Societal Benefits from Reductions in Emissions of Methane and Black Carbon

Drew Shindell
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Society faces multiple problems arising from the emission of pollution into our atmosphere, including wide ranging impacts on both public health and climate change. Swift and large reductions in carbon dioxide emissions are vital if we are to avoid the worst consequences of climate change in the longer-term, for example from 50 to 100 years from now. At the same time, we are already experiencing effects of climate change that go well beyond global warming, such as shifts in rainfall patterns, rising sea levels, and more intense storms and heatwaves. Hence in parallel, reductions in emissions of other pollutants, including methane and black carbon (also referred to as soot) merit immediate, forceful action as these improve air quality while simultaneously slowing the rate of climate change over the next several decades.

Air pollution is literally killing people. It is the leading environmental cause of premature death, leading to ~7 million premature deaths per year (outdoor and indoor) globally [1]. Air pollution in the US causes about 135,000 premature deaths, 180,000 non-fatal heart attacks, 150,000 cases of hospitalization for respiratory and cardiovascular disease, ~130,000 emergency room visits for asthma, 18 million lost work days and 11 million missed school days [2]. Many of the compounds contributing to air pollution also drive climate change [3].

Multiple, peer-reviewed scientific studies have shown that aggressive reductions of those air pollutants that cause warming, in particular methane and black carbon, can reduce the rate of warming over the next several decades by approximately half [4-6]. A strategy to quickly and dramatically reduce these pollutants hence complements efforts to reduce carbon dioxide, as carbon dioxide reductions have little effect over the next few decades due to how long this gas stays in the atmosphere, which can be hundreds to thousands of years, and the time it will take to change human systems so that they generate less carbon dioxide. Slowing near-term climate change would benefit those already suffering from the impacts of climate changes. It would also improve the chances for both biological and human systems to adapt to the pace of change. Benefits of black carbon reductions are especially large in and near snow and ice covered regions such as the Arctic or the Himalayas.

At the same time, in comparison with projected emissions based on current legislation worldwide, an analysis of one approach to implementing these reductions showed that the improved air quality under such a strategy could save ~45 million lives and increase crop yields by about 1 billion metric tons due to ozone reductions [4,7,8]. China, India and the United States are projected to see the largest gains in crop yields due to the cleaner air, with over 100 million tons of increased yield in the US. The economic value of the benefits of methane emissions reductions is well above the typical costs of emissions controls, which are less than $250, and sometimes emissions reductions can even be made at a cost savings [9]. Though hydrofluorocarbons (HFCs) do not directly cause poor air quality, curtailing the rapid growth in emissions of these compounds can provide substantial benefit in terms of reducing near-term climate change [6].

Thus efforts to control emissions of methane, black carbon (and co-emissions) and HFCs can provide multiple, large benefits to society. Since neither the damages attributable to climate change nor those due to degraded air quality are incorporated in our current economic markets, emissions reductions are a textbook example of a societal good that could benefit from government intervention. In part this is because the damages due to air pollution are not paid by the emitter, so that there is no economic incentive for emissions reductions, even in cases when emissions controls would be less expensive than the damages they would prevent. The damages are instead paid by those who bear increased health care costs and food prices. The emissions reduction measures described in prior work [4] along with use of low-global warming substitutes instead of HFCs can greatly reduce the damages from climate change over the next few decades while saving tens of millions of lives and hundreds of millions of tons of crops in comparison with business as usual, all at relatively modest cost.

In particular, reducing methane emissions from the oil and gas industry, coal mines and municipal waste and black carbon-related emissions from diesel vehicles, cookstoves, kerosene lighting and small industries such as brick kilns and coke ovens have been identified as actions that would provide great societal benefits [4,5,9-11]. In addition, the Arctic is extremely sensitive to the warming climate, and emissions of black carbon and other particles (or particle precursors) can have an especially large impact there [12,13]. Hence the specific actions in the Super Pollutants Act of 2014 to target many of these activities, to reduce emissions from polar shipping and to encourage use of low-global warming HFC substitutes are, based on the scientific evidence, likely to lead to substantial societal benefits on multiple fronts. The bill's efforts to promote financing would also address an important barrier to implementation [5,9].

