in place. Norway chairs the Sub-Committee on Pollution Prevention and Response (PPR) which has the following responsibilities regarding black carbon: i) develop a definition for Black Carbon emissions from international shipping; (completed) ii) consider measurement methods for Black Carbon and identify the most appropriate method for measuring Black Carbon emissions from international shipping; and (completed) iii) investigate appropriate control measures to reduce the impact of Black Carbon emissions from international shipping. (not completed).
Russian Federation	Specific information not submitted

114 2017 Recommended Action 1d: *Work to accelerate efforts under the International Maritime Organization to mitigate black carbon from international shipping*

Sweden	Sweden works internationally within the IMO for a global regulatory framework to promote innovative solutions and technology development, such as purification filters, which can reduce the emissions of BC. Furthermore, Sweden is working to ensure that the IMO will enforce the ban on ships using fuel that has a sulphur content of 0.5 percent or higher from the 1th of January 2020. The lower sulphur content in the fuel is expected to have a positive effect on the emissions of BC.
USA	The U.S. has participated in IMO correspondence groups working to evaluate alternative black carbon monitoring methodologies and emission control measures that might be appropriate for maritime users.
EU	Submission to IMO subcommittee Pollution Prevention and Response 5 on efficient enforcement practices and strategies for compliance with the 0,50% Sulphur requirements from 2020 that also will reduce BC emissions.

Oil and gas

Table A2: Status of the recommended actions 2017 to reduce emissions from on oil and gas production

Actions to adopt and implement oil and gas methane emission reduction strategies[115]

COUNTRY	STATUS
Norway	Emissions to air from the Norwegian offshore and onshore oil and gas sector are regulated through several acts; the Pollution Control Act and The Greenhouse Gas Emission Trading Act, the CO_2 Tax Act (offshore) and the Sales Tax Act. Pursuant to the Pollution Control Act, a number of special regulations have been issued. Specific emission limit values are set on a case to case basis in individual permits, based on best available techniques (BAT) as defined nationally or in the EU. In addition local factors are taken into account when the emission limits are set (Ambient air quality guidelines). BAT is defined in the EU Directive 2010/75/EU on industrial emissions, Article 1 and Annex I and III (hereinafter the IE Directive).
Russian Federation	Specific information not submitted
USA	In May of 2016, U.S. EPA finalized three rules that together addressed methane, VOC, and other air pollution emissions from new, reconstructed and modified oil and gas sources. On September 11, 2018, EPA proposed targeted improvements to the 2016 New Source Performance Standards for the oil and gas industry that streamline implementation, reduce duplicative EPA and state requirements, and significantly decrease unnecessary burdens on domestic energy producers.
Canada	• Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector) – this will reduce methane emissions from the oil and gas sector by 40-45% below 2012 levels by 2025, • Natural Resources Canada research and technology development roadmap to address wellbore leakage • Regulatory measures and financial incentives to reduce venting and flaring (Alberta, Saskatchewan and British Columbia) • Oil and Gas Commission Flaring Venting and Reduction Guideline (British Columbia) • Climate Leadership Plan, including a target to reduce methane emissions from new oil and gas extraction and processing by 45% by 2025 (British Columbia) • Clean Infrastructure Royalty Credit Program (British Columbia) • Goal to cut methane emissions by 45% from oil and gas by 2025 (Alberta)
Kingdom of Denmark	Denmark's oil and gas methane emission reduction strategy is embedded in Denmark's climate change mitigation policies. Oil and gas methane emissions are included in Denmark's non-ETS greenhouse gas emissions regulated under the EU Effort Sharing Directive in 2013-2020 and under the EU Effort Sharing Regulation in 2021-2030.

115 2017 Recommended Action 2a: *Adopt and implement oil and gas methane emission reduction strategies*

Actions related to reducing flaring[116]

COUNTRY	STATUS
Norway	Flaring of natural gas is only permitted when necessary for safety reasons.
Russian Federation	Specific information not submitted
USA	Specific information not submitted
Kingdom of Denmark	Methane emissions from oil and gas production in the Danish part of the North sea are minimised as venting of methane is not acceptable during normal operations on manned platforms and as offshore flaring is minimized through a series of actions such as pipelines for a large majority of the oil and gas produced, focus on limiting unnecessary flaring in permits for oil and gas infrastructure expansions and through the ongoing supervision of oil and gas production. In an international context flaring in the Danish part of the North Sea is considered to be at a low level. In 2017, Denmark endorsed the World Bank's Zero Routine Flaring by 2030 initiative.
Canada	• Endorsed the World Bank's Zero Routine Flaring by 2030 initiative • Regulatory measures and financial incentives to reduce venting and flaring (Alberta, Saskatchewan and British Columbia) • Oil and Gas Commission Flaring Venting and Reduction Guideline (British Columbia) • Eliminated associated gas flaring in 2010 (British Columbia) • Carbon tax applied to flared gas (British Columbia)

116 2017 Recommended Action 2b: *Develop implementation plans for the Zero Routine Flaring by 2030 Initiative and report on progress and best practices to the Arctic Council*

Actions urging firms to engage in multilateral fora and domestic programs promoting voluntary methane and black carbon emission reductions[117]

COUNTRY	STATUS
Norway	Firms operating offshore Norway are encouraged to engage in such fora and programs. Examples of such important programs and forums are the Climate and Clean Air Coalition, the Global Methane Initiative, Global Gas Flaring Reduction
Russian Federation	Specific information not submitted
Denmark	Oil and gas production firms active in the Danish part of the North Sea have in the past been encouraged to engage in activities promoting energy efficiency and emission reductions. Reiteration could be considered.
USA	The Natural Gas STAR Program is a flexible, voluntary partnership that encourages oil and natural gas companies—both domestically and abroad—to adopt cost-effective technologies and practices that improve operational efficiency and reduce emissions of methane. These voluntary activities include nearly 50 technologies and practices and have resulted in domestic methane emissions reductions of over 25 MMT CO_2e in 2015. These methane emissions reductions have cross-cutting benefits on domestic energy supply, industrial efficiency, revenue generation, and greenhouse gas emissions reductions. The 2015 emission reductions are equivalent to the additional revenue of approximately $160 million in natural gas sales. U.S. EPA launched an expanded voluntary effort, the Natural Gas STAR Methane Challenge, in 2016. The Methane Challenge program provides incentives and opportunities for partner companies to undertake and be recognized for ambitious voluntary methane emission reductions, principally from existing methane sources.
Canada	Specific information not submitted

117 2017 Recommended Action 2c: *Urge firms to engage in multilateral fora and domestic programs aimed at promoting voluntary methane and black carbon emission reductions*

Residential combustion

Table A3: Status of the recommended actions to reduce emissions from residential combustion

Actions to reduce emissions from new biomass combustion appliances[118]

