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Black Carbon: The Most Important Ignored contributor to Climate Change

Kate DeAngelis

COMMENT

Black Carbon: The Most Important Ignored Contributor to Climate Change

KATE DEANGELIS*

Black Carbon (BC)[1] is a type of aerosol[2] emitted into the atmosphere through the incomplete combustion of fossil fuels and biomass.[3] BC emissions come from industry, transportation, residential cook stoves, and open burning.[4] Uncertainties regarding the exact effects of BC have slowed global action in mitigating its impacts even though it is a leading contributor to climate change and has deleterious effects on public health. International treaties and domestic laws and regulations would slow climate change and improve public health by encouraging technology transfer and providing funding to developing countries for BC mitigation. The United States (U.S.) should use current or new laws to provide cleaner technologies and financial support to developing nations for BC abatement.[5] As two of the largest emitters of BC, India and China should also use existing laws and regulations to decrease BC.[6] Additionally, the international community has a responsibility to either amend the Kyoto or Gothenburg Protocols to include BC, or

* Executive Notes Editor, *Maryland Journal of International Law* 2010–2011; J.D., University of Maryland School of Law, May 2011.

1. BC is sometimes referred to as elemental carbon (EC) or soot.

2. An aerosol is a fine particle suspended in the air.

3. KAREN BICE ET AL., BLACK CARBON: A REVIEW AND POLICY RECOMMENDATIONS 3 (2009). Biomass is biological material (e.g., wood chips) that is used as fuel, such as in residential cook stoves.

4. *Id.*

5. *See infra* Part I.

6. *See infra* Part II.B–C.

create an entirely new framework for reducing BC emissions.[7] Fast action is necessary for BC mitigation in order to slow global and regional warming[8] and improve the health and air quality of poor rural and urban areas throughout the world.

I. BLACK CARBON'S ENVIRONMENTAL AND HEALTH IMPACTS

BC contributes to global warming in two ways. First, dark BC heats the air by absorbing radiation from sunlight.[9] Second, cloud droplets form around BC particles, which increases the level and degree of cloud formation and disturbs the thermal gradient.[10] When the clouds become darker, they are less able to reflect sunlight, which makes the earth's surface warmer.[11]

BC also causes strong regional warming effects in the Arctic and the Himalayas because BC deposits promote melting by lowering ice or snow albedo.[12] In the Arctic, BC has caused 0.5-1.4 degrees Celsius of warming over approximately the last one hundred years and has substantially contributed to rapid warming over the past thirty years.[13] Scientists have documented similar warming effects in

7. *See infra* Part III.

8. Global warming refers to the increase in the average temperature of the earth over time. Some controversy exists regarding whether climate change or global warming is a better phrase to describe the shifting in climate that is currently occurring, but this paper uses the two phrases interchangeably.

9. Surabi Menon et al., *Climate Effects of Black Carbon Aerosols in China and India*, 297 SCI. 2250, 2250 (2002).

10. Andrew C. Revkin, *Debate Rises Over a Quick(er) Climate Fix*, N.Y. TIMES, Oct. 3, 2000, at F1. A thermal gradient is the rate of temperature change with distance.

11. *Id.*

12. James E. Hansen & Makiko Sato, *Trends of Measured Climate Forcing Agents*, 98 PROC. NAT'L ACAD. SCI. 14,778, 14,778 (2001). Albedo is the ability to reflect sunlight.

13. Drew Shindell & Greg Faluvegi, *Climate Response to Regional Radiative Forcing During the Twentieth Century*, 2 NATURE GEOSCIENCE 294, 298 (2009). A 2005 study found that BC particles, derived from incomplete combustion of fossil fuels and biomass, might have a severe impact on the sensitive Arctic climate. Dorothy Koch & James Hansen, *Distant Origins of Arctic Black Carbon: A Goddard Institute for Space Studies ModelE Experiment*, 110 J. GEOPHYSICAL RES. 1, 1 (2005). This effect could accelerate polar ice melting and alter the area's temperature profile, cloud temperature and amount, the seasonal cycle, and the tropopause level (between the troposphere and the stratosphere in the atmosphere). *Id*. Koch and Hansen's model suggests that the predominant sources of Arctic soot

the Himalayas because of its proximity to India and China, which are large producers of BC emissions.[14] BC contributes to the melting of the Himalayan glaciers, which threatens the water supply of more than ten percent of the world's population.[15]

BC causes grave health problems and even death in humans. These health impacts include pneumonia, acute lower respiratory infections (ALRI), chronic obstructive pulmonary disease (COPD), and lung cancer.[16] These effects fall disproportionately on the developing world because BC emissions originate primarily in developing nations.[17] BC sources from household use of solid fuels alone cause about 1.8 million deaths each year.[18] Creating international treaties to reduce BC would slow global and regional warming and would improve public health, especially in the developing world.

today are from biomass burning and industrial and biofuel emissions in Asia. *Id.* at 10.

14. BICE ET AL., *supra* note 3, at 16.

15. *Id.* at 15.

16. World Health Org., *Indoor Air Pollution: National Burden of Disease Estimates*, at 1, U.N. Doc. WHO/SDE/PHE/07.01 (2007).

17. For example, over seventy-five percent of open burning is concentrated in developing countries. Andrew P. Grieshop et al., *A Black-Carbon Mitigation Wedge*, 2 NATURE GEOSCIENCE 533, 533 (2009). In addition, older vehicles and dirty industries with high BC emissions are more highly concentrated in the developing world. *Id.* This causes urban areas in developing nations to have levels of particulate air pollution ten or more times greater than urban areas in developed countries. *Id.* Furthermore, over seventy-five percent of the BC emitted from residential fuel use occurs in poorer parts of the world. *Id.*

Asia is the largest contributor of BC emissions, producing almost forty percent of global BC emissions and more than fifty percent of warming BC emissions. BICE ET AL., *supra* note 3, at 7–8. In contrast, scrubbers and filters installed in factories and vehicles have greatly reduced BC emissions in the United States and Europe. Elisabeth Rosenthal, *Soot from Third-World Stoves Is Target in Climate Fight*, N.Y. TIMES, Apr. 16, 2009.

18. Majid Ezzati et al., *Comparative Quantification of Mortality and Burden of Disease Attributable to Selected Risk Factors*, *in* GLOBAL BURDEN OF DISEASE AND RISK FACTORS 241, 248 (Alan D. Lopez et al. eds., 2006). This is the global total, but they all occur in the low and middle-income parts of the world with none in the high-income countries. *Id.* Additionally, three hundred million total excess deaths caused by indoor smoke from solid fuels have occurred in developing nations, while none occur in developed countries. Grieshop et al., *supra* note 17. These statistics make indoor use of solid fuel the fourth largest contributor to the total burden of disease in the developing world. *Id.*

II. DOMESTIC ACTION MUST BE TAKEN TO MITIGATE BC

A. *United States*

The U.S. must address BC emissions through existing environmental statutes and regulatory programs or by passing new legislation that specifically addresses BC. Companies and states have challenged the federal government's authority to regulate greenhouse gases and other air pollutants. Despite this, legal options are available to government agencies that would allow them to regulate BC without the courts overturning such actions. Federal courts have held that the issue of whether the EPA should set mandatory limits for carbon dioxide emissions was not a political question.[19] These decisions support the idea that federal agencies could implement and enforce the regulation of BC without the courts dismissing the issue as a political question. States could then use the federal common law of nuisance against sources of BC emissions. States have successfully used this tactic to bring litigation against sources of greenhouse gases (GHGs).[20] The Second Circuit held that states were not barred from regulating carbon dioxide emissions simply because current air pollution laws did not provide them with that power.[21] The court also found the threat caused by GHGs actionable under the federal common law of nuisance.[22] This decision supports a claim that the Clean Air Act or other laws would not preempt BC regulation.

While no U.S. legislation or court decisions have mandated measures to mitigate the effects of BC, the Environmental Protection Agency (EPA) could use the Clean Air Act (CAA) to regulate BC.

19. Connecticut v. Am. Elec. Power Co., 582 F.3d 309, 332 (2d Cir. 2009), *cert granted*, 131 S. Ct. 813 (2010).

20. *Id.*; Massachusetts v. EPA, 549 U.S. 497, 533 (2007).

21. *Am. Elec. Power Co.*, 582 F.3d at 330–31.

22. *Id.* at 378–80. The federal common law of nuisance includes a public nuisance (an unreasonable interference with a right that is common to the public as a whole) and private nuisance (nontrespassory invasions of another's interest in the private use and enjoyment of land). Government authorities and private parties can bring public nuisance claims as long as they demonstrate that the nuisance has harmed them in a manner not shared with the general public. The Supreme Court has found the federal common law of nuisance preempted for other types of pollution; in *Milwaukee v. Illinois*, the Court held the Clean Water Act preempted Illinois' common law nuisance claim regarding discharged sewage. 451 U.S. 304, 319–20 (1981).

According to the CAA, an air pollutant includes "any physical, chemical, biological, radioactive . . . substance or matter which is emitted into or otherwise enters the ambient air."[23] After the EPA identifies air pollutants, it must publish air quality criteria for those air pollutants that the agency anticipates will endanger public health or welfare.[24] The Supreme Court has interpreted air pollutant to include carbon dioxide because the statutory definition is very broad.[25] The Court further held that if the EPA made a finding of endangerment, the CAA would require the EPA to regulate carbon dioxide.[26] This inclusive definition of air pollutant would also encompass BC, allowing the EPA to regulate BC as the Court permitted the EPA to regulate greenhouse gases. Therefore, the EPA should decide whether sufficient information exists to make an endangerment finding for BC, and thereby be required to regulate BC.

