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Why Black Carbon and Ozone Also Matter

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At last, world leaders have recognized that climate change is a threat. And to slow or reverse it, they are launching initiatives to reduce greenhouse gases, especially carbon dioxide, the gas responsible for about half of global warming to date. Significantly reducing emissions of carbon dioxide is essential, as they will likely become an even greater cause of global warming by the end of this century. But it is a daunting task: carbon dioxide remains in the atmosphere for centuries, and it is difficult to get governments to agree on reducing emissions because whereas the benefits of doing so are shared globally, the costs are borne by individual countries. As a result, no government is moving fast enough to offset the impact of past and present emissions. Even if current emissions were cut in half by 2050—one of the targets discussed at the 2008 UN Climate Change Conference—by then, humans' total contribution to the level of carbon dioxide in the atmosphere would still have increased by a third since the beginning of this century.

Meanwhile, little attention has been given to a low-risk, cost-effective, and high-reward option: reducing emissions of light-absorbing carbon particles (known as "black carbon") and of the gases that form ozone. Together, these pollutants' warming effect is around 40–70 percent of that of carbon dioxide. Limiting their presence in the atmosphere is an easier, cheaper, and more politically feasible proposition than the most popular proposals for slowing climate change—and it would have a more immediate effect.

Time is running out. Humans have already warmed the planet by more than 0.5 degrees Celsius since the nineteenth century and produced enough greenhouse gases to make it a total of 2.4 degrees

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Celsius warmer by the end of this century. If the levels of carbon dioxide and nitrous oxide in the atmosphere continue to increase at current rates and if the climate proves more sensitive to greenhouse gases than predicted, the earth's temperature could rise by as much as five degrees before the century ends.

A temperature change of two to five degrees would have profound environmental and geopolitical effects. It would almost certainly melt all the Arctic summer sea ice. As a result, the Arctic Ocean would absorb more sunlight, which, in turn, would further amplify the warming. Such a rise could eliminate the Himalayan and Tibetan glaciers, which feed the major water systems of some of the poorest regions of the world. It would also accelerate the melting of the Greenland and Antarctic ice sheets, raising the sea level worldwide and provoking large-scale emigration from low-lying coastal regions. Cycles of droughts and floods triggered by global warming would spell disaster for agriculture-dependent economies.

Some of global warming's environmental effects would be irreversible; some of its societal impacts, unmanageable. Given these consequences, policymakers worldwide seeking to slow climate change must weigh options beyond just reducing carbon dioxide, especially those that would produce rapid results. Cutting black carbon and ozone is one such strategy.

POWERFUL POLLUTANTS

The warming effect of carbon dioxide has been known since at least the 1900s, and that of ozone since the 1970s, but the importance of black carbon was discovered only recently. During the past decade, scientists have used sophisticated instruments on drones, aircraft, ships, and satellites to track black carbon and ozone from their sources to remote locations thousands of miles away and measure and model how much atmospheric heating they cause.

Black carbon, a widespread form of particulate air pollution, is what makes sooty smoke look blackish or brownish. It is a byproduct of incomplete, inefficient combustion—a sign of energy waste as much as energy use. Vehicles and ships fueled by diesel and cars with poorly maintained engines release it. So do forest fires and households and factories that use wood, dung, crop waste, or coal for cooking, heating, or other energy needs.

Black carbon alters the environment in two ways. In the sky, the suspended particles absorb sunlight, warming up the atmosphere and in turn the earth itself. On the earth's surface, deposits of black carbon on snowpacks and ice absorb sunlight, thereby heating the earth and melting glaciers. The Arctic sea ice and the Himalayan and Tibetan glaciers, for example, are melting as much as a result of black carbon as they are as a result of the global warming caused by carbon dioxide. The warming effect of black carbon is equal to about 20–50 percent of the effect of carbon dioxide, making it the second- or third-largest contributor to global warming. No one knows exactly how much warming it causes, but even the most conservative estimates indicate a nontrivial impact. And its large contribution to the melting of glaciers and sea ice, one of the most alarming near-term manifestations of climate change, is well documented.