COUNTRY	STATUS
Canada	• CCME Code of Practice for Residential Wood Burning Appliances • CCME Model Municipal By-law for Regulating Wood Burning Appliances • Guideline for operating wood-burning appliances (Nunavut) • Measures to control emissions from wood-burning appliances in provinces and municipalities across Canada, including regulatory measures (emissions standards, certification requirements, operation and maintenance requirements, no burn days/ advisories, prohibition of wood burning appliances, and wood burning by-laws) and non-regulatory measures • The city of Montreal has introduced new standards for stoves and fireplaces. From 2018 they must emit less than 2.5 g $PM_{2.5}$ per hour and must not be used on days with really high PM.
Kingdom of Denmark	In 2008 Denmark adopted performance standards for new wood-burning stoves, limiting emissions of PM to 10 g/kg. The performance standards have been revised in 2015 and 2017, where Denmark adopted new performance standards for new wood-burning stoves, limiting emissions of PM to 55 g/kg in 2015 and 4 g/kg in 2017. Throughout several heating seasons, DEPA has conducted a series of nationwide information campaigns on proper wood burning. Most recent with the campaign ”Quit Smoking for Wood Stoves”. Denmark has got unique data on wood burning combustion plants. In 2017 the Danish EPA agreed with the Danish National Chimney Sweeper Organization, that they systematically gathered their data from all the country from all 150 ’chimney sweep districts’. Data is received for 97% of all districts. These 1:1 data will allow more precise emission inventory of particles, to target scrapping schemes etc.
Finland	The implementation of The European Union’s Ecodesign directive will start in 2020 (boilers)[119] / 2022 (stoves)[120].
Iceland	Since Iceland relies largely on its renewable energy sources, fuel use for residential heating is low. Residential heating with electricity is subsidized and occurs in areas far from public heat plants.
Norway	Some cities like Oslo and Bergen already have exchange programs and give subsidies to residents who exchange their old wood stoves. Lately more cities take part in the exchange program and more money (Bergen funds 50 mill. NOK) has become available from the counties. Burn right campaigns are being organised all over the country in cooperation with the fire brigade. In Bergen, the city government has announced a ban on using old wood stoves starting in 2021.

118 2017 Recommended Action 3a: *Reduce emissions from new biomass combustion appliances by accelerating deployment of cleaner and more efficient new heating sources when installing or reinstalling appliances and promoting proper operation and maintenance.*

119 EU regulation 2009/125/EC for boilers

120 EU regulation 2009/125/EC for stoves

Russian Federation	Specific information not submitted
Sweden	In 2018 some eco-design requirements for boilers[121] (PM, OGC and CO) and room heaters[122] (CO) were introduced.
USA	In the United States, EPA's Burn Wise Program provides free best burn practices educational tools (Wet Wood is a Waste brochure) to their various partners including state governments, chimney sweepers, wood stove manufacturers and retail stores to help reach wood burning appliance operators. US EPA also encourages stove operators use wood moisture meters to enhance their ability to achieve optimal stove operation.
Germany	In 2010 the German government amended the order regarding small and medium combustion appliances (Verordnung über kleine und mittlere Feuerungsanlagen) [123]. For new appliances emissions limits are stricter than the Eco-design regulation.

121 EU regulation 2015/1189 for solid fuel boilers

122 EU regulation 2015/1185 for solid fuel local space heaters

123 https://www.gesetze-im-internet.de/bimschv_1_2010/BJNR003800010.html

Actions to reduce emissions from legacy biomass combustion appliances[124]

COUNTRY	STATUS
Canada	Change-out programs are available in several Canadian jurisdictions; British Colombia, Nova Scotia, New Brunswick and Ontario.
Kingdom of Denmark	Successful scrapping 20,000 inefficient wood stoves within the first 2 years of a EUR 6.5 million scrapping schemes for old wood stoves. Households with woodstoves from 1990 or earlier were eligible to receive EUR 300 for scrapping the stove. In addition to the incentive, the government engaged chimney sweepers to serve as a trusted interlocutor with households, and deterred the sale of old stoves in the second-hand market by applying emissions standards to both new and second-hand stoves (provided in a statutory order for woodstoves from 2008, https://www.retsinformation.dk/Forms/R0710.aspx?id=105319). A new scrapping scheme (about 7 million EUR) has been decided to be implemented in 2019-2020. Households with woodstoves from 1994 or earlier can receive EUR 300 for scrapping the stove.
Finland	The Act on the Protection of Public Health 763/1994 (Sections 27 and 51) authorizes municipalities to regulate the use of stoves or even prohibit it, and the use of solid fuels in specific areas. Multiple information campaigns aimed to raise people's awareness about emissions and impacts of small-scale combustion and to guide people towards right stove operation and wood storage and as a result reduce the emissions, including black carbon.
Iceland	Wood burning for household heating is very limited in Iceland. Iceland relies largely on its renewable energy sources, therefore fuel use for residential heating is low. Residential heating with electricity is subsidized and occurs in areas far from public heat plants.
Norway	Enova (a government mandated support program) has support schemes. ENOVA SF is owned by the Norwegian Ministry of Climate and Environment and makes financial contributions so that individuals and businesses can start using the newest and most climate friendly technologies. They have programs for energy efficiency, including enhanced home heating efficiency. n the city of Oslo residents can apply for grants from the city's climate and energy fund to replace old stoves. The grant is NOK 3 000 in central areas of the city where air pollution is worst. In other areas the grant is NOK 1 500. In the period 1998-2010, a total of NOK 16 million was granted for the replacement of 5862 stoves.[125]
Russian Federation	Specific information not submitted
Sweden	Municipalities are able to, on the basis of the ordinance (1998:899) on environmentally hazardous activities and health protection, issue regulations for a "temporary ban on small-scale wood burning with some solid fuels in the specified areas. In November 2017, the Swedish Environmental Protection Agency and the Swedish Energy Agency launched an information campaign regarding energy-efficient wood burning techniques. A goal of the campaign is to reduce black carbon emissions since household wood burning is one of the primary sources of black carbon emissions.

124 2017 Recommended Action 3b: R*educe emissions from legacy (i.e., old technology) biomass combustion appliances by accelerating replacement with cleaner and more efficient new heating sources and promoting proper stove operation and maintenance*.

125 Measures to reduce emissions of Short-Lives Climate Pollutants in the Nordic countries

USA	EPA's Burn Wise Program provides free best burn practices educational tools (Wet Wood is a Waste brochure) to their various partners including state governments, chimney sweepers, wood stove manufacturers and retail stores to help reach wood burning appliance operators. US EPA also encourages stove operators use wood moisture meters to enhance their ability to achieve optimal stove operation. Based on feedback from experts at U.S. EPA, experience from a range of U.S. state programs suggests that providing 30 percent of the entire project cost is a good starting point to incentivize replacement, unless the program focuses on lower income households, in which case incentives near full replacement cost are needed. EPA has published a guide for successfully implementing a wood stove changeout program.[126] In Oregon, the law requires removal and destruction of uncertified (i.e., not EPA-certified) wood stoves and fireplace inserts when a home is sold. This has resulted in over 3,600 stoves being removed from homes.
Germany	In 2010 the German government amended the order regarding small and medium combustion appliances (Verordnung über kleine und mittlere Feuerungsanlagen) [127]. To reduce emissions from existing appliances they must comply with emission limits for PM and CO. The transition period after which the emission limits come into force for existing installations depend on the age of the appliance. The chimney sweeper monitors that the appliance complies with the limits every second year by measurements during operation. If the appliance does not comply with the emissions limits it must be retrofitted or shut down. To comply with the new emission limits owners of space heaters must show a certificate from the manufacturer to the chimney sweeper.
Poland	The city of Krakow adopted an anti-smog resolution in 2016. As of January 1st, 2019, a ban on burning of solid fuel in boilers and space heaters is introduced. The city of Krakow offered a subsidy up to 100% between 2013-2016, 80% in 2017 and 60% in 2018. Additional subsidies are available to the poorest households with compensation given for higher fuel cost of cleaner fuels as a part of the social care system.[128]
EU	LIFE Programme funded project in Malopolska region of Poland, focusing on reducing air pollution from combustion of solid fuels in obsolete household boilers (http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5440). Peer-to-peer workshop on policies and measures to reduce pollution from domestic solid fuel combustion (http://ec.europa.eu/environment/eir/p2p/index_en.htm).