Another option is to reduce BC emissions through the Clean Water Act (CWA). The CWA requires the Administrator of the EPA to "develop and publish . . . criteria for water quality accurately reflecting the latest scientific knowledge . . . on the concentration and dispersal of pollutants."[27] Regulation of BC under the CWA may be feasible because BC is deposited onto glaciers and sea ice.[28] Evidence exists of BC contaminating the snow and water in areas of

23. Clean Air Act, 42 U.S.C. § 7602(g) (2006).

24. *Id.* § 7408.

25. *Massachusetts*, 549 U.S. at 528–29.

26. *Id.* at 533.

27. Clean Water Act, 33 U.S.C. § 1314(a)(1) (2006). Sea ice qualifies under the CWA because "navigable waters" includes all waters of the U.S., including the territorial seas, which encompasses areas of sea ice. *Id.* § 1362(7). Additionally, the CWA covers glaciers because a significant nexus exists between glaciers and the nation's navigable waters. *See* Rapanos v. United States, 547 U.S. 715, 742 (2006).

28. *See* V. Ramanathan & G. Carmichael, *Global and Regional Climate Changes Due to Black Carbon*, 1 NATURE GEOSCIENCE 221, 222 (2008). BC darkens the surface of snow, which changes the snow's albedo, causing melting to occur more rapidly. *Id.* at 224. BC has the same effect when deposited on glaciers. James Hansen & Larissa Nazarenko, *Soot Climate Forcing Via Snow and Ice Albedos*, 101 PROC. NAT'L ACAD. SCI. 423, 427 (2004). In addition, BC causes an increase in melt water, which further hastens the melting of glaciers. *Id.* Therefore, by regulating BC, the EPA would be accomplishing the goal of the CWA, which includes maintaining the chemical integrity of the country's water systems. Clean Water Act § 1251(a).

the U.S. containing glaciers or sea ice. For example, snow samples in Alaska revealed high concentrations of BC in Alaska and other Arctic regions.[29] Since BC qualifies as a pollutant under the CWA, the EPA is obligated to set BC standards, which would require BC concentrations on sea ice and glaciers not to exceed pre-industrial levels. If the EPA establishes these standards, states with glaciers or sea ice will be required to either adopt the EPA's standards or create their own limits on BC.[30] Additionally, the EPA pursuant to section 304(a)(2) of the CWA should publish information regarding how BC affects bodies of water in order for states to create the best methods of reducing BC in the state's water systems.[31] Since BC is polluting bodies of water in the U.S., the federal government should use the CWA to regulate BC emissions and educate the states on the harmful effects BC has on water ecosystems and human health.

Since the majority of the BC emissions in the U.S. come from the transportation sector, the federal government and individual states should decrease vehicle and ship pollution. One approach to reducing BC emissions from vehicles and ships is to add filters to diesel engines that trap particulate matter from the exhaust.[32] The EPA's clean diesel programs target the diesel trucks that do not meet the current clean diesel standards.[33] The EPA's Verification Program evaluates the ability of retrofit technologies to reduce some emissions.[34] This verification process should specifically assess the capabilities of different technologies to lower these emissions. BC

29. Hansen & Nazarenko, *supra* note 28, at 423.

30. Clean Water Act § 1313(b)–(c).

31. *See id.* § 1314(a)(2).

32. *E.g.*, *Diesel Particulate Filters*, CORNING, http://www.corning.com/environmentaltechnologies/products_services/particulate_filters.aspx (last visited Dec. 23, 2010). For instance, Corning produces a filter that has a cellular structure with separate channels open and sealed at opposite ends, so that BC particles are too large to go through the pores of the cell walls. *Id.* Another method for making diesel cleaner would be to make changes in the vehicle fleets through cleaner fuels. *Black Carbon and Climate Change: Hearing Before the H. Comm. on Oversight and Gov't Reform*, 100th Cong. 9 (2007) (statement of Mark Z. Jacobsen, Professor of Civil and Environmental Engineering, Atmosphere/Energy Program, Stanford University). Converting diesel vehicles to electric and/or hydrogen fuel cell vehicles powered by renewables would reduce these emissions. *Id.* at 6.

33. Energy Policy Act of 2005, Pub. L. No. 109-58, §§ 791–97, 119 Stat. 594, 838–44.

34. *Id.* § 792, 119 Stat. at 839–41.

reductions should also be a goal of the 2008 Locomotive and Marine Diesel Rule, which aims to decrease particulate matter and nitrogen oxide from marine and locomotive diesel engines.[35] Finally, to properly address BC, EPA's regulations should require ships to use cleaner low-sulfur fuels or renewable power, such as sail or kite-propulsion.[36]

B. *China*

Emission reductions in Asia would have an ameliorative effect on global warming and air quality. Achieving certain emissions goals in India and China could decrease BC emissions by seventy percent.[37] Laws and multilateral agreements should focus on cook stoves because they produce the majority of BC in Asia.[38] The dissemination of improved cook stoves would not only decrease BC

35. 40 C.F.R. § 1042.101 (2009); Control of Emissions of Air Pollution from Locomotive Engines and Marine
Compression-Ignition Engines Less Than 30 Liters per Cylinder, 73 Fed. Reg. 25,098 (May 6, 2008) (to be codified at 40 C.F.R. pt. 9, 85, 86, 89, 92, 94, 1033, 1039, 1042, 1065, 1068).

36. ELLYCIA HARROULD-KOLIEB, SHIPPING IMPACTS ON CLIMATE: A SOURCE WITH SOLUTIONS 10–11 (2008). Decreased shipping speeds would reduce the amount of fuel used and BC emissions created by ships. *Id.* at 9. Restrictions placed on shipping in the Arctic and other areas sensitive to the effect of BC on albedo would help to slow melting in the Arctic and other glacial regions. *See id.* at 7. This is especially important because ships emit 0.13 Tg (teragrams) of BC each year, which will only increase as regional melting causes the number of navigation days to increase. Marine Env't Prot. Comm. of the Int'l Mar. Org., Prevention of Air Pollution from Ships: Second IMO GHG Study 2009, 59th Sess., tbl. 8-2, MEPC 59/INF.10 (Apr. 9, 2009), *available at* http://www.imo.org/includes/blastDataonly.asp/data_id%3D26047/INF-10.pdf.

37. Robert E. Baron et al., *An Analysis of Black Carbon Mitigation as a Response to Climate Change*, COPENHAGEN CONSENSUS CENTER, 11, 14, http://fixtheclimate.com/uploads/tx_templavoila/AP_Black_Carbon_Baron_Montgomery_Tuladhar_v.4.0.pdf (last visited Apr. 14, 2011).

38. Rosenthal, *supra* note 17. The term cook stove refers to a primitive form of stove that traditionally uses biomass (e.g., dung) as fuel to cook the food. The newer solar cook stoves have three main variations: the box cooker, curved concentrator cooker, and panel cookers. *How Solar Cookers Work*, SOLAR COOKERS INT'L, http://solarcookers.org/basics/how.html (last visited Jan. 4, 2011). Pots are placed in the box cooker, the lid is closed, and then the box heats up with the energy from the sun. *Id.* With a curved concentrator cooker, a parabolic is placed under a pot and is then adjusted to best harvest the energy from the sun to heat the food. *Id.* Panel cookers combine aspects of box and curved concentrator cookers in order to heat the food. *Id.*

emissions, but would also improve the quality of life for rural populations in Asia.[39] Diesel engines are another source of BC in Asia.[40] Retrofit technologies for diesel engines, similar to ones used in the United States, would reduce these BC emissions in Asia. A final source of BC in Asia is pollution emitted from coal fire power plants; power generation from renewable energy sources can replace coal.

Since China is a huge emitter of BC, it is crucial that the country uses its domestic laws to mitigate BC.[41] China is more likely than other countries to work to reduce BC because the nation has already experienced its severe environmental[42] and public health effects[43] and

39. *See* AMULYA K.N. REDDY ET AL., ENERGY AFTER RIO: PROSPECTS AND CHALLENGES 8–9 (1997). Women and children spend a great deal of time using and being near the cook stove. Kirk R. Smith, Sumi Mehta & Mirjam Maeusezahl-Fuez, *Indoor Air Pollutants from Household Use of Solid Fuels*, *in* COMPARATIVE QUANTIFICATION OF HEALTH RISKS 1435, 1436 (Majid Ezzati et al. eds., 2004). This time-intensive process of collecting biomass for the stove can be a physical strain and can potentially expose them to hazards such as snakebites. *Id.* at 1456; REDDY ET AL., *supra*, at 8. These forms of fuel create incredibly dirty plumes of smoke that women and children then inhale, causing many respiratory problems. Smith, Mehta, & Maeusezahl-Fuez, *supra*, at 1464–65. New stoves that use solar energy reduce soot by ninety percent. Rosenthal, *supra* note 17. India and China are ideal places for solar cook stoves because of their average annual sunlight, population size, and cooking fuel scarcity. *Where Solar Cook?*, SOLAR COOKERS INT'L, http://solarcookers.org/basics/where.html (last visited Jan. 4, 2011).

40. Rosenthal, *supra* note 17.

41. China's BC emissions have doubled since 2000. *New Science and Developments in Our Changing Environment*, 2009 U.N. Env't Programme Y.B. 26, U.N. Doc. UNEP/GC.25/INF/2.

