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Multilateral Climate Change Mitigation

By ELIZABETH BURLESON*

I. Introduction

THE EARTH'S CLIMATE is a public good.¹ A single country does not benefit from investing in climate protection unless doing so becomes a collective effort.² Society's inability to reach consensus on climate change mitigation has resulted in the tragedy of the commons.³ Humanity was able to overcome a similar crisis through an international cooperative effort to reduce the ozone hole.⁴ International chlorofluorocarbon protocols addressed the over-exploitation of the global commons.⁵ As Tom Tietenberg notes, "[t]he atmosphere is but one of many commons and climate change is but one example of over-exploitation of the commons."⁶ The World Bank predicts

warmer temperatures, more variable precipitation, and an increased incidence of extreme climatic events. When coupled with sea level rise, this will adversely impact agriculture, water resources, human settlements, human health, and ecological systems and will

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1. DEV. COMM. OF THE WORLD BANK GROUP, CLEAN ENERGY AND DEVELOPMENT: TOWARDS AN INVESTMENT FRAMEWORK viii (2006), available at [http://siteresources.worldbank.org/DEVCOMMINT/Documentation/20890696/DC2006-0002\(E\)-CleanEnergy.pdf](http://siteresources.worldbank.org/DEVCOMMINT/Documentation/20890696/DC2006-0002(E)-CleanEnergy.pdf).

2. Thomas Pfeiffer & Martin A. Nowak, *Climate Change: All in the Game*, 441 NATURE 583, 583 (2006).

3. The term "tragedy of the commons" dates back to Garret Hardin's seminal article in 1968, Garret Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243 (1968), available at <http://www.sciencemag.org/cgi/content/full/162/3859/1243>.

4. William D. Nordhaus, *Life After Kyoto: Alternative Approaches to Global Warming Policies*, (Nat'l Bureau of Econ. Research, Working Paper No. 11889, 2005), http://nordhaus.econ.yale.edu/kyoto_long_2005.pdf. See also William D. Nordhaus, *After Kyoto: Alternative Mechanisms to Control Global Warming*, 96 AM. ECON. REV. 31, 31, available at http://www.econ.yale.edu/~nordhaus/homepage/AEA_kyoto_120905.pdf.

5. *Id.*

6. Tom Tietenberg, *The Tradable-Permits Approach to Protecting the Commons: Lessons for Climate Change*, 19 OXFORD REV. ECON. POL'Y 3 (2003), available at <http://oxrep.oxfordjournals.org/cgi/reprint/19/3/400?ijkey=324rjCyD25Jfk&keytype=ref>.

undermine economic development and the ability to achieve many of the Millennium Development Goals (MDGs).⁷

The World Bank goes on to point out that the poorest individuals in the most vulnerable countries face the greatest danger with the least ability to adapt.⁸

The world's population continues to grow rapidly while supplies of important fuels decline. Global energy demand will rise by 50% to 60% by 2030 according to the International Energy Agency.⁹ Inefficient cities with carbon intensive energy infrastructures are expanding.¹⁰ Our dependence upon economic growth makes us reliant upon increasing the energy supply.

Countries hesitant to join an international mitigation effort dominate fossil fuels consumption and production.¹¹ On the energy demand side, fifteen countries contribute over 75% of global carbon emissions annually.¹² Eighty-three percent of global emissions come from twenty-five nations.¹³ The United States uses 25% of global oil to satisfy less than 5% of the world's population.¹⁴ On the energy supply side, traditional carbon-based energy sources remain within the juris-

7. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at 5. "The incremental annual costs to adapt to projected climate change are likely to lie in the \$10 billion to \$40 billion per year range." *Id.* at ix.

8. *Id.* at viii.

9. Richard Black, *Energy Gap: Crisis for Humanity?*, BBC NEWS, Jan. 26, 2006, <http://news.bbc.co.uk/1/hi/sci/tech/4648710.stm> (citing the International Energy Agency).

10. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at 5. See also Katherine Sierra, *Infrastructure, Meeting an Increased Demand from Developing Countries*, <http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:20127296%7emenuPK:34480%7epagePK:34370%7etheSitePK:4607,00.html> (last visited Jan. 28, 2007) ("Private sector investments to infrastructure in developing countries have declined significantly since their peak in 1997. As a consequence, infrastructure needs are great—both in terms of access and quality—and developing countries face an enormous shortage of funds for infrastructure development.").

11. Daniel M. Kammen & Gregory F. Nemet, *Real Numbers: Reducing the Incredible Shrinking Energy R&D Budget*, ISSUES IN SCI. & TECH. 84, 85 (Fall 2005), available at <http://www.issues.org/22.1/realnumbers.html>.

12. SWEDISH ENVTL. PROT. AGENCY, KYOTO AND BEYOND: ISSUES AND OPTIONS IN THE GLOBAL RESPONSE TO CLIMATE CHANGE 28 (2002), <http://www.internat.naturvardsverket.se/documents/issues/climate/report/Kyoto.pdf>.

13. Hon. Eileen Claussen, President, Opening Statement at the Climate Conference of the Energy and Natural Res. Comm: United States Senate Panel: Trading and International Competitiveness (Apr. 4, 2006), http://www.pewclimate.org/what_s_being_done/in_the_congress/april_4_06.cfm.

14. Senator Dick Lugar, U.S. Senate Foreign Relations Comm., Address to the Brookings Institution: U.S. Energy Security—A New Realism (Mar. 13, 2006), <http://lugar.senate.gov/pressapp/record.cfm?id=252509>.

diction of a dozen nations.¹⁵ These countries must participate in multilateral legal action that achieves climate stabilization.

Sustained trust will be needed to coordinate the legal, scientific, and economic dimensions of climate change mitigation. Meaningful multilateral action that establishes collective standards with individual country implementation is necessary to address global climate change. Emissions trading and regulation of the transportation and energy sectors must be central concerns for international decision makers that craft post-2012 carbon emission protocols. Resolving equity and efficiency aspects of tradable permits and clean technology transfer can achieve sustainable development. Global carbon market integration, coupled with progressive transportation and energy sector strategies, are integral to climate stabilization.

This Article explores critical elements of a legal framework for climate stabilization. Given the urgent need for international coordination to stabilize the climate, Part II considers current climate instability. This is followed by a discussion of current climate strategies in Part III and future mitigation measures in Part IV. This Article concludes that multilateral coordination can develop a viable legal framework for climate stabilization.

II. Scientific Consensus on Current Climate Instability

The atmosphere's concentration of carbon dioxide has increased by more than 30 percent over the last 250 years, largely due to human activity. Two-thirds of that rise has occurred in the past 50 years.¹⁶

—Socolow, Hotinski, Greenblatt, and Pacala

The director of the NASA Goddard Institute for Space Studies, James Hansen, warns that the 2001 United Nations Intergovernmental Panel on Climate Change ("IPCC") sea-level predictions were based upon thermal expansion of ocean water, with slight change in ice-sheet volume.¹⁷ The 2001 IPCC calculation was too low and did not reflect the speed with which ice sheets are melting, according to Hansen.¹⁸ He believes that we are at the brink of dangerous anthropogenic interference and that we should not stand by and allow global

15. SWEDISH ENVTL. PROT. AGENCY, *supra* note 12, at 28.

16. Socolow, Hotinski, Greenblatt, & Pacala, *Solving the Climate Problem: Technologies Available to Curb CO₂ Emissions*, 46 ENV'T 8, 19 (Dec. 2004), available at http://www.princeton.edu/~cmi/resources/CMI_Resources_new_files/Environ_08-21a.pdf.

17. James Hansen, *Defusing the Global Warming Time Bomb*, 290 SCI. AM. 3, 72 (Mar. 2004) [hereinafter Hansen, *Defusing the Global Warming Time Bomb*].