The ozone in the lower level of the atmosphere is another major contributor to global warming that deserves attention. (This is different from the ozone in the stratosphere, which shields life on earth from the sun's ultraviolet rays.) A potent greenhouse gas, its warming effect is equal to about 20 percent of that of carbon dioxide. Unlike black carbon, which exists as particles, ozone is a gas. Ozone in the atmosphere is not emitted directly but formed from other gases, "ozone precursors," such as carbon monoxide (from the burning of fossil fuels or biomass), nitrogen oxides (from lightning, soil, and the burning of fossil fuels), methane (from agriculture, cattle, gas leaks, and the burning of wood), and other hydrocarbons (from the burning of organic materials and fossil fuels, among other sources).

Most important, black carbon and ozone stay in the atmosphere for a much shorter time than does carbon dioxide. Carbon dioxide remains in the atmosphere for centuries—maybe even millennia—before it is absorbed by oceans, plants, and algae. Even if all carbon dioxide emissions were miraculously halted today, it would take several centuries for the amount of carbon dioxide in the atmosphere to approach its preindustrial-era level. In contrast, black carbon stays in the atmosphere for only days to weeks before it is washed away by rain, and ozone (as well as some of its precursors) only stays for weeks to months before being broken down. Nonetheless, because both are widespread and continuously emitted, their atmospheric concentrations build up and cause serious damage to the environment.

Although reducing the emissions of other greenhouse gases, such as methane and halocarbons, could also produce immediate results, black carbon and ozone are the shortest-lived climate-altering pollutants, and they are relatively underrecognized in efforts to stem climate change. Reducing the emissions of these pollutants on earth would quickly lower their concentrations in the atmosphere and, in turn, reduce their impact on global warming.

AN EASIER EXTRA STEP

Another promising feature of black carbon and ozone precursor emissions is that they can be significantly limited at relatively low cost with technologies that already exist. Although the sources of black carbon and ozone precursors vary worldwide, most emissions can be reduced without necessarily limiting the underlying activity that generated them. This is because, unlike carbon dioxide, black carbon and ozone precursors are not essential byproducts of energy use.

The use of fossil fuels, particularly diesel, is responsible for about 35 percent of black carbon emissions worldwide. Technologies that filter out black carbon have already been invented: diesel particulate filters on cars and trucks, for example, can reduce black carbon emissions by 90 percent or more with a negligible reduction in fuel economy. A recent study by the Clean Air Task Force, a U.S. nonprofit environmental research organization, estimated that retrofitting one million semitrailer trucks with these filters would yield the same benefits for the climate over 20 years as permanently removing over 165,000 trucks or 5.7 million cars from the road.

The remaining 65 percent of black carbon emissions are associated with the burning of biomass—through naturally occurring forest fires, man-made fires for clearing cropland, and the use of organic fuels for cooking, heating, and small-scale industry. Cleaner options for the man-made activities exist. The greenest options for households are stoves powered by the sun or by gas from organic waste, but updated designs for biomass-fueled stoves can also substantially cut the amount of black carbon and other pollutants emitted. Crop waste, dung, wood, coal, and charcoal are the cheapest, but also the least efficient and dirtiest, fuels, and so households tend to shift away from them as soon as other options become reliably available. Thus, the challenge in lowering black carbon emissions is not convincing people to sacrifice their lifestyles, as it is with convincing people to reduce their carbon dioxide emissions. The challenge is to make other options available.

Man-made ozone precursors are mostly emitted through industrial processes and fossil-fuel use, particularly in the transportation sector. These emissions can be reduced by making the combustion process more efficient (for example, through the use of fuel additives) or by removing these gases after combustion (for example, through the use of catalytic converters). Technologies that both minimize the formation of ozone precursors and filter or break down emissions are already widely used and are reducing ozone precursors in the developed world. The stricter enforcement of laws that forbid adulterating gasoline and diesel with cheaper, but dirtier, substitutes would also help.