42. Levels of BC in the Tibetan plateau have soared since the 1990s, which has accelerated the decreasing of the plateau's glaciers and threatens to extinguish an important source of fresh water for China and the surrounding countries. Michael Sheridan, *The Perils of Warming Chill China*, THE AUSTRALIAN, Nov. 9, 2009.

43. BC emissions from indoor air pollution in China are responsible for over twenty thousand deaths in children under the age of five from acute lower respiratory infections (ALRI). World Health Org., *supra* note 16, at 2. Chronic obstructive pulmonary disease (COPD), caused by BC and other pollutants emitted while using solid fuel, causes close to 350,000 deaths of people aged thirty and older. *Id.* In China, BC causes almost eighteen thousand lung cancer deaths each year of those thirty years and older. *Id.* In total, BC and co-emitting pollutants are responsible for about 380,000 deaths each year. *Id.* This large number of deaths accounts for 1.6% of the total annual burden of disease in China. *Id.*

has demonstrated a willingness to invest in cleaner technologies.[44] China has specifically targeted BC emissions through an extremely successful cook stove program, distributing approximately two hundred million improved cook stoves.[45] The Chinese government could use two national laws to continue the distribution of cleaner cook stoves and reduce BC emissions: the Law on the Prevention and Control of Atmospheric Pollution[46] ("Air Pollution Control Law") and the Renewable Energy Law.[47]

44. Evidence of this includes the fact that China has doubled their wind capacity for four consecutive years, so that the installed capacity was just over 25 GW in 2009. *Gains in Global Wind Capacity Reported*, N.Y. TIMES, Feb. 15, 2010, http://green.blogs.nytimes.com/2010/02/15/gains-in-global-wind-capacity-reported. Additionally, China's "Green Lights Project" will phase-out the sale and production of incandescent lights in order to sell more efficient bulbs. Nathanial Gronewold, *U.N. Chief Nudges Beijing Toward Greater Climate Leadership*, CLIMATEWIRE, July 27, 2009. This program could possibly reduce 237 million metric tons of carbon dioxide emissions and save up to 216 kilowatt-hours of electricity over the next decade. Lisa Friedman, *The Planet's 2 Biggest Emitters Open New Round of Climate Talks*, CLIMATEWIRE, July 27, 2009.

45. Vinod Vinod Mishra et al., *Indoor Air Pollution: The Quiet Killer*, 63 ASIAPACIFIC ISSUES 1, 6–7 (2002), http://www.eastwestcenter.org/fileadmin /stored/pdfs/api063.pdf. The Ministry of Agriculture (MOA) implemented this National Improved Stove Program (NISP), which was first initiated in 1982. Kirk R. Smith et al., *One Hundred Million Improved Cookstoves in China: How Was It Done?*, 21 WORLD DEV. 941, 941 (1993). The first phase of the program, running from its inception until 1992, included giving funding to counties for them to subsidize more efficient stoves. Jonathan E. Sinton et al., *An Assessment of Programs to Promote Improved Household Stoves in China*, 8 ENERGY FOR SUSTAINABLE DEV. 33, 37 (2004). The second phase, from 1990 to 1995, greatly reduced subsidies and instead focused on giving tax and loan benefits to counties. *Id.* at 37–38. Finally, the third phase focused only on expanding the program, mostly through increasing the use of other energy-saving devices. *Id.* at 38.

From 1983 to 1990 the national government spent about $11.2 million. *Id.* at 39. Most of the budget of this cook stove program was spent on research and development, rather than the cost of the stove. *Id.* Households bore most of the cost of the actual cook stove, showing that people are willing to pay, at least partially, for an improvement in living conditions. *Id.*; Mishra et al., *supra*, at 6.

46. Law on the Prevention and Control of Atmospheric Pollution (promulgated by the Standing Comm. Nat'l People's Cong., Apr. 29, 2000, effective Sept. 1, 2000) (China), *translated at* http://www.gov.cn/english/laws/2005-09/07/ content_29877.htm. The law aims to promote human health and sustainable development through the control and prevention of air pollution. *Id.* art. 1.

47. Renewable Energy Law (promulgated by the Standing Comm. Nat'l People's Cong., Feb. 28, 2005, effective Jan. 1, 2006) (China), *translated at* http://www.npc. gov.cn/englishnpc/Special/CombatingClimateChange/2009-08/25/content_151530 1.htm.

The Chinese Air Pollution Control Law could reduce BC emissions from cook stoves, coal plants, and diesel engines. The law requires that the country eventually eliminate emissions from air pollutants and that local governments ensure their jurisdictions meet defined standards for air quality.[48] The distribution of solar cook stoves would not only help local government meet these standards, [49] but also fulfills a requirement of the law: "For other users of domestic cooking ranges in urban areas of large or medium-sized cities not delimited as areas where the use of seriously polluting fuels is prohibited, they shall, within a time limit, start to use sulfur-fixed briquette of coal or other clean energy."[50] The law also requires the sorting and washing of the coal used in power plants,[51] which has led to the closing of many inefficient and heavily polluting plants.[52] Renewable energy advocates could encourage further change by using the law to support reducing the dependence on coal: "Enterprises shall give priority to the adoption of clean production techniques . . . . The State practi[c]es an elimination system for the outdated production techniques and equipment which cause serious pollution to the atmospheric environment."[53] Finally, the law requires vehicles to meet emissions standards.[54] The increase in car ownership in China makes enforcing emissions standards for diesel vehicles

48. Law on the Prevention and Control of Atmospheric Pollution, art. 3. "No units may discharge atmospheric pollutants in excess of the density specified by the State or by local authorities." *Id.* art. 13.

49. Foreign non-profit organizations could provide technical and financial assistance to these local governments. For instance, One Earth Designs will use $667,000 that it won to build and distribute solar-powered cookers to residents in China. *U.S. Entry Wins Prize for Solar-Powered Cooker*, PITT. TRIB. REV., Sept. 25, 2010; *see also SolSource 3-in-1*, ONE EARTH DESIGNS, http://oneearth designs.org/solsource.html (last visited Jan. 4, 2011).

50. Law on the Prevention and Control of Atmospheric Pollution, art. 29.

51. "The State promotes the dressing of coal by washing to reduce the sulfur and ash in coal, and restricts the mining of high-sulfur or high-ash coal." *Id.* art. 24.

52. Jimin Zhao, *Reform of China's Energy Institutions and Policies: Historical Evolution and Current Challenges* 28 (Harvard Univ., Working Paper No. 2001-20, 2001).

53. Law on the Prevention and Control of Atmospheric Pollution, art. 19.

54. "No motor vehicles and vessels shall be permitted to discharge atmospheric pollutants in excess of the prescribed discharge norms. No unit or individual may manufacture, sell or import motor vehicles or vessels that discharge pollutants in excess of the prescribed discharge norms." *Id.* art. 32.

especially important to ensure BC emissions do not increase along with car ownership.

China's 2005 Renewable Energy Law articulated ambitious goals for alternative forms of energy, which would reduce BC emissions from coal plants. The law promoted the development and utilization of renewable energy, protection of the environment, realization of a sustainable economic and social development, and an increase in the supply of energy.[55] Local governments must prepare a renewable energy development plan in rural areas to "promote biomass energy like the marsh gas, etc. conversion, household solar energy, small-scale wind energy and small-scale hydraulic energy, etc."[56] The distribution of solar cook stoves promotes household solar energy. The renewable energy development fund, which the law established, could help finance these solar cook stoves: "The Government budget establishes [a] renewable energy development fund to support the . . . [c]onstruction of renewable energy projects for domestic use in rural . . . area[s]."[57] The government also promoted renewable energy development and utilization by giving preferential treatment to the renewable energy market.[58] The problem with the law is that many specifics, such as what "preferential treatment" entailed, were left undetermined.

The 2009 amendments have added details to the law's framework in order to improve implementation. One amendment will help achieve BC abatement by forcing grid operators who do not connect a renewable energy operation to pay that operation twice the

55. Renewable Energy Law (promulgated by the Standing Comm. Nat'l People's Cong., Feb. 28, 2005, effective Jan. 1, 2006) art. 1 (China), *translated at* http://www.npc.gov.cn/englishnpc/Special/CombatingClimateChange/2009-08/25/content_1515301.htm.

> Grid enterprises shall enter into grid connection agreement[s] with renewable power generation enterprises that have legally obtained administrative license or for which filing has been made, and buy the grid-connected power produced with renewable energy within the coverage of their power grid, and provide grid-connection service for the generation of power with renewable energy.

Id. art. 14.

56. *Id.* art. 18.

57. *Id.* art. 24.

58. *Id.* art. 4.

value of the non-distributed electricity.[59] This amendment aims to address the fact that grid companies have not followed the law's requirement that renewable energy capacity be quickly connected to the grid.[60] This failure to connect to the grid has allowed for an even greater increase in the reliance on coal because the renewable energy capacity has not kept pace with renewable energy production.[61] Since the use of coal results in a greater amount of BC, BC emissions will decrease if the Chinese government ensures that the installed renewable energy capacity is put to use.