18. *Id.*

warming to exceed one degree Celsius.¹⁹ Elizabeth Kolbert of *The New Yorker* cautions, "since our species evolved, average temperatures have never been much more than two or three degrees higher than they are right now."²⁰ The 2007 IPCC report predicts a likely increase in temperatures of 2 to 4.5 degrees Celsius if carbon concentrations double from pre-industrial levels.²¹

Once an ice-sheet begins to melt, water from surface lakes flows down vertical shafts to the base of the ice sheet where it forms rivers that cause large sections of the ice sheet to separate from the base.²² The self-reinforcing collapse of ice sheets occurs quickly.²³ The melted ice causes significant sea-level rise, leading to inundated coastlines around the world.²⁴ Sea levels are approximately half a foot higher than a century ago.²⁵ The Greenland ice sheet has been losing ice at an alarming rate of fifty cubic kilometers a year.²⁶ A rise in this rate will significantly increase sea levels.

According to Hansen, "[w]e are getting dangerously close to the tipping point for the Arctic, as summer sea ice has already decreased about 25% since the late 1970s."²⁷ He calls for international cooperation and strong policy leadership before high carbon infrastructure is built that will place us further away from being able to keep global

19. *Id.* Hansen offers hope that Intergovernmental Panel on Climate Change predictions may come out even, however, given a lack of emphasis upon existing technology, emission reductions, and air pollution trends. *Id.* at 72–75. See also R.B. Alley et al., *Abrupt Climate Change*, 299 SCIENCE 2005, 2006 (2003), available at http://nordhaus.econ.yale.edu/acc_science_280303.pdf. Abrupt climate change is comparable to tipping a canoe, "leaning slightly over the side of a canoe will cause only a small tilt, but leaning slightly more may roll you and the craft into the lake." *Id.*

20. Elizabeth Kolbert, *The Climate of Man—II*, NEW YORKER, May 2, 2005, available at <http://www.wesjones.com/climate2.htm>.

21. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE ("IPCC"), CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, SUMMARY FOR POLICYMAKERS 12 (2007), <http://www.ipcc.ch/SPM2feb07.pdf> (noting that the loss of the Greenland ice sheet would increase sea levels by seven meters, the report clarifies that dynamical processes related to ice flow were not included in current models). *Id.* at 7.

22. Hansen, *Defusing the Global Warming Time Bomb*, *supra* note 17, at 74–75. See also Jim Hansen, *Greenland Ice Cap Breaking Up at Twice the Rate It Was Five Years Ago, Says Scientist Bush Tried to Gag*, INDEPENDENT, Feb. 17, 2006, available at <http://news.independent.co.uk/environment/article345926.ece> [hereinafter Hansen, *Greenland Ice Cap Breaking Up*].

23. Hansen, *Defusing the Global Warming Time Bomb*, *supra* note 17, at 74–75.

24. *Id.* See also Elizabeth Kolbert, *the Climate of Man—I*, NEW YORKER, Apr. 25, 2005, available at <http://www.wesjones.com/climate1.htm>.

25. Kolbert, *The Climate of Man—II*, *supra* note 20.

26. Quirin Schiermeier, *Climate Change. A Sea Change*, 439 NATURE 256, 258 (2006).

27. James Hansen, Presentation at New School University: Can We Still Avoid Dangerous Human-Made Climate Change? (Feb. 10, 2006), http://www.columbia.edu/~jeh1/new_school_text_and_slides.pdf.

warming below one degree Celsius.²⁸ Seventy percent of the human-caused rise in greenhouse gas emissions has occurred since 1950.²⁹ Hansen points out that “[w]e have to stabilize emissions of carbon dioxide within a decade, or temperatures will warm by more than one degree. That will be warmer than it has been for half a million years, and many things could become unstoppable.”³⁰ He concludes that we must proceed with mitigation measures, emphasizing energy efficiency and carbon neutral renewable energy sources.³¹

Significant permafrost melt has resulted from disproportionately rapid warming across the Arctic.³² A northern migration of the permafrost line will release trapped methane into the atmosphere, further increasing global warming.³³ At Sweden’s Abisko Scientific Research Station, two hundred kilometers within the Arctic Circle, mean temperatures from December to February have risen by approximately 5.5 degrees Celsius over the past century.³⁴ The area is warming at an eight-fold rate compared to the rest of the Northern Hemisphere.³⁵ Bruce Molina of the United States Geological Survey and Jeanne Sauber of NASA’s Goddard Space Flight Center note that the melting of ice sheets that have checked seismic activity is likely to trigger earthquakes.³⁶

The ice melt itself has also created dangerous conditions. “The ongoing and projected increased loss of sea-ice in the warming Arctic poses a significant threat to the polar bear,” according to University of Chicago climate scientist Pamela Martin and colleagues from institu-

28. *Id.* at 10.