Actions to reduce emissions by promoting enhanced home heating efficiency[129]

COUNTRY	STATUS
Canada	• EnerGuide energy efficiency home evaluations • Canada's Buildings Strategy
Kingdom of Denmark	Several policies and measures are implemented to improve heating efficiency in the residential sector in Denmark (see Chapter 4.3.5.1.10 in Denmark's 7th National Communication under the UNFCCC: https://unfccc.int/sites/default/files/resource/8057126_Denmark-NC7-BR3-2-NC7-DNK-Denmarks-NC7-and-BR3_1January2018-12MB.pdf).

126 https://www.epa.gov/sites/production/files/2015-08/documents/howtoimplementawoodstovechangeout.pdf

127 https://www.gesetze-im-internet.de/bimschv_1_2010/BJNR003800010.html

128 https://www.unece.org/index.php?id=45535

129 2017 Recommended Action 3c: *Reduce emissions by promoting enhanced home heating efficiency for residential dwellings, especially those heated with biomass.*

Finland	Several policies and measures are implemented to improve heating efficiency: Renewed Building regulations (2012) http://www.ym.fi/fi-fi/maankaytto_ja_rakentaminen/lainsaadanto_ja_ohjeet/rakentamismaarayskokoelma Ministry of the Environment Decree (4/13) on improving the energy performance of buildings undergoing renovation or alteration. Information dissemination and campaigns targeted to residents and other users of buildings.
Iceland	Iceland relies largely on its renewable energy sources, therefore fuel use for residential heating is low. Residential heating with electricity is subsidized and occurs in areas far from public heat plants.
Norway	ENOVA SF is owned by the Norwegian Ministry of Climate and Environment and makes financial contributions so that individuals and businesses can start using the newest and most climate friendly technologies. They have programs for energy efficiency, including enhanced home heating efficiency. In June 2018 the Norwegian Government adopted a ban on the use of mineral oil for heating of buildings from 2020. The ban covers the use of mineral oil for both main heating or additional heating in residential buildings, public buildings and commercial buildings. The purpose of the ban is to reduce greenhouse gas emissions from the buildings sector and is estimated to reduce at least 340 000 tonnes of CO_2 each year in the period 2016 - 2035. Schemes to support households to phase out the use of mineral oil for heating of buildings have been in place for several years.
Russian Federation	Specific information not submitted
Sweden	The building regulation sets overall requirements for energy efficiency to limit the use of energy by low energy losses, low demand for energy for heating and cooling and effective use of electricity. Requirements are expressed as maximum specific energy use.
USA	Many U.S. states and the federal government offer tax incentives for improving home energy efficiency. The Department of Energy maintains a website where consumers can search for relevant savings: https://www.energy.gov/savings/search.
EU	Revised Energy Performance of Buildings Directive, June 2018, focusing on long-term renovation strategies, aiming at decarbonising the national building stocks by 2050. Existing directive already set the target that all new buildings from 2021 should be nearly zero-energy buildings. (https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings)

Solid waste disposal

Table A4: Status of the recommended actions 2017 to reduce emissions from solid waste treatment

Actions to avoid methane emissions by preventing the landfilling of organic waste[130]

COUNTRY	STATUS
Canada	Technical document on municipal solid waste organics processing Commitment to reduce food waste in Canada by 50% Consultations on strategies to reduce avoidable food waste, increase organics diversion, and increase recycling and reuse Commitment to develop a national food policy Provincial and municipal recycling programs Solid Waste Resource Management Regulations (Nova Scotia)
Kingdom of Denmark	The waste sector's contribution to the direct reduction of greenhouse gas emissions consists mainly in: • banning the landfilling of organic waste (since 1997), • utilising gas from closed as well as existing landfills, • optimising the oxidation of gas in landfill covers (biocovers), • recovery of shredder waste from landfills. On the top of this there are measures that indirectly reduce greenhouse gas emissions: • increasing recycling of plastic-, paper-, cardboard-metal-, WEEE-, wood-, and glass-waste, that will substitute primary production of materials • using waste (except for plastics) as an energy source in dedicated incineration plants • digestion of organic waste to produce biogas. Further information is available from Chapter4.3.9 in Denmark's 7th National Communication under the UNFCCC (https://unfccc.int/sites/default/files/resource/8057126_Denmark-NC7-BR3-2-NC7-DNK-Denmarks-NC7-and-BR3_1January2018-12MB.pdf).
Finland	The government decree on landfills (331/2013) prohibits the disposal of organic waste to landfills from 2016 onwards. This has increased incineration as a way to handle biodegradable waste. In 2016, two new waste handling facilities were put into service. The plants use mechanical (the other also biological) handling to pretreat waste flows in order to secure safe and high-quality recycling and restrict organic waste ending up to landfills.
Iceland	Numerical targets have been set to encourage the reduction of landfilling of biodegradable waste, in accordance with the EC Landfill Directive (1999/31/EC). At the same time, numerical targets have also been set to increase the recovery and recycling of waste, which in part is biodegradable waste.
Norway	Landfilling of food waste and garden waste was prohibited from 2002. From 2009 a ban on landfilling of all biodegradable waste with a content of more than 10 percent total organic carbon was imposed.

130 2017 Recommended Action 4a. *Avoid methane emissions by preventing the landfilling of organic waste.*

Russian Federation	Specific information not submitted
Sweden	Under the Ordinance on Landfilling of Waste, a ban on landfilling of combustible materials was introduced in 2002, and a similar ban was imposed on organic material in 2005. The ordinance also regulates the collection and disposal of methane gas from landfills. In 2000 a tax was imposed on waste disposed in landfills. The tax started at 250 SEK per tons of landfilled waste, and by 2015 had increased to 500 SEK per ton of landfilled waste. The Climate Leap is a green investment program that has supported new facilities to convert biodegradable waste or manure to biogas.
USA	Working with U.S. Department of Agriculture and partners in the states and tribes, U.S. EPA plans to secure action on the 2030 food loss and waste reduction goal by working with leaders in the food system (e.g., private, government, nonprofit, academia, faith) to promote action and bring more successful interventions and tools to advance the sustainable management of food. EPA launched a Call to Action by Stakeholders page, which identifies current opportunities and challenges in reducing food loss and waste in the United States. EPA will continue to help facilitate discussion by co-hosting summits where leaders in various sectors can exchange ideas and identify needed actions, provide leadership and technical assistance, conduct outreach and share information, develop new tools, and celebrate the successes of stakeholders.
EU	Circular Economy Package, May 2018 is setting recycling targets for all EU member states and decides that by 2035 landfilling should maximum be 10 % of the total municipal waste generation (http://europa.eu/rapid/press-release_IP-18-3846_en.htm)

Actions adopting regulations or incentives for landfill gas capture and control[131]