C. *India*

India must also address its high BC emissions in order to slow the melting of the Himalayan glaciers, improve the health of the country's large urban and rural populations, and clean the air in both heavily populated and rural areas. India's Supreme Court, domestic laws and regulations, and private initiatives all provide opportunities for BC mitigation. India's Supreme Court has interpreted the Constitution's guarantee of a right to life in Article 21 as including the right to a clean environment.[62] This right should include the right to clean air free from BC particles because they deprive Indian nationals of the right to life through a high incidence of respiratory illnesses and cancer.[63]

59. *See* Keith Bradsher, *China's Edge in Renewable Energy*, N.Y. TIMES, Feb. 6, 2010, *available at* http://www.statesman.com/opinion/insight/chinas-edge-in-renewable-energy-217186.html. The power grid is an interconnected network for supplying electricity to consumers. Grid companies deliver that electricity using the power grid.

60. Vivian Wai-yin Kwok, *Weaknesses In Chinese Wind Power*, FORBES, Jul. 20, 2009.

61. *See id.*

62. Charan Lal Sahu v. Union of India, (1989) 2 S.C.R. 597, 712 (India); Subhash Kumar v. State of Bihar, (1991) 1 S.C.R. 5, 14 (India).

63. *See* World Health Org., *supra* note 16, at 2. A study in rural Orissa showed that a high incidence of respiratory illness existed, most likely because of indoor air pollution caused by cook stoves. Esther Duflo, Michael Greenstone & Rema Hanna, *Cooking Stoves, Indoor Air Pollution and Respiratory Health in Rural Orissa*, 43 ECON. & POL. WKLY. 71, 71 (2008). Another study in Tamil Nadu monitored the indoor air quality and compared the levels of respirable particles between homes where cooking was done using gas or kerosene and homes using wood or animal dung. Jyoti Parikh et al., *Exposures from Cooking with Biofuels: Pollution Monitoring and Analysis for Rural Tamil Nadu, India*, 26 ENERGY 949, 954–55 (2001). Average pollution levels of 76 $\mu g/m^3$ and 101 $\mu g/m^3$ in kitchens

The Indian Supreme Court has also tried to decrease air pollution through judicial activism. In *M.C. Mehta v. Union of India*, the Court ordered the country's public transportation system to adopt cleaner technologies in order to decrease the emissions from these dirty vehicles.[64] The Court ordered all government-owned vehicles to begin using cleaner technologies.[65] This ruling has probably decreased BC emissions since the use of diesel fuel results in this pollution. The Court could mandate similar programs to further reduce BC emissions by requiring filters in diesel engines or the use of cleaner technologies. Moreover, if citizens were to bring a suit against the government regarding cook stoves, the Court might establish a similar program requiring the government to replace all residential cook stoves with cleaner technologies.

The Indian government should use the Air Act of 1981[66] to mitigate BC. The law defines an air pollutant as "any solid, liquid or gaseous substance . . . present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment."[67] According to this definition, BC is an air pollutant. Therefore, the government should set air quality standards for BC, as the law requires for all air pollutants.[68] The government recently established new air quality standards, but they did not directly address BC; instead the regulation set limits on sulfur dioxide, nitrogen dioxide and other air pollutants.[69] While lowering other emissions could also

using kerosene and gas, respectively, contrasted with levels of 1500 to 2000 $\mu g/m^3$ in kitchens where biomass fuels were used. *Id.* at 957. Additionally, 340 deaths of Indians ages thirty and over are attributed to lung cancer that was caused by coal use. World Health Org., *supra* note 16, at 3.

64. S.C. Writ Pet. (Civil), M.C. Mehta v. Union of India (July 28, 1998) (No. 13029/1985), *available at* http://www.elaw.org/resources/text.asp?ID=1051.

65. *Id.*

66. *See* The Air (Prevention and Control of Pollution) Act, 1981, No. 14, Acts of Parliament, 1981 (India), *available at* http://www.moef.nic.in/legis/air/air1.html.

67. *Id.*

68. *See id.*

69. National Ambient Air Quality Standards, 2009, 826 Gen. S. R. & O. 3 (India), *available at* http://moef.nic.in/downloads/rules-and-regulations/Latest_48_FINAL_AIR_STANDARD.pdf. The standards, updated for the first time in fifteen years, provide a legal framework to protect public health and control air pollution based on European Union standards and World Health Organization

result in a reduction of BC because of its co-emission with other pollutants, the government should include specific standards for BC in the next revision of the national ambient air quality standards.

India launched the National Biomass Cookstove Initiative (NBCI) in December of 2009 to address BC emission from domestic cook stoves.[70] These new cook stoves use a cleaner combustion to reduce BC and other air pollutants produced from the incomplete combustion of other cook stoves.[71] Through the combination of energy and economic policies, this project has instituted economically sustainable business solutions as well as a reduction in BC.[72] The NCBI has great potential to lower the BC emissions in India, but the program is flawed because improvements are not made across the board.[73] There are many different factors that the program could focus on, such as number of particles and total fuel use.[74] In order to achieve the greatest reductions of BC, the program must decrease the total number of polluting particles. Simply reducing the amount of fuel being used is insufficient. Despite these problems, the distribution of these improved cook stoves would save approximately

recommendations. Madhur Singh, *India Tightens Air Quality Standards, Adds Substances to List for Monitoring*, 32 INT'L ENV. REP. 1084, 1084 (2009).

70. Press Release, Ministry of New and Renewable Energy, Launching of the 'National Biomass Cookstove Initiative' on 2nd December 2009 at New Delhi (Dec. 2, 2009), *available at* http://mnre.gov.in/press-releases/press-release-02122009.pdf. The Department of Non-Conventional Energy Sources started the Indian National Programme on Improved Chulhas (NPIC) in 1983 and had distributed nearly twelve million improved cook stoves by 1992. Food & Agric. Org. of the U.N., Reg'l Wood Energy Dev. Programme in Asia, Indian Improved Cookstoves: A Compendium, at 1 (July 1993), *available at* http://www.fao.org/docrep/006/AD585E/ad585e00.pdf. Since these cook stoves were neither particularly efficient nor very sturdy, of the thirty-five million that the government distributed, none of them are still in use. Burkhard Bilger, *Hearth Surgery: The Quest for a Stove that Can Save the World*, THE NEW YORKER, Dec. 21, 2009, at 84.

71. Press Release, Ministry of New and Renewable Energy, *supra* note 70.

72. *See id.*

73. John Guy, Senior Policy Advisor, Envtl. Prot. Agency Office of Transp. & Air Quality, Remarks at the Woodrow Wilson Center's U.S.-China Cooperation: The Co-benefits of Reducing Black Carbon (Mar. 17, 2010) (video available on the Wilson Center's website).

74. *Id.*

0.5 to one billion tons of pollutants contributing to climate change, including BC.[75]

Other private initiatives also provide cleaner cook stoves to rural residents in India. For example, Project Surya provides solar and other efficient cook stoves to rural residents in India.[76] The objective is to reduce BC emissions in order to improve the health of a nation that is heavily dependent on the use of biofuels and biomass in its households.[77] Additionally, the project aims to improve local air quality, inhibit the production of atmospheric brown clouds, and slow global warming through the reduction of BC emissions.[78] The project takes a people-centered approach by involving children in the data collection process and educates rural residents about solar and other new technologies.[79] Project Surya places a special emphasis on involving the inhabitants in all steps of implementation, creating an empowering environment for the inhabitants to promote change, and training students on implementing new technologies in rural areas.[80] This type of small-scale program is an integral part of reducing BC, especially in rural Asia.

These small-scale programs have great potential, but a number of cultural and economic factors continue to hinder the promotion of improved cook stoves. A major issue for the solar cookers in India has been that women tend to do the cooking in the early morning and late evening.[81] These are times when there is very little or no sun, making the solar cook stoves an impractical alternative for the millions of women in India who must be out working all day.[82]

75. Ben Block, *India Announces Improved Cook Stove Program*, WORLDWATCH INST. (Dec. 2, 2009), http://www.worldwatch.org/node/6328.

76. *See generally* V. RAMANATHAN & K. BALAKRISHNAN, PROJECT SURYA, REDUCTION OF AIR POLLUTION AND GLOBAL WARMING BY COOKING WITH RENEWABLE SOURCES: A CONTROLLED AND PRACTICAL EXPERIMENT IN RURAL INDIA (2007), *available at* http://www.projectsurya.org/storage/Surya-WhitePaper.pdf; Baron et al., *supra* note 37, at 17.

77. RAMANATHAN & BALAKRISHNAN, *supra* note 76.

78. *Id.*

79. *Id.*; Baron et al., *supra* note 37, at 17.

80. RAMANATHAN & BALAKRISHNAN, *supra* note 76.

81. Veerabhardan Ramanathan, Scripps Inst. of Oceanography, Remarks at the Woodrow Wilson Center's U.S.-China Cooperation: The Co-benefits of Reducing Black Carbon (Mar. 17, 2010) (video available on the Wilson Center's website).