29. Hansen, *Defusing the Global Warming Time Bomb*, *supra* note 17, at 72.

30. Hansen, *Greenland Ice Cap Breaking Up*, *supra* note 22, at 1.

31. *Id.*

32. Deborah Zabarenko, *Thawing Permafrost Could Unleash Tons of Carbon*, REUTERS, June 15, 2006, available at http://today.reuters.co.uk/news/newsArticle.aspx?type=ScienceNews&storyID=2006-06-15T180503Z_01_N14246495_RTRIDST_0_SCIENCE-ENVIRONMENT-PERMAFROST-DC.XML.

33. The degree to which forests will transition from net absorbers of carbon dioxide to net producers remains to be seen. Richard Black, *Water Builds the Heat in Europe*, BBC News, Nov. 12, 2005, <http://news.bbc.co.uk/1/hi/sci/tech/4419880.stm>. See also Richard Black, *Earth—Melting in the Heat?*, BBC News, Oct. 7, 2005, <http://news.bbc.co.uk/1/hi/sci/tech/4315968.stm>.

34. “[T]he last Ice Age was only 4–5C cooler than today.” Alex Kirby, *Climate Change: Uncharted Waters?*, BBC NEWS, Dec. 3, 2004, <http://news.bbc.co.uk/1/hi/sci/tech/4061871.stm>. For a discussion of Abisko Scientific Research Station’s Arctic warming findings, see Quirin Schiermeier, *Arctic Ecology: On Thin Ice*, 441 NATURE 7090, 146, 146 (2006).

35. Schiermeier, *supra* note 26, at 146–147.

36. Sharon Begley, *How Melting Glaciers Alter Earth’s Surface, Spur Quakes, Volcanoes*, WALL ST. J., June 9, 2006, at A11, available at <http://proquest.umi.com/pqdlink?did=1052795531&sid=1&fmt=3&clientId=44880&RQT=309&VName=PQD>.

tions including Columbia, Harvard, and Stanford.³⁷ Their letter submitted to the Fish and Wildlife Service on June 15, 2006 clarifies that global surface temperature is currently “not in a steady state,” nor will it be for years to come.³⁸ They urge the Fish and Wildlife Service to acknowledge the threat of Arctic warming on the polar bear by listing it as an endangered species.³⁹ Once a species is listed, the Endangered Species Act provides significant provisions for habitat preservation.⁴⁰ The Endangered Species Act requires the United States Fish and Wildlife Service to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range.⁴¹ Polar bears are not the only species impacted by global warming but their preservation may provide a legal catalyst with which to address climate equilibrium.⁴² The United States Secretary of the Interior, Dirk Kempthorne, has proposed putting the polar bear on the endangered species list as a threatened species.⁴³

The National Oceanic and Atmospheric Administration states that “[h]uman activity has been increasing the concentration of greenhouse gases in the atmosphere (mostly carbon dioxide from combustion of coal, oil, and gas; plus a few other trace gases). There is no scientific debate on this point.”⁴⁴ On May 2, 2006, a scientific study commissioned by the second Bush Administration agreed that human

37. Press Release, by Steve Koppes, University of Chicago, Climate Scientists Spotlight Arctic Warming, Plight of Polar Bears: Public Comment Period on Threatened Species Listing Ends Today (June 16, 2006), <http://www-news.uchicago.edu/releases/06/060616.polarbear.shtml>.

