Integrating Black Carbon into Climate Change Agreements:

The need, challenges and practical first steps

innovo
energy solutions group, llc

By

Remy Garderet

Daniel W. Emmett

November 2009

Acknowledgements

The authors would like to thank Professors Ann Carlson and Cara Horowitz of UCLA School of Law for their guidance and thoughtful criticism, Rick Margolin of Innovo for his insights and edits, Terry Tamminen of the New America Foundation for his inspiration and encouragement, Dr. Alan C. Lloyd of the International Council for Clean Transportation for the invitation to the Global Atmospheric Pollution Forum in Stockholm on air pollution and climate change, Dr. V. Ramanathan, Dr. Tami Bond, and Dr. Mark Jacobson for their groundbreaking work on black carbon and climate change, and finally Rob Rutherford of Rotec Ltd. for working tirelessly on solutions to reducing black carbon emissions from diesel engines.

About the Authors

Remy Garderet is Climate and Energy Fellow at Innovo Energy Solutions Group where he specializes in climate-change related policy and incentives for commercialization of clean technologies. In addition to his role at Innovo, Remy is a Principal of Manta Consulting and Policy Director at Energy Independence Now Coalition. Remy holds a Masters focused on Economics and Energy Policy from the Johns Hopkins School of Advanced International Studies, and a BA in Communications and Latin American Studies from Stanford University.

Daniel Emmett is Managing Director at Innovo Energy Solutions Group where he focuses on the environmental impacts of traditional and emerging technologies and the shifting regulatory and policy landscapes affecting markets for these technologies. Mr. Emmett is also a founding Board Member and Executive Director of Energy Independence Now Coalition where he directs programs in policy development and advocacy in support of advancing clean transportation to address climate change, air quality and petroleum reduction objectives in California. Daniel holds a BA from the University of California Santa Cruz in Environmental Studies and Economics, and an MA in International Development Policy from Stanford University.

Contents

Executive Summary

Black carbon, emitted from the burning of biomass and fossil fuels, is increasingly being recognized as a significant contributor to climate change, second only to CO_2. As the scientific knowledge about black carbon's negative consequences grows, it is also becoming apparent that targeting these emissions, which have a short life-span in the atmosphere, offers a unique opportunity to have a fast impact on the climate and to take actions that could avoid some irreversible climate changes.

The heightened interest in black carbon builds on the long-known association of these emissions with localized air pollution and the severe negative health impacts of polluted air. Reducing black carbon emissions therefore promises significant co-benefits, improving the health of local people while contributing to the global climate change effort.

The immediate climate impact of action on black carbon, the possibility of avoiding an accelerated melting in the Arctic and alpine glacier regions, and the major health co-benefits of a black carbon effort are grounds enough for concerted action. Yet, while many policy and advocacy groups have begun to elevate the topic within air pollution-related organizations, and while these efforts are successfully raising awareness of the problem and bringing together decision makers within the context of national, bi-lateral and multi-lateral air pollution-related agreements, the topic of black carbon remains largely absent from the global climate negotiations in Copenhagen in December 2009. Despite a compelling case for action on black carbon, it is surprising that the sense of urgency on this topic is not greater, and that policy discussions on how to incorporate black carbon into our climate change efforts are not being more publicly and widely debated.

The limits of current black carbon efforts

Though the science around black carbon is not as advanced as that of CO_2 and other greenhouse gases (GHGs), sufficient consensus exists on black carbon to provide appropriately accurate metrics on how to assess the climate value of actions to reduce black carbon emissions. However, given the complexities of black carbon, there is a natural tendency to address this problem separately from other long-term GHGs, and to approach it using regional and national regulations that have worked well for controlling other aerosols in the industrialized world.

Air pollution-driven initiatives, which target black carbon separately from the other long-term GHGs, may have tactical advantages, but they are likely to be insufficient in getting the meaningful black carbon action that is needed to address climate change. While the industrialized world has a long record of success using regulatory approaches to air pollution, regulatory institutions in many developing countries remain weak, and vehicle emissions standards are typically either non-existent, insufficient, or not well enforced. In sectors other than transport, such as rural residential energy use, the options for developing countries are also not easily addressed by regulatory approaches. Even in industrialized economies, black carbon from certain sectors, such as international shipping, remains difficult to regulate via existing frameworks.

The other problem with addressing black carbon independently as an air pollution issue is that each country views black carbon action differently in relation to CO_2 and other GHGs. For a successful global agreement, it will be essential to recognize that countries want to prioritize their short-term and long-term contributions in different ways.

To be able to achieve the scale to rapidly reduce black carbon emissions, the issue must be elevated beyond air pollution circles and integrated into climate change agreements, both at the global UN scale and in the national and sub-national agreements that follow from it. It is only in this context, where black carbon is considered alongside the long-term GHGs, that some of the major benefits which addressing black carbon offers will be realized. These benefits include providing nations the flexibility they need to prioritize their climate efforts, as well as allowing some of the major market mechanisms to be engaged to direct funds to these black carbon reducing projects.

Integrating black carbon into climate change agreements

The limitations of addressing black carbon independently through air pollution frameworks all point to a need to address it jointly with the existing GHG gases, and to seek a global agreement that recognizes both simultaneously. This approach would focus on adding black carbon to the already acknowledged climate warming gases, the so-called "Kyoto Six." Although this may be the ultimate end goal, there are several reasons to believe it may not be feasible at this time, and that an intermediate, partially integrated solution might be a more realistic objective.

A clear benefit of adding black carbon to the Kyoto Six would be to leverage the existing institutions & mechanisms that have been established for GHGs, both by governments and the business community. An integrated framework would also remove the burden on individuals, companies or countries to choose how to trade-off the long-term GHGs and short-term warming aerosols.

However, there are serious practical challenges to overcome in doing this: the slow, consensus-driven IPCC system would be time consuming, and countries may be uncertain of what mechanisms they could use to reduce black carbon, given that much of it is outside the market and beyond their normal regulatory reach. These challenges suggest that an intermediate approach in which black carbon is only partially integrated may be more realistic.

Several practical first steps towards integration of black carbon into climate frameworks

1. The first important element that should be sought is to allow a country to meet part of its national GHG target through projects that reduce black carbon in its own territory, with certain limits related to its level of development. Countries could approach domestic black carbon reduction in a variety of ways, using regulations or market incentives and black carbon-specific funds to promote such projects. Recognizing these black carbon achievements would give local leaders the domestic political support to engage in international climate agreements and give them recognition at international forums for their contributions to climate change.
2. The second set of policies that need to be advanced are cross-border market mechanisms and incentives aimed at directing a flow of funds to black carbon related projects in developing countries. Since reductions can in some cases be made for the equivalent of less than $1 per ton of CO_2, allowing black carbon projects in developing countries to serve as 'offsets' for formal CO_2 targets in industrialized countries is one logical mechanism. In practical terms, this would involve broadening the scope of the Clean Development Mechanism (CDM) and Joint Implementation (JI) in the Kyoto Protocol to incorporate black carbon.
3. Another action would be to create international funds administered by multi-lateral banks, which specifically pay out compensation to black carbon projects in developing countries. The development of voluntary black carbon markets also needs to be promoted, as these serve as important precursors to formal markets.
4. Finally, one core aspect of the existing climate framework that needs to be strengthened are the measurement, reporting and verification (MRV) procedures, and this effort could be extended to include black carbon. Expanding both voluntary and compliance-based verification systems to assess black carbon projects would help establish legitimacy for such actions.

Therefore, although a climate change agreement that fully incorporates black carbon is unlikely in the near future, steps can and should be taken to work towards this. These should aim to encourage developing countries to sign up to a climate agreement under the condition they could meet a portion of their targets through black carbon projects, and aim to develop market mechanisms that can steer investment toward black carbon projects in their countries. A commitment by the countries meeting in December in Copenhagen to consider expanding the CDM to incorporate black carbon projects would be a clear and effective first step in this direction.

1. Introduction

Black carbon emissions are increasingly being recognized as a significant contributor to climate change, second only to CO_2. As the scientific knowledge about black carbon's negative consequences grows, it is also becoming apparent that targeting these emissions, which have a short life-span in the atmosphere, offers a unique opportunity to have a fast impact on the climate and to take actions that could avoid some irreversible climate changes.

This new interest in black carbon particles builds on the long-known association of these and other air-born particles, or aerosols, with severe negative health impacts of polluted air.[1] Reducing black carbon emissions therefore promises significant co-benefits: improving the health of local people while contributing to the global climate change effort.

