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Viewpoint

Short-lived non-CO_2 pollutants and climate policy: fair trade?

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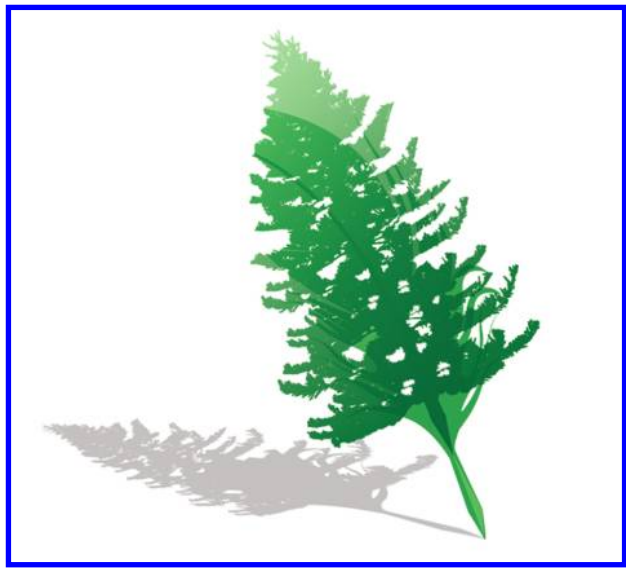
Author's Viewpoint



RHONDA SAUNDERS

Human burning of fossil fuels and biofuels for energy use affects global climate change through increasing carbon dioxide (CO_2), but also a host of other short-lived non-CO_2 effects that are complex and involve impacts that are both warming and cooling. The most important are ozone, a warming greenhouse gas, and fine aerosol particles, including sulfate, black carbon (soot), organic carbon, and nitrate. Most aerosol particles scatter solar radiation back to space and lead to cooling, except for black carbon, which absorbs solar radiation and warms the planet. Aerosol particles have additional climate effects through changing cloudiness. Hence, the combined short-lived non-CO_2 effect of a particular emission source may be warming or cooling depending on the characteristic emissions mix unique to that activity leading to large differences in the net climate impacts between sectors. For many key emission sectors, the non-CO_2 climate impacts outweigh those of CO_2 on short time scales (20−30 years) (*1, 2*), and therefore radically alter the impacts of emission reduction versus the greenhouse-gas only impact currently used in climate policy. A corollary is that allowances in cross-sector carbon trading are not created equal: the real climate benefits of across the board emissions reductions from a particular sector may be enhanced or reduced depending on the non-CO_2 effects. Accurate assessments of environmental policies affecting specific sectors must include the overall impact rather than simply CO_2. Despite the substantial impacts on climate, the short-lived non-CO_2 effects are not included in the Kyoto Protocol or any multinational cross-sector emissions trading scheme. To date, only the aviation sector has stirred interest in attempting to account for the short-lived non-CO_2 climate impacts in proposals to include this sector in the European Union Emissions Trading Scheme in 2012. A critical question emerges: should the non-CO_2 climate impacts be included for other sectors already included in emissions trading schemes? And, how?

It is not easy. The magnitudes of the short-lived non-CO_2 climate impacts are associated with larger uncertainties compared to the greenhouse gases, although understanding of the aerosol particle global effects has improved recently (*3*). A major hurdle is the difficulty in the development of a common scale (or metric) to compare impacts of the short-lived agents alongside CO_2 (*4*). Current available metrics to quantify the CO_2 and non-CO_2 climate impacts are all essentially based on the radiative forcing (RF) concept, which is a measure of planetary energy imbalance caused by a perturbation to the Earth system, such as the addition of a greenhouse gas or aerosol particulate. The global warming potential (GWP) and integrated radiative forcing (IRF) are forward-looking applications of RF designed to assist the development of policy. Both of these metrics assess the climate impact of a specific pollutant relative to CO_2 and depend on the time scale considered. The use of GWP is questionable for the short-lived non-CO_2 effects and robust values do not currently exist.