Emission reduction efforts targeting these pollutants are currently being pursued by many nations, intergovernmental and non-governmental organizations, especially via the Climate and Clean Air Coalition. Additional US leadership in this area could help inspire others to step up their activities to put into place these urgently needed emissions reduction measures, all of which are developed and in use but need to be much more widely applied to reap the full potential societal benefits. International success in reducing emissions of methane, black carbon (and co-emissions) and HFCs would provide clear benefits to the public. Success could demonstrate that emissions can indeed be successfully reduced through concerted action across government, industry and civil society for the sake of protecting the climate (at least in part). Success would also highlight how consideration of the full environmental consequences of emissions, including both climate change and air pollution, can guide development and implementation of optimal solutions to both problems.

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COMMENT

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SANJIT DAS/PANOS

A woman in Jharkhand, India, burns raw coal into charcoal, which emits toxic gases that harm her health and affect the climate.

Clean up our skies

Improve air quality and mitigate climate-change simultaneously, urge **Julia Schmale** and colleagues.

In December, the world's attention will fall on climate-change negotiations at the 20th United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties in Lima, Peru. The emphasis will be on reducing emissions of long-term atmospheric drivers such as carbon dioxide, the effects of which will be felt for centuries. At the same time, the mitigation of short-lived climate-forcing pollutants (SLCPs) such as methane, black carbon and ozone — which are active for days or decades — must be addressed (see 'Compounds of concern').

SLCPs cause poor air quality and are responsible for respiratory and cardiovascular diseases. Particulate matter in the atmosphere is the leading environmental cause of ill health, and air pollution is causing about 7 million premature deaths annually[1]. Interactions between warming, air pollution and the urban heat-island effect (which causes cities to be markedly warmer than their surrounding rural areas) will raise health burdens for cities worldwide by mid-century[2]. Air pollution also damages ecosystems and agriculture.

Current air-quality legislation falls short. Existing measures would prevent just 2 million premature deaths by 2040. We estimate that around 40 million more such deaths would be avoided if concentrations of methane, black carbon and other air pollutants were halved worldwide by 2030 (see 'Clean air').

This is not an 'either-or' decision: coordinated action on both climate change and air pollution is necessary. And it is tractable: for example, electric-car sharing or shifting from fossil fuels to renewable power generation would reduce consumption and overall emissions and lead to behavioural ▶

shifts that are beneficial in both the near and long term[3].

But defining joint CO_2 and SLCP reduction goals is difficult. Researchers need to spell out the benefits and trade-offs of separate and joint air-pollution and climate-change mitigation in terms of public health, ecosystem protection, climate change and costs. A suite of mitigation policies must be designed and applied on all scales — from cities to the global arena.

DOUBLE JEOPARDY

Studies[4,5] estimate that rigorous reductions of global methane and black-carbon-related emissions by 2030 could prevent around 2.4 million premature deaths per year that result from air pollution, and save 50 million tonnes of crops through avoided ozone damage (methane is a precursor for ozone production). Global mean temperature rise would be slowed by about 0.5 °C by mid-century. The rate of sea-level rise would be reduced by 20% in the first half of this century by such measures alone, and by 50% in the second half if CO_2 and SLCP mitigation are combined[6].

Lower air pollution also has societal benefits. Methane captured from landfills or manure can be used to run residential stoves, for example. In developing countries, replacing conventional cooking stoves with clean-burning technologies allows people — women and children, in particular — to invest time in education or financially rewarding work, rather than spending time collecting wood or other materials for basic family needs[7].

All SLCPs must be reduced in concert. Sulphate aerosols cool the climate, as happens following volcanic eruptions. But delaying sulphur dioxide mitigation as a way to temporarily mask global warming is problematic. Greater stresses on people's health and the environment already result from today's enhanced particulate concentrations and acidified rain.

> ***"Energy ministries tend to focus on CO_2 reductions and environment ministries manage air quality."***

Coordinated action to mitigate SLCPs and CO_2 is hampered by fragmented policies. For example, energy ministries tend to focus on CO_2 reductions and environment ministries manage air quality. Greenhouse gases are subject to global agreements, whereas air pollutants are more usually limited locally by legislation. Regulation of different climate-forcing compounds is patchy.

Anthropogenic emissions of methane are predicted to increase by about 25% (more than 70 million tonnes annually) by 2030[4], yet the gas is hardly regulated. Methane is covered by the Kyoto Protocol, but most countries' controls focus on CO_2. In the European Union (EU), for example, methane is not covered by the national emissions ceiling directive, the directive on ambient air quality or the EU Emissions Trading System. The EU's industrial emissions directive omits major sources of the gas, such as cattle farming.