Black carbon is not alone in having these dual impacts. In fact, the attention to black carbon emissions has emerged in a more general context in which climate scientists increasingly understand the complicated direct and indirect effects of short-term air pollutants on overall long-term climate change. As stated in a recent assessment of this issue by a broad community of scientists and policymakers in Stockholm in 2008: "Current science emphasizes the urgent need to address air pollution and climate change in an integrated way. We should no longer treat these two issues separately as we strive to achieve sustainable development and a low carbon society."[2] This integrated approach is clearly a more scientifically sound way of moving forward and provides multiple win-win solutions while lowering the costs of achieving many objectives.

However, the policy challenges of this convergence of climate change and air quality objectives are complex. In particular, they include some key questions such as: should black carbon regulations take place within the framework of traditional air pollution policies, or rather in climate-specific ones, or in some merging of the two? Given that in the long-term we will need action on both black carbon and CO_2, how should these diverse options be prioritized? And what kind of policy tools, from regulatory mechanisms to market incentives, are best suited to reducing these emissions?

These are complex issues, and the subject of this paper. In particular, we explore these policy questions with an important underlying premise: countries around the world, from the most industrialized to the poorer developing countries, each face a unique situation when it comes to black carbon, in terms of their emissions profile, the cost of addressing these emissions, the institutional and political ability to take action, and their ability to pay. When overlaid with an equally varied CO_2 profile, this makes for a great patchwork of different perspectives on how a given country should prioritize and implement its black carbon efforts in relation to its other climate change and development efforts.

So whereas the science of black carbon is now clear, serious debate about the ideal policy to encourage action is still absent in high level forums. The ideal approach to addressing black carbon will need to strike a difficult balance: on the one hand, there is a strategic, long-term imperative to get as many countries on board the overall climate mitigation effort, targeting both aerosols and GHGs. On the other hand, practical and tactical considerations dictate that high priority efforts need to move forward quickly, unrestrained by global consensus.

2. About Black Carbon: the problem and the opportunity[1]

Emissions of black carbon

Black carbon is the main element of what we know as soot and is emitted from open biomass burning (slash and burn agriculture, forest fires etc.) and from energy-related burning from sources such as diesel engines and residential fuel burning for warmth and cooking.

All countries have black carbon emissions, but economic development tends to result in the use of increasingly clean technologies, such as better stoves and emission controls on vehicles, which reduces black carbon emissions for given activities as countries become richer and are able to prioritize spending on clean air.[3] This improvement is offset in part by the increase in total energy use and attendant GHG emissions that accompany development, as well as the changing nature of industrial development. In particular, as most residential and industrial activities are cleaned up, transportation increasingly dominates the profile of a country's black carbon emissions, as growth of personal transport and goods movements outpaces the technological improvements made in its emissions.[4]

Environmental impacts

Black carbon stays in the atmosphere for only several days to weeks, whereas CO_2 has an atmospheric lifetime of more than 100 years.[5] While it is in the atmosphere, black carbon affects the climate in several interrelated ways, which scientists are only recently beginning to untangle. This includes warming the air as it absorbs and scatters light ("direct effects"), changes in the formation and thickness of clouds ("semi-direct effects"), cooling the earth through the dimming it causes ("indirect effects"), and - very importantly - reducing albedo, the ability to reflect sunlight, when deposited on snow and ice, which causes it to melt faster.

Scientists are now finding that the combination of these effects appear to make black carbon the second most important contributor to global climate change: the most recent findings show that "soot and other forms of black carbon could have as much as 60 percent of the current global warming effect of carbon dioxide, more than that of any greenhouse gas besides CO_2." These effects are greater than previously thought, and include accounting for how black carbon mixes with other aerosols such as sulfates, as well as its effects at the full range of altitudes at which the warming effect occurs.[6]

Black carbon is of particular importance in the Arctic, where it settles on ice and snow, reducing its reflectivity and increasing the rate of melting.[7] The Arctic climate is highly sensitive to the surface warming that black carbon causes, and it appears to warm the Arctic more than any other agent except CO_2. Most Arctic black carbon comes from fuel-combustion, not from open fires.[8] It is believed that the emissions from Northern Europe result in over 60% of the black carbon that is currently deposited on the Arctic,[9] and it is becoming clear that this black carbon is responsible for a significant portion of the observed warming in the upper latitudes, which is greater than the global mean. The most recent study by NASA and Columbia University scientists finds that black carbon from North America and Northern Europe has played a major role in this warming. Although its effect was temporarily masked by the sulfates co-emitted before clean air policies were implemented, this black carbon impact is now being unmasked and compounded by the rapid rise in black carbon emissions from northern Asia.[10]

Black carbon also has other severe regional impacts: scientists have identified at least five regional hot spots, and long-range transport from these hot spots gives rise to wide-spread plumes over the adjacent oceans. One example of a regional impact of black carbon is the rapid

---

[1] For more details, see Appendix: "The Role of Black Carbon in Climate Change" http://www.innovoenergy.com/pdfs/INNOVO-ENERGY-The-Role-of-Black-Carbon-in-Climate-Change-Appendix.pdf

melting of the snowpack and glaciers of the Himalayas, now thought to be caused in large part by the effect of black carbon.[11] This effect could have dramatic implications for food security in both China and India, which depend on the water runoff from the Himalayas. Similar impacts are being observed in the European Alps and California Sierras.[12]

Health impacts

Unlike CO_2, black carbon also has negative health effects. Its emission is directly associated with particulate matter, now widely recognized as a direct cause of higher daily death rates and reduced life expectancy. The World Health Organization (WHO) estimates that outdoor air pollution of particulate matter leads to approximately 800,000 premature deaths per year and indoor air pollution to about double that number.[13] Many other studies have confirmed the specific links between particulate emissions and heart attacks, cancer, respiratory illnesses, reproduction and fetal development, nervous toxicity and more. [14] Black carbon is particularly dangerous, with recent studies singling it out from other general particles (PM2.5) as having an even greater effect on health than general particle emissions.[15]

The opportunity: fast climate impact with local co-benefits

These recent findings make the benefits of focusing on black carbon mitigation clearer than ever. In contrast to CO_2, reduction of which will take decades and even centuries to reduce climate impacts, black carbon reductions will have an almost instant effect, offering a fast-impact global climate change strategy. Although this black carbon action cannot offset the need for long-term CO_2 reductions, it provides a time-buying strategy to keep temperature increases below a critical value. In particular, reducing black carbon deposits on the Arctic and mountain snow-packs offers a quick way to prevent these sensitive systems from reaching irreversible tipping points that would have global impacts.[16]

Also, unlike many efforts for CO_2 and the other long-term gases, black carbon reductions can provide regional environmental benefits that the emitting countries may experience directly. India and China, both highly dependent on the snow-melt from the Himalayas, have a clear self-interest in preventing an irreversible melting of the base of that snowpack.

Alongside these environmental benefits are immediate health co-benefits. Cleaning up the air in the city of a developing country, or reducing the respiratory problems in rural villages where dirty stoves are in use provides tangible, local health benefits and a visible improvement in the quality of life.

Black carbon reductions are thus associated with improvement in living standards and health, rather than as sacrifices to convenience. This is in stark contrast to CO_2 emissions, which are associated with the convenience of using easily available fossil fuels. Black carbon reductions therefore correlate with and support development, not limit it, and any effort to advance this clean-up would be viewed positively.

Low-cost options in the developing world

The diverse sources of black carbon and its association with activities both in industrialized and developing countries means that there is a wide range of costs associated with eliminating these emissions. While switching from an open wood burning stove to a more efficient stove can be done for as little as $3, installing particle traps on diesel trucks can cost several thousand dollars.[17]

In industrialized countries, where many advances have already been made to reduce air pollution from a wide range of stationary sources, and where residential cooking is done using gas or electricity rather than open fires, the remaining black carbon reduction opportunities are primarily in the transportation sector. In many cases, the marginal cost of these actions appears relatively high when viewed in isolation, compared with CO_2 measures. These are mainly diesel emissions from on-road vehicles (cars and trucks), many off-road uses (in construction for example), as well as locomotive and marine sources.[18] However, many existing strategies to reduce CO_2 in these

sectors, such as a transition to zero emission and low carbon fuels like biogas, hydrogen and electric drive, would reduce both CO_2 and black carbon emissions simultaneously, creating an additional gain for industrialized countries.[19]

In developing countries, by contrast, black carbon reductions are typically still available from a much greater range of activities than just transport, and at very low cost. As well as cleaning up the transport sector, improvements in rural residential energy use, agricultural burning practices, and small industrial activity can all achieve significant black carbon reductions.

Many people are now starting to see that these low cost black carbon options could catalyze climate change action in developing countries, which could simultaneously reap the local health co-benefits. Black carbon reductions could be a way for these countries to contribute to the global climate effort in ways that visibly improve local standards of living.