Climate policy options, mitigation strategies, and emissions-trading target entire sectors. The only existing metric that has been proposed to account for the total climate impact of an activity is radiative forcing index (RFI). This straightforward approach was first introduced for specific application to the aviation sector. RFI is defined as the ratio of total non-CO_2 + CO_2 RF to that from CO_2 alone and gives a numerical indicator of the additional climate impacts associated with non-CO_2 effects at a specific time point. RFI is time-dependent, even for constant emissions, because the CO_2 RF increases over time from the steady accumulation of CO_2 emissions in the atmosphere while the non-CO_2 RF remains constant. RFI is also dependent on changes to emissions sectors that affect a particular pollutant, for example, reductions through technological improvements and/or increases due to growth. Figure 1 presents RFI values for a range of key fossil and biofuel sectors based on data from ref *2*. The lines do not all converge to RFI = 1 because the non-CO_2 effects are important for many sectors even out to the 100-year time scale. Four broad categories emerge. The first group are sectors for which RFI > 1 where the net non-CO_2 effects are warming. RFI values for both on- and off-road land transportation range from 2.4 on 10−20-year time scales to 1.3 on 50−100-year time scales. Household

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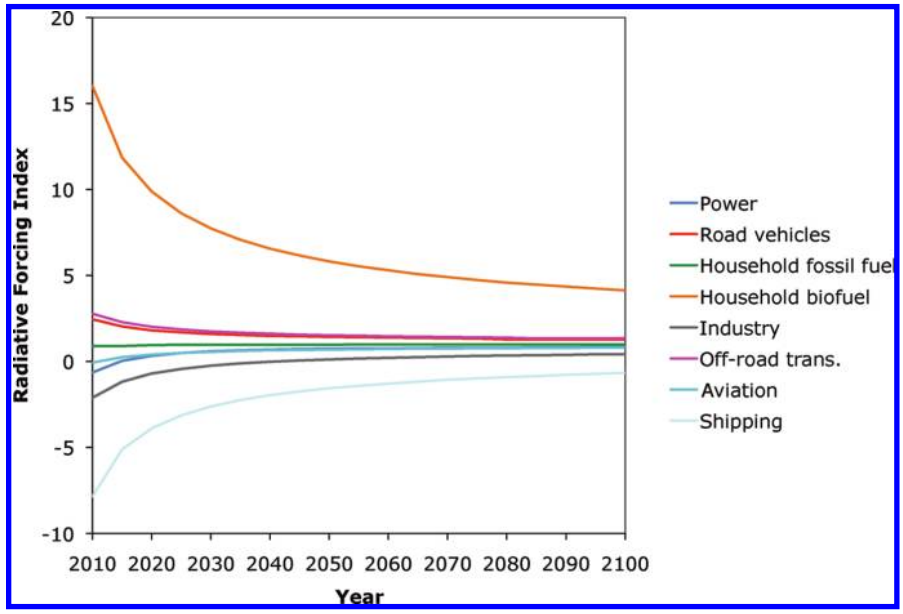

FIGURE 1. Radiative forcing index (RFI) for key fossil and biofuel economic sectors due to perpetual constant year 2000 emissions based on model data from ref *2*.

biofuel burning has the largest RFI value of all the sectors, ~16 on short time scales decreasing to 4 on the longer time scales. Reducing emissions from these sectors implies unambiguous climate benefits. The second group has $0 < RFI < 1$ and includes sectors having net cooling non-CO_2 RF that is outweighed by the CO_2 RF. Power and aviation emissions are in this category. Other assessments have found larger RFI for aviation than here (*5, 6*). In the third category, $RFI \approx 1$ such that the non-CO_2 RF is not important relative to the CO_2 RF and is therefore relatively time-independent. Only household fossil fuel burning falls into this category. Finally, a group exists for which RFI is negative, i.e., < 0, for this assessment, shipping and industry are included. RFI for shipping is −8 on short time scales and approaches −0.5 on longer time scales. Industry RFI is −2 on short-time scales and becomes positive on longer time scales, ~0.4. The RFI values highlight the severe difficulties in the use of the metric itself. For example, RFI < 1 (power, aviation, industry, shipping) might imply that increasing emissions from these activities is somehow beneficial to climate when in fact it would increase CO_2 and other (cooling) air pollutants, not beneficial to air quality or climate. The major conclusion here is that these results do not support the use of any simple multiplicative factor on short-time scales. Concerns about anthropogenic forcing of the climate system beyond an irreversible tipping point coupled to the important role that the non-CO_2 effects play in global climate change, urgently call for the development of new metrics that would appropriately quantify the non-CO_2 effects relative to CO_2. Furthermore, a new multimodel assessment of the net climate impacts of specific emissions sources is needed.

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