Air-quality policies in the EU and the United States have been partially successful in reducing periods of extreme ozone concentration. But average regional concentrations have not declined in the past two decades across Europe, and there is still no legally binding limit, only a target. Trends in the United States are mixed and vary seasonally; in east Asia, surface ozone is increasing.

For black carbon, there are almost no regulatory obligations to report emissions or measure ambient concentrations. Few regional and local assessments have been made. Little change in global black carbon emissions is predicted by 2030, because reductions in North America, Europe and northeast and southeast Asia and the Pacific will be offset by increases in south, west and central Asia and in Africa[4].

Unlinked and narrow air pollution and climate-policy interventions can have mixed results on both fronts. In the EU, for example, legislated vehicle-emissions limits have reduced particulate concentrations by 45% between 1995 and 2008 and are projected to reduce black carbon by more than 90% by 2025 compared with 2000. Yet CO_2 emissions from the ever-growing transport sector are rising. And air quality is not under control. Unregulated residential emissions from biomass heating are rising, and will account for 80% of black-carbon emissions in Europe in 2025.

Also problematic are lax targets. For example, the annual EU limit for particulate matter smaller than 2.5 micrometres ($PM_{2.5}$) that will be binding by 2015 is

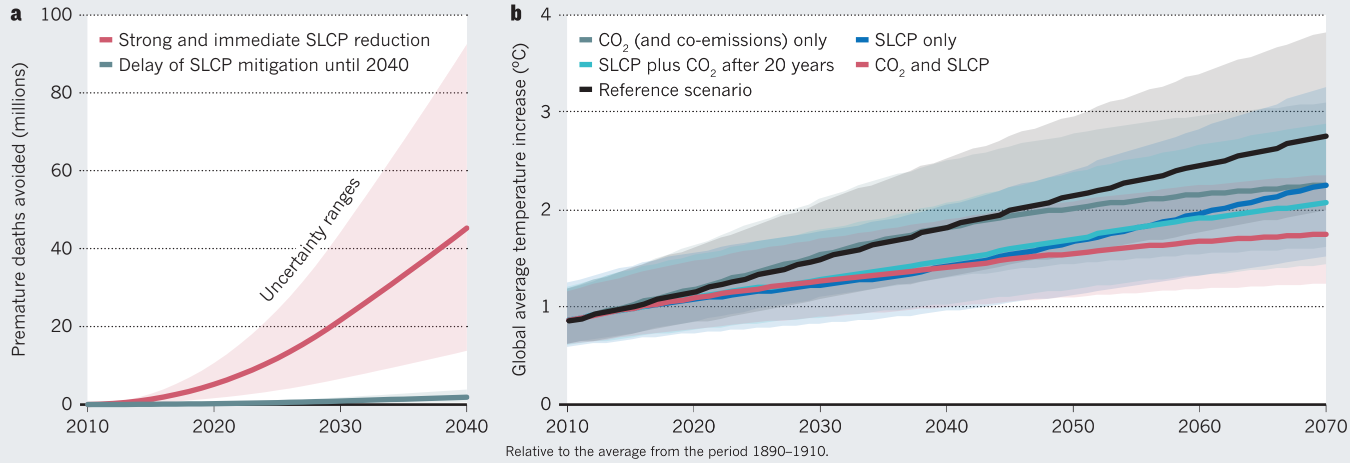
COMPOUNDS OF CONCERN

Common air pollutants and industrial chemicals have major influences on the climate, human health and agriculture even though they persist for only a short time in the atmosphere.

SUBSTANCE	MAIN EMISSION SOURCES	CHARACTERISTICS
Methane	Oil and gas production Livestock farming Landfills and waste-water treatment Rice cultivation	**Lifetime:** 10 years **Health:** Precursor of ozone production, hampers plant metabolism **Climate:** Second most important climate forcer after CO_2
Lower-atmospheric ozone	Traffic and transport Residential heating and cooking Agricultural and forest fires Brick production Oil and gas production	**Lifetime:** One month **Health:** Causes respiratory diseases, hampers plant metabolism **Climate:** Greenhouse gas — formed photochemically through reactions involving methane, nitrogen oxide, carbon monoxide and volatile organic compounds
Black carbon	Traffic and transport Residential heating and cooking Agricultural and forest fires Brick production Oil and gas production	**Lifetime:** Days **Health:** Causes respiratory diseases, carcinogenic **Climate:** Warms lower atmosphere, changes precipitation, melts snow and ice it is deposited on
Sulphur dioxide and nitrogen oxides	Traffic and transport Residential heating and cooking Agricultural and forest fires Brick production Oil and gas production	**Lifetime:** Days **Health:** Components of particulates, ozone precursors, cause acidification and eutrophication of ecosystems, cause respiratory and cardiovascular illnesses **Climate:** Contribute to negative radiative forcing, mask global warming
Hydrofluorocarbons	Air conditioning Refrigeration Foam-blowing Fire suppression Solvents	**Lifetime:** Months to decades **Climate:** Strong greenhouse gases