3. Challenges posed by black carbon

As mentioned earlier, black carbon - like other aerosols - differs considerably from long-term greenhouse gases in several key ways. Although it poses some policy challenges, leading scientists in the field are confident that these do not prohibit action.[20]

Agreeing on a GWP or other black carbon metric

The first policy challenge for black carbon relates to measuring the climate impact. Under the Kyoto Protocol, actions to reduce GHGs are evaluated using the "100 year global warming potential" (GWP), a figure given in relation to the effect of CO_2 over 100 years, which is given a GWP of 1. Although the 100yr GWP is adequate for comparing long-lived gases, it greatly under-estimates the impact of short-lived gases and aerosols on the climate. For example, although the range of estimates for the 100yr GWP of black carbon is estimated by Dr. Jacobson to be from 1500–2240, if one compares black carbon to CO_2 over a 20yr timeframe, the GWP (20yr) is 4470.[21] To compare long-term and short-term impacts, a choice must be made on the time horizon to prioritize.

The other scientific challenge in coming up with a metric is in actually calculating the temperature impacts of the black carbon emissions. While the temperature effects of GHGs are generally proportional to their radiative forcings (the change in net energy radiated in and out of the atmosphere) as measured high in the atmosphere, the relationship between radiative forcing and temperature is not as simple for aerosols: radiative forcing has to be 'normalized' in a complex way to translate into a true measure of the temperature effect on the globe. Comparing the radiative forcing figures of black carbon to CO_2 is therefore misleading and may significantly underestimate black carbon's actual importance to global warming.

As mentioned earlier, the regional and localized sensitivity to black carbon is also important to measuring the effect of black carbon, with the Arctic being a clear example. Black carbon's effect in reducing snow albedo (reflexivity) in the Arctic is estimated to be largest for Europe, suggesting that black carbon emission reductions from this region are more efficient to mitigate climate change.[22]

In the most recent assessment of the International Panel on Climate Change (IPCC), the uncertainty of the effects caused by aerosols still dominated the overall uncertainty of the total climate change impact, creating an impression that aerosols were beyond the reach of consensus, and therefore policy. Much of that uncertainty was linked to poor knowledge of the emission constituents of aerosol pollutants, a problem which is now being addressed by new measurement technologies which identify the detailed chemistry of air pollution in real time, and can help both identify the source and the resulting weather patterns.[23]

None of these challenges relating to a black carbon metric are insurmountable, however. GWP figures for a range of sources and timeframes are available,[24] with given ranges of uncertainty for different sectors. Whether these GWP or other measures are ultimately used, the methodology

needs to include the inputs for what time horizon to consider and how to normalize the radiative forcing to translate it into actual global temperature impact.[25] The variation in regional impacts could in theory be incorporated into GWP figures, assigning a higher GWP figure to emissions that are close to the Arctic. For simplification, a simple northern hemisphere vs. southern hemisphere GWP number could also be used.[26]

What is clear is that as scientists are able to disaggregate the effects of aerosols, black carbon dominates so clearly and with such magnitude that it can no longer be ignored: the balance has now tipped in favor of taking action despite the remaining uncertainties on the exact metric to use.

Incorporating all sectors

A second policy challenge relating to our incomplete knowledge is whether we should target black carbon from all sources or just from those where the effects are well quantified. The argument for selecting specific sectors would be that there is great confidence in some sectors. According to Dr. Tami Bond, "…aerosols emitted from diesel engines and biofuel for cooking, warm climate with a very high probability, and contribute a substantial fraction of the total forcing from these sources….The greatest forcing by far results from diesel superemitters, because the emission factor is the higher."[27] This confidence in some sectors has led some to suggest that just transport-related emissions should be regulated, where the impact is unequivocally a net warming impact with little range in uncertainty, and that other sectors or types of emissions be left until science can catch up.

The danger with this approach is that it would leave a very large proportion of black carbon emissions un-addressed. Transport is not the biggest source in many countries. In China, for example, only 5-11% is estimated to come from mobile sources while 55-65% of black carbon emissions come from residential burning.[28]

Rather than exclude other sectors, it is therefore more appropriate to keep all black carbon emissions on the table. If necessary, the black carbon GWP figures for some types of sources such as forest clearing or wildfires could be discounted to account for the greater uncertainty around those numbers. As the scientific understanding or monitoring of these sources improves, these discount factors could be reduced, without changing the mechanism or scope of coverage of any black carbon control regime.

Other aerosols, and the "unmasking" effect

A third complication relating to reducing black carbon is that it is emitted simultaneously with other aerosols which have their own significant climate change impacts, and so some would argue that we should address effects of all aerosols, and not single out black carbon. This could also include ozone and ozone pre-cursors, which are also a major contributor to short-term warming and are currently not included in climate change agreements.

This approach would change priorities by creating a framework for comparing the climate effects of the different aerosols. For example, when emissions of soot are reduced, the net climate effect of reducing that soot varies depending on the ratio of black carbon (the warming agent) to the cooling effect of the organic carbon and co-pollutants such as sulfur dioxide that are emitted alongside it.[29] This means that reducing fossil fuel black carbon emissions (from diesel, for example) has a greater cooling effect on the climate than reducing the same amount of black carbon emitted from biomass burning (such as that from rural stoves), where black carbon's warming effect is tempered by the shade created by the organic carbon haze.

Considering black carbon jointly against other short-term aerosols and ozone would therefore, from a strictly climate-oriented perspective, seem like a good idea to ensure the greatest net climate benefit from any given investment. It would result in prioritizing actions targeted at fossil fuel burning, rather than biomass burning.

But while there may be substantial climate-specific benefits of regulating black carbon together with other short-term agents, several additional yet equally important considerations warrant black carbon-specific regulations.

These are primarily health-related: while fossil fuel soot (dominated by black carbon) has an effect on the climate that is three times greater than biomass soot, that same biomass soot has seven times the negative health effects than fossil fuel soot, given the many other co-pollutants it contains.[30] Short-term aerosols are associated with such a wide range of negative health and local environmental effects that all efforts to reduce them should be supported, even if – like sulfur dioxide – they are temporarily cooling the climate. Establishing a climate-oriented agreement that creates a perverse incentive to preserve emissions of these other co-pollutants is irrational.[31]

The underlying assumption of air pollution efforts has been, and should continue to be, that the world community is committed to reducing pollutants that are harmful to health, such as sulfur dioxide, and that if these improvements "unmask" an even greater climate problem, then we must tackle that climate problem at its source. Black carbon therefore warrants specific targeting, unrelated to other aerosols.

A general need for retrofits and changes, not just new standards

A fourth challenge with black carbon stems not from its scientific properties but rather from the types of investments that are needed. To take advantage of the black carbon opportunity, proactive intervention into existing equipment is needed - setting standards for new technologies and waiting for a natural turnover of stock to clean things up will not be sufficient.

In the transport sectors of both developed and developing countries, the slow turnover of vehicles calls for a focus on retrofit programs to achieve fast results. In developing nations especially, targeting the clean-up or removal of super-emitters and dirty public transport fleets is needed to have an immediate environmental, economic, and political payback, rather than just strict standards on new vehicles.

Some technical challenges exist for these transport retrofits. Many existing particle traps to reduce black carbon emissions for diesel vehicles can only be used where low or ultra-low sulfur diesel is available, and so it is often argued that desulfurization is a necessary first step before black carbon emissions can be addressed. However, a new generation of retrofit technologies that is effective at reducing a large percentage of black carbon and other particulate emissions even in the presence of sulfur is now entering the market and offers an opportunity to advance simultaneously with the desulfurization and black carbon reductions.

Likewise, addressing the black carbon caused by rural cookstoves in Asia cannot be based on standards for new equipment. It requires a concerted effort to intervene in the existing stock of stoves, replacing them with newer, less polluting versions. This is a proactive development project, requiring the resources of the institutions that have been working in remote and rural regions for many years.

All these types of targeted retrofit projects can be costly, however, and since they often impact goods and transport services for poorer segments of society, there is understandable political reluctance to impose costly retrofit requirements unless financing is available to offset the costs.

Thus whereas many actions undertaken on long-term greenhouse gases are focused on changing decision making at the margin, such as affecting prices that incentivize investment in a renewable electricity plant rather than a coal one for example, our efforts on black carbon are in many ways different: they require a greater emphasis on a concerted clean-up effort, rather than a redirection of future investments.

4. The need to elevate and integrate black carbon into climate change frameworks

All of the evidence therefore points to an urgent need to address black carbon emissions. The immediate climate impact of such action, the possibility of avoiding an environmental catastrophe in the Arctic and alpine glacier regions, and the major health co-benefits of a black carbon effort are grounds enough for concerted action. Though not as advanced as GHG science, aerosol understanding is sufficient to give us a clear signal with appropriately accurate metrics on how to assess the climate value of action from most sectors. The technologies for most of the actions are widely available, and in most cases are not prohibitively costly.