Fully applying existing emissions-control technologies could cut black carbon emissions by about 50 percent. And that would be enough to offset the warming effects of one to two decades' worth of carbon dioxide emissions. Reducing the human-caused ozone in the lower atmosphere by about 50 percent, which could be possible through existing technologies, would offset about another decade's worth. Within weeks, the heating effect of black carbon would lessen; within months, so, too, would the greenhouse effect of ozone. Within ten years, the earth's overall warming trend would slow down, as would the retreat of sea ice and glaciers. The scientific argument for reducing emissions of black carbon and ozone precursors is clear.

A POLITICAL POSSIBILITY

Reducing emissions of black carbon and ozone precursors is also a politically promising project. It would yield significant benefits apart from slowing climate change, giving governments economic and developmental incentives to reduce them. Reducing ozone precursors, for its part, would have recognizable agricultural benefits. Ozone lowers crop yields by damaging plant cells and interfering with the production of chlorophyll, the pigment that enables plants to derive energy from sunlight. One recent study estimated that the associated economic loss (at 2000 world prices) ranged from $14 billion to $26 billion, three to five times as large as that attributed to global warming. For policymakers concerned about agricultural productivity and food security, these effects should resonate deeply.

In countries where a large portion of the population still depends on biomass fuels, reducing black carbon emissions from households would improve public health and economic productivity. Nearly 50 percent of the world's population, and up to 95 percent of the rural population in poor countries, relies on solid fuels, including biomass fuels and coal. The resulting indoor air pollution is linked to about a third of the fatal acute respiratory infections among children under five, or about seven percent of child deaths worldwide. Respiratory illnesses associated with the emissions from solid fuels are the fourth most important cause of excess mortality in developing countries (after malnutrition, unsafe sex, and waterborne diseases).

These health problems perpetuate poverty. Exposure to pollutants early in life harms children's lung development, and children who suffer from respiratory illnesses are less likely to attend school. Air pollution leaves the poor, who often earn a living from manual labor, especially worse off. Collectively, workers in India lose an estimated 1.6–2.0 billion days of work every year to the effects of indoor air pollution. Reducing black carbon emissions from households would thus promote economic growth and, particularly for rural women and children, improve public health.

Furthermore, both black carbon and ozone precursor emissions tend to have localized consequences, and governments are more likely to agree to emissions-reduction strategies that can deliver local benefits. With carbon dioxide and other long-lasting, far-spreading greenhouse gases, emissions anywhere contribute to global warming everywhere. But the effects of black carbon and ozone are more confined. When it first enters the atmosphere, black carbon spreads locally and then, within a week, dissipates more regionally before disappearing from the atmosphere entirely in the form of precipitation. Ozone precursors, too, are more regionally confined than carbon dioxide, although background levels of ozone are increasing around the globe.

Because the effects of black carbon and ozone are mostly regional, the benefits from reducing them would accrue in large part to the areas where reductions were achieved. The melting of the Himalayan and Tibetan glaciers is almost reason enough for countries in South and East Asia to take rapid action to eliminate black carbon emissions. So is the retreat of the Arctic sea ice for countries bordering the Arctic Ocean. Regional groupings are also more likely than larger collections of countries to have dense networks of the economic, cultural, and diplomatic ties that sustain difficult negotiations. Moreover, both black carbon and ozone can be contained through geographically targeted strategies because many of the sources of black carbon and ozone are largely fixed. And so even if one country in a region seeks to regulate emissions, that country's polluting activities are unlikely to move to another country with less stringent policies—a common concern with agreements to reduce carbon dioxide emissions.

CLEANING UP

So what can be done to curb black carbon and ozone precursor emissions? A logical first step is for governments, international development agencies, and philanthropists to increase financial support for reduction efforts. Although some money for this is currently available, neither pollutant has emerged as a mainstream target for public or private funding. Simply recognizing black carbon and ozone as environmental problems on par with carbon dioxide would make policymakers more inclined to spend development funds and the "green" portions of stimulus packages on initiatives to tackle them. Developed countries could put their contributions toward customizing emissions-reduction technologies for the developing world and promoting their deployment—an important gesture of goodwill that would kick-start change.

