Socio-Economic Analysis of Air Pollution and Climate Forcer Emission Reductions in the Arctic Council Member States

An EU-funded ABC-iCAP Project Policy Brief

This policy brief was prepared as one of the deliverables under the project Arctic Black Carbon impacting on Climate and Air Pollution (ABC-iCAP), funded by the European Union.

We have assessed the population health, climate and economic benefits with a scenario where the Arctic Council member states invest in maximum technically feasible emission-control measures for air pollutants and short-lived climate forcers during the coming decades.

We have also included a sustainable development transition scenario with phase-down of fossil fuels, approximately in line with the 2 °C global warming target set by the Paris Agreement.

The views expressed in this policy brief are the responsibility of its authors and do not necessarily reflect the views of their affiliated agencies or countries.

This policy brief is available also in Russian. In case of any discrepancies, the English version constitutes the original text.

Abbreviations

SLCF: Short lived climate forcers
CLE: Current legislation
MFR: Maximum technically feasible emission reductions
MFR&SD: Maximum technically feasible emission reductions & sustainable development

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Key results

- Investments in maximum technically feasible emission reduction techniques and simultaneous phasedown of the use of fossil fuels result in substantial socio-economic health and climate benefits.

- The emission sectors with the largest climate impacts, as well as climate change mitigation potentials, are power and heating plants, transports, industries, and residential combustion.

- Investments in maximum technically feasible emission reductions for air pollutants and methane without substantial reductions in the use of fossil fuels is insufficient as a climate mitigation option.

- With phasedown of fossil fuels, as represented by the maximum technical feasible emission reduction and sustainable developement (MFR&SD) transition scenario, the global surface temperature impact from climate forcers emissions by 2050 could be reduced by 49-58 percent, 10-30 years after the emissions have occurred.

- Benefits from mitigation measures are unevenly distributed between countries.

- The socio-economic analysis likely underestimates the full climate and health impacts of air pollutants and climate forcers and the related economic costs.

Policy recommendations

To reach the MFR&SD scenario, approximately in line with the 2 °C global warming target set by the Paris Agreement:

- The Arctic Council member states need to take the lead in rapidly phasing down the use of fossil fuels in all sectors, as this is a prerequisite for effective climate mitigation.

- Arctic Council member states need to implement all necessary air pollutants and short-lived climate forcers emission regulations.

We suggest that:

- More sectors and climate forcers could be considered for inclusion in the EU emission trading system.

- The scope of climate border adjustments should expand to include more commodities.

- Arctic Council member states should investigate how emissions from wildfires can be included in national climate emission reporting and assess how new policy measures can reduce those emissions.

- The US and Canada should consider introducing national emission trading systems as soon as possible and align them to the EU emission trading system.

Introduction

Investigating the benefits of action

In 2023, 6.8 percent of the global population - 540 million people - were living in the Arctic Council member states.

At the same time, they were responsible for approximately 30 percent of the global production of fossil fuels - oil, gas, coal - and 20 percent of the global energy related climate forcers emissions.

The yearly production of fossil fuels in the Arctic Council member states is planned to continue to increase, at least until 2030.

The fossil fuel production sector is also a major source of the potent climate forcers methane and black carbon. The methane is released into the atmosphere from venting and unintended leakage of associated petroleum gas (APG) while black carbon is formed when the APG is flared.

In December 2023, at the COP28 meeting in Dubai, the United States committed to reduce their emissions of methane from the oil and gas production sector with 80 percent until 2030. Also at COP28, Canada proposed regulations seeking to implement a new target to cut methane emission from oil and gas industry by at least 75 percent of 2012 levels by 2030. While the COP28, for the first time ever, resulted in an agreement to transition away from fossil fuels, no binding agreements have been taken on how to reduce the production of fossil fuels.

The MFR&SDS scenario is not ambitious enough to keep global warming at or below 1.5°C

In ABC-iCAP we have investigated the benefits of implementing maximum technically feasible emission-control measures for air pollutants and short-lived climate forcers (SLCF) during the coming decades.

We have also included a sustainable development transition scenario (MFR&SD) with phasedown of fossil fuels approximately in line with the 2 °C global warming target set by the Paris Agreement.

Based on the results we provide policy recommendations. According to the MFR&SD scenario, the Arctic Council member states' net CO_2,eq emissions will decrease by 26 percent in 2030 and 52 percent in 2050, compared to year 2020, and by 27 percent and 53 percent compared to year 2010.

The methane emissions from the fuel production and distribution sector in Canada and US, which accounted for approximately 50 percent of the total anthropogenic methane emissions from these countries in 2020, will be reduced with 45 percent until 2030 and with 59 percent until 2050 in the MFR&SD scenario.