38. *Id.*

39. *Id.*

40. Endangered Species Act of 1973, 16 U.S.C. §§ 1531–44 (2000).

41. *Id.*

42. Press Release, by Steve Koppes, University of Chicago, Climate Scientists Spotlight Arctic Warming, Plight of Polar Bears: Public Comment Period on Threatened Species Listing Ends Today (June 16, 2006), <http://www-news.uchicago.edu/releases/06/060616.polarbear.shtml>.

43. Press Release, Interior Secretary Kempthorne, U.S. Department of the Interior Office of the Secretary, Announces Proposal to List Polar Bears as Threatened Under Endangered Species Act (Dec. 27, 2006), http://www.doi.gov/news/06_News_Releases/061227.html.

44. The greatest warming has occurred in North America and Eurasia between 40 and 70°N. Northern Hemisphere annual snow cover extent has consistently remained below average since 1987 and has decreased by about 10% since 1966. Nat'l Oceanic and Atmospheric Admin., Global Warming: Frequently Asked Questions, <http://www.ncdc.noaa.gov/oa/climate/globalwarming.html> (last visited Feb. 12, 2007) (noting that “[p]re-industrial levels of carbon dioxide (prior to the start of the Industrial Revolution) were about 280 parts per million by volume (“ppmv”), and current levels are about 370 ppmv.”). *Id.*

activity has resulted in global warming of the lower atmosphere.⁴⁵ Sustaining commitment to multilateral climate change mitigation is scientifically warranted and within political reach.

III. The United Nations Framework Convention on Climate Change and the Kyoto Protocol

In 1957, the International Council of Scientific Unions initiated the International Geophysical Year—a one year period of time dedicated to a global assessment of the atmosphere.⁴⁶ This research uncovered a striking rise of atmospheric carbon dioxide concentrations. In 1975, Syukuro Manabe and Richard Wetherald estimated that if carbon dioxide levels doubled, the average global climate would increase by three degrees Celsius.⁴⁷ The First World Climate Conference took place in 1979, and the World Meteorological Organization and the United Nations Environment Programme created the Intergovernmental Panel on Climate Change in 1988.⁴⁸ President George H.W. Bush became one of the first heads of state to sign the United Nations Framework Convention on Climate Change (“UNFCCC”) at the 1992 Earth Summit in Rio de Janeiro.⁴⁹ “Let us join in translating the words spoken here into concrete action to protect the planet,” he urged the international community.⁵⁰ President George H.W. Bush submitted

45. TOM M. L. WIGLEY ET AL., TEMPERATURE TRENDS IN THE LOWER ATMOSPHERE—UNDERSTANDING AND RECONCILING DIFFERENCES, THE U.S. CLIMATE CHANGE SCIENCE PROGRAM EXECUTIVE SUMMARY (2005), <http://www.climatechange.gov/Library/sap/sap1-1/final-report/sap1-1-final-execsum.pdf>. See also Andrew Revkin, *Federal Study Finds Accord on Warming*, N.Y. TIMES, May 3, 2006, available at <http://www.nytimes.com/2006/05/03/science/03climate.html?ex=1304308800&en=cceeb376fd01312e&ei=5088&partner=rssnyt&emc=rss>.

46. The National Academies (“NAS”), The International Geophysical Year (“IGY”), <http://www.nas.edu/history/igy/> (last visited Feb. 12, 2007).

47. See generally Syukuro Manabe & Richard T. Wetherald, *The Effect of Doubling the CO₂ Concentration on the Climate of a General Circulation Model*, 32 J. ATMOSPHERIC SCI. 3, 10 (1975).

48. IPCC WORKING GROUP 1, TECHNICAL SUMMARY REPORT, <http://www.ipcc.ch/pub/wg1TARtechsum.pdf> (last visited Feb. 12, 2007). The objective of the IPCC is to “provide an assessment of the understanding of all aspects of climate change including how human activities can cause such changes and can be impacted by them.” *Id.* at 22.