COUNTRY	STATUS
Canada	• Gas Tax Fund • Green Infrastructure Fund • Green Municipal Fund • EcoAction Community Funding Program • Solid Waste Resource Management Regulations (Nova Scotia) • Specified Gas Emitters Regulation (Alberta) • Prescribed Landfills Regulation (Manitoba) • Landfilling Sites Regulation (Ontario) • Landfill Gas Management Regulation (British Columbia) • Landfill Gas Regulation (Quebec)

131 2017 Recommended Action 4b: *Adopt regulations or incentives for landfill gas capture and control*

Kingdom of Denmark	Methane emissions from Danish landfills are reduced by: • utilising gas from closed as well as existing landfills, • optimising the oxidation of gas in landfill covers (biocovers). Further information is available from Chapter 4.3.9 in Denmark's 7th National Communication under the UNFCCC (https://unfccc.int/sites/default/files/resource/8057126_Denmark-NC7-BR3-2-NC7-DNK-Denmarks-NC7-and-BR3_1January2018-12MB.pdf).
Finland	The EU Landfill directive (1999/31/EC) regulates use and characteristics of a landfill site. Methane relevant part is Annex I sect. 4, requiring all landfills receiving biodegradable waste to collect gas. The document "Guidance on landfill gas control" was accepted in 2013. While not binding, the guidance helps authorities and operators in their effort of effective methane collection.
Iceland	Landfill operators are obliged to collect the landfill gas permeating from landfills accepting biodegradable waste, in accordance with the EC Landfill Directive (1999/31/EC).
Norway	The Landfill Directive was incorporated into national law in 2002 in the waste regulation. All landfills with biodegradable waste must have a system for extracting landfill gas. The gas must be utilized or flared if utilization is not economically viable. The County Governors follow up the landfills by monitoring and compliance control.
Russian Federation	Specific information not submitted
Sweden	The EC Landfill Directive requires that the landfilling of biodegradable waste be reduced and for methane to be collected from landfills. Sweden has introduced more far reaching national instruments than those required under the directive, resulting in earlier attained emissions reductions.
USA	In 2016, U.S. EPA finalized two rules updating both the U.S. EPA's 1996 New Source Performance Standards for new and modified landfills and the 1996 guidelines for existing landfills in order to reduce emissions of methane-rich landfill gas. In 2017, the agency announced that several issues in these rules would be reconsidered in consultation with states and stakeholders. The U.S. EPA's Landfill Methane Outreach Program (LMOP) reduces methane emissions at MSW landfills by supporting the voluntary recovery and use of landfill gas for energy. LMOP focuses its efforts on smaller landfills that are not required to collect their landfill gas, as well as larger landfills that collect their gas but flare it rather than use it as an energy source. As of 2016, there were 648 operational landfill gas energy projects in the United States, of which LMOP assisted more than 550. In 2016, the program's efforts reduced methane emissions from landfills and avoided CO_2 emissions totaling approximately 42.5 MMT CO_2e. Nearly 650 LMOP-assisted landfill gas energy projects have collectively reduced and avoided over 427 MMT CO_2e since the program began in 1994.

Appendix 2

Black carbon emission data

Table A2.1: Inventories and projections of black carbon emissions as reported by Arctic States in 2015 and 2017 national reports or 2018 CLRTAP national submissions (kt/year). All numbers in this table were rounded to two significant figures: as a result, totals may not sum exactly. Any nation that did not report projected emissions will have emissions in 2025 equal to their emissions in 2013.

	2013	2014	2015	2016	Change (%) in 2016 compared with 2013	Projection 2025	Change (%) in 2025 compared with 2013
Canada	43	41	38	35	-18 %	31	-28 %
Denmark	4.8	4.3	4.3	4.2	-12 %	2.9	-40 %
Finland	5.0	4.9	4.5	4.7	-6.0 %	4.0	-19 %
Iceland	0.23	0.21	0.20	0.20	- 13 %	0.16	-30%
Norway	3.8	3.4	3.2	3.2	-16 %	2.6	-31 %
Russian Federation	360*	NE	NE	NE		NE	
Arctic Zone of the Russian Federation (not included in the Total)	29*						
Sweden	3.4	3.2	2.9	2.9	-16 %	2.1	-39 %
US**	310	260	NE	NE	-16 %	160	-48 %
Total	730	NE	NE	NE		NE	
Total without Russian Federation	370	320	320	320	-16%	200	-46%

NE = Not Estimated

* Russian data from the 2015 national report;

** US emissions in the 2013 column are from the 2015 Summary of Progress and Recommendations and represent 2011 emissions. Emissions reported here do not include prescribed burning or wildfire emissions. The 2025 projection is from the 2015 national report