With such a compelling case, it is surprising that the sense of urgency on this topic is not greater, and that policy discussions on how to incorporate black carbon into our climate change efforts are not being more publicly and widely debated.

Some progress has begun on this front in the media. A recent article in *Foreign Affairs* by Dr Ramanathan, one of the leading black carbon scientists, makes the case that black carbon actions are the "low hanging fruits" of climate change efforts, and that the narrow focus on CO_2 will not only be insufficient to stabilize the climate in time, but will also lead to misdirected actions.[32] A prominent article in the New York Times in April 2009 also highlighted the issue, focusing on the replacement of cooking stoves in India as one of the tangible actions.[33]

Many policy and advocacy groups have also begun to elevate the topic within air pollution-related organizations. These efforts are successfully raising awareness of the problem and bringing together decision makers within the context of national, bi-lateral and in some cases multi-lateral air pollution-related agreements. However, they are still not clearly apparent in the preparations for the global climate negotiations in Copenhagen in December 2009.

There is a fear among some that a focus on black carbon in the global climate negotiations would undermine the existing efforts on the long-term GHGs. As Dr. Ramanathan puts it: “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 the issue was an effort by developed countries to divert attention from the need for them to reduce their carbon dioxide emissions.” Others believe there may be negotiation tactics at work, whereby a maximum agreement is reached on CO_2 before black carbon is introduced in the mix.

However, it is our belief that these fears are clearly outweighed by the urgency of our climate predicament, and that black carbon action, given its practical, economic and political advantages, is much more than a distraction – it is an unparalleled opportunity to seize.

To be able to achieve the scale needed to rapidly reduce black carbon emissions, the issue must be elevated beyond the air pollution circles, where it is treated as an independent problem, and integrated into the climate change agreements, both at the global UN scale and in the national and sub-national agreements that follow from it.

It is only in this context, where it is considered alongside the long-term GHGs, that some of the major benefits from addressing black carbon will be realized. These benefits, which we explore below, include providing nations the flexibility they need to prioritize their climate efforts, as well as allowing some of the major market mechanisms to be engaged to direct funds to these black carbon reducing projects.

5. Current climate-related initiatives

Global focus on GHGs, and regional focus on air pollution

As is well known, many efforts are currently underway to address climate change, with a strong emphasis on the effect of CO_2. These climate change-focused agreements have been under development at the global, regional, national and even sub-national level for many years. The overarching one is the U.N. Framework Convention on Climate Change (UNFCCC) from which

the Kyoto Protocol was developed. The successor treaty covering the period starting in 2012 is currently being developed in the run-up to the United Nation Climate Change Conference (COP15) in Copenhagen in December 2009.

This global agreement is complemented by a wide range of regional programs, such as the European Trading Scheme (ETS), and very significant programs at the national and sub-national levels, where targets and mechanism to achieve them are well under way. Almost without exception, these existing policy frameworks have been built around the six "Kyoto" greenhouse gases - carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, and two fluorocarbons.

Aerosols, although they are recognized by the IPCC as playing a major role in climate change, have to date not been incorporated in any of the global negotiations, and have therefore been largely excluded from the national and sub-national programs that have been developed in support of the global efforts. Though there has been some discussion in Australia of incorporating black carbon into the targets, the European ETS and California AB32 agreements are more typical: they include no targets or action on black carbon or any other aerosols.

On the air pollution side, an even more diverse range of agreements exists than for climate change, built over many years to address successive air pollution-related effects. Some are global, like the extremely successful Montreal Protocol, which although it was established with the objective of preventing the ozone 'hole' rather than global warming, has proved a very effective mechanism for both. However, the majority of air pollution agreements are national, bi-lateral or regional in scope, and were designed with specific air pollutants and environmental problems in mind (e.g. sulfur dioxide and acid rain).

An increasing number of voices are stressing the need to consider air pollution and climate change jointly, with some non-government entities and institutions raising awareness of the issue and gathering scientists and policy-makers together. These include the Stockholm Institute, the Institute for Governance and Sustainable Development (promoting the "Fast-Action" concept), the International Council on Clean Transportation and environmentally-oriented non-profits and foundations such as ClimateWorks.

The key policy question in this convergence of issues is whether air pollution mechanisms should be built on, and expanded to, incorporate global action on black carbon, or whether black carbon should be integrated into the existing GHG-related frameworks. [34]

The air pollution approach to black carbon

In terms of current activities, most development is emerging within the regional air pollution frameworks rather than from GHG policy.

These include interest from the UN's Convention on Long Range Transboundary Air Pollution, and regional efforts by countries at risk, such as the members of the Arctic Council, which have all promoted discussions on the subject of black carbon. At the national level, the issue is also on the table. In the U.S., the Waxman-Markey bill, drawing on several black carbon-related bills in the U.S. congress, proposes to expand the mandate of the EPA to include black carbon regulation, as well as study the options for international action.

All of these regional and national initiatives are in many ways taking existing air pollution-focused organizations and networks and attempting to reinforce their mandate in order to target black carbon.

These efforts are critical, and worthy of support. They help establish a global awareness of the severity of the problem, and create a policy backdrop against which individual countries can begin to shape their national policies, in effect legitimizing efforts to study the black carbon emissions and explore the country-specific options to address them.

The regional air pollution frameworks also offer many advantages over the global climate-focused negotiations, which may be one of the reasons we have seen most activity in these policy arenas.

On the one hand, regional agreements can be tailored to the specific concerns of their member countries. Northern Europeans and Arctic member states focus on their concern for the melting ice caps, and can target their activities and agreements on the specific sectors that are most relevant to them, such as industry and transport, narrowing down to such specific problems as marine transportation pollution. India and China, on the other hand, have a shared regional concern to avoid a rapid melting of the Himalayan glaciers, and can focus specifically on the biomass burning activities that emit most of the regionally-relevant black carbon. [35]

Regional air pollution agreements are also potentially more nimble and flexible, and can get a smaller group of countries to agree on specific actions, rather than broad targets in a quicker timeframe. Another perceived advantage of using the regional air pollution agreements to advance black carbon efforts is not to muddy the waters of the ongoing negotiations on the long-term GHGs.

However, targeting black carbon independently using these regional and national air pollution frameworks, although it offers considerable tactical advantages in terms of putting black carbon on the agenda quickly, may ultimately be insufficient to galvanize the necessary action and finances that are needed.

6. The limits of treating black carbon through air pollution frameworks

The air pollution-driven initiatives, which target black carbon separately from the other long-term climate warmers, may have the tactical advantages discussed above, but they are likely to be insufficient in getting the scale of black carbon action needed for a variety of reasons.

Regulatory approaches are limited for many developing countries

One challenge with addressing black carbon as an independent air pollution problem is the emphasis on regulatory command-and-control solutions. If these pollution frameworks can only provide top-down accords that set standards and regulations on emission limits or technologies, they will be depending on national regulatory agencies' ability to implement and enforce these actions. This may be an effective strategy for member countries of the Organization for Economic Cooperation & Development (OECD) but has proven to be insufficient in many developing country contexts, and is unlikely to address some of the difficult rural energy use patterns.

There is no doubt that air regulations have immense power for transformation in economically developed countries. Great gains have already been made using these mechanisms, and it is understandable that these countries would build upon them for black carbon. In the transport sectors, the technologies and solutions for black carbon mitigation are well known: a variety of particle traps and other retrofit devices as well as fuel switching have been proven to be effective at reducing particle emissions, and are available in these countries, where ultra-low sulfur diesel is sold. Although there is a need to adapt these technologies to applications that are not currently served, including marine, locomotive and off-road engines, this is basically an expansion of existing technology and regulations. It includes setting standards for new diesel engines, and requiring retrofits to existing vehicles.

In the U.S., the EPA and California Air Resource Board have a good track record of being able set emissions standards, verify and certify technologies that meet them, and enforce these actions. There is little doubt that these kinds of institutions have the capability to apply the same regulatory approaches to climate change objectives that were used for clean air purposes, given sufficient political backing. In this regard, California's recent regulation for clean diesel from the on-road heavy-duty sector, which sets both new vehicle and retrofit requirements, is a typical approach worthy of support and adoption elsewhere. At the federal level, one can also expect that the current attempts (e.g. under the Waxman-Markey bill) to expand the mandate of the EPA to include climate change objectives could incorporate black carbon, and regulate it accordingly. To address the off-road and other transport sectors, some technology incentives may also be required to help accelerate commercialization of particle traps and retrofit devices for niche engine types, but the same tried-and-proven approach is likely to be effective.