Regardless of the source of the funding, aid should support the deployment of clean-energy options for households and small industries in the developing world and of emissions-reduction technologies for transportation around the world. This could mean distributing solar lanterns and stoves that use local fuel sources more efficiently or paying for small enterprises to shift to cleaner technologies. The specific fixes for small-scale industry will vary by economic activity—making brick kilns cleaner is different from making tea and spice driers more efficient—but the number of possible customers for the new technologies offers some economies of scale. When it comes to transportation, policy options include subsidizing engine and filter upgrades, shifting to cleaner fuels, and removing the incentives, created by government subsidies that favor some fuels over others, for adulterating fuel and for using diesel.

Deploying technologies to reduce emissions from so many culturally embedded activities, from cooking to driving, will not be easy. Enforcing emissions controls on many small, mobile polluters is harder than regulating larger sources, such as power plants. And in customizing technologies, close attention will need to be paid to the varied needs of households and industry. But creating and enforcing regulations and subsidizing and disseminating energy-efficient technologies are challenges that have been met before. The "green revolution"—the remarkable growth in agricultural productivity that occurred in the second half of the twentieth century—introduced radical changes to small-scale farming. Other development initiatives have influenced fertility, gender equality, schooling, and other household decisions more sensitive than those about cooking and driving.

Moreover, the infrastructure for international financial and technological transfers already exists in the form of the World Bank, regional development banks, and UN programs that have supported development around the world for decades. The Global Environment Facility, a development and environmental fund that started as a World Bank program and is now the world's largest funder of environmental projects, is well suited to finance cleaner technologies.

Governments and international agencies should also finance technology that tracks air quality, which is generally undermonitored. In the major cities of most developing countries, the number of sensors has not kept up with the growth in population or economic activity. In rural areas, air pollution is not tracked at all. Improving the monitoring of air quality and disseminating the data would inform policymakers and environmental activists. And tracking individuals' emissions—through indoor air-pollution monitors or devices attached to cars' tailpipes—could help motivate people to curb their emissions. Experimental initiatives to measure individuals' carbon footprints and energy use have been shown to change people's behavior in some settings.

Aid alone will not be enough, however. International organizations must also help governments identify and act on opportunities that mitigate climate change and promote development. International development institutions, such as the UN Environment Program and the multilateral and regional development banks, could sponsor research, set up interministerial working groups, and establish standards for monitoring and reporting public expenditures. These initiatives would make it easier to identify possible areas of coordination among public health, agricultural, environmental, and antipoverty programs. In most countries, domestic institutions are not designed to encourage cooperation among different authorities. Pitching the reduction of black carbon and ozone precursor emissions as public health and agricultural policies could help such efforts compete for scarce funds; enabling the clearer calculation of the environmental benefits of development policies would make policymaking more informed. Much in the same way that international development organizations currently support good governance to improve infrastructure and services, they should also promote better environmental governance.

RESPONDING REGIONALLY

The current piecemeal approach to climate science—in particular, the tendency to treat air pollution and climate change as separate issues—has at times led to bad policy. The decision of many countries to promote diesel as a means to encourage fuel efficiency, for example, may have had the inadvertent effect of increasing black carbon emissions. And air-pollution laws designed to reduce the use of sulfate aerosols, which cause acid rain, have ironically led to more warming because sulfates also have a cooling effect. Had policymakers instead integrated efforts to reduce air pollution with those to slow global warming, they could have ensured that the reduction of sulfates was accompanied by an equivalent reduction in greenhouse gases.

A single global framework would be the ideal way to integrate various strategies for mitigating climate change. Bilateral or multilateral agreements are more feasible for getting started on reducing black carbon and ozone precursor emissions. These can strengthen governments' incentives to act by discouraging free-riding and by motivating governments to take into account the larger-scale impacts of their own emissions. Because the sources of black carbon and ozone vary from region to region, agreements to reduce them need to be tailored to suit regional conditions. In the Northern Hemisphere, for example, ozone precursors mostly come from industrial processes and transportation, whereas in the Southern Hemisphere, especially tropical regions, they mostly come from natural emissions (soils, plants, and forest fires). The sources of black carbon vary by region, too: in Europe and North America, transportation and industrial activity play a larger role than the burning of biomass, whereas the reverse is true in developing regions.