82. *Id.*

Another difficulty is creating a cook stove that will cook the food in such a way that maintains traditional flavors and consistency.[83] Biomass cook stoves create a unique flavor that is often lost when substituted for more efficient forms of fuel.[84] Also, the stove is an important, if not the only, source of heat for many households, so taking the cook stove out of the kitchen may require them to use an equally polluting fuel for warmth.[85] Finally, engineers and scientists must strike a delicate balance when designing more efficient cook stoves and create a low emitting stove that is affordable and easy to use.[86] Efficient stoves are worthless if the intended users cannot afford repairs or are turned-off by an overly sleek and foreign design.[87]

III. TREATY SOLUTIONS

International treaties or regional agreements could reduce BC emissions by encouraging the use of cleaner technologies, cooperation among nations, and financial support. Unfortunately, the international community has been slow in addressing BC pollution. Part of the reason for this failure is that BC is rarely emitted on its own, but rather is usually co-emitted with organic compound (OC).[88]

83. For example, the Ethiopian injera, a spongy cake eaten at every meal, has been extremely hard to make with a more efficient stove because the injera must have a bubble of a certain size in the batter or else it is considered not worth eating. Bilger, *supra* note 70. Engineers tried to create a stove made with steel because it is more efficient than ceramic, but the steel caused burn spots because the thin and watery batter of the injera easily moved during cooking. *Id.*

84. The substitution of a stove with new technology might create other logistical issues. For instance, using a solar cooker requires the stoves to be used outside. For many cultures cooking is a very private activity that should only occur in the home. HUGH WARWICK & ALISON DOIG, SMOKE: THE KILLER IN THE KITCHEN 20 (2004). Fire is also considered sacred in many cultures, so taking the fire out of the household is like taking away the source of life. *Id.* at 19.

85. *See* Smith, Mehta & Maeusezahl-Fuez, *supra* note 39, at 1437. The use of solid fuels in households for heat would probably continue even if the stove were removed, especially in areas that have an abundance of wood and coal. *Id.* at 1444.

86. Bilger, *supra* note 70.

87. *Id.* Another concern is local users modifying a super-efficient stove so that it loses its benefits because they do not understand the newer technology. For instance, the local builder might augment the size of the stove's mouth to fit larger sticks, which allows in too much cold air. *Id.*

88. Surabi Menon et al., *Climate Effects of Black Carbon Aerosols in China and India*, 297 SCI. 2250, 2250 (2002); BICE ET AL., *supra* note 3.

OC and other co-emitters tend to have a cooling effect because of the way they scatter sunlight.[89] Different sources have different ratios of BC with some having a greater proportion of BC and others having a greater amount of co-emitters.[90] These variations make it difficult to fully predict the effects of decreasing BC, partly because little research exists regarding the effects of BC in its pure form.[91]

Multiple options exist for targeting BC in an international agreement. The first possibility is to revise the Kyoto Protocol to include BC, thereby requiring signatories to reduce their BC emissions similar to the Protocol's attempts to lower greenhouse gases.[92] Alternatively, the international community could use programs, such as the clean development mechanism (CDM) and programmatic CDM, to effectively reduce BC emissions.[93] Other possibilities are to add BC to the Gothenburg Protocol[94] or create a new treaty that solely addresses BC.[95] All three options have different benefits and drawbacks, but there are currently only serious discussions about including BC in the Gothenburg Protocol, making it the most likely method of achieving global BC reductions.

A. *The Kyoto Protocol and Its Successors*

The United Nations Framework Convention on Climate Change (UNFCCC) was designed to stabilize greenhouse gas concentrations in the atmosphere at a level that would avert any sudden anthropogenic alterations to the climate system to ensure continued

89. Menon et al., *supra* note 88. BC and other co-emitting particles make up soot, which is the product of the incomplete combustion of coal, diesel engines, biofuels, and open biomass burning. *Id.* at 2250, 2252. These emissions are particularly large in India and China because of the low-temperature household burning of coal and biofuels. *Id.* at 2250.

90. Grieshop et al., *supra* note 17. The more BC a source emits, the greater the warming effects; the more OC or other co-emitting cooling aerosols that a source produces, the greater the cooling effect. *Id.* For example, residential combustion of solid fuels has a greater proportion of BC and therefore has a strong warming effect. *Id.*

91. *Id.*; BICE ET AL., *supra* note 3, at 8–9. Most data measures BC with various co-emitters, which can lead to uncertainty about the effects of BC on its own. Grieshop et al., *supra* note 17; BICE ET AL., *supra* note 3, at 7.

92. *See infra* Part III.A.

93. *See infra* Part III.B.

94. *See infra* Part III.C.

95. *See infra* Part III.D.

food production and sustainable development.[96] The Kyoto Protocol to the UNFCCC sets specific limits on greenhouse gas emissions.[97] The Protocol, which entered into force on February 16, 2005, created a mitigation scheme based on the principle of "common but differentiated responsibilities."[98] Annex I countries, constituting developed nations and those who were in the process of transitioning to a market economy, must reduce their greenhouse gas emissions by at lease five percent below 1990 levels between 2008 and 2012.[99] Developing nations, which are not included in Annex I, may participate in a clean development mechanism (CDM).[100] CDM allows Annex I countries to invest in emission-reducing projects in non-Annex I countries, which then gives the Annex I parties credits towards their emission reductions.[101] Another flexible mechanism is emissions trading so that Annex I nations can fulfill their commitments.[102]

With the Kyoto Protocol set to expire in 2012, future Conferences of the Parties (COP) hope to set a new framework to address climate change. These negotiations could include BC because BC mitigation helps achieve UNFCCC's goal of limiting anthropogenic contribution to climate change. Three reasons exist for why the global community must achieve BC abatement alongside the

96. United Nations Framework Convention on Climate Change art. 2, May 9, 1992, S. TREATY DOC. NO. 102-38, 1771 U.N.T.S. 107, *available at* http://unfccc.int/resource/docs/convkp/conveng.pdf.

97. Kyoto Protocol to the United Nations Framework Convention on Climate Change art. 3, Dec. 10, 1997, 37 I.L.M. 22, *available at* http://unfccc.int/resource/docs/convkp/kpeng.pdf. Specifically, the Protocol aims to reduce carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. *Id.* annex A, 37 I.L.M. at 42.

98. *Id.* art. 10, 37 I.L.M. at 36. "Common but differentiated responsibilities" means that all parties are responsible for protecting the environment, but that some countries (i.e., developed nations) historically are more responsible and have more financial and technological resources to decrease their polluting emissions.

99. *Id.* art. 3(1), 37 I.L.M at 33. The countries in the process of transitioning to a market economy referred mainly to former Communist nations. *Id.* annex B, 37 I.L.M. at 43.

100. *Id.* art. 12(2), 37 I.L.M. at 38.

101. *Id.* art. 12(3), 37 I.L.M. at 38. The Protocol also allows Annex I countries to meet their reduction commitments jointly as long as their combined aggregate emissions do not exceed their allowed amounts. *Id.* art. 4(1), 37 I.L.M. at 34.

102. *Id.* arts. 6(1), 17, 37 I.L.M. at 35, 40. This trading must only be supplemental to domestic action. *Id.*

reduction of carbon dioxide. First, recent studies estimate that BC is responsible for eighteen percent of the planet's warming—second only to carbon dioxide.[103] Even though more carbon dioxide is emitted into the atmosphere annually, BC might actually have a greater impact on our environment.[104] One ton of BC causes about six hundred times the warming of one ton of carbon dioxide over a one hundred year period.[105] Second, reduction of BC would have a much quicker effect on climate change than carbon dioxide because the impact of BC reduction is almost immediate.[106] Unlike carbon dioxide, which lingers for millennia in the atmosphere, BC has an atmospheric lifetime of only a few days or weeks.[107] Third, BC-mitigation technologies already exist—the so-called "low-hanging fruit."[108] In contrast, reducing carbon dioxide requires new or future technologies that are expensive and is further complicated because almost every facet of modern life creates carbon dioxide.[109] Therefore, the UNFCCC treaty system has the greatest chance of successfully averting dangerous effects of climate change if it includes binding BC emission targets.

103. Rosenthal, *supra* note 17.

104. *See* Grieshop et al., *supra* note 17.

105. *Id.*

106. *Id.*

107. *Id.*; BICE ET AL., *supra* note 3, at 14. Focusing on the mitigation of BC could give the world additional time before reaching the dangerous two degrees Celsius of warming, allowing more time for the UNFCCC to create a binding treating. *See* Mario Molina et al., *Reducing Abrupt Climate Change Risk Using the Montreal Protocol and Other Regulatory Actions to Complement Cuts in CO_2 Emissions*, 106 PROC. NAT'L ACAD. SCI. 20,616, 20,617 (2009), *available at* http://www.pnas.org/content/106/49/20616.full.pdf. Scientists consider two degrees Celsius of warming above pre-industrial temperatures to be dangerous because of the expected consequences: ice melting, widespread loss of biodiversity, famine, and meters of sea level rise. *Id.* More than one hundred countries have set a threshold for dangerous warming at two degrees Celsius. *Id.* at 20,616. This extra time is especially important since the commitments made after Copenhagen could still lead to a dangerous three degrees Celsius of warming. David Roberts, *Post-Copenhagen Scorecard*, FOREIGN POL'Y, Feb. 4, 2010.

108. Rosenthal, *supra* note 17. "Low-hanging fruit" refers to the pollutants for which reduction technologies already exist, making them relatively quick and simple climate fixes. *Id.*

109. Revkin, *supra* note 10. Every aspect of human life from the cars we drive to the way we heat our homes creates carbon dioxide. People are often unwilling, however, to commit the time or resources necessary to change these behaviors.

Since the highest emissions of BC are found in the developing world, the U.S. and other developed countries could use BC as a bargaining chip to allow developing countries higher caps on carbon dioxide in exchange for stricter regulations on BC emissions.[110] Plans to reduce BC might encourage developing countries, which are currently hesitant to negotiate with high greenhouse gas-emitting wealthier countries, to become involved in the current discussions. Once a climate change treaty regime that included BC went into effect, the globe would quickly experience beneficial impacts on the climate and public health.