It can be noted that that the MFR&SD scenario is not ambitious enough to keep global warming at or below 1.5°C – as called for in the Paris Agreement. This will require that the global CO_2,eq emissions are reduced by 45 percent from 2010 levels already in 2030, and that net zero emissions are reached in 2050. Nor it is in line with the year 2050 net zero CO_2 eq emission target set by Canada, United States and the European Union.

Socio-economic analysis

It's beneficial to rapidly phase down fossil fuel use

Our analysis demonstrates that it is socio-economically beneficial for the Arctic Council member states to invest in the best available technology to reduce air pollutants and climate forcers in combination with a phasedown of fossil fuels.

Investments in maximum technically feasible emission reduction techniques result in substantial socio-economic health benefits (Fig. 1).

Implementation of the MFR&SD scenario in the Arctic Council member states would reduce the number of premature deaths by 70 000 - 130 000 cases in the world by 2030 and 85 000 - 180 000 cases by 2050, compared to the CLE scenario.

The estimated range in absolute number of saved lives primarily reflects the different exposure response functions applied by the different model systems. The number of saved lives is greatest in Russia and US, which have the largest populations of the Arctic Council member states.

Investments in maximum technically feasible emission reductions (MFR) for air pollutants and methane without substantial reductions in the use of fossil fuels is insufficient as a climate mitigation option. This is seen when comparing the climate impacts of the projected emissions in the CLE and MFR scenarios.

Implementation of the MFR scenario, in Arctic Council member states, is estimated to result in a 3.2-7.0 percent reduction in the global surface temperature impact from climate forcers emissions by 2050, 10-30 years after the emissions occurred (Fig. 3A).

However, with phasedown of fossil fuels, as represented by the MFR&SD scenario, the global surface temperature impact from climate forcers emissions in year 2050 could be reduced by as much as 49-58 percent, 10-30 years after the emissions have occurred (Fig. 3B).

Although we only considered the social costs for four climate damage sectors, the estimated net socio-economic climate benefits of the phasedown of fossil fuels are of the same magnitude as the health benefits of reduced air pollution levels (Fig. 1).

The investment measures are collected from the sustainability scenario in the International Energy Agency World Energy Outlook 2018.

The investment costs to keep global warming below the 2 °C target will be immense (Fig. 1).

The largest climate forcers emissions among the Arctic Council member states are from sources in US, Russia and Canada (Fig. 4).

From a climate warming impact perspective, we estimated that the Arctic Council member states' anthropogenic climate forcers emissions, in one single year as of 2020, contributed to a social cost of 1.4 trillion € (0.3-3.2 trillion €, 5 to 95 percentile range), integrated over the coming decades to centuries.

Of these climate warming damage costs, ~85 percent can be attributed to carbon dioxide, ~9 percent to methane, ~4 percent to nitrous oxide and ~2 percent to Black Carbon.

The emission sectors with the largest climate impacts as well as climate change mitigation potentials are power and heating plants, transports, industries, and residential combustion.

In the MFR&SD scenario the largest absolute climate forcers emission reductions, compared to the CLE scenario, would be accomplished in the power and heating plant sector, followed by transports (primarily light duty vehicles) and fuel production and distributions (Fig. 5).

The additional climate forcers emissions reductions in the MFR&SD scenario compared to the CLE scenario for industries and heavy-duty vehicles would be relatively modest, -10 percent and -15 percent by 2050. The CO_2,eq emissions from heavy-duty vehicles, in the MFR&SD scenario, would increase with +6 percent compared to the reference year 2020.

It's important to reduce emissions wherever abatement is found to be the most cost-effective

The socio-economic analysis showed that the combined net effect would be positive for the MFR&SD scenario for the years 2030 and 2050.

Among the Arctic Council member states, the largest socio-economic benefits can be achieved in the countries with the largest population, emissions and economies; US, Russia, and Canada.

It's important to reduce emissions wherever abatement is found to be the most cost-effective, however, making sure policy measures are put in place in countries with large emissions will naturally have a greater impact on the overall socio-economic benefits.

