***POLICY IMPLICATIONS OF A NEW SCIENTIFIC CONSENSUS ON BLACK CARBON: COOKSTOVE MITIGATION OPTIONS***

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## Overview:

## Policies to alleviate global warming should address all of the major radiative forcing pollutants—CO2, Black Carbon (BC), methane, and nitrogen oxides. A new study by a group of 31 international scientists has concluded that BC emissions are about three times higher than previously estimated and the Global Warming Potential (GWP) of BC is many times higher than previously estimated—3200 for a 20 year time horizon. Using that GWP, the wordwide warming effect of BC is about 79% of the effect of CO2. That warming effect is more than all the coal-fired power plants on earth. For CO2, only about 2.5% of its full residence time impact is felt in the first year. Since the amount of BC emissions worldwide go down by about .7% per year, the cooling effect of that decline is about 22% of the yearly warming effect of the CO2 emissions.

Whereas most of the pollution causing radiative forcing originates in developing countries, and the damaging effects of that pollution are felt mainly in developing countries, most of the economic research has been on the benefits and costs of CO2 mitigation in developing countries. That is a basic mismatch in climate policy research.

## Methods and results:

## We specifically examine the potential for mitigating BC via substituting away from the current very dirty forms of household woodstoves in the rural developing world. In the last few years, there have been field studies of substituting better woodstoves for the very basic woodstoves now in use in various underdeveloped countries—China, India, Senegal, Ghana and Guatemala. These field studies are not very encouraging. In spite of inclusion of intensive education on the effects of indoor air pollution, training on the proper maintenance of the stoves, and follow-on counselling, most of the households returned to use of the traditional cookstoves within less than a year. Those studies were useful in showing the high bar that new cookstove technology would have to meet—enough improvement in energy efficiency to substantially reduce the time devoted to firewood collection, easy access to the fuel chamber even if it is enclosed, easy access to the cooking utensil area, no electricity requirement (e.g. for a fan), almost no maintenance requirement (e.g.for chimney cleaning), and very low or free acquisition cost of the stove. The current technology vintages are not close to achieving these difficult requirements.

 We did not conduct our own field study, and we did not focus on replacing traditional woodstoves with improved woodstoves. Instead, we looked at the possibility of partial substitution away from woodstoves toward use of gas-fired stoves. We used data from a survey of rural households in Mexico, which had been conducted by Mexican government agencies and the University of California at Davis. Rural Mexico is a better environment than many other rural areas for a number of reasons. A larger portion of rural household derive more of their income from non-agricultural activities, and thus they see a higher monetary opportunity cost to the time devoted to firewood collection. Many family members have lived in the United States and thus are more receptive to the substitution of new technologies for the traditional woodstoves. Also, the system for distribution of propane in rural areas is better in rural Mexico than in other countries because of the efforts of the national oil company PEMEX.

 We constructed a benefit-cost model in Excel and ran various scenarios through it. We tested the sensitivity of the B/C ratio to the following key parameters:

* The B/C ratio was quite sensitive to the price of propane. Mexico is one of those countries with a high “fracking” potential, although that potential remains largely unexploited.
* An interesting methodological problem came up in our work. We first thought that we could just use the BC 20 year GWP of 3200 because the economic useful life of the stoves is much less than that. However, that is methodologically tricky because the GWP is defined in relation to CO2 and its radiative forcing impacts are only felt very slowly over a much longer atmospheric residence period. So, we wound up using both the 20 year BC GWP of 3200 and the 100 year GWP of 910. As expected that does have a big impact on the B/C ratios.
* The other input variable that had a big impact on the B/C ratios was the assumed Social Cost of Carbon (SCC). In 2013, the U.S. government had an interagency task force collect and review the empirical literature from academic studies. That resulted in a directive from the U.S. Office of Management and Budget to use an assumed SCC of $36 per tonne of CO2, which also corresponds to a SCC of $36 per GWP. That was the initial input assumption in our modelling. However, there are indications that the actual amounts of money necessary to mitigate a GWP of CO2 in the European Union and California may be much higher—perhaps in the multiple hundreds of Euros or dollars. If developing countries have to choose between renewable energy alternatives with those kinds of pricetags and mitigating BC via cookstove replacement, then the cookstove replacement might still be attractive.

## Conclusions:

 To those whose focus is only toward substituting renewable energy for fossil energy, this research may seem to be a form of blasphemy because it looks at the benefits and costs of substituting away from a form of renewable energy, use of firewood in cookstoves, toward use of propane or similar fuels in cookstoves. However, depending on the values of the key parameters, this can be a good environmental bargain.

 Much depends on events outside the rural areas of developing countries. Will the fracking revolution continue to expand and involve more and more of the developing countries? Will LNG imports affect mainly just the developed nations, or eventually affect the developing countries as well? Will national oil companies view use of propane or similar products to be an important potential tool for mitigating BC? And will the costs of replacing fossil fuels with renewable energy turn out to be so expensive that other options, even those involving fossil fuels, will come to look attractive?

 We have not tried to analyse those scenarios of futue energy deveopments. We just develop an analytical framework for looking at the circumstances under which gas stove subsititution for woodstoves could become an economically efficient choice.