In Europe, although the approach is similar to the United States, the political challenge may be greater given the widespread use of light-duty diesel. As in the United States, however, there has been significant achievement in steadily tightening standards for on-road vehicles using direct regulation. Germany plays a pivotal role in the continuation of these trends for diesel, as the home of those car companies that have invested the greatest in a push for a new generation of cleaner light-duty diesel vehicles.

In contrast to the industrialized world, the available options to reducing black carbon in developing countries are generally quite different. In terms of the transport sector, the air pollution-oriented regulatory capacity in these countries is often not as established or as effective as in industrialized countries, and it has generally proved less successful in reducing tailpipe emissions. There are exceptions of course, and good intentions: some countries such as India and China have established targets that indicate an intent to follow the increasingly strict emissions profiles set by the European Union.[36] But in many other developing countries institutions remain weak, and vehicle emissions standards are typically either non-existent, or not well enforced, and the control of super-emitting old trucks and buses encounters stiff political and popular resistance. The experience with desulfurizing fuel, where many countries have repeatedly set targets and then postponed them, indicates that using basic command-and-control policies for black carbon is unlikely to be a sufficient approach in the developing world.[37]

Another difference in these markets is that they do not typically set the standards for new vehicles, and often accept older vehicles that no longer meet OECD air quality standards. There are some emerging exceptions where there is an opportunity to set standards for new vehicles aimed only at a developing country market (e.g. India's Tata Nano), but developing countries generally have little influence on the emissions profiles of the next generation of new cars. Their vehicles are typically an older generation of vehicles and have slow turnover, with very old super-emitting trucks and buses still typical in urban environments.

In sectors other than transport, the options for developing countries are also not easily addressed by regulatory approaches. Black carbon emissions are associated with many rural, biomass-burning activities, including slash-and-burn agricultural practices and residential use of biomass for cooking purposes. Although a range of technical solutions, such as improved stoves and fuel switching opportunities are available, the world development community has been attempting to transform these practices for many years with great difficulty. There are many reasons for this difficulty, including cultural inertia, high transaction costs, and poorly developed substitute markets, but these practices are clearly deeply entrenched.

The new information emerging on black carbon may provide an additional incentive to attempt to transform these practices by highlighting the health and climate co-benefits of such programs. But as with transportation projects, these are not changes that can be typically addressed through command-and-control standards and regulation, and they can be both politically sensitive and costly.

For all these reasons, black carbon policy in developing countries needs to go beyond the regulatory approaches of developed countries. Specifically, regulations need to be accompanied with well thought out development projects and financing that enable local politicians to turn their commitments into reality.

Countries need to prioritize their GHG and black carbon efforts

The other problem with addressing black carbon as an independent, air pollution-style problem is that the issue resonates very differently from one country to another in relation to the need to sign up to a long-term GHG agreement.

Although scientists emphasize that from a climate perspective we must simultaneously address the long-term GHGs and short-term warming aerosols, and that neither is a substitute for the other, political reality is different. All countries need to prioritize their actions, both in the international community and domestically, and a range of positions will inevitably emerge on the relative importance of black carbon action versus long-term climate change commitments.

If the global community is to address both the long-term climate change gases as well as the short-term warming agents like black carbon, each country will have a different calculation in how to balance its contribution to these two needs. Though many activities are win-win, some activities clearly have a greater short-term and local reward.

Recognizing this need for countries to individually prioritize their short-term and long-term contributions is essential if the global community is to commit to a significant agreement, and in order to do that, black carbon needs to be included as an integral part of climate negotiations.

The need for flexibility

Beyond their differing regulatory capacity and their different prioritization of local and global efforts toward climate change, countries also face a wide range of other local conditions and development priorities that need to be balanced. China, India and Indonesia each face very different profiles of sustainable development and health priorities, and institutional ability to incorporate black carbon into these efforts. As well as different costs mentioned earlier, each country also has a varying ability to pay for and deliver the necessary black carbon regulations and projects to address the problem.

These differences, both between and among industrialized and developing countries, must be acknowledged and need to be kept in mind in forging international agreements. Flexibility is a key element of any major global effort on black carbon, and air pollution regulations that single out black carbon will increasingly run into this barrier as they attempt to extend to more diverse nations.

The need to capture the economic gains from specialization

One significant opportunity that air pollution regulations may miss by focusing on black carbon independently of other GHGs is the different relative costs of black carbon mitigation between developed and developing nations. Efforts are currently underway to make accurate estimates of these costs.[38] Previous estimates suggest that in developed countries, where significant efforts have already taken place to reduce emission particles, many remaining black carbon reductions are very expensive, and in comparison to counterpart CO_2 reduction may not be seen as cost-effective from a strictly climate change standpoint. [39] For example, retrofitting a diesel truck, at a cost of $500-$10,000 could be equivalent to a relatively high $36-$71 per ton of CO_2, when evaluated using a 100yr GWP, although under a 20yr GWP even that is much more favorable. ($11-$23). In contrast, many retrofit projects and new technology options in the developing world are highly cost-effective in relation to their equivalent CO_2 action, with cookstove replacement representing a cost of less than $1 per ton of CO_2 equivalent black carbon, clearly a bargain compared to most CO_2 actions.[40]

Although all of these figures are subject to the evolving science of black carbon, and more detailed analysis of costs, it is clear that there is a wide range of costs around the world to achieve similar emission reductions. Given that these do not correspond directly to CO_2 costs in each of these locations, there is a clear opportunity for arbitrage between actions in different regions of the world, where countries could in theory focus their climate change efforts on actions that they can undertake relatively more cost-effectively than other countries. There are, in other words, overall gains to be made from 'trade' in different climate change-related actions.

In simplified terms, this opportunity is sometimes characterized by the suggestion that developing countries should focus their efforts on black carbon, while industrialized countries focus on CO_2. It would make financial sense, given the lower-cost black carbon opportunities in developing countries, and might address some of the equity issues, where developing countries contend that the industrialized countries are to blame for the CO_2 problem, and therefore responsible for cleaning it up.

Clearly, this is overly simple, especially when considering rapidly industrializing countries such as China. However, the notion captures several important points: different countries may wish to offer different parts of the solution to climate change depending on their level of development and

local priorities. In addition, the most cost-effective way to achieving overall climate goals may be for each country to focus its efforts on what it can do more cost-effectively than other nations, rather than for everyone to do the same thing.

Regional air pollution agreements are not substitutes for integrated action

The three issues mentioned above - the need for tools other than regulation, the need for flexibility in prioritizing GHG and black carbon at the local level, and the need to capture the economic gains from specialization - all indicate that it makes sense to address black carbon jointly with the existing GHG gases, and to seek a global agreement that recognizes both simultaneously.

The danger in following the current approach, in which black carbon is targeted independently and exclusively through existing air pollution frameworks, is that we may miss some important benefits of joint action. Though it is clearly worthwhile to advance black carbon action using existing frameworks, given that they can achieve fast, focused efforts, we should not abandon the ultimate goal of incorporating black carbon into the broader, global climate effort.

7. Complete integration of black carbon into the GHGs accords

An alternative path to using air pollution-style black carbon agreements is to use the existing GHG policy frameworks, and to integrate black carbon into their mechanisms. This would approach the convergence from the climate change standpoint, rather than air pollution perspective, and focus on adding black carbon to the already acknowledged climate warming gases, the so-called “Kyoto Six.” Although this may be the ultimate end goal, there are several reasons to believe it may not be feasible at this time, and that an intermediate, partially-integrated solution might be a more realistic objective.

Appeal of full integration with GHGs

A clear benefit of attempting to add black carbon to the Kyoto Six would be to leverage the existing institutions and mechanisms that have been established for GHGs, both by governments and the business community. This includes a wide range of regulatory and market mechanisms, from the UN institutions and processes developed for the Kyoto Protocol (such as emissions trading under the Clean Development Mechanism and Joint Implementation), some very significant regional initiatives such as the European Trading Scheme, the RGGI (Regional Greenhouse Gas Initiative in the northeastern U.S.) and the emerging Western Climate Initiative in the U.S.

Integrating black carbon fully would also leverage the institutions and regulations developed at the national level in many countries to enforce the targets set by the treaty members, and the large business sector that has emerged to respond to the need to track, manage and audit carbon footprints. It could also flow on to the significant voluntary markets, such as the Chicago Climate Exchange, built on the UN paradigm in anticipation of a formal market in countries such as the U.S. For both regulatory and voluntary markets, piggybacking on what is referred to as the carbon sector would be a tremendous force for black carbon mitigation if it could be leveraged.

