

## How charcoal fires heat the world

The greenhouse gas emissions from charcoal burning and production are significantly higher than previously believed, according to research published in *ES&T* (10.1021/es026058q). The findings have important implications for the developing world.

Up to 2 billion people worldwide prepare their food and heat their homes with the traditional biomass fuels of dung, crop residues, wood, and charcoal, according to Dan Kammen, a professor of public policy at the University of California at Berkeley and a coauthor of the research. He estimates that 250 million people use charcoal for their domestic energy at least once a week, mainly in Africa, parts of Asia, and Brazil.

The University of California research could lead to developing nations receiving more aid through the Clean Development Mechanism associated with the Kyoto Protocol, rather than simply through organizations that focus on development like the United Nations Development Programme, the World Bank, the Swedish International Development Agency (SIDA), Germany's Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), and the United Kingdom's Department for International Development (DFID), says Sivan Kartha, a senior scientist who is knowledgeable about the use of biomass as a cooking fuel at the Tellus Institute, a nonprofit environmental organization.

Charcoal is currently considered preferable to wood as an indoor cooking and heating fuel because it offers public health benefits. "Cookstoves . . . produce a volume of particulates that are trapped with the women and children inside homes," explains Kammen, whose previous research shows that charcoal stoves produce 75–95% less of the particu-

late matter that makes exposure to wood and dung fires a leading cause of childhood mortality in the developing world (*Lancet* 2001, 358, 619–625). "You can reduce the total burden of respiratory illness by a

from traditional open fires and improved ceramic woodstoves. Kammen, Bailis, and Majid Ezzati of Resources for the Future, a nonprofit, nonpartisan organization that focuses on environmental and



Exposure to smoke from wood fires is a major cause of lower respiratory infection, a leading cause of death and disease in children under five.

factor of 2 by switching from biomass to charcoal," he explains.

But this newest research makes clear that some complex tradeoffs may be involved, and charcoal's prognosis is no longer so clear, says Rob Bailis, the paper's lead author. The apparent health benefits of charcoal over wood contrast with the higher greenhouse gas emissions and the greater deforestation associated with charcoal, he explains. The fact that the Intergovernmental Panel on Climate Change may underestimate the greenhouse gas emissions from household fuel burning by underestimating total charcoal consumption makes the issue all the more significant, he adds.

Previous studies show that the CO<sub>2</sub> emissions from charcoal stoves are actually a bit lower than those

natural resource issues, decided to take the analysis one step further by calculating the emissions of carbon monoxide, methane, and non-methane hydrocarbons (NMHC) associated with burning charcoal. When they weighted each emitted pollutant with its 20-year global warming potential, they found that non-CO<sub>2</sub> emissions were 5549 ± 2700 grams of carbon (g of C) in 20-year CO<sub>2</sub> equivalent units, a number significantly higher than the emissions from traditional three-stone wood fires (2860 ± 680 g of C) or improved ceramic woodstoves (4711 ± 919 g of C).

The emissions from the charcoal stoves used in Kenya—as well as those from burning wood there—are also higher than previously believed, because the researchers took into account the fact that many

Kenyans keep their stoves burning all day, Bailis says. This is the kind of reality that laboratory calculations don't often factor in, although he acknowledges that lab tests are crucial because they enable measurements to be taken that are very difficult to obtain in the field.

When the non-CO<sub>2</sub> greenhouse gas emissions from producing charcoal are also taken into account, it looks even less favorable. Emissions from producing and burning charcoal are 6–13 times the emissions from woodstoves on a g of C per kilogram (kg) of fuel burned basis, according to the paper.

"The methods of production people use for charcoal are quite variable," Bailis says. In many cases, African charcoal is produced by teenage boys who cut down and burn trees, often from a protected or remote forest, and sometimes in a country other than their own, Kammen explains. The inefficient combustion process they use generates formaldehydes in addition to the greenhouse gases and particulates, he says. He says that most Brazilian charcoal is better for the environment because it is produced relatively efficiently through large-scale facilities where conditions are carefully controlled. Similar production methods are in limited use in Africa, but there are few incentives to change from traditional methods, he adds.

Although biomass burning has a major impact on the global environment because of the huge number of people who use such fuels, funding for domestic energy projects like upgrading cookstoves has fallen off in recent years, says Evans Kituyi, an atmospheric scientist with the Nairobi-based African Centre for Technology Studies (ACTS), one of the 27 member organizations in the Eastern Africa Energy Technology Development in Kenya network.

"Most donors believe they have

had enough with stoves in the country," Kituyi says. "None of our members has handled stove dissemination money for over eight years. Only RETAP [the Renewable Energy Technology Assistance Programme, a nonprofit group based in Kenya] received [a] grant of U.S. \$50,000 to disseminate institutional stoves to various boarding schools in Kenya and promote growing of woodlots on school compounds. This project, based around Mt. Kenya, has been very successful," he says.

"It is ironic that a \$50,000 grant is a windfall in this field, when the cost-effectiveness of improved stoves outstrips almost any other investment in public health in developing nations," Kammen says.

"Woodstoves have had a rough ride," says a World Bank employee familiar with such nonelectric fuel issues. "Except at the country level, you tend to have donors promoting stoves for awhile, then they drop out and the whole thing falls apart." The World Bank's Global Environment Facility (GEF) has only funded one project related to more efficient cookstoves (in Mali), says Eric Martinot of the GEF's Climate Change Program.

Although the greenhouse gas emissions from charcoal production and use in the United States pale in comparison to other sources, Kammen says that he and Bailis are working on a paper that evaluates the implications of barbecuing in the developed world. "Barbecue use in large amounts is certainly not the greatest thing for the environment," he says. Research set for publication next month by Matthew Fraser, an environmental engineer at Rice University, also points out that microscopic bits of fatty acids are released by grilled meat when grease sizzles on hot coals, producing particulate matter that can contribute to regional haze. —KELLYN BETTS

## News Briefs

### Europeans willing to pay to reduce climate change

Almost 90% of Europeans responding to a survey considered global climate change to be serious problems, according to the European Commission's research directorate, which conducted the survey of 16,000 citizens from 15 European Union member states. One-third of the respondents said they would pay more for energy from renewable resources. The respondents also favored increasing research into renewable energies (69%), cleaner means of transport (51%), and nuclear fusion (21%). *Energy: Issues, Options and Technologies* is available at [www.europa.eu.int/comm/research/energy/pdf/eurobarometer\\_energy\\_en.pdf](http://www.europa.eu.int/comm/research/energy/pdf/eurobarometer_energy_en.pdf).



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### Pollution prevention pays

Industrial pollution prevention programs protect the environment, but they're even more effective at saving money, according to the first national study of "P2" in the United States. Produced by the National Pollution Prevention Roundtable, the study documented that between 1998 and 2000, every dollar spent on P2 generated \$6.00 of savings. Better yet, 13 P2 programs spent \$1.9 million in projects during those two years that helped their businesses save \$404 million. According to a survey published in the report, however, 70% of respondents indicated that a lack of capital hindered them from implementing pollution prevention efforts. *An Ounce of Prevention is Worth 167 Billion Pounds of Cure — A Decade of Pollution Prevention Results: 1990-2000* is available at [www.p2.org/p2results/PressRelease.cfm](http://www.p2.org/p2results/PressRelease.cfm).