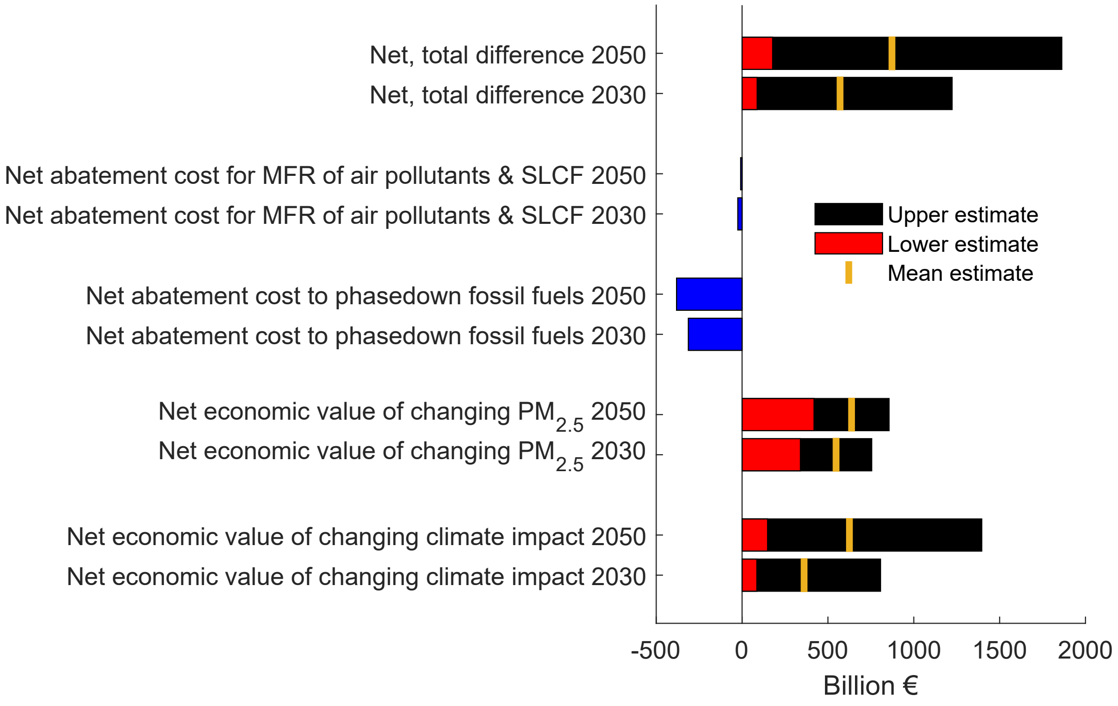

Figure 1. Maximum technically feasible reductions of air pollutants and phasedown of fossil fuels are socio-economically beneficial. The figure illustrates the abatement costs and socio-economic benefits achieved if all Arctic Council member states follow the projected MFR&SD emission scenario instead of the CLE scenario.