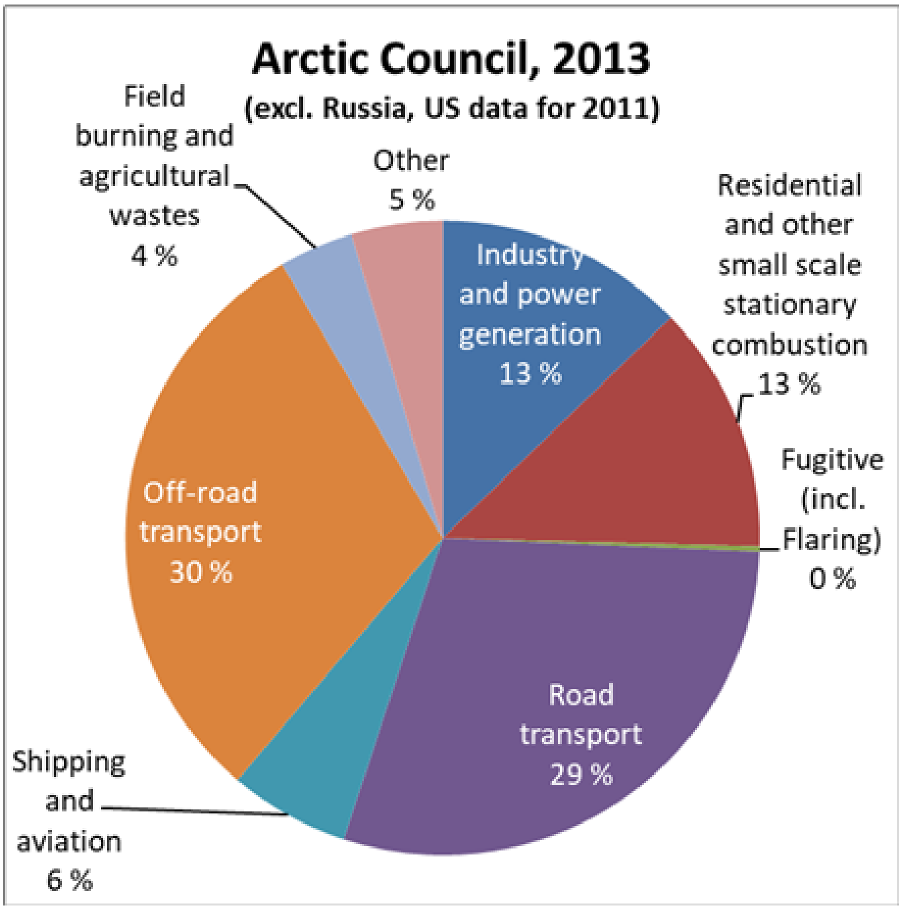
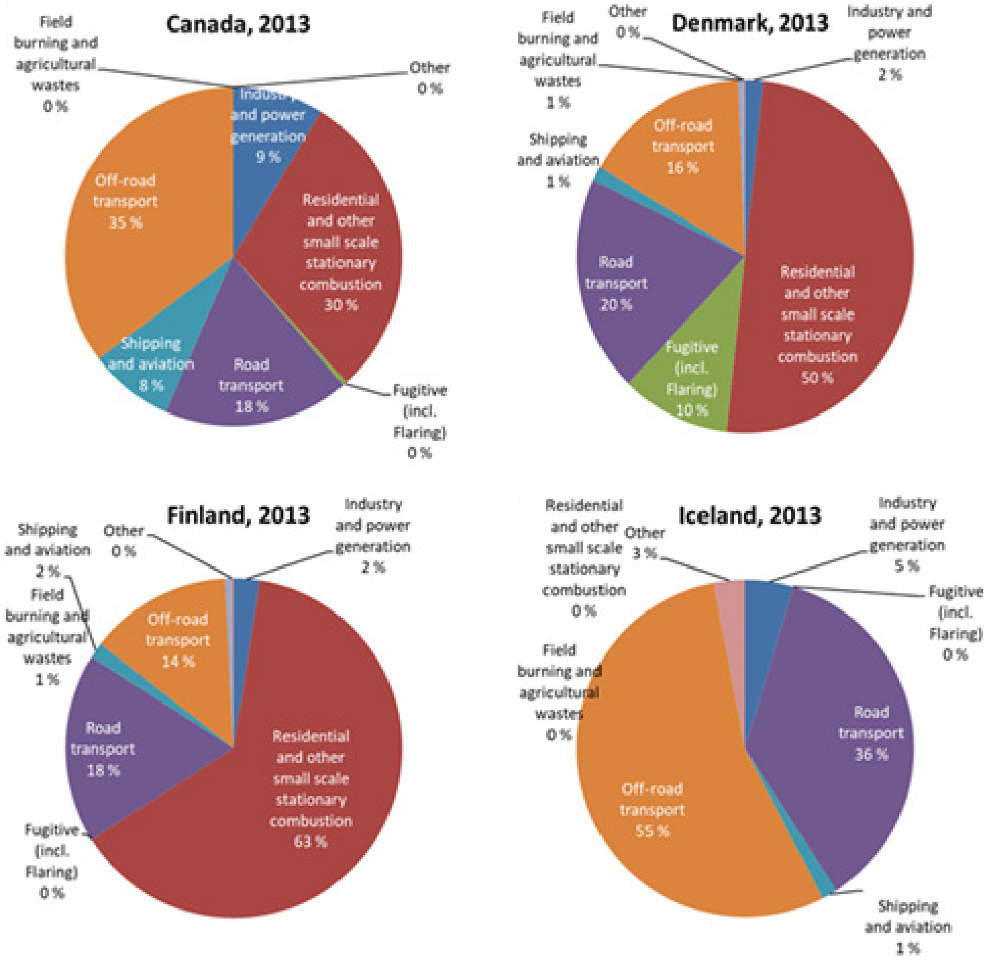


Figure A2.2: Black Carbon emissions in the Arctic Council in 2013 by main sectors



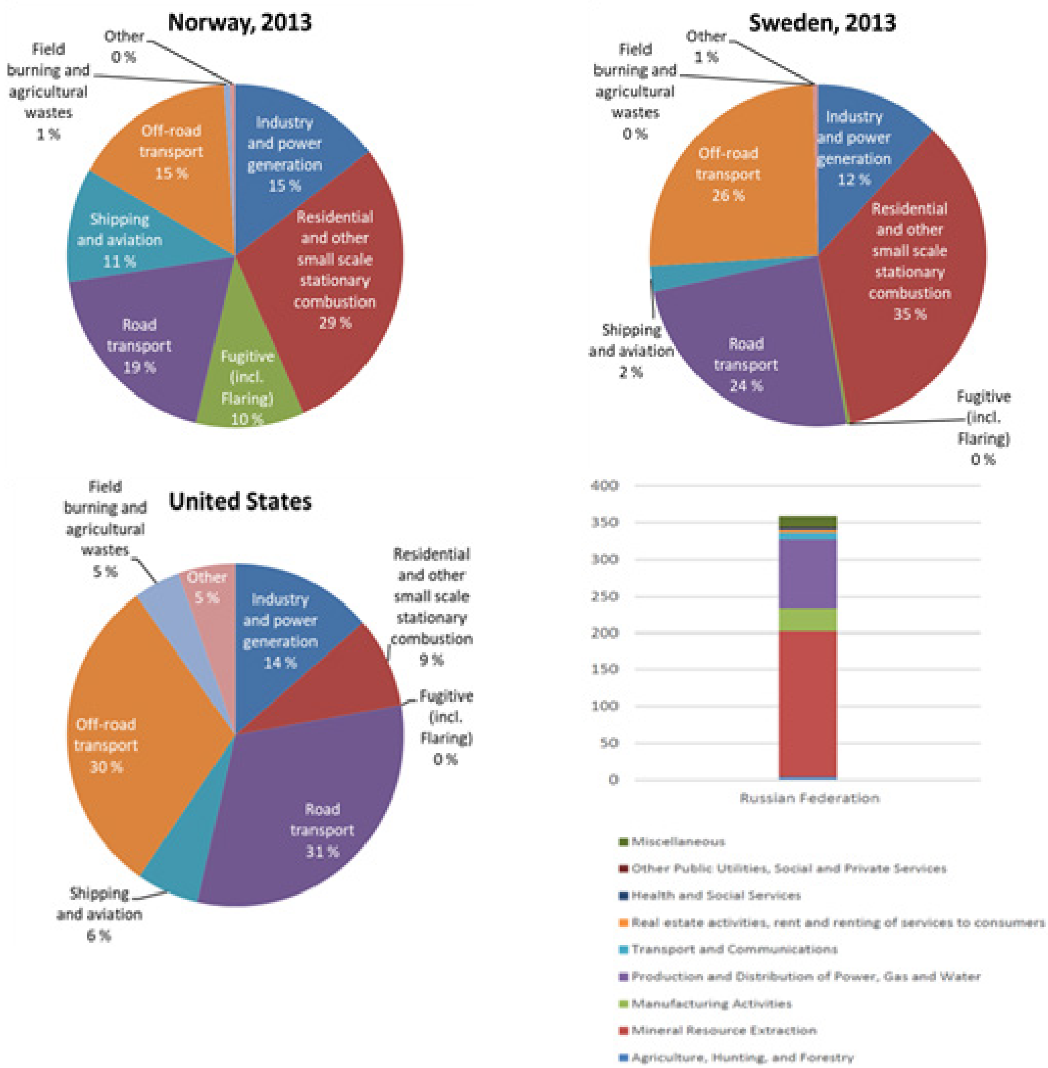


Figure from Expert Group on Black Carbon and Methane (2017). Summary of Progress and Recommendations.