49. United Nations Framework Convention on Climate Change, Intergovernmental Negotiating Committee for a Framework Convention on Climate Change OR, 5th Sess., Annex, UN Doc. A/AC.237/18 (PartII)/Add.1 (1992), 31 I.L.M. 849, available at <http://unfccc.int/resource/docs/a/18p2a01.pdf> [hereinafter *UNFCCC*]. One hundred sixty-five countries ratified the UNFCCC. The convention entered into force March 21, 1994. *Id.* See also Elizabeth Kolbert, *The Climate of Man—III*, NEW YORKER, May 9, 2005, available at <http://www.wesjones.com/climate3.htm>.

50. President George H.W. Bush, Speech upon signing the UNFCCC: U.S. Environment Initiatives and the U.N. Conference on Environment and Development (June 12,

the convention to the United States Senate within three months. The Senate unanimously ratified the convention in October 1992. The United States was the first industrialized nation to ratify the convention, which called for developed countries to return their emissions to 1990 levels by the year 2000.⁵¹ The convention entered into force in March of 1994.⁵²

In keeping with the UNFCCC principle of common but differentiated responsibilities,⁵³ the Kyoto Protocol set binding emission reduction targets for six greenhouse gases across a five-year period.⁵⁴ The Protocol recognized historical differences in the emissions of developed and developing states and in their respective capacity to contribute economic and technical solutions. Article 3 and Annex B of the Kyoto Protocol mandated a 5.2% reduction of 1990 levels of carbon emissions by creating absolute emissions targets. The United States committed to reducing carbon emissions by 7% below 1990 levels.⁵⁵ The European Union agreed to lower carbon emissions by 8% below 1990 levels, using a "bubble" that offers flexibility between various European Union countries.⁵⁶

The Kyoto Protocol sets a fixed quantity of global carbon emissions. Seeking to reduce emissions to 5.2% below 1990 levels, developed countries that have ratified the Kyoto Protocol have agreed to reach quantified emissions levels based upon the given circumstances

1992), in 3 U.S. DEPARTMENT OF STATE DISPATCH SUPPLEMENT, JULY 1992, at 4, available at <http://dosfan.lib.uic.edu/ERC/briefing/dispatch/1992/html/Dispatchv3Sup4.html>.

51. UNFCCC, *supra* note 49, art. 4, at 6.

52. For a general description of the UNFCCC, see CLIMATE CHANGE SECRETARIAT, CARING FOR CLIMATE: A GUIDE TO THE CLIMATE CHANGE CONVENTION AND THE KYOTO PROTOCOL, INFORMATION SERVICES OF THE UNFCCC SECRETARIAT 5 (2005), http://unfccc.int/resource/docs/publications/caring2005_en.pdf (last visited Feb. 12, 2007). See also *Road from Kyoto Part I: Where Are We, Where Are We Going, and How Do We Get There?: Hearing Before the House Comm. on Sci.*, 105th Cong. 2 (1998), available at http://www.house.gov/science/charter_full_02-4.htm [hereinafter *House Comm. on Sci.*].

53. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at 21, 24.

54. Conference of the Parties to the Framework Convention on Climate Change: Kyoto Protocol, Dec. 10, 1997, *Kyoto Protocol*, U.N. Doc. FCCC/CP/1997/L.7/add. 1, 37 I.L.M. 22 (1998); *Kyoto Protocol* to the UNFCCC, Feb. 16, 2005, Art. 3 [hereinafter *Kyoto Protocol*], available at <http://unfccc.int/resource/docs/convkp/kpeng.pdf>. The greenhouse gases listed in Annex A of the Kyoto Protocol include: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆). *Id.* at Annex A.

55. *House Comm. on Sci.*, *supra* note 52.