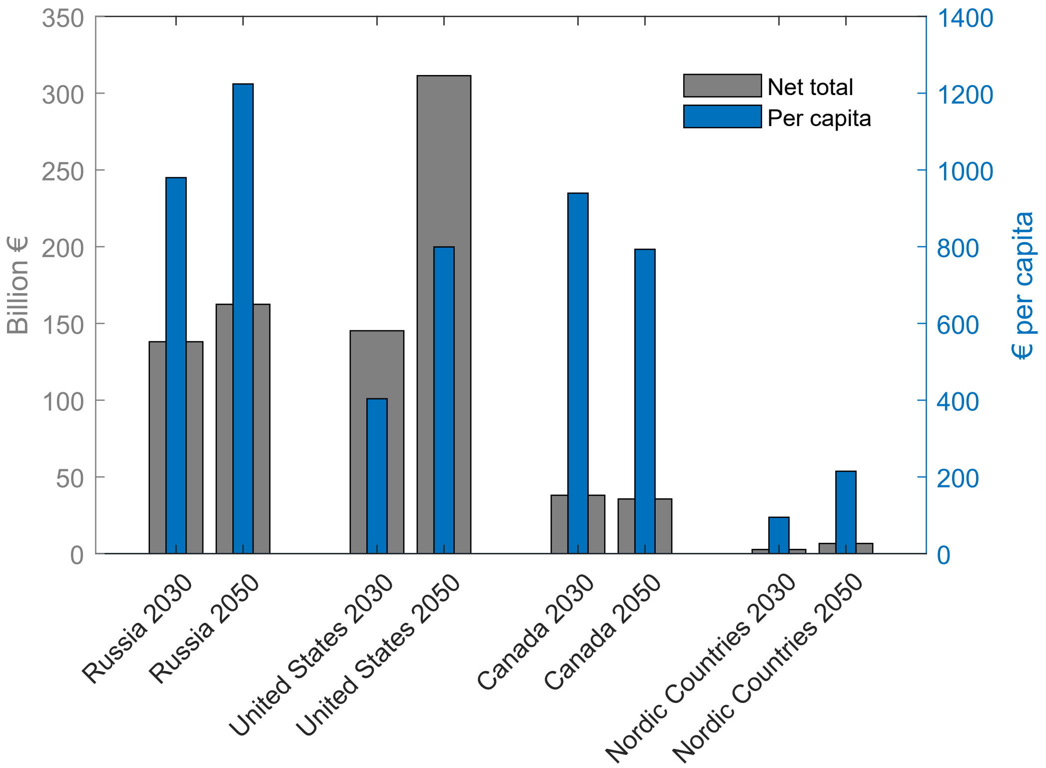

Figure 2. Estimated socio-economic net benefits for United States, Canada, Russia and the Nordic Countries. Maximum technically feasible reductions of air pollutants and phasedown of fossil fuels in all Arctic Council member states are socio-economically beneficial for all countries (regions). Per capita, the benefits are largest in Russia and smallest in the Nordic Countries.

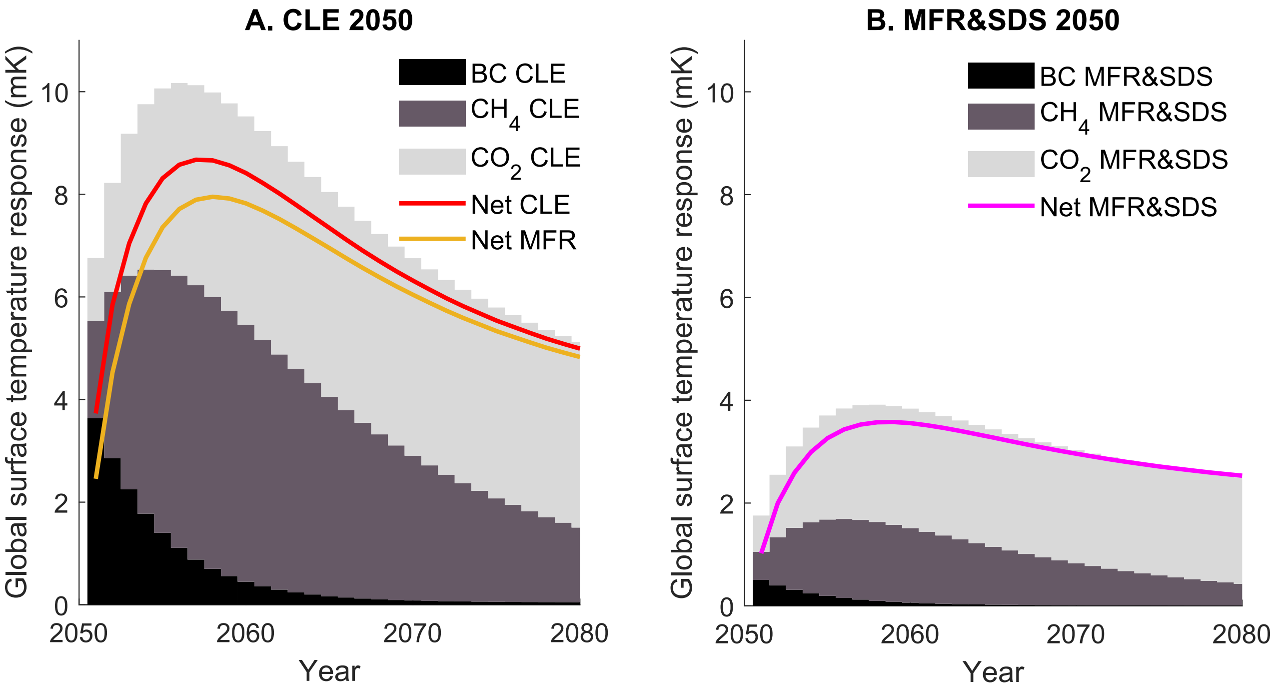

Figure 3. Calculated global surface temperature responses, in milli Kelvin (mK), 1-30 years (2051-2080) after a full year (year 0, 2050) of anthropogenic climate forcers emissions (excluding wildfires) from all Arctic Council member states, as projected with the CLE, MFR and MFR&SD emission scenarios. The temperature response caused by the individual climate forcers Black Carbon (BC), methane (CH_4) and carbon dioxide (CO_2) are illustrated by the shaded areas. The total net temperature responses from 10 major climate forcers (CO_2, CH_4, BC, N_2O, OC, CO, NOx, SO_2, NMVOC and NH_3) are given by the colored lines.