Figure A2.3: Black Carbon emissions in the Arctic States in 2013 by main sectors

Table A2.2: Black carbon emissions in 2013-2016 and available projections of Observer States according to the 2017 national reports or 2018 CLRTAP national submissions (kt/year). All numbers in this table were rounded to two significant figures: as a result, totals may not sum exactly. Any nation that did not report projected emissions will have emissions in 2025 equal to their emissions in 2013

	2013	2014	2015	2016	Decrease vs latest year (%)	2025	Decrease (%)
France	39	34	32	31	-20%	NE	
Germany	17	16	15	14	-17%	9.0	-50 %
Italy	26	24	24	23	-12%	NE	
Japan*	17	NE	NE	NE		NE	
Netherlands	4.1	3.7	3.4	3.2	-21%	NE	
Poland	21	20	20	21	+0.53%	NE	
Spain	39	38	37	36	-6.0%	NE	
South Korea**	13	NE	NE	NE		NE	
Switzer-land***	1.3	1.1	1.2	1.1	-17%	0.88	-32%
United King-dom***	21	19	19	18	-13%	NE	
Total	200	190	180	180	-10%		

NE = not estimated.

* 2012 emission data

** 2014 emission data

*** 2025 emission projection according to the WM scenario

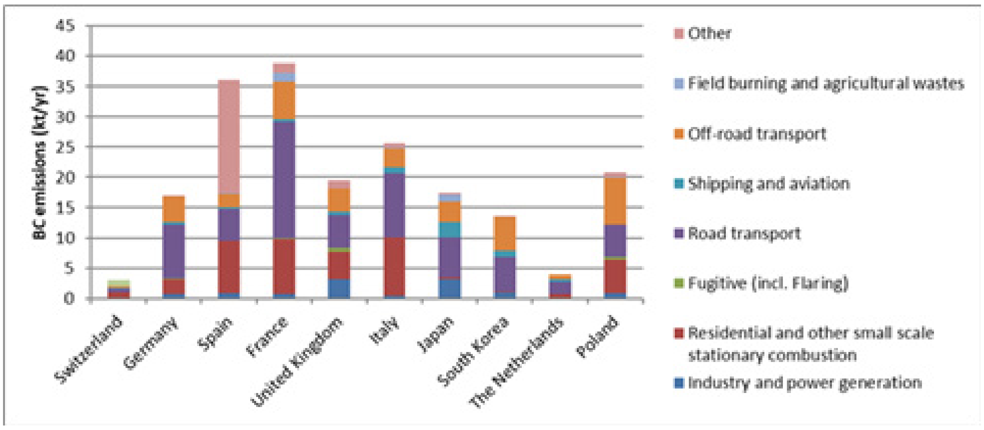
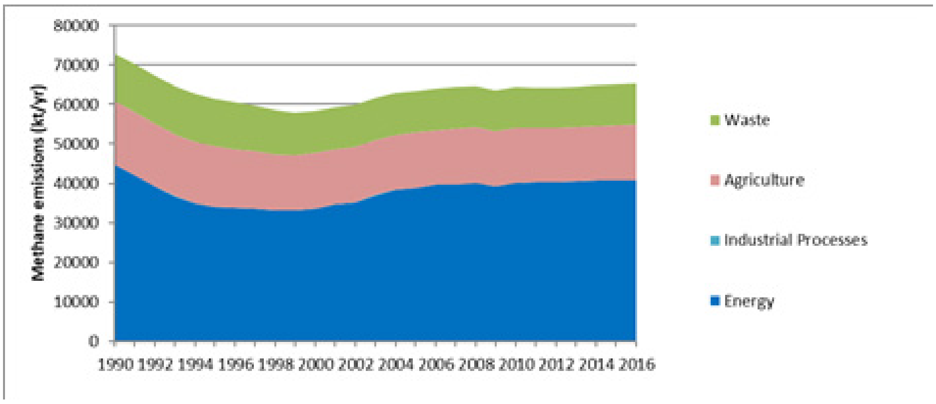


Figure A2.4: Black Carbon emissions in the Arctic Council Observer States in 2013 by main sectors

Methane emission data

A



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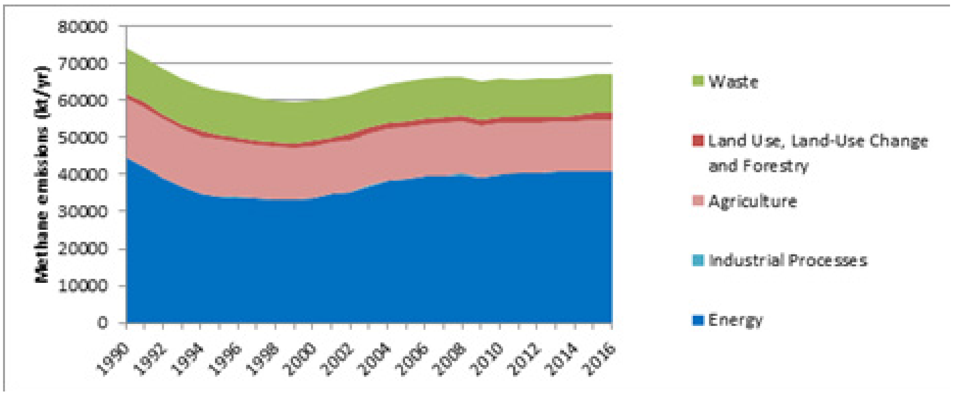
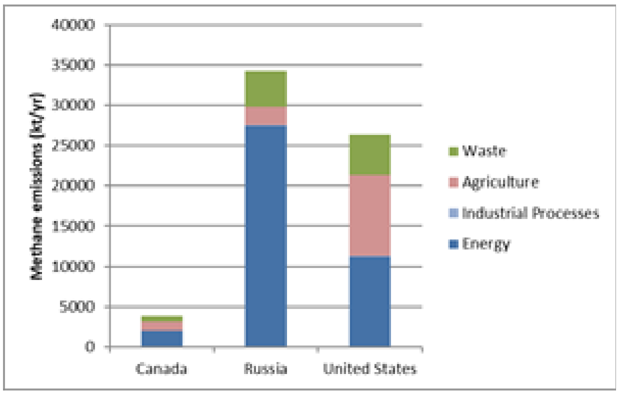


Figure A2.5: Methane emissions (A) without and (B) with LULUCF in the Arctic Council in by main sectors between 1990 and 2016



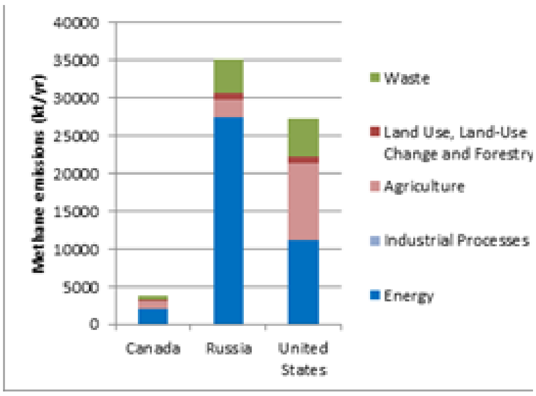


Figure A2.6: Methane emissions without (left) and with (right) LULUCF in Canada, Russia and the United States in 2016 by main sectors