56. Established under the Kyoto Protocol, the EU bubble allows some EU members to reduce emissions by more than the 8% EU cap and enables other EU members to reduce emissions by less than the EU cap. *House Comm. on Sci.*, *supra* note 52.

of each Annex I country.⁵⁷ Such a quantitative approach provides greater certainty about the reduction of carbon than non-binding targets, price-based commitments, price cap proposals, or intensity targets.⁵⁸ Yet, quantitative policies do not provide precise cost measurements. President Clinton and Vice-President Gore signed the Kyoto Protocol on behalf of the United States on December 11, 1998. Gore has since launched a bipartisan climate change education campaign.⁵⁹

Article 2 of the UNFCCC calls for “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”⁶⁰ This provision goes on to state that “[s]uch a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.”⁶¹ The second Bush Administration’s Climate Action Report—2002 admitted that global warming has “dangerous” consequences and that greenhouse gas emissions are contributing to climate change.⁶² According to the second Bush Administration, however, the United States economy was not robust enough to achieve absolute emissions targets, particularly in the absence of binding commitments from other major carbon emitters.⁶³ The United States’ ability to join

57. The following forty countries (and the European Economic Community) agreed to limit their greenhouse gas emissions: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, the Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom, and the United States. UNFCCC Annex I, at 26.

58. SWEDISH ENVTL. PROT. AGENCY, *supra* note 12, at 28.

59. Timothy Gardner, *Gore to Train 1,000 to Spread Word About Climate*, REUTERS, June 12, 2006, available at http://today.reuters.com/news/newsarticle.aspx?type=TopNews&storyid=2006-06-13T113833Z_01_N12361864_RTRUKOC_0_US-ENVIRONMENT-GORE.xml&src=rss (last visited June 12, 2006); see also Gary Gentile, *Gore’s Global Warming Doc Wins Oscar*, CBS NEWS, Feb. 26, 2007, available at <http://www.cbsnews.com/stories/2007/02/26/ap/entertainment/mainD8NH6JQG2.shtml>.

60. UNFCCC, *supra* note 49, art. 2, at 5.

61. *House Comm. on Sci.*, *supra* note 52, at 4.

62. U.S. DEPT. OF STATE, U.S. ACTION REPORT—2002, THIRD NATIONAL COMMUNICATION OF THE UNITED STATES OF AMERICA UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE 5–6, 27 (2002), available at <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsUSClimateActionReport.html>.

63. “[O]ne of the first acts of newly-elected President George W. Bush was to formally withdraw the U.S. from Kyoto. Bush said the U.S. would not ratify the treaty because it would damage the U.S. economy and major developing nations like China and India were not covered by its provisions,” CBC NEWS, *Kyoto and Beyond: Kyoto Protocol FAQs*, available at

international climate change consensus has been compromised by the Senate's passage of the Byrd-Hagel Resolution, insisting that the United States not sign a climate change agreement unless developing countries were also required to reduce emissions.⁶⁴ International co-operation on climate change mitigation has been further delayed by the second Bush Administration's un-signing of the Kyoto Protocol in 2001. The United States remains bound by the UNFCCC to reduce rather than increase greenhouse gas emissions.⁶⁵ Rather than lowering greenhouse gas emissions in relation to a baseline, the second Bush Administration's target of making the economy 18% more energy efficient has increased greenhouse gas emissions.⁶⁶ The EPA notes that United States carbon emissions have increased 15.8% between 1990 and 2004, rising 1.7% in 2004 alone.⁶⁷

The Kyoto Protocol required ratification by nations contributing at least 55% of greenhouse gas emissions. Kyoto's target was difficult to reach without the United States, which contributed 36.1% of those emissions. Yet, 141 countries cooperated in bringing the Kyoto Protocol into force by February 2005, legally binding member countries to lower carbon emissions.⁶⁸

<http://www.cbc.ca/news/background/kyoto/>. See also SWEDISH ENVTL. PROT. AGENCY, *supra* note 12, at 34.