An integrated framework would also remove the burden on individuals, companies or countries to choose how to trade-off the long-term GHGs and short-term warming aerosols. Parties could easily evaluate the combined impact of their activities, and evaluate alternative courses of action. This is important not only for the market, but for agencies planning projects, regulations or other investments which look different when both Kyoto gases and black carbon are jointly assessed, as opposed to looking through the GHG lens alone. By establishing a CO_2 equivalency, black carbon would get incorporated into the process just as methane and other high global warming potential gases currently are.

The practical challenges of full integration

Although this full integration of black carbon into the long-term GHGs framework should remain the ultimate goal, there are practical challenges to overcome. These indicate that an intermediate approach may be more realistic and allow some progress while the finer details of integrating black carbon are worked on.

One challenge to full integration is to quickly build sufficient consensus on the metrics to be adopted. As discussed earlier, aerosol scientists are increasingly confident of the numbers they are seeing to capture the climate impact of black carbon, but the process of raising the broader scientific community's comfort level with these is likely to be slow. Though all technically feasible, the key decisions regarding the parameters of the metrics would need to be addressed within the IPCC context. These include which timeframe to agree upon for a black carbon GWP, whether to assign different GWPs depending on a source's proximity to sensitive ecosystems, and whether to discount the GWP given to some sources if the profile of their emissions is less certain. While all feasible, doing these within the slow, and consensus-driven IPCC system could be time-consuming.

Another complication with adding black carbon to the Kyoto Six is that any over-action taken on black carbon is qualitatively different than over-action on CO_2 if it turns out the climate change problem is less severe than estimated. While eliminating black carbon is a no-regrets policy with clear health and environmental benefits aside from the climate ones, reducing fossil energy consumption for CO_2 reasons is a much more subtle costs-benefit calculation. This could impact how the IPCC evaluates the different levels of certainty about black carbon

Another challenge to fully integrating black carbon into existing climate change agreements is that it will necessitate that each country recalculate its baseline emissions data to add the emissions of black carbon to the picture, a monumental task that may seem institutionally daunting. Clearly, tracking black carbon from the millions of unregulated and un-monitored sources is much harder than tracking CO_2, and yet it is argued that it can be done and is qualitatively similar to methane. The challenge would be eased if there were more monitoring equipment to track emissions, both within cities and especially in rural areas.[41]

Adapting domestic economic tools

Another challenge with complete integration of black carbon into the existing global framework is that many of the national policies that have been put in place to reach the UN targets have assumed that they can rely in large part on cap-and-trade regimes, or carbon taxes to be implemented at the local level. While it is definitely possible, and in fact advantageous, to harness market mechanisms to reduce black carbon, just adding black carbon to the Kyoto Six could create concern that the available tools countries have to achieve their new targets are insufficient.

Market mechanisms to reduce pollution typically aim to incorporate the negative environmental or social "externality" of the pollutants into the price users pay, and thereby incentivize consumers to reduce this activity, or invest in ways to clean it up. The usual way is to either simply tax the pollution, or to set up a cap-and-trade mechanism that, like a tax, raises the price of the polluting product but also ensures that a specific environmental outcome is achieved, with polluters being given the flexibility of trading pollution allowances to meet their targets.

The problem with a generic black carbon tax is that the vast majority of black carbon emissions occur outside of the price-and-tax system, as gathered biomass is burned in remote rural villages in developing countries. Other emissions from the transport and industrial sectors are also extremely hard to tax: unlike CO_2—where a known amount is released with any given volume of fuel used—black carbon emissions depend on the specific engines, so it cannot be associated with fuel volumes purchased. Penalty taxes could theoretically be applied to the purchase of equipment that is known to be polluting, or to re-registration of old high-emitting vehicles, but given the highly regressive nature of such penalties, they are politically difficult.

A domestic cap-and-trade system for black carbon in which sectors are given a slowly shrinking allowance to pollute and forced to innovate or purchase their way to compliance works in theory, but also runs into practical difficulties. As with the tax challenge, tracking the individual sources of black carbon is almost impossible and even if it were possible, the political backlash in allowing polluters to buy their way out of their local clean-up obligations is likely to be much stronger than it was for CO_2, which causes no direct local health harm.

These difficulties with monitoring and enforcing black carbon on a national-level scale may be the reason that market mechanisms for black carbon have received little attention. Instead of taxing undesired black carbon emissions, regulators tend to ban them. And since it is hard to envisage a monitoring system that could quantify, let alone enforce a cap on black carbon, the idea of a specific black carbon cap-and-trade regime is generally disregarded as impractical.

One of the challenges of complete integration of black carbon may therefore be that countries would be uncertain of what mechanisms they could use to reduce black carbon, given that much of it is outside the market and beyond their normal regulatory reach.

With all these concerns, as well as the institutional danger of tying black carbon action up into an arduously slow UNFCC and IPCC processes, black carbon advocates are understandably wary of attempting to fully integrate black carbon into the UN system.

The need for a partial integration

The above discussion suggests that regulatory, air pollution-style approaches are unlikely to be sufficient on the one hand, while full integration into the existing U.N. system – though appealing – is practically challenging and difficult to imagine in the short termshort-term. This is not to suggest neither should be advanced - given the nature of political momentum, it is still prudent to advance these efforts by bringing regulatory pressure to bear from regional and national air pollution perspectives, while raising awareness within the ranks of the UNFCC apparatus and the scientific process of the IPCC.

However, additional effort must be made to partially integrate black carbon efforts into the global climate negotiation process.

We believe these efforts should focus on two possible separate fronts:

1) Allow countries to get credit, up to a limit, for the gains they make from black carbon projects.

2) Develop the market-based mechanism that will provide financial support for these black carbon actions in developing countries and in difficult-to-regulate sectors such as international shipping.

8. Recognition of national black carbon achievements under the global agreement.

The first important step in integrating black carbon action under a global agreement is to allow a country some degree of flexibility on prioritizing its climate change actions. In this case, a country could be allowed to meet part of its national GHG target through projects that reduce black carbon in its own territory. For example, a large transportation retrofit project would be acknowledged as a credit towards the country's obligations under the international GHG agreement.

There are several parameters that could be used to contain this system: Depending on its level of development, a country could be given a pre-set limit on how much it can credit black carbon toward its target (e.g. 5% for an OECD country vs. 30% for a poorer developing nation). Alternatively, a pre-set limit (e.g. 10%) could be established for all nations, while poorer nations would use 20yr GWP figures in their calculations (thereby prioritizing short-term action such as black carbon), while industrialized countries would use 100yr GWP figures to emphasize the long-term commitments. [42]

These projects could be initiated by a government, and accounted for in its international records. Alternatively, in countries with domestic cap and trade systems, individual companies could be

permitted to meet part of their obligation through domestic investments in black carbon reducing projects. The value of that credit would be based on the agreed upon GWP metric of black carbon.

Domestic black carbon funds

Once there is recognition under a global agreement, one relatively simple way for countries to promote black carbon action on their own territory would be to set up domestic black carbon funds. These could be funded through revenue from CO_2 taxes or the sales of CO_2 allowances in domestic cap and trade regimes. The funds could then be awarded to projects that prove specific, quantifiable black carbon reductions and be given away on a first-come, first-served basis to incentivize a fast response from sectors that are most able to act quickly.

The advantages of a simple black carbon fund are that the project-by-project focus avoids the challenges of integrating black carbon into existing domestic climate programs where baselines, targets and monitoring challenges remain. On a project-by-project level, black carbon reductions can be relatively easily quantified. For example, a retrofit or fuel-switching project to a particularly polluting segment of the transport sector is measurable, as is the impact of instituting a new regulation on tailpipe emissions for new vehicles. Likewise, the black carbon reductions from a development project that results in substitution of clean stoves in a given number of households can be quantified. An entity undertaking such a project should be either financially compensated, or somehow credited for its contribution to alleviating the global black carbon problem.

Although such funds are plausible in richer countries, developing countries are less likely to be able to afford such an across-the-board social 'purchase' of black carbon reductions. Clearly, these countries will need more than domestic black carbon-focused funds. Market mechanisms to stimulate financial flows towards black carbon projects should be pursued.

Benefits of an integrated approach

There are of course scientific concerns to such schemes, since these black carbon reductions are also not—strictly speaking—substitutes for their GHG counterparts, despite their important and real climate benefits. Since the black carbon was not in the original baseline, they too could be seen as diluting the original objective. But we believe these objections could be assuaged by placing reasonable limits on the amount of black carbon offsets that can be used towards a country's target in the same way that CO_2 offsets are permitted, with limitation, under most cap and trade regimes.

Most importantly, if such flexibility is what it takes to get developing countries to agree to binding agreements, the overall global gains could far outweigh the concerns.