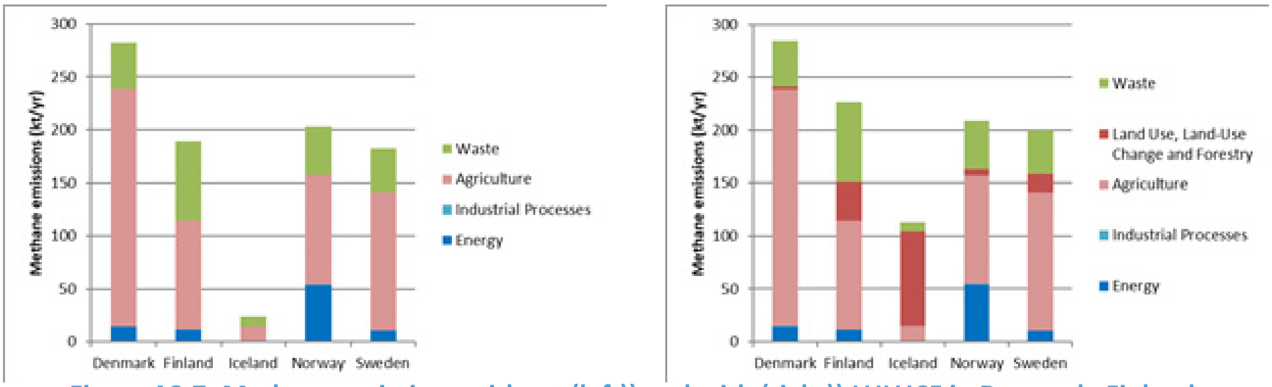


Figure A2.7: Methane emissions without (left)) and with (right)) LULUCF in Denmark, Finland, Iceland, Norway and Sweden in 2016 by main sectors

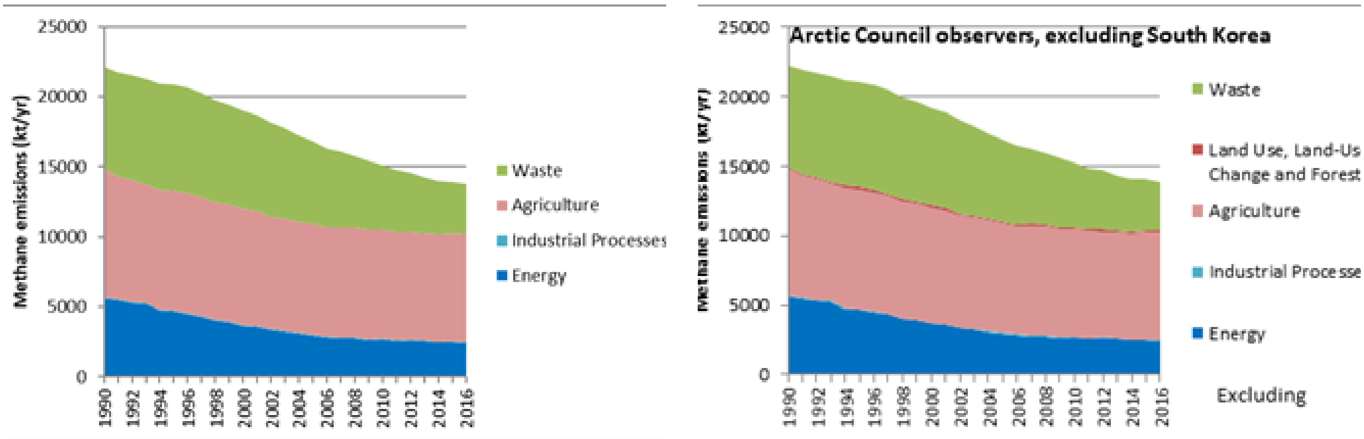


Figure A2.8: Methane emissions without (left) and with (right) LULUCF in the Arctic Council observers, excluding South-Korea, between 1990 and 2016 by main sectors

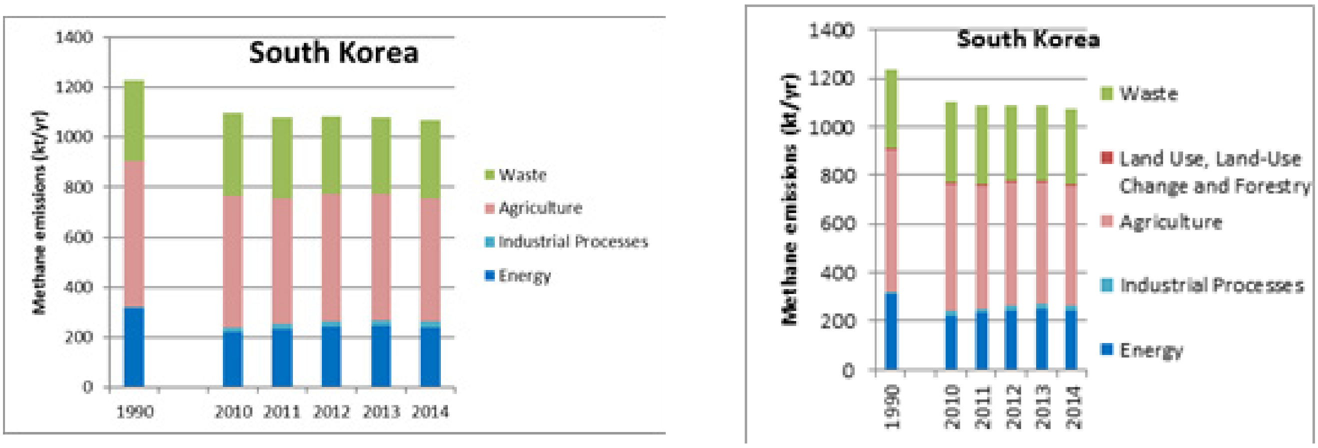
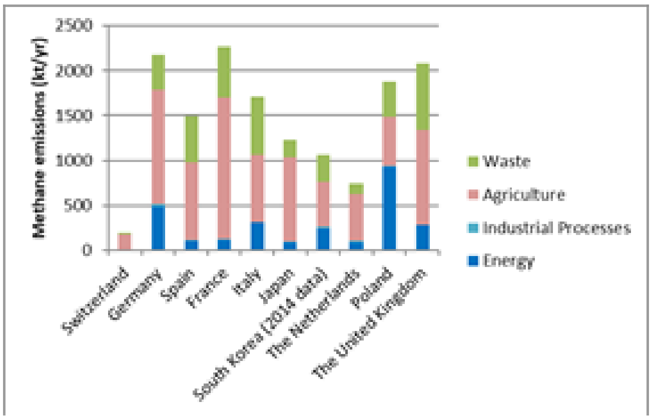


Figure A2.9: Methane emissions without (left) and with (right) LULUCF in South-Korea, between 1990 and 2014 by main sectors



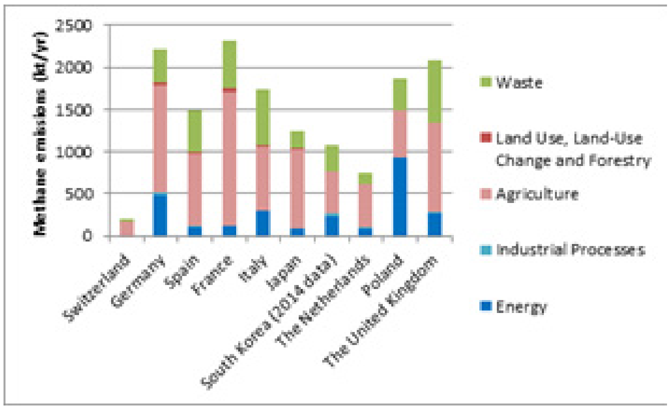


Figure A2.10: Methane emissions without (left) and with (right) LULUCF in the Arctic Council observers in 2016 by main sectors

Follow-up of the recommendations for improving the technical basis of the Expert Group work:

Recommendation A1: Follow Convention on Long-Range Transboundary Air Pollution guidelines, or comparable methodology, when developing black carbon inventories and projections.