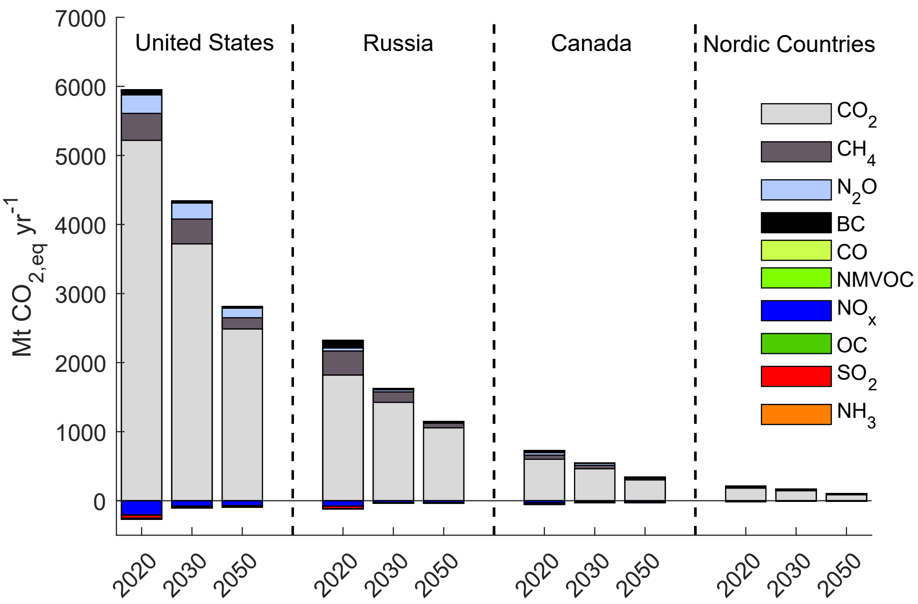

Figure 4. Carbon dioxide equivalent (CO_2eq) emissions from 10 major climate forcers, for US, Russia, Canada and the Nordic countries for the MFR-SD scenario in year 2020, 2030 and 2050. From a climate social cost perspective, the major climate forcers are carbon dioxide, methane, nitrous oxide and black carbon. NOx, SO_2, NH_3 and OC have all net cooling effects on the climate, which is reflected by their negative CO_2eq emissions.