While BC should be a part of global climate negotiations, including BC in greenhouse gas reduction programs is not a perfect fit. The properties of BC make it difficult to include in an emissions trading scheme, which is most successful for large stationary sources with homogenous environmental impacts, because it has strong regional effects and is emitted from small or mobile sources.[111] Additionally, unlike large factories and power stations that emit greenhouse gases, monitoring this large number of small individual BC-emitting sources would make verifying emissions extremely expensive.[112] A further complication is the unwillingness of India and China to discuss the issue because they are afraid that including BC in negotiations would divert attention from the responsibility of richer nations to reduce their much larger carbon dioxide emissions.[113]

B. *Alternatives to Direct Regulation of BC under the UNFCCC*

Direct UNFCCC regulation of BC is not the only mechanism for reducing BC through an international climate change framework. One alternative would be the allotment of a portion of the

110. BICE ET AL., *supra* note 3, at 37.

111. *Id.*

112. *Id.*

113. Randeep Ramesh & Suzanne Goldenberg, *Soot Clouds Pose Threat to Himalayan Glaciers*, THE OBSERVER, Oct. 4, 2009, at 17. India's environment minister, Jairam Ramesh, believes that BC is "another issue" that should not be brought "into the mainstream." *Id.* The real reason for India and China's hesitation might have more to do with the fact that including BC in negotiations may show that developing countries play a larger role in global warming than originally thought. *See* Bryan Walsh, *Why India Is Playing Hard to Get on Climate Change*, TIME, Nov. 6, 2009.

Copenhagen Green Climate Fund to BC mitigation. Established by the Copenhagen COP in December 2009, the fund would initially be worth ten billion dollars and operate from 2010 to 2012.[114] By 2020, the fund would provide $100 billion per year in financing climate change mitigation to help developing nations adapt to the effects of global warming.[115] The U.S. contribution would include five million dollars to reduce the effects of BC in the Arctic region.[116] The Copenhagen fund would not be essential for nations with strong economies and large monetary reserves, like China, but it would help BC mitigation in poorer countries in Africa and Asia where limited funds inhibit pollution reduction.[117]

Programmatic approaches are another method for reducing BC. This approach uses voluntary multiple actions to achieve reduction of emissions of global warming pollutants over a period of time.[118] The

114. James Kanter, *Copenhagen Sets Money on the Move*, INT'L HERALD TRIB., Dec. 21, 2009, *available at* http://www.nytimes.com/2009/12/21/business/energy-environment/21iht-green21.html.

115. *Climate Change: U.S. Pledges $5 Million in Funding to Reduce Soot*, INT'L ENV'T DAILY, Dec. 18, 2009. Another goal of the fund is to promote the preservation of forests. Lisa Friedman & Darren Samuelsohn, *Hillary Clinton Pledges $100B for Developing Countries*, N.Y. TIMES, Dec. 17, 2009, *available at* http://www.nytimes.com/cwire/2009/12/17/17climatewire-hillary-clinton-pledges-100b-for-developing-96794.html. Environmental activists have stated that the fund would need to be closer to $140 or even $200 billion annually by 2020 in order to actually be effective. Kanter, *supra* note 114. Others have complained that the offers by industrial companies to contribute are full of caveats and loopholes, so that money may not be distributed in sufficient amounts to developing countries that are particularly vulnerable to the effects of climate change. *Id.* Moreover, financing remains uncertain as many industrialized countries have yet to pledge any sort of commitments. *Id.*

116. *Climate Change: U.S. Pledges $5 Million in Funding to Reduce Soot*, *supra* note 115.

117. One such project is at the Aprovecho Research Center's Stove Camp where engineers and scientists from all over the world get together each year to build and test stoves that are highly efficient, but are also culturally sensitive. Bilger, *supra* note 70; *Stove Camp*, APROVECHO RES. CENTER, http://www.aprovecho.org/lab/conferences/stove-camp (last visited Feb. 7, 2011). The participants of the camp experiment with many different types of methods in searching for the perfect stove that will cook the food properly while reducing the amount of fuel needed. Bilger, *supra* note 70. Engineers try everything from inexpensive materials like mud to experimenting with expensive thermoelectric generators. *Id.*

118. Exec. Bd. of the Clean Dev. Mechanism, *Procedures for the Registration of a Programme of Activities as a Single CDM Project Activity and Issuance of Certified Emission Reductions for a Programme of Activities* (Version 03), at 1

same program can be used at multiple sites without the need for new UN approval.[119] These actions, called CDM Program of Activities, are more appropriate for BC abatement because they are regionally specific, rather than global in nature. These projects involve a large number of dispersed emissions, making them ideal for the distribution of more efficient solar cook stoves.[120] Programmatic approaches "enhance the chances of small and poor countries getting access to the CDM" because the projects in these countries are not economically viable unless you are able to group them.[121] Many small activities are within one program, which reduces transaction costs and acts as a potential catalyst for transformation of an entire sector.[122] These activities, commenced by the program, can help to implement a policy of BC mitigation while creating certified emissions reductions (CERs).[123]

Programmatic approaches have the potential to increase both the number of projects in extremely low-income countries and the types of actions qualifying for CERs. Currently, six percent of approved projects are located in Brazil, twelve percent are in India, sixty percent are in China, and three percent are in the whole continent of Africa.[124] Wealthier countries that are rapidly industrializing, such as China and India, have significant advantages over poorer countries because large, heavily emitting industries in these countries are an

(May 28, 2009), *available at* http://cdm.unfccc.int/EB/047/eb47_repan29.pdf. Either a government policy or a private industry initiative could coordinate the program activity. *Id.*

119. Meraiah Foley, *Bringing Carbon Offset Into the Home*, INT'L HERALD TRIB., Dec. 15, 2009, *available at* http://www.nytimes.com/2009/12/15/business/global/15bulb.html.

120. Michael W. Wara & David G. Victor, *A Realistic Policy on International Carbon Offsets* 19 (Stanford Program on Energy & Sustainable Dev., Working Paper No. 27, 2008), *available at* http://iis-db.stanford.edu/pubs/22157/WP74_final_final.pdf.

121. U.N. Env't Programme, *Potential For Barriers For End Use Energy Efficiency Under Programmatic CDM*, at 1 (2007) (by Miriam Hinostroza, Chia-Chen Chang, Xianli Zhu & Jorgen Fenhann), *available at* http://cd4cdm.org/Publications/pCDM&EE.pdf.

122. The World Bank, *State and Trends of the Carbon Market*, at 37 (2008) (by Karan Capoor & Philippe Ambrosi), *available at* http://siteresources.worldbank.org/NEWS/Resources/State&Trendsformatted06May10pm.pdf.

123. *E.g.*, U.N. Env't Programme, *supra* note 121, at 19 (explaining that a German company could get CERs for a solar cooker project in India).

124. Foley, *supra* note 119.

easy target for a CDM project.[125] Additionally, most countries cannot afford to go through the long process of UN approval.[126] The CDM Program of Activities makes it easier for industrialized countries to receive carbon credits by engaging in projects in the poorest countries of the world. BC is an ideal target for CDM program activities because most of the world's BC emissions are located in undeveloped countries. Currently, CDM projects focus on industrial emissions, but the programmatic approach could address many other sources of emissions.[127] These projects could reduce pollution from mobile and household sources of BC and other pollutants contributing to global warming. The question still remains whether these programmatic CDM approaches will be successful since the UN has only approved one project.[128]

C. *Convention on Long Range Transport of Air Pollution*

The Convention on Long-Range Transboundary Air Pollution (CLRTAP) sought to "gradually reduce and prevent air pollution including long-range transboundary air pollution."[129] The parties agreed to conduct research, exchange information, and develop methods of combating the discharge of air pollutants.[130] The 1999

125. *Id.*

126. *Id.*

127. *See* U.N. Env't Programme, *supra* note 121, at 23.

128. Only one program has successfully become a CDM Program of Activities. An Australian company, Cool nrg International, is giving thirty million energy efficient light bulbs to low and middle-income households in Puebla, Mexico. Foley, *supra* note 119; *Achievements*, COOL NRG, http://www.coolnrg.com/index.php/General/achievements.html (last visited Apr. 17, 2011). Cool nrg receives CERs, which it can then sell to either a country or company in need of credits to achieve emission targets. Foley, *supra* note 119. The project reduces both Mexican families' electricity bills and subsidies from the Mexican government to low income families for electricity. *Id.* Cool nrg expects that Mexican families will save $165 million each year and the Mexican government will save $200 million each year. *Id.*

129. Convention on Long-Range Transboundary Air Pollution art. 2, Nov. 13, 1979, T.I.A.S. No. 10,541, 1302 U.N.T.S. 217.

130. *Id.* art. 3, 1302 U.N.T.S. at 219. Under the agreement, contracting parties were also required to use "the best available technology which is economically feasible" in developing the best strategies and policies to reduce air pollution and create air quality management systems. *Id.* art. 6, 1302 U.N.T.S. at 220. The parties also pledged to implement education and training programs regarding the environmental aspects of pollution by major air pollutants. *Id.* art. 7(f), 1302 U.N.T.S. at 220.