During the 2017-2019 period, the Expert Group received black carbon emission data from 7 Arctic Council countries and 10 Observer States. The Expert Group is pleased to note that there has been a substantial increase in the number of submissions of black carbon emission data since the first reporting period.

Recommendation A2: Maintain a continuous dialogue with the work under the Convention on Long-Range Transboundary Air Pollution to propagate best practices for black carbon inventories

The dialogue with the CLRTAP Centre for Emission Inventories and Projections (CEIP) has been maintained, partly thanks to the support from the European Union's Action on Black Carbon. This work is expected to provide information on current gaps and possibilities to improve the emission inventories. The dialogue will be maintained with a view to further improve data quality and strengthen knowledge exchange between the CLRTAP and the Arctic Council countries.

Appendix 3

National actions, national action plans, or mitigation strategies contributing to the reduction of methane and other greenhouse gas (GHG) emissions from agriculture and animal husbandry

Country	National mitigation measures
Canada	Canada's agricultural and agri-food sector programs: • Canadian Agricultural Partnership, a $3 billion policy framework for agriculture launched in April 2018, aims to advance innovation in the agriculture sector, reduce greenhouse gas (GHG) emissions, and help producers adapt to climate • Agricultural Greenhouse Gases Program, where a third of the funded projects are addressing methane emissions from livestock systems. • Agricultural Clean Technology Program which supports research, development and adoption of agricultural clean technologies in the areas of precision agriculture and bioproducts, including sensors for automated feed distribution and biodigesters. Provincial efforts to optimize environmental practices: • Prince Edward Island is employing the use of robotics in dairy farming and food additives in livestock production to reduce methane emissions. • Quebec's Programme Prime Vert aims to help farmers protect the environment by supporting the capture, destruction or recycling of methane from manure pits and providing project funding to promote GHG emissions reductions in the agricultural sector.
Finland	The Ministry of Agriculture and Forestry has prepared a climate programme in 2014 (MMM, 2014) that presents a list of actions aimed to guide the agriculture sector to reduce its greenhouse gas emissions, ao. CH_4. The programme points out dietary changes for milk cows as an additional potential measure. The Common Agricultural Policy (CAP) of the EU with the Rural Development Programme 2014 to 2020 supports several measures for climate change mitigation including more efficient handling, storage and use of manure. There is also a support system for investments in renewable energy, for example, in biogas plants The Climate Programme for agriculture of 2014 includes specific actions to mitigate the climate change. Research projects to reduce emissions include studies to develop estimation methods of cattle feeding and the feeding of dairy cows. Finland also contributes EU-research projects aiming at mitigation measures by improved knowledge on effects of feeding, manure management, rumen microbiota and participates in Nordic co-operation in cattle breeding aiming improving feed efficiency

Norway	• A main goal is to reduce the climate and environmental impact per unit of different goods produced. • Research is conducted on emissions from livestock production, in order to create a better foundation for emission mitigation measures. • Funding is provided for research work relating to the reduction of methane emissions both enteric and soil sources. • 15 million NOK was set aside in 2017 to fund a genetic research project aimed at breeding cows with reduced methane production. Other projects include feed-composition research to reduce enteric methane.
Denmark	• An increasing share of the manure is expected to be treated in biogas plants or acidified during storage in the future - leading to a decrease in CH_4 emissions from manure. • In order to stimulate expansion of the biogas sector the subsidy on the sales price of electricity production based on biogas was adjusted by the Energy Policy Agreement of 22 March 2012. The Energy Policy Agreement continued funding biogas for combined heat and power (CHP) and introduced subsidy equality so that biogas sold to the natural gas grid would receive the same subsidy as biogas used at CHP plants. In addition the agreement also introduced a new subsidy when biogas is used in industrial processes, as a fuel for transport or for the production of heat. • As part of the Danish Rural Development Programme 2007-2013, financial aid has been provided to investments in biogas plants in 2010 and in 2012. In 2012 support was awarded to both new and existing biogas plants to the amount of DKK 262 million. Consequently, the latest projection from the Danish Energy Agency expects an increase in biogas production from 3.9 PJ in 2007 to 13.8 PJ in 2020 from agricultural sources – i.e. the major part of total production of 15.4 PJ from all biogas plants (WEM2017). With this, a five to six fold in-crease in the volume of manure used for biogas generation before 2020 is expected. The biogas production is expected to result in a reduction of the annual emissions of methane and CO_2 by approximately 0.9 million tonnes of CO_2 equivalents by 2020 including the reduced CO_2 emissions from substitution of fossil fuels, primarily natural gas. Reduction in the emission of nitrous oxide is not included in this figure. The expected effect was re-estimated in September 2016 by DCE under Aarhus University. • The 1st allocation of the budget under the National Green Climate Fund in June 2017 included an earmarking of 9,0 million DKK for developing solutions in existing biogas plants and associated suppliers of feedstock with a view to reduce the retention time of manure. This is expected to increase the production of biogas per unit input of manure while at the same time reducing emissions of methane. • With the Energy Agreement from June 2018 it was agreed to earmark DKK 240 million annually over a 20-year period to expand the use of biogas and other green gasses; these funds will be used for upgrades, transport and industrial processes. The funding will be implemented during the period 2021-2023 and will help to ensure the continued expansion and improved efficiency of this technology in Denmark. These funds will likely be allocated through tenders with price ceilings. The procurement model will be developed in dialogue with the industry. An additional 5.4m DKK will be allocated for a bioenergy task force in 2019-2021, whose areas of focus will include potential efficiency improvements in biogas and sustainability in various forms of bioenergy, including biogas from wastewater. A portion of this funding will be earmarked for organic biogas. • With the Climate and Air Proposal from October 2018 the following additional measures have been proposed by the government:

	◦ "C21: Improvement of biogas plants. There are good greenhouse gas gains to be achieved by stopping leaks in biogas plants. It will require efforts to propagate technologies and procedures that can reduce emissions. In cooperation with the biogas industry, the government therefore initiates a targeted effort to reduce methane emissions from Danish biogas plants. The total reduction effect of this initiative over the period 2021-2030 is estimated at approximately 1.1 million tonnes CO_2 equivalents (accumulated annual reductions)." and ◦ "C30: Strategy for development of the natural gas system. Under the Energy Agreement, the Government will formulate a gas strategy that will provide the necessary basis for a market-based and commercially-utilized gas system. The strategy should, inter alia, explore the potential of biogas and other green gases, thus contributing to a climate-neutral Denmark by 2050 at the latest.
Sweden	In January 2015, the Government introduced a support scheme for biogas production through anaerobic digestion of manure. The support, which is in place between 2015 and 2023, aims to increase biogas production from manure and thereby gain two-fold environmental and climate benefits through reduced methane emissions from manure and the substitution of fossil energy. The biogas generated can be used to generate electricity or heat, or as vehicle fuel. The subsidy amounts to a maximum of 0.40 SEK/kWh of biogas produced. Between January 2015 and September 2016, a total amount of SEK 69 million was shared among 51 biogas plants (Swedish Board of Agriculture 2017). The Local Climate Investment Program has supported biogas production from manure. By January 2019 about 10 plants had received support for biogas from manure that when in full production will produce 300 000 MWh of biogas.

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