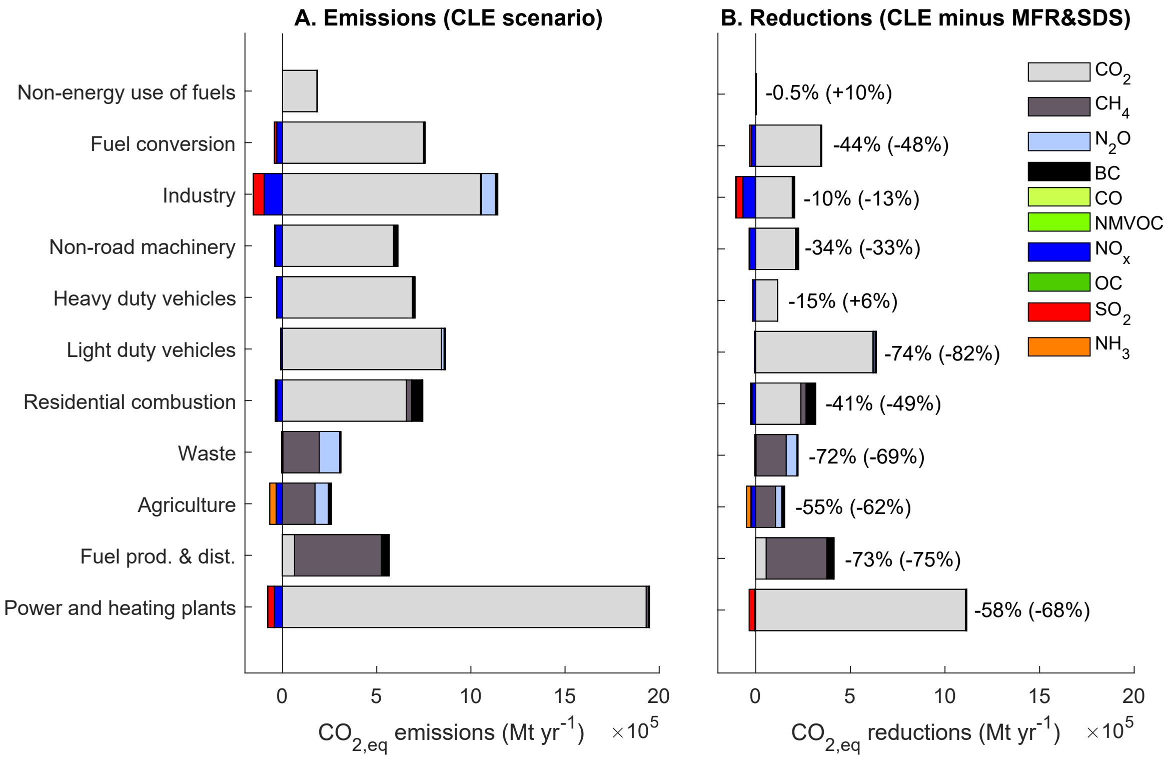

Figure 5. Arctic Council member states carbon dioxide equivalent (CO_2eq) emissions from 10 major climate forcers for the key anthropogenic emission sectors in the Arctic Council member states. ***Panel A*** *shows the projected total emissions in the year 2050 according to the CLE emission scenario.* ***Panel B*** *shows the projected emission reductions in the year 2050, which will be accomplished if the emissions in all Arctic Council member states follow the MFR&SD scenario instead of the CLE scenario. The relative emission reductions per sector are given in number of percentages, the numbers within brackets are the reductions relative to the emissions in year 2020.*

Black carbon and wildfires

Black carbon, BC, emissions from the Arctic Council member states, including wildfire emissions, continue to have a substantial impact on the average global surface temperature: +40 milli Kelvin, 16 percent of the total global BC surface temperature response in 2015-2020, according to our estimates.

However, the impact decreases rapidly with increasing time after the emissions (Fig. 3), and on a decade to century perspective the climate forcing from long-lived greenhouse gases dominates.

On the other hand, if the emissions remain, BC continues to be one of the major climate forcers in the Arctic.

The Canadian boreal forest fires in the summer of 2023 contributed to almost half of the global BC emissions from wildfires 2023. If this becomes a regularly reoccurring phenomenon, the global climate impact will be significant.

The trend of increasing wildfire emissions in the Arctic also raises concerns that BC will continue to constitute a major climate forcer in the future Arctic climate system (Fig. 6).

If the magnitude of the 2023 boreal forest wildfire will become the norm in the future, it may result in a global surface temperature increase of roughly 0.1 Kelvin.

Wildfires emissions were not considered in the emission policy scenarios applied in the ABC-iCAP air pollution and climate forcers socio-economic assessment.

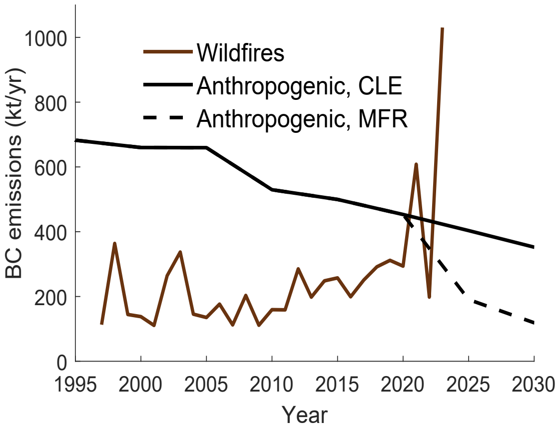

Figure 6. Estimated black carbon emissions from wildfires and anthropogenic sources within the Arctic Council member state borders.

Actions benefit different actors

Actions to reduce emissions of all long- and short-lived climate forcers and air pollutants are warranted considering climate and health impacts modelling showed associated net economic benefits.

Our study showed that substantial socio-economic benefits would follow from implementing the MFR&SD scenario. The problem is that the effects of emission reductions and their cost affect countries, companies, and people differently. See Figure 7.

Investment costs would disproportionately affect companies, while a lowering of health impacts from air pollution and climate change would benefit people in all parts of society and other parts of the world.

Therefore, those investments would not be made spontaneously. Hence, there would be a need for new or revised policies.

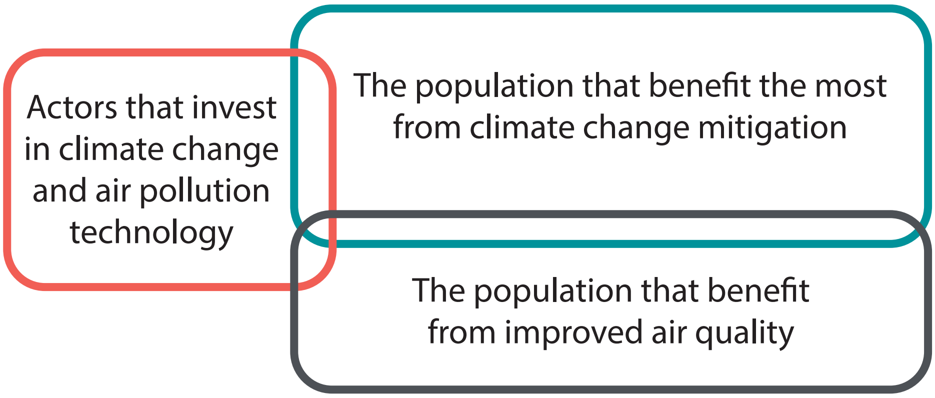

Figure 7. A schematic figure showing that socio-economic benefits and costs of emission reductions do not affect the same actors.

