

A person in a white shirt and dark pants is working with bricks in a smoky, industrial setting. The person is bent over, handling bricks. The background is filled with thick white smoke or steam, and there are stacks of bricks and other industrial equipment visible. The overall scene suggests a brick-making or similar industrial process.

BEYOND CO₂

The Other Agents of Influence

Drew Shindell identifies climate change mitigation measures that target soot and methane—and have a huge bonus: they also improve human health and food security.

International and domestic efforts to curb climate change largely have focused on reducing the amount of carbon dioxide (CO₂) in the atmosphere. While these actions remain important, we can do more. Black carbon (“soot”) and ozone, of which methane is a primary precursor, are the only two agents known to cause both global warming and degraded air quality. Black carbon is emitted during incomplete combustion of fossil fuels and biomass, and methane is a gas emitted from many sources, including landfills and coal mines. Both have major implications for human health and agriculture.

When the dark particles of black carbon absorb sunlight, either in the air or when they accumulate on snow and ice and reduce their reflectivity, they increase radiative forcing (a pollutant’s effect on the balance of incoming and outgoing energy in the atmosphere, and the concept behind global warming), and thus cause warming. They can also be inhaled deeply into human lungs, where they cause cardiovascular disease and lung cancer.

Methane has a more limited effect than black carbon on human health, but it can lead to premature death from the ozone it helps form. That ozone is also bad for



plants, so methane also reduces crop yields. It is a potent greenhouse gas as well, with much greater potential to cause global warming per ton emitted than CO₂. But its short atmospheric lifetime—less than 10 years, versus centuries or longer for CO₂—means that the climate responds quickly and dramatically to reductions. CO₂ emissions, in contrast, affect the climate for centuries, but plausible reductions will hardly affect global temperatures before 2040.

Recently I worked with an international team of researchers, including experts from the Stockholm Environment Institute, the Joint Research Centre of the European Commission, the U.S. Environmental Protection Agency, and others, to demonstrate the advantages and cost-effectiveness of addressing climate change through action on black carbon and methane. Our study suggests that implementing the right combination of emissions reduction measures would have large benefits for the global and regional climate, as well as for human health and food security.

Analyzing Existing Pollution Control Policies

We began by estimating the worldwide emissions reductions from approximately 400 existing pollution control measures. We then selected the measures that best mitigated warming as well. For example, measures that reduce sulfur dioxide emissions improve air quality but may increase warming, and were therefore excluded. We were left with the top 14 measures, which achieved nearly 90 percent of the maximum reduction in net global warming potential.

Of the 14 measures selected, 7 target methane emissions (from coal mining, oil and gas production, long-distance gas transmission, municipal waste and landfills,

wastewater, livestock manure, and rice paddies). The other 7 controls target black carbon emissions from incomplete combustion and include both technical measures (for diesel vehicles, biomass stoves, brick kilns, and coke ovens) and regulatory measures (for agricultural waste burning, high-emitting vehicles, and domestic cooking and heating).

Identifying Winning Combinations

The next step was to compare the effects of those high-impact pollution control measures with a reference case based on energy and fuel projections from the International Energy Agency. Our team modeled various scenarios—methane control measures, methane plus black carbon control measures, CO₂ control measures, and various combinations of measures—that would change the pollutants' atmospheric concentrations and radiative forcing.

A combination of measures to control black carbon, methane, and CO₂ could keep global mean warming at less than 2°C (relative to the preindustrial era) during the next 60 years—something that reducing the emissions of any one agent cannot achieve by itself.

Worldwide, methane emissions reductions in the coal mining and oil and gas production sectors would have the largest effects, with measures to target municipal waste coming in third. Sectors involving fossil fuel extraction and distribution—for which emissions control technology is readily available—would account for nearly two-thirds of the benefits. Regionally, the benefits of reducing emissions from coal mining in China would be largest, followed by oil and gas production in Africa, the Middle East, and Russia. Controls targeting coal mining in South Asia, gas transmission in Russia, and municipal waste in the United States and China would also yield large benefits.

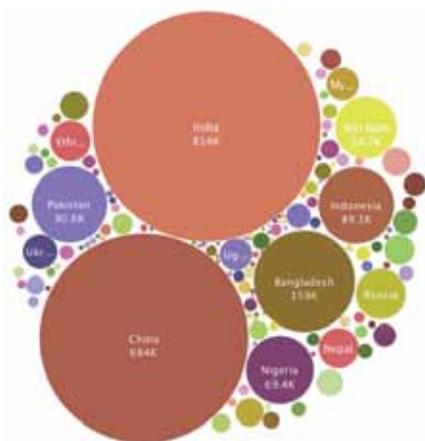
For black carbon, reductions in emissions from diesel vehicles and traditional cookstoves would have the largest climate effects. Reducing emissions from brick kilns, coke ovens, and burning of agricultural waste would generate additional benefits.