Gothenburg Protocol to CLRTAP aimed to abate eutrophication, acidification, and ground level ozone.[131] The Protocol, which entered into effect in 2005, set ceilings on the emissions of nitrogen oxides, sulfur dioxide, ammonia, and volatile organic compounds to be met by 2010.[132] It also required the parties to exchange information, technologies, and techniques that reduce the above-mentioned emissions by increasing energy efficiency, less-polluting transportation, and low emission burners.[133]

The Executive Body of the CLRTAP created the Ad Hoc Expert Group on Black Carbon (Expert Group) with the goal of establishing "options for potential revisions to the Gothenburg Protocol that would enable the Parties to mitigate BC as a component of PM for health purposes while also achieving climate co-benefits."[134] The end result was a report that identified current information on BC and the areas that needed further research, the potential to reduce BC through new and existing legislation, and the scientific and technical requirements to achieve those reductions.[135] In the report the Executive Body recommended that BC should be included in the revision of the Gothenburg Protocol because "[c]ontrolling emissions of BC will result in health benefits and climate benefits, especially in sensitive regions such as the Arctic."[136] By incorporating BC into the Protocol, there is a high probability that great reductions of BC emissions could be achieved just as the CLRTAP was very successful in reducing air pollutants in developed countries.[137] UNECE must

131. Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-Level Ozone art. 2, Nov. 30, 1999, U.N. Doc. EB.AIR/1999 [hereinafter Gothenburg Protocol]. Eutrophication is the existence of excessive nutrients that deplete the level of oxygen in a body of water.

132. *Id.* art. 3, annex II.

133. *Id.* art. 4(1).

134. Exec. Body of the Convention on Long-Range Transboundary Air Pollution, *Establishment of an Expert Group on Black Carbon*, Dec. 2009/5, *available at* http://www.bceg.org/documents/Decision%202009_5%20on%20EG%20on%20Black%20Carbon.pdf.

135. U.N. Econ. & Soc. Council, Exec. Body for the Convention on Long-Range Transboundary Air Pollution, *Report by the Co-Chairs of the Ad Hoc Expert Group on Black Carbon*, U.N. Doc. ECE/EB.AIR/2010/7 (Sept. 30, 2010), *available at* http://www.unece.org/env/documents/2010/eb/eb/ece.eb.air.2010.7.e.pdf.

136. *Id.* ¶¶ 18, 53.

137. BICE ET AL., *supra* note 3, at 36.

ensure that the revision is actually completed and adopted by December 2011 as is currently planned so that the parties can achieve meaningful reductions in BC. If it does so, the CLRTAP will be the first international treaty to try to curb BC emissions by incorporating BC into the Gothenburg Protocol as a component of fine particulate matter.[138]

D. *A Treaty to Abate Black Carbon*

The international community could create a separate treaty that solely addresses BC similar to the Montreal Protocol phasing out ozone-depleting substances. The Montreal Protocol froze the production and consumption of chlorofluorocarbons (CFCs) and halons at 1986 levels.[139] The protocol then called for a fifty percent reduction in CFC use by industrialized countries over a ten-year period, followed by the total elimination of CFCs by 2000.[140] This treaty has caused an eighty-five percent reduction in ozone-depleting substances, so that the ozone should have begun to recover.[141] The Montreal Protocol is a success story for international environmental law; a treaty for BC could achieve similar results.

The international community should use incremental policymaking, targets, and timetables in addressing BC because these mechanisms contributed to the success of the Montreal Protocol. Incremental policymaking allows for flexibility in order to adapt to economic, environmental, and scientific changes.[142] A BC treaty

138. Press Release, United Nations Econ. Comm'n for Europe, UNECE Takes the Lead in Tackling Air Pollution Issues Affecting Human Health with Additional Benefits for Climate Change by Reducing Black Carbon Emissions (Apr. 15, 2011), *available at* http://www.unece.org/press/pr2011/11env_p16e.htm.

139. Montreal Protocol on Substances that Deplete the Ozone Layer art. 2, Sept. 16, 1987, S. TREATY DOC. NO. 100-10, 26 I.L.M. 1550, 1552, *available at* http://www.unep.org/OZONE/pdfs/Montreal-Protocol2000.pdf.

140. *Id.* art. 2(4), 26 I.L.M. at 1552–53. The European Community and the United States were actually able to complete the phase-out before the deadline because the phase-out was less expensive than originally thought and because of the discovery of greater damage to the ozone. ROBERT V. PERCIVAL ET AL., ENVIRONMENTAL REGULATION: LAW, SCIENCE, AND POLICY 1133 (6th ed. 2009).

141. Laura Thoms, *A Comparative Analysis of International Regimes on Ozone and Climate Change with Implications for Regime Design*, 41 COLUM. J. TRANSNAT'L L. 795, 804–05 (2003).

142. *Id.* at 807. Incremental policymaking allows for stronger rules to be established when the issue is viewed as important and for more effective rules to be

should include targets that are reached over an established period of time. Set timetables allow for accountability, so that parties to the treaty can hold each other accountable to make sure that BC reduction is being achieved. Additionally, each party should be able to choose the best timeframe to decrease BC through targets and timetables similar to those allowed by the Montreal Protocol to successfully decrease ozone-depleting chemicals.[143] Each country will have different financial and technical resources, so commitments to reduce BC emissions will vary depending on a country's abilities. For instance, China has more financial resources and a better ability to quickly distribute new technology than most countries in Africa, so China should achieve its targets faster. This gradual approach gives time to create alternatives and to adjust to the changes necessary to mitigate BC.[144] If a country's economy is growing rapidly, such as in China, that nation should properly adjust its goals to reflect its increased ability to achieve reductions faster.

The same parties to the treaty should renegotiate multiple times, increasing incentives to cooperate and decreasing the tendency to defect or free ride.[145] Once the BC treaty has been in place for a period of time, countries should reevaluate their original BC targets to see if they are still possible or whether they should be increased due to faster-than-expected reductions. Since relatively inexpensive and easily distributable technologies, such as clean cook stoves, already exist, nations will probably achieve reductions faster than many governments would expect.

Developed countries could offset their BC emissions by giving technical and financial assistance to developing countries similar to the CDM in the UNFCCC. This structure would fit perfectly into a BC treaty because developed nations have already made great reductions in their BC emissions through more efficient and cleaner

adopted when issue salience is low, which stops players from ignoring the rules. *Id.* at 808.

143. *See id.* at 810.

144. *Id.* Targets and timetables in the Montreal Protocol allowed CFC producers to discover and market alternatives to CFCs, so that developing countries would also be less likely to invest in old CFC technology. *Id.* Since many technological alternatives, such as solar cook stoves, already exist, timetables may not play quite as large of a role as they did with the Montreal Protocol.

145. *Id.* at 808.

diesel engines. Developed nations could transfer this technology to developing nations, as well as provide other resources, such as newer cook stoves and alternatives to open biomass burning.

To achieve an international treaty similar to the Montreal Protocol, the scientific community would need a greater consensus regarding the impacts of decreasing BC emissions. Scientific cooperation and communication and international recognition of human-induced ozone depletion permitted the creation of the Montreal Protocol.[146] In contrast, some uncertainty still exists regarding whether the reduction of BC would have a cooling or warming effect.[147] This disagreement is slowly beginning to change. Achim Steiner, the Executive Director of UNEP, admitted the importance of BC and the need to "deploy observing skills, technologies and science to understand" these emissions.[148] A joint UNEP and World Meteorological Organization report prompted policymakers to enact international solutions regarding CFCs.[149] UNEP's recognition of the need to address BC might have a similar effect, motivating the international community to create a new treaty.

IV. BILATERAL AND REGIONAL COOPERATION

Regional and bilateral cooperation is necessary to effectively reduce BC. The U.S. and other industrialized countries can provide funding and technology transfers to developing countries with high BC emissions.[150] All countries involved benefit because air pollution and climate change are transboundary problems, so when developing countries decrease their pollution, the U.S. and the rest of the world also see a decrease in pollution. Moreover, the U.S. and other industrialized nations learn about what the best methods are for reducing air pollutants by conducting demonstrations in developing countries.[151] Countries can then use these successful approaches

146. *Id.* at 810.

147. *See supra* notes 88–91.

148. Press Release, U.N. Env't Programme, Address by Achim Steiner to the High-Level Segment of the 3rd World Climate Conference (Sept. 3, 2009) (available on U.N. Env't Programme website).

149. Thoms, *supra* note 141, at 806.

150. *See infra* Part IV.A.

151. *See infra* Part IV.A.–B.

throughout the world, possibly for CDM credits under the UNFCCC.[152]

The U.S. is currently working with both China and India to help decrease their emissions. These programs focus on clean air and clean energy—two goals that are essential for the reduction of hazardous emissions. Reducing air pollution is an important step in mitigating climate change.[153] Since BC has a strong radiative forcing effect, it is a prime target to reduce both air pollution and slow climate change.[154] The U.S. has partnered with developing countries to work on a variety of key sectors to achieve these goals; the primary goals have been vehicle emission reduction and air quality management. The reason for the former is that a large source of BC in India and China comes from vehicles because many people in these countries view vehicles to be in good working order as long as they still run, no matter how polluting.[155] The emphasis on the latter is because many developing countries, including China and India, have dire air quality problems in their cities.[156]

A. *Transportation Sector*

The EPA and China's State Environmental Protection Agency (SEPA) signed a Memorandum of Understanding on clean fuels and vehicles.[157] In this document, the EPA promised to provide over $200,000 for diesel retrofit demonstrations and technical expertise.[158] The project included the use of two different technologies: one reduced particulate matter as much as thirty percent and another

152. *See infra* note 179.