Effective policy instruments

In the full-length report we discuss different policy options and conclude that emission trading systems in combination with carbon border adjustments can be the most promising policy option for mitigating climate change.
Technical regulations, as shown with the MFR scenario, are effective for mitigating air pollutants.

Emission trading systems

Emission trading systems (ETS) are highly cost effective for mitigating climate forcers on a multilateral scale, especially if designed properly.

The reason is that they create a situation where all climate measures are less expensive per CO_2,eq emission unit than the ETS price would be profitable. An ETS will also ensure that the emissions are capped at a certain level (while for example a tax there is uncertainty about the level of emissions). There is already an ambitious ETS in place that include all EU countries, Norway, Iceland, Liechtenstein and Northern Ireland.

From 2026 the trade will include methane and N_2O emissions for the shipping sector. There are still no plans for adding Black Carbon to the system. Russia doesn't have any ETS, and US and Canada only have regional ETS.

Carbon border adjustment

Carbon border adjustments impose tariffs on imports based on their carbon footprint, aligning costs with domestic emission standards. This policy aims to prevent businesses from relocating to regions with lax environmental regulations, promoting global emission reductions.

Carbon border adjustment can encourage a cost-effective distribution of climate mitigation measures between countries and address consumption-based emissions in countries with low national emissions.

Wildfires

As wildfires contribute to a significant and likely increasing share of the climate forcers emissions in the Arctic Council member states, we think it is important that the Arctic Council include emissions from wildfires in climate reporting and climate policy making.

Policy recommendations

We conclude that there are large socio-economic benefits to gain by implementing effective and efficient climate and air pollution mitigation policies.

Our study also concludes that the benefits are unevenly distributed between countries and that we need policy instruments that implement mitigation measures more cost-effectively between countries.

It would be especially beneficial if the US and Canada would implement more effective climate policy instruments since Canada's CO_2,eq emission per capita is among the highest in the world and the US has the second largest absolute CO_2,eq emissions in the world.

Mitigation of air pollutants

In the report we discuss different policy options for mitigating air pollutants and concluded that technological regulations are effective policy instruments. Examples of technological emission regulations included in the MFR and MFR&SD scenarios are:

- Full compliance of the Euro 6 emission standards for all light- and heavy-duty vehicles by 2050, as compared to a 77 percent compliance in the CLE scenario.

- Increasing the share of pellet fueled stoves, 65 percent of fuel used by 2050, for domestic heating purposes. In the CLE scenario the pellet fueled stoves are used to combust less than 1 percent of the biofuels used for domestic heating by 2050.

- Full recovery and use of associated petroleum gas (APG) during the extraction of crude oil in all Arctic Council member states, implemented before 2030. In the CLE scenario 31 percent and 6 percent of the APG formed during the crude oil extraction in Russia and Canada respectively, will continue to be flared or vented.

Summary

- Arctic Council member states need to take the lead in rapidly phasing down the use of fossil fuels in all sectors, as this is a prerequisite for effective climate mitigation.

- Arctic Council member states should be further encouraged to implement all necessary air pollutants and short-lived climate forcers emission regulations, in line with the MFR&SD scenario.

- The US and Canada could consider introducing national emission trading systems as soon as possible and align these to the EU ETS.

- There is a need to include more sectors, activities and climate forcers in the EU emission trading system and expand the scope of climate border adjustments to include more commodities.

- Arctic Council Member states should investigate how emissions from wildfires can be included in national climate emission reporting and assess how new policy measure can reduce those emissions.

Method

We have compared the effects of the maximum technically feasible air pollution emission reductions and and more ambitious climate change mitigation (the MFR&SD scenario) with a current legislation baseline emission scenario (CLE).

In the comparison, we have analyzed the cost and benefits among all Arctic Council member states using 2020 as the reference year.

Effects are calculated for the years 2030 and 2050. The study encompassed socio-economic effects of premature mortality and morbidity due to PM2.5, and climate change damages that covers four climate damage sectors: agriculture, climate related mortality, building energy expenditures and sea level rise.

The damages were weighed against the abatement costs for maximum technically feasible emissions-control measures and phasedown of the use of fossil fuels. More details about the methods used for calculating socio-economic costs of climate forcers and air pollution are presented below and in the full-length report.

How did we assess the socio-economic costs of air pollution?