The impact of emissions on the climate is scientifically complex, and it depends on a number of factors that have not yet been adequately taken into account when devising climate models. The challenge, then, is to quickly create agreements that consider the complex links between human activities, emissions, and climate change and that can adjust over time as the scientific understanding of the problem evolves. Regional air-pollution agreements are easier to update than global agreements with many signatories. The UN Convention on Long-Range Transboundary Air Pollution (most of whose signatories are European or Central Asian states) and its subsequent pollutant-specific protocols provide a ready model for regional agreements on short-lived climate-changing pollutants. The specific provisions of these agreements are based on the costs of reductions, scientists' knowledge of the sources and distribution of air pollution, and the ability to measure reductions—considerations that should also inform the regulation of black carbon and ozone precursor emissions. Moreover, these agreements commit countries to particular actions, not just specific outcomes. This is wise, given that emissions are difficult to monitor and quantify precisely.

Black carbon and ozone can also be built into existing bilateral discussions. The High-Level India-EU Dialogue, a working group of scientists and policymakers from Europe and India, is one such existing forum. In February 2009, it was already urging governments from Europe and India to work together to recognize and reduce the threat from black carbon. Participants proposed an interdisciplinary research project that would determine the effects of biomass-based cooking and heating on health and the climate and assess the obstacles to a large-scale deployment of cleaner stoves. Black carbon and ozone are also natural candidates for U.S.-Chinese cooperation on energy and climate change: China would reap public health and agricultural benefits from reducing emissions, and the United States would earn goodwill for helping China do so.

By building on existing air-pollution agreements, the risk of distracting climate-change negotiations from the substantial task of promoting the reduction of carbon dioxide emissions could be avoided. Putting black carbon and ozone on the table in high-level climate talks could backfire if developing nations thought that they would be tacitly admitting responsibility for global warming by committing to reducing emissions of black carbon and ozone precursors or believed that the issue was an effort by developed countries to divert attention from the need for them to reduce their carbon dioxide emissions. Therefore, efforts to reduce emissions of black carbon and ozone precursors should be presented not as substitutes for commitments to reducing carbon dioxide emissions but as ways to quickly achieve local environmental and economic benefits.

THE LOW-HANGING FRUIT

Historically, initiatives to slow global warming have focused on reducing the emissions of carbon dioxide and other greenhouse gases and largely ignored the role played by air pollution. This strategy makes sense for the long run, since carbon dioxide emissions are, and will continue to be, the most important factor in climate change. But in the short run, it alone will not be enough. Some scientists have proposed geoengineering—manipulating the climate through the use of technology—as a potential option of last resort, but the reduction of black carbon and ozone precursor emissions offers a less risky opportunity for achieving the same end.

Such an approach would quickly lower the level of black carbon and ozone in the atmosphere, offsetting the impact of decades of greenhouse gas emissions, decelerating the rush toward a dangerously warm planet, and giving efforts to reduce carbon dioxide emissions time to get off the ground. These pollutants are also tractable policy targets: they can be reduced through the use of existing technologies, institutions, and strategies, and doing so would lead to local improvements in air quality, agricultural output, and public health. In short, reducing black carbon and ozone precursor emissions is a low-risk, high-potential addition to the current arsenal of strategies to mitigate climate change.

At the current rate of global warming, the earth's temperature stands to careen out of control. Now is the time to look carefully at all the possible brakes that can be applied to slow climate change, hedge against near-term climate disasters, and buy time for technological innovations. Of the available strategies, focusing on reducing emissions of black carbon and ozone precursors is the low-hanging fruit: the costs are relatively low, the implementation is feasible, and the benefits would be numerous and immediate.