This type of partially-integrated system would provide a range of benefits in terms of promoting black carbon projects.

- First, such projects remain in the country – there is no sense that a country can pay its way out of its obligation to clean up its emissions. Each country does its part, and can choose to include some black carbon as part of the mix if it makes sense financially, politically, or technologically.
- Second, allowing credit for such projects gives local leaders the domestic political support to participate in global climate change action: by highlighting win-win projects that have both tangible local health benefits and contribute to climate change mitigation, they could associate being part of the UN agreement with promoting economic development, rather than slowing it.
- Third, it would allow developing countries to gain recognition at international forums for their contributions to climate change, where they currently may not.
- Fourth, the political benefits could result in a qualitative shift in many developing country positions during climate negotiations. Allowing this type of added flexibility on how a country

can achieve its domestic climate change target, and how it can customize the balance between actions to address short-term and long-term pollutants, would make more countries able to agree and participate in a binding international agreement.

- Finally, it is possible that the added flexibility would allow for more ambitious targets to be agreed upon, as countries feel more confident in their technical and political ability to achieve them given the added flexibility. Enabling greater targets could help to offset the scientific concerns of undercutting the achievements of the long-term GHG gases.

Viewed in this way, crediting domestic black carbon projects provides an opportunity to bridge the equity issues that have plagued the climate change agreements. A system that incorporates black carbon action would recognize that flexibility is the critical element of a global agreement on climate change, and that allowing credit for black carbon is one part of that flexibility. Although this does not provide any type of international financial flows, it formally recognizes that countries with different stages of economic development can offer different types of contributions to the climate mitigation challenge.

9. Developing market mechanisms and incentives for black carbon projects

In addition to acknowledging the need for flexibility in how each country sets its priorities, the second set of policies that need to be advanced relate to international market mechanisms and incentives aimed at directing a flow of funds to black carbon-related projects in developing countries.

International black carbon offsets

One mechanism that could provide financial flows and deserves greater attention is allowing black carbon projects in developing countries to serve as 'offsets' for formal CO_2 targets in industrialized countries. In this scenario, a country or company (e.g. a utility in the United States) might meet part of its CO_2 reduction requirement by investing in a black carbon-focused transportation retrofit project in a developing country, receiving credit for doing so. The amount of that credit would depend on the GWP of black carbon. In practical terms, this involves broadening the scope of the Clean Development Mechanism (CDM) and Joint Implementation (JI) mechanism in the Kyoto Protocol to incorporate black carbon.

There would clearly need to be limits placed on the amount of offsets that could be used to meet a domestic target. In part, this is because every country wants to see local projects occur, especially if they have health co-benefits. But in the same way as in the CO_2 markets, there is an important need to balance this desire for local action with the considerable advantages from enabling true, tangible benefits from low-cost climate projects that might otherwise not occur.

As noted earlier, any attempt to compare long-term and short-term climate impacts faces difficulties, and these trading arrangements are no exception. Scientifically speaking, crediting a country or company under a long-term GHG system for progress made on short-term aerosols is not an exact trade-off, and even black carbon reductions in one part of the world are not strictly equivalent to an equal quantity of black carbon reductions in another region. But with certain limits, they may still play an important role in achieving immediate, cost-effective climate benefits.

These offsets would harness market forces and provide financial flows towards some of the cheapest climate change improvement projects worldwide, including black carbon in that mix. They could provide a valuable incentive for politicians and private entities in developing countries to structure and organize black carbon projects that would otherwise not receive any attention.

International black carbon funds

To address the needs of developing countries, a black carbon fund could also be established at an international level (through the World Bank's GEF fund, for example), and specifically pay out compensation to projects in relation to their verified reduction in black carbon. A fixed payment

per ton of black carbon eliminated could be set. The fund could be focused on developing countries, prioritized according to the latitude or sector, and would help incentivize projects that may otherwise not occur.

Less formally, developed countries could individually earmark international aid to specifically seek out black carbon-related projects, as is being proposed as part of the current United States climate change bill (Waxman-Markey).

Voluntary markets

Black carbon efforts should also look at the lessons learned from the development of the voluntary markets for CO_2, where there are no formal or regulatory requirements to reduce emissions. In these contexts (such as the United States in the last decade) a significant voluntary market has emerged, where individuals and companies choose to reduce their net impacts by purchasing CO_2 offsets even though they face no requirement to do so. To serve this demand, a voluntary carbon market has developed, creating a supply of carbon offset projects for such buyers.

While the value of carbon traded in voluntary markets (such as the Chicago Climate Exchange in the U.S.) is well below that traded in formal markets, and there is still considerable uncertainty about the reliability of the certification systems that control this supply of offsets, it is beyond debate that this market has served as an important precursor to the formal carbon markets. A range of new companies and jobs have emerged - from carbon auditors, project developers and certification bodies, to carbon trading and accounting platforms - raising the public's comfort with the notion of measuring, managing and offsetting one's carbon impact. These voluntary markets have been important drivers of investment, and when formal cap-and-trade systems are proposed in previously unregulated markets (e.g. California, RGGI), there is strong pressure to preserve this ability of organizations and individuals to make voluntary climate investments that go beyond their obligations, and for the carbon allowance cap to be adjusted accordingly.

Therefore, although some are skeptical of the ultimate role and magnitude of financial flows that a voluntary market for black carbon could generate, such ideas should not be too easily dismissed. Some efforts in this direction have been initiated. Dr Ramanathan, working with the Chicago Climate Exchange, has suggested that a stream of revenue could be established to rural Indian households who switch their cook stoves to reduce black carbon emissions.[43]

If voluntary certification bodies are able to expand their portfolio and offer black carbon reduction projects, the demand for them may emerge. At the very least, it may provide a stepping stone towards formal standards, help in raising public awareness of black carbon's climate role, and help establish an expertise on project-level black carbon accounting that does not currently exist.

10. Promoting certification

The above discussion suggests that in addition to the current efforts to add black carbon to regional air pollution agreements, we must continue to advance the ultimate objective of integrating black carbon into the global climate change framework and support the development of market mechanisms to incentivize black carbon projects.

Although it may be overly optimistic to expect such achievements from the Copenhagen round in December 2009, there are some key underlying building blocks that should be advanced to support this kind of progress. One of the core elements of the existing climate framework that needs to be strengthened are the measurement, reporting and verification (MRV) procedures. In fact, some argue that improving the MRV system should be one of the main objectives and realistic goals of the upcoming Copenhagen round.[44]

This same logic could be applied to black carbon. What is needed, to initiate action on black carbon under a whole range of scenarios, are several building block components:

1. A metric that describes black carbon's climate impact, with a GWP agreed upon by the IPCC.

2. Protocols for quantifying black carbon reductions from retrofit and other projects.

3. Entities able to certify that specific black carbon reductions have occurred.

These will be needed for any mechanism that attempts to quantify black carbon reductions and their climate change value. Whether it is a World Bank-funded black carbon project, or offsets sold to a voluntary buyer of black carbon credits, or a formal black carbon credit issued to developing countries as part of its GHG target, reliable standards for quantification of black carbon reductions are critical. Any advances to develop these should therefore be supported, regardless of the ultimate mechanism being sought.

There are currently a range of registries and certification schemes evolving to calculate, verify, monitor and report climate change-related emissions. Some of these, such as The Climate Registry, have grown under voluntary markets. Organizations that certify CO_2 projects for such voluntary markets now need to be encouraged to expand their product base and protocols to begin looking at black carbon. As black carbon is increasingly discussed at the international and regulatory level, they are likely to begin to see an emerging market for black carbon deals, both in terms of the demand for certified projects, and proposals for projects that supply such credits.

However, there is also a critical need for a formal, globally agreed-upon system to quantify and certify black carbon-related projects. Without such a formal system, black carbon projects will not gain legitimacy quickly enough, or have their contribution to climate mitigation recognized sufficiently.

With this in mind, it makes sense to look to the Kyoto Protocol's Clean Development Mechanism as a starting point for black carbon. Though it has received considerable criticism in its effectiveness and transparency, the CDM still remains the primary, internationally agreed-upon certification of CO_2 projects. While there is no apparent successor or replacement to this mechanism, efforts should continue to improve and build upon it. This should include expanding the CDM definitions to include black carbon, as a stepping stone towards integrating black carbon into the global agreements. Such a move would help galvanize the IPPC to establish formal GWP figures for black carbon. Expanding the CDM to include black carbon would help establish legitimacy for black carbon actions, even while it is a work in progress.