153. U.N. ECON. COMM'N FOR EUR., CATALYZING CHANGE: THE UNECE RESPONSE TO THE CLIMATE COUNTDOWN 29.

154. *Id.* Radiative forcing is the heating of the planet that occurs when there is more incoming energy than energy leaving the atmosphere.

155. Guy, *supra* note 73.

156. Press Release, Envtl. Prot. Agency, Clean Diesel Retrofit Demonstration Project Underway in Beijing (Nov. 10, 2005), http://yosemite.epa.gov/opa/admpress.nsf/4d84d5d9a719de8c85257018005467c2/40a1cf46ebdcb7e4852570b50062e270!OpenDocument; Lea Terhune, *United States, India Cooperating To Cut Vehicular Air Pollution*, WASH. FILE, Sept. 8, 2006, http://www.america.gov/st/washfile-english/2006/September/20060908171452 mlenuhret0.9092327.html.

157. Press Release, Envtl. Prot. Agency, *supra* note 156.

158. *Id.* Southwest Research Institute agreed to contribute the same amount of funding and manage the bus retrofits. *Id.*

technology decreased particulates by more than ninety percent when used with low-sulfur fuel.[159] The U.S. started by conducting a demo project with retrofitting thirty buses in Beijing with diesel filters, which take out particulates including BC.[160] This program has been so successful that the EPA estimated that the Chinese government had retrofitted about five thousand buses in Beijing with these filters in the time leading up to the 2008 Olympics.[161]

The U.S. has also partnered with India in order to cut their vehicular air pollution. The United States Trade and Development Agency (USTDA) provided almost $300,000 to the city of Pune in India's Maharashtra state.[162] The money funded a retrofit program similar to the one in China: buses were retrofitted with diesel particulate filters and diesel oxidation catalysts.[163] Through the use of these technologies and low-sulfur diesel fuel, the program aimed to reduce BC and other particulate emissions.[164] The goal of the project was to create the most efficient system for Pune that the Indian government could then use in other Indian cities.[165] Through these projects, all three countries were able to learn about effective methods of decreasing BC emissions from vehicles, which the national government could then implement on a larger scale.

B. *Air Quality Management*

The U.S. has applied air quality management technologies and methods to Chinese cities. EPA, SEPA, and Shanghai Environmental Protection Bureau assessed a variety of air quality management elements, including regional and local air quality modeling, development of control strategies, and the development and use of an

159. *Id.*

160. ENVTL. PROT. AGENCY, OAR-CCD-05-06, BEIJING DIESEL RETROFIT PROGRAM, *available at* http://www.epa.gov/air/grants/05-06.pdf; Press Release, Envtl. Prot. Agency, *supra* note 156.

161. U.S. ENVTL. PROT. AGENCY, EPA-420-R-09-006, REPORT TO CONGRESS: HIGHLIGHTS OF THE DIESEL EMISSIONS REDUCTION PROGRAM 37 (2009), *available at* http://www.epa.gov/cleandiesel/documents/420r09006.pdf.

162. Terhune, *supra* note 156.

163. *Id.*

164. *See id.*

165. *Id.*

emissions inventory.[166] These three administrative bodies are also working together to develop regulations, increase public participation and outreach, and to design and use an air-monitoring network.[167] The project compares the ability at the national and regional level in these areas.[168] This assessment project provides training and workshops in order to improve capacity and transfer technology in modeling, monitoring, and inventories.[169] The program has mainly focused on Beijing, Shanghai, Pearl River Delta, and the Yangtze River Delta.[170]

An obstacle to improving the air quality in China is the inability of the government to properly enforce environmental legislation and policies. The Integrated Environmental Strategies program aims to build China's capacity by evaluating, developing, and implementing policies that protect public health, clean the air, and reduce pollution contributing to climate change.[171] The program in China focused on policies at the national and local levels for the cities of Shanghai and Beijing.[172] China still has cities with some of the worst air pollution in the world.[173] The country needs to implement strong clean air policies and increase its use in cleaner technologies to successfully abate BC emissions. The EPA and other government and business partners have helped China to achieve a greater understanding of the

166. *Clean Air and Energy Projects in China*, ENVTL. PROT. AGENCY, http://www.epa.gov/international/air/chinaair.html (last visited Feb. 8, 2011).

167. *Id.*

168. *Id.*

169. *Id.*

170. *Id.*

171. *Id.*

172. *Integrated Environmental Strategies: China*, ENTVL. PROT. AGENCY, http://www.epa.gov/ies/china/index.htm (last visited Feb. 8, 2011). The Shanghai study aimed to use several different energy and environmental policies to figure out which policy most successfully reduced pollutant levels. *Integrated Environmental Strategies: Shanghai*, ENTVL. PROT. AGENCY, http://www.epa.gov/ies/china/shanghai.htm (last visited Feb. 8, 2011). The Beijing program aimed to evaluate different strategies and technologies for reducing air pollution, provide help for the clean up prior to the Olympics, and give scientific support in dealing with pollution control. *Integrated Environmental Strategies: Beijing*, ENTVL. PROT. AGENCY, http://www.epa.gov/ies/china/beijing.htm (last visited Feb. 8, 2011).

173. BLACKSMITH INST. & GREEN CROSS, THE WORLD'S WORST POLLUTION PROBLEMS: THE TOP TEN OF THE TOXIC TWENTY 31 (2008); *see also China Is Set to Lose 2% of GDP Cleaning Up Decades of Pollution*, BLOOMBERG, Sept. 17, 2010.

most effective technologies and policies for reducing air pollutants, including BC. China can use this knowledge to clean the air in other cities throughout the country and further reduce their BC emissions. Unlike other countries with heavily polluted cities, China does not lack funding for new technologies. Rather, China needs to improve its policies to ensure that companies actually use these new technologies and understand the effect of BC on air quality and public health. The U.S. and other developed countries should provide technical and policy expertise to help this process.

Various American and Indian government agencies agreed in 2002 to work together to solve environmental problems so India could follow a more sustainable development path.[174] Part of this cooperation includes air quality management in order to prevent and control air pollution, improve environmental health, and strengthen environmental laws.[175] The goal is to introduce methodologies and technologies to create an effective science-based air quality management system.[176] Once again Pune was the test city, which was an ideal location because of its congestion and similarity to other Indian cities.[177] The goal now is to replicate the successful clean air strategies used in Pune in other cities around India.[178] These programs are very important to successfully reduce BC. Unlike in developed countries, much of the air pollution in Indian cities contains high quantities of BC emissions. These monitoring projects

174. Memorandum of Understanding Between the Environmental Protection Agency of the United States of America and the Ministry of Environment and Forests of the Government of India Concerning Cooperation in Environmental Protection, U.S.-India, Jan. 16, 2002, http://www.epa.gov/oia/regions/Asia/india/mou.html.

175. *Id.* The agreement does not mention BC specifically, but the reduction of air pollution and strong clean air legislation will almost definitely help in the mitigation of BC.

176. *India Air Quality and Climate Change*, ENVTL. PROT. AGENCY, http://www.epa.gov/oia/air/india.htm (last visited Mar. 21, 2011); *see also* ENVTL. PROT. AGENCY, AIR QUALITY MONITORING REPORTS PART 1 AND 2, *available at* http://www.epa.gov/oia/air/pdf/monitoring_rpt_1and2.pdf (last visited Mar. 21, 2011); ENVTL. PROT. AGENCY, AIR QUALITY MONITORING REPORTS PART 3, *available at* http://www.epa.gov/oia/air/pdf/monitoring_rpt_3.pdf (last visited Mar. 21, 2011); *see generally* PATRICK GAFFNEY & MICHAEL BENJAMIN, PUNE, INDIA REGIONAL EMISSIONS INVENTORY STUDY (2004).

177. *India Air Quality and Climate Change*, *supra* note 176.

178. *See id.*

are integral to an effective BC mitigation strategy because many lawmakers and other government officials do not realize the contribution of BC to India's air quality issues. These projects have the potential to educate policymakers on the importance of reducing BC and give them knowledge of the best way to accomplish BC abatement.

The desire to participate in the CDM encourages the U.S. and other developed countries to engage in these bilateral initiatives. By taking part in these clean air programs in India and China, the U.S. is able to get credits towards its emission reductions. The U.S. already has strong requirements for vehicles, which reduce emissions by ninety percent.[179] Therefore, the U.S. can give this technology to other countries that have high vehicle emissions and few requirements for emissions. By providing funding and technology, the U.S. is able to greatly reduce vehicle pollution and gain credit towards its own emissions. Without this help, developing countries would have a hard time getting these programs started because of a lack of money, technology, or infrastructure. Once the U.S. helps with a demonstration in a developing country, the country has a better idea of what technologies work best for emission reductions and how it should implement such a program.

V. CONCLUSION

Although some uncertainties still remain about the exact effects of BC, enough conclusive scientific evidence exists regarding the negative impact of BC emissions on public health and global warming to justify international action. Multiple solutions will play a role in helping abate BC. First, national governments, especially the United States, China, and India, must use domestic laws to address BC in order to reduce each country's emissions and help other nations abate their BC emissions through funding and technology transfer. Second, the international community must either revise the Kyoto Protocol or the Gothenburg Protocol to include BC, or they must create a new treaty focused solely on BC. Finally, bilateral cooperation is important to provide funding and cleaner technologies to ensure the reduction of BC in developing and emerging countries.

179. Guy, *supra* note 73; Press Release, Envtl. Prot. Agency, *supra* note 156.