CLEAN AIR

More than 40 million deaths from respiratory and cardiovascular diseases could be prevented by 2030 by halving the concentration of short-lived climate-forcing pollutants (SLCPs) in the atmosphere immediately (**a**). Joint approaches to mitigating SLCPs and carbon dioxide are more effective than separate measures in limiting global average temperature rise[4] (**b**).



2.5 times higher than that recommended by the World Health Organization (WHO). And the current PM_{10} (particulates smaller than 10 micrometres) limit is twice that recommended by the WHO. If the EU meets its limit on PM_{10}, no further action to meet the legal requirements will be needed, because the $PM_{2.5}$ value will also be met.

Some coordinated efforts to reduce air pollution and slow climate change have begun. The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC), formed in 2012, now includes 42 nations, the European Commission and more than 50 organizations. It focuses on mitigating methane and black-carbon emissions for transport, brick, oil and natural-gas production, household cooking and heating. Since 2009, the Arctic Council runs task forces to reduce black-carbon and methane emissions to slow climate change in the region, and has produced two reports in addition to a scientific assessment of black carbon in the Arctic. But so far, only Norway has developed a national action plan to reduce SLCPs.

None of these efforts addresses structural and behavioural changes. Coordinated action to reduce SLCPs and CO_2 simultaneously is not an objective, because it is assumed that parallel reductions will happen under different policy umbrellas.

DOUBLE DUTY

Effective mitigation of SLCPs will require detailed assessments of the multiple impacts of emitted air pollutants together with CO_2, their sources, their atmospheric interactions and their potential for mitigation[8].

Combined efforts at the city and state level will be particularly important because this is where most people are exposed to air pollution, and 75% of global CO_2 emissions is generated in cities. Positions and task forces should be created to promote joint emissions-reduction strategies across municipal and regional departments. For example, climate policies that encourage combined heat and power plants with low power capacities for cities — thus potentially exempting them from air-quality regulations[3] — should be avoided.

Scaling up and coordinating local efforts and national strategies are necessary. For example, local efforts in the Arctic can be only partly effective because the region is subject to imported pollution from the residential and transport sectors of countries at lower latitudes.

Global organizations such as the CCAC, the World Meteorological Organization and the WHO could assume coordinating roles. Arctic Council member states should take a leadership role in national actions to reduce black carbon and methane at their next ministerial meeting in 2015. The European Commission should propose ambitious emissions limits for methane to the national emissions ceiling directive.

> ***"Unlinked and narrow air pollution and climate-policy interventions can have mixed results on both fronts."***

It is important that steps to limit SLCPs do not distract from CO_2 mitigation, and vice versa. We calculate, building on work[5] by D.S. and colleagues, that a delay of 20 years in reducing CO_2 emissions would result in 0.4 °C more warming by the end of the century than if measures were put in place immediately, with the result that the 2 °C temperature mark would be crossed in the mid-2060s rather than just after 2100 (see 'Clean air').

The 2015 Conference of the Parties meeting in Paris needs to pursue its primary mission to reduce CO_2 for the climate's sake. That said, the scientific community must speak out against recommendations — explicit or implicit[9,10] — to exclude SLCPs from discussions of climate-change mitigation or to delay their reduction. Tens of millions of lives are at stake, along with damage to agriculture, ecosystems and cultural heritage. ■

Julia Schmale *was a science-policy project leader at the Institute for Advanced Sustainability Studies, Potsdam, Germany, and is now at the Paul Scherrer Institute, Villigen, Switzerland.* **Drew Shindell** *is professor of climate sciences at the Nicholas School of the Environment, Duke University, Durham, North Carolina, USA.* **Erika von Schneidemesser** *is a project leader,* **Ilan Chabay** *is a senior fellow and* **Mark Lawrence** *is scientific director at the Institute for Advanced Sustainability Studies, Potsdam, Germany.*
e-mail: julia.schmale@gmail.com

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