And even while there are no formal targets or credit schemes available for black carbon, CDM endorsement of black carbon projects would begin to build a 'supply' of black carbon projects and set standards for a future system that does recognize them. It is likely that such a signal would be of interest to a range of non-state actors, even while countries are still getting comfortable with the notion of formal black carbon targets. A formal CDM black carbon measure would help U.N. development and health agencies, bi-lateral aid agencies, and the World Bank to establish a systematic assessment of black carbon projects. It could channel the flow of funds from these entities, as well as from health and environmental organizations who want to "buy-and-retire" black carbon credits. All of this could be done even before any formal global targets or offset mechanisms are agreed upon.

11. Conclusions

Many efforts are now underway to highlight the climate benefits of action on black carbon emissions. Given the complexities of addressing black carbon, there is a natural tendency to address this problem separately from other long-term GHGs, and to approach it using regional and national regulations that have worked well for controlling other aerosols in the industrialized world.

While this approach has advantages in the short-run, in terms of getting commitments to black carbon action, it should not be seen as a substitute for the ultimate goal of a global climate agreement that incorporates both black carbon and long-term GHGs. This is true for several reasons: one is that relying on command-and-control regulations alone may not translate well into developing country contexts where air pollution regulations have been much less effective than in industrialized countries. These countries need to undertake major clean-up projects in the

transportation sector, as well as projects to transform rural household and agricultural practices, and they will require financial support from the developed world to do so.

But the other problem with treating black carbon separately from CO_2 is that it misses the greatest political opportunity of all. Black carbon reductions are a unique way for developing countries to contribute to the global climate change effort while simultaneously addressing local clean air priorities and achieving these co-benefits for their local populations. If black carbon commitments are negotiated simultaneously with long-term GHG agreements, there is a possibility to forge an international agreement that encompasses both the developing world's low-tech problem of air pollution and the industrialized world's problem of over-reliance on fossil fuels. Such a system would allow countries to contribute in different ways depending on their level of economic development.

Though a fully integrated climate change agreement is unlikely in the near future given the practical challenges that remain and slow moving UN apparatus, steps should be taken to work towards this, and some degree of partial integration attempted. We believe two broad efforts would help advance this: first, to encourage developing countries to sign up to a climate agreement under the condition they could meet a portion of their targets through black carbon projects and second, to begin to develop market mechanisms, including offsets and black carbon funds, that can steer investment toward black carbon projects in developing countries.

Underlying both of these efforts is a need to establish broadly accepted protocols for quantifying and certifying black carbon emission projects. A commitment by the countries meeting in December in Copenhagen to consider expanding the CDM to incorporate black carbon projects would be a clear and effective first step, even while no specific targets on black carbon are set.

Although scientific knowledge of black carbon remains imperfect, and there is still progress to make on the young carbon markets, it is clear that black carbon projects have real, tangible and immediate climate benefits, and that many of these worthwhile projects have not occurred despite years of well intentioned air quality regulation and development assistance. It is time to ramp up the effort on these actions, both through bottom-up development of certification protocols, and by putting black carbon squarely on the negotiating table at this next round of climate negotiations.

---

[1] Schwartz, T. *Testimony for the Hearing on Black Carbon and Climate Change*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007

[2] Stockholm Institute, 2008.

[3] Bond, Tami. *Can Warming Particles enter Global Climate Discussion?* Environmental Research Letter, 2 (2007) 045030.

[4] Bond, Tami. *Testimony for the Hearing on Black Carbon and Global Warming*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007

[5] Ramanathan V, Carmichael, G. Global and regional climate changes due to black carbon Nature Geoscience 1, 221 - 227 (2008) Published online: 23 March 2008

[6] University of California - San Diego. *Black Carbon Pollution Emerges As Major Player In Global Warming*. ScienceDaily. (2008, March 24)

[7] Hansen, J., and L. Nazarenko (2004), *Soot climate forcing via snow and ice albedos*, Proc. Natl. Acad. Sci.,101(2), 423–428.

[8] Zender, Charles. In *Testimony for the Hearing on Black Carbon and Climate Change*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007

[9] See Boucher, as quoted in Witherspoon, 2009. Presentation on ClimateWorks Black Carbon Initiative, Sacramento, April 2009

[10] Shindell, D and Faluvegi, G. *Climate response to regional radiative forcing during the twentieth century*. Nature Geoscience 2, 294 - 300 (2009)

[11] Ramanathan, 2007

[12] Leahy, Stephen. Snow Cover turnig to lake in the Himalayas, from Inter-press service Newws Agency. May14, 2009. (See http://westcoastclimateequity.org/?p=2990

[13] GAP Forum, Scientific understanding behind the development of integrated co-benefits strategies: Background paper for the Global Atmospheric Pollution Forum Stockholm Conference on “Air Pollution and Climate Change: Developing a Framework for Integrated Co-benefits Strategies” 17 –19 September 2008

[14] Energy Independence Now Fact Sheet. *What Are the Health Harms Associated With Petroleum-Based Fuels and Combustion By-Products? See www.einow.org*

[15] Schwartz, T. *Testimony for the Hearing on Black Carbon and Climate Change*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007

[16] Bond, Tami. *Testimony for the Hearing on Black Carbon and Global Warming*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007
[17] Bond & Sun *Can reducing black carbon emissions counteract global warming?*. Environ. Sci. Technol., 2005, 39 (16).
[18] See Bond, 2009 and Walsh, *On and Off Road Policy Strategies*. ICCT Black carbon workshop, London 2009
[19] Jacobson, *Examining Effects of Black Carbon on Climate and How to Mitigate Them Through Different Transportation Options.* ICCT Black carbon workshop, London 2009
[20] See U.S.House of Representatives Testimonies from Bond, Jacobsen and others
[21] Jacobson, M. *Testimony for the Hearing on Black Carbon and Global Warming*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007
[22] Reddy, S and Boucher O, *Climate impact of black carbon emitted from energy consumption in the world's regions*. GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L11802, doi:10.1029/2006GL028904, 2007
[23] See Prather, Kim. "Particles in the Air and their potential impact on Regional Climate". Presented at the CEC Climate Change Conference, Sacramento, Sept 2009
[24] See for example, Jacobson M. *Testimony for the Hearing on Black Carbon and Global Warming*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007
[25] Bond, T and Sun,H. *Can reducing black carbon emissions counteract global warming?*. Environ. Sci. Technol., 2005, 39 (16)
[26] Jacobson, personal communication, Sept 2009.
[27] Bond, Tami. *Testimony for the Hearing on Black Carbon and Global Warming*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007
[28] Kebin, HB. BC *Control Strategies in Transportation Sector in China*. Presentation to the ICCT workshop on black carbon, London, January 2009
[29] Jacobson, M. *Testimony for the Hearing on Black Carbon and Global Warming*, House Committee on Oversight and Government Reform, United States House of Representatives, October 18, 2007
[30] Jacobson. Presentation to the CEC conference on Climate Change. Sacramento, Sept 2009.
[31] For example, see Ramanathan 2008, on how switching to natural gas reduces future warming commitment; but unmasks the aerosol cooling
[32] Ramanathan, Wallack. *The Other Climate Changer*. Foreign Affair, Sept/Oct 2009, p.113.
[33] Rosenthal, Elisabeth. New York Times, April 15th 2009.
[34] *Air Pollution and Climate Change: Developing a Framework for Integrated Co-benefit strategies*. Report to Economic Commission for Commission Europe on the September 2008 Stockholm Institute..
[35] Ramanathan, Wallack. *The Other Climate Changer*. Foreign Affair, Sept/Oct 200
[36] Walsh, On and Off Road Policy Strategies. ICCT Black carbon workshop, London 2009.
[37] See Rojas, L. *An international strategy for black carbon controls in the transport sector. The case of Mexico*. ICCT Black carbon workshop, London 2009/
[38] See Witherspoon, C. *Black Carbon: Fast Action Opportunity to Prevent a Global Catastrophe*. ClimateWorks, March, 2009
[39] Bond & Sun. *Can reducing black carbon emissions counteract global warming?*. Environ. Sci. Technol., 2005, 39 (16)
[40] Bond & Sun. *Can reducing black carbon emissions counteract global warming?*. Environ. Sci. Technol., 2005, 39 (16)
[41] Ramanathan, Wallack. *The Other Climate Changer*. Foreign Affairs, Sept/Oct 2009
[42] Bond & Sun. *Can reducing black carbon emissions counteract global warming?*. Environ. Sci. Technol., 2005, 39 (16).
[43] Ramanathan, as stated at CEC Climate Change Conference, Sacramento, Sept 2009
[44] Levi, Michael. *Copenhagen's Inconvenient Truth*. Foreign Affairs, Sept/Oct 2009

innovo
energy solutions group, llc

www.innovoenergy.com

+ 1 310 600 4887