Based on the CLE, MFR and MFR&SD emission scenarios we calculated PM2.5 concentrations on a global 0.1°x0.1° grid scale using the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model, which accounts for emission dispersion between regions. The derived yearly average PM2.5 concentration maps were then used to calculate population weighted PM2.5 exposures.

The number of premature deaths related to air pollution was estimated either directly with the GAINS model or using the Economic Valuation of Air pollution (EVA) model. These models apply either linear or non-linear PM2.5 exposure response functions.

Environmental and health economics often use the monetary valuation of a statistical life to perform socio-economic cost-benefit analysis. It is valuable to use monetary valuation of a statistical life when estimating the cost of environmental health impacts. We used a value of a statistical life in 2020 of 6.03 million EUR when calculating the socio-economic costs of air pollution related mortality.

We also assessed morbidity costs, including major air pollution related diseases, hospital admissions and restricted activity days with the EVA model system. The number of premature deaths was the major factor that drove the socio-economic cost of air pollution (~93 percent of the total health costs according to the EVA model system).

How did we assess the socio-economic costs of climate forcers emissions?

The socio-economic costs of climate forcers emissions were assessed using the concept of social cost of climate forcers, denoted by SC_X , where X represent a climate forcer X, e.g. CO_2 (SC_{CO_2}).

SC_X values were estimated using discounted marginal damages of CO_2 emission functions (SC'_{CO_2}) and calculated Global Temperature Potentials (GTP_X).

We applied a value for the social cost of carbon dioxide emissions SC_{CO_2} of 162 Euros per ton of CO_2,eq emissions, for emissions occurring in year 2020. This SC_{CO_2} value and the corresponding SC'_{CO_2} were taken as the preferred mean values from a recent publication using the integrated assessment model GIVE.

The SC_{CO_2} value, as well as the SC_X of all other climate forcers, were scaled up with the projected global gross domestic production (GDP) increases of 30 percent and 100 percent in the years 2030 and 2050 SC_{CO_2} (2030) = 211 € and SC_{CO_2} (2050) = 324 €).

The SC_{CO_2} derived with the GIVE model accounts for the cost related to temperature mortality, effects on agriculture, sea-level rise, and energy costs for residential and commercial buildings (e.g. air conditioning).

By using the ratio between the calculated social cost of climate forcers X and the social cost of CO_2 SC_{CO_2} as the emission metric we can translate the estimated global surface temperature impacts of any climate forcer (Fig. 3) into CO_2 equivalent emissions (Fig. 4 and Fig. 5).

These CO_2 equivalent emissions should at least in theory account for the climate impacts and related social costs integrated from year 1 up to several centuries after the emissions occur.

Our derived SC_{CH_4} /SC_{CO_2}) becomes 15, when applying the preferred mean SC'_{CO_2}, function from the GIVE model.

Major uncertainties with the socio-economic assessment of air pollution and climate forcers emissions

All method steps leading to the final socio-economic costs and benefits of stringent air pollution and climate policies are accompanied by uncertainties. Below we have listed a few major uncertainties with a potentially large impact on the results and how they were addressed.

1. The integrated climate impacts and related socio-economic costs of all climate forcers were assessed using the concept of social cost of climate forcers.

This was based on calculated values of the social cost of CO_2 (SC_{CO_2}) from a previous study using the GIVE model. The default SC_{CO_2} value used is the reported preferred mean value from 10 000 individual Monte Carlo simulations.

However, we also used lower (5 percentile) and upper (95 percentile) estimates of SC_{CO_2} of 40 € and 360 € in year 2020. This is reflected in the upper and lower estimates of the net economic value of changing climate impacts in figure 1.

2. For air pollution related mortality, we used both the GAINS and EVA model systems to estimate the air pollution related number of premature deaths. We tested different PM2.5 exposure response functions with the EVA model system. The upper and lower estimate of the net economic value of changing PM2.5 levels reported in figure 1 represents the range of premature mortality estimates from the GAINS and EVA model system.

3. For Black Carbon we derived new regional and sector specific global temperature potentials (GTP) to better account for how the global surface temperature response is influenced by the region where the BC emission occurs. The values were compared against previous GTP estimates found in the literature. See the full report for more details about the applied GTP estimates for all climate forcers.

To summarize, we can conclude that the socio-economic analysis performed in the ABC-iCAP project likely underestimated the full climate and health impacts of air pollutants and climate forcers and the related economic costs. This is because many climate and health effects were excluded because they were too uncertain to be monetized.

Still, our results indisputably demonstrated that it is socio-economically beneficial to invest in maximum technical feasible reductions of air pollutants and short-lived climate forcers in combination with a rapid phasedown of fossil fuels in the Arctic Council member states.

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