Effects on Health and Agriculture

The human health benefits from black carbon measures are larger than those of methane measures because fine particulates are so dangerous to human health. The estimate of avoided premature deaths due to outdoor air pollution is 0.7 million to 4.7 million per year (Figure 1)—substantial compared with other causes of premature death projected for 2030, including tuberculosis (0.6 million deaths per year), traffic accidents (2.1 million), and tobacco use (8.3 million).

Indoor air quality is also a problem in many developing countries. For India and China, implementation of all black carbon measures would avert an additional 373,000 premature deaths per year due to indoor air pollution. Other developing nations in Asia and Africa with large populations and high

Figure 1. Annually Avoided Premature Deaths from Black Carbon Control Measures Due to Outdoor Air Pollution



Source: Shindell et al. 2012.

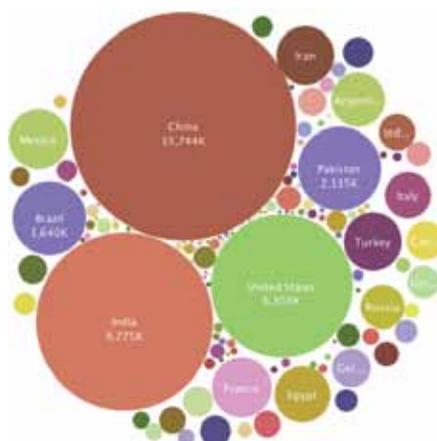
emissions of particulate matter also would see big reductions in premature deaths from measures to control black carbon.

For crop production, methane measures plus black carbon measures would boost yields the most, in terms of total tonnage, in China, India, and the United States; the Middle East would see high percentage increases in yields, as would Central and South Asia and Mexico (Figure 2). The largest impacts on changes in total production would occur where the seasonal timing of crops coincides with high concentrations of ozone.

Effects on Climate

Our research suggests that although the effects on climate would be distributed over the Earth more evenly than the effects on health, some regions would receive greater benefits than others. Northern Asia, southern Africa, and the Mediterranean would have the greatest reduction in potential warming with combined methane and black carbon reduction efforts. The measures to reduce black carbon emissions would be important for the Arctic and the Himalayas,

Figure 2. Annual Crop Production Increase from Black Carbon and Methane Control Measures (Maize, Rice, Soy, and Wheat)



limiting snow and ice melting by substantially reducing projected warming over the next three decades. The black carbon measures also could reduce drought risk in southern Europe and the Sahel belt across the north of the African continent, and would reduce disruption of traditional South Asian monsoon patterns.

An Important Opportunity

Are these measures worth the costs of implementation? Our economic analysis used the value of a statistical life (for health), world market prices (for crops), and the social cost of carbon and global mean temperature effects (for climate) to help answer this question. A very conservative benefit–cost analysis indicates that most of the measures considered in the study would produce benefits greater than the abate-

ment costs; for approximately two-thirds of the measures, the benefits would far exceed the costs.

The study's results demonstrate that a few air quality measures can provide substantial warming mitigation—benefiting global and regional climates, and improving human health and agricultural yields. While these measures can have great climate benefits, the added benefits of protecting public health and food supplies—priorities in most countries—will hopefully be motivating factors for implementation. ●

FURTHER READING

Shindell, Drew, et al. 2012. Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security. *Science* 335(6065): 183–89.

The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants

An international coalition involving Canada, Sweden, Mexico, Ghana, Bangladesh, the United States, and the United Nations Environment Programme has embarked on a program to mitigate global warming—but not by reducing CO₂ emissions. The hope is to slow climate change through action on black carbon and methane.

The new effort—the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, announced by Secretary of State Hillary Rodham Clinton on February 16—will fund educational projects and share practices to reduce black carbon and methane emissions. When it comes to reducing carbon dioxide emissions, Clinton said, the world has not done enough. “So this coalition is intended to complement—not supplant—the other actions we are, and must be, taking,” she said. “When we discover effective and affordable ways to reduce global warming—not just a little, but by a lot—it is a call to action.”

The Obama administration is committing \$12 million in new funding to the new effort, on top of the \$10 million in annual support to the existing Global Methane Initiative and Global Alliance for Clean Cookstoves. The coalition met for the first time in Stockholm in April, in conjunction with the 40th anniversary of the Stockholm Conference on Environment, and expanded to include four additional countries and the World Bank.