64. S. Res. 98, 105th Cong., 143 Cong. Rec. S8138-39 (daily ed. July 25, 1997) (enacted) [hereinafter *Byrd-Hagel Resolution*]. See also Leah H. Martinez, *Post Industrial Revolution Human Activity and Climate Change: Why the United States Must Implement Mandatory Limits on Industrial Greenhouse Gas Emissions*, 20 J. LAND USE & ENVTL. L. 403, 417 (2005). See also *Foreign Affairs Preemption and State Regulation of Greenhouse Gas Emissions*, 119 HARV. L. REV. 1877, 1885 (2006). There has been a policy shift since Congress passed the Global Climate Protection Act ("GCPA") in 1987. See Pub. L. No. 100-204, 101 Stat. 1407, 1103(a) (1987). The GCPA rendered it United States policy to work toward multilateral agreements. *Id.* As the incoming chair of the Senate Environment and Public Works Committee, Barbara Boxer has expressed a commitment to enact meaningful climate change legislation, Elizabeth Shogren, *New Congress Gives Hope to Environmentalists: All Things Considered* (NPR radio broadcast Nov. 10, 2006) <http://www.npr.org/templates/story/story.php?storyId=6469295>.

65. UNFCCC, *supra* note 49, art. 2, at 5.

66. U.S. CLIMATE ACTION REPORT—2002, *supra* note 62, at 5-6. See also Bradford C. Mank, *Standing and Global Warming: Is Injury to All Injury to None?*, 35 ENVTL. L. 1, 21 (2005).

67. U.S. EMISSIONS INVENTORY 2006: INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2004, EPA #430-R-06-002 2-1 (2006), [http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR6MBLNN/\\$File/06Trends.pdf](http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR6MBLNN/$File/06Trends.pdf).

68. Russia's ratification of the Kyoto Protocol in November 2004 made the treaty legally binding. The implosion of Russia's economy since 1990 lowered emissions by 35%, enabling Russia to meet Kyoto commitments. Russia is likely to acquire billions of dollars by selling its unused permits to emit carbon. *Climate Change: The Big Emitters*, BBC News, July 4, 2005, <http://news.bbc.co.uk/1/hi/sci/tech/3143798.stm>.

IV. Multilateral Legal Approaches to Climate Mitigation

Multilateral negotiations for the Kyoto Protocol's second commitment period are underway. On November 30, 2005, parties adopted the rules and regulations of the Kyoto Protocol at the Eleventh Session of the Conference of the Parties to the UN Framework Convention on Climate Change ("COP 11") and the First Meeting of the Parties to the Kyoto Protocol ("MOP 1") held in Montreal.⁶⁹ The Montreal Mandate does not require binding emission reductions from developing countries but requires participating developed countries to take on binding emission reductions for the commitment period from 2013 to 2017. Country specific targets will be negotiated and adopted in 2007 at COP/MOP-3.⁷⁰

Article 3.9 of the Kyoto Protocol called upon parties to begin post-2012 negotiations before the end of 2005.⁷¹ Upon realizing that the rest of the international community was prepared to proceed with post-2012 negotiations without the United States, the second Bush Administration acquiesced to participate in a dialogue under the UNFCCC.⁷² The Montreal Conference of 2005 succeeded in launching parallel negotiations under the Kyoto Protocol and the UNFCCC.⁷³ As a result, countries such as the United States that have not ratified Kyoto will join the post-2012 dialogue.⁷⁴

Many climate change mitigation proposals are complementary rather than mutually exclusive.⁷⁵ Countries can commit to emissions trading. Doing so would be compatible with additionally committing to research and development ("R&D") by ratifying a Zero Emissions Technology Treaty ("ZETT") to foster widespread technological advances.⁷⁶ Wind turbines, solar photovoltaic ("solar PV")⁷⁷ systems,

69. United Nations Climate Change Conference, (COP 11 and COP/MOP 1) Nov. 28 to Dec. 9, 2005, http://unfccc.int/meetings/cop_11/items/3394.php.

70. INT'L INST. FOR SUSTAINABLE DEV., GOVERNING CLIMATE: THE STRUGGLE FOR A GLOBAL FRAMEWORK BEYOND KYOTO 41 (2005), *available at* http://www.iisd.org/pdf/2005/climate_governing.pdf. Define COP/MOP-3.

71. Meinhard Doelle, *The Cat Came Back, or the Nine Lives of the Kyoto Protocol*, 16 J. Envtl. L. & Prac. 261, 275 (2006). Meinhard Doelle is the Associate Director at Dalhousie Law School's Marine & Environmental Law Institute in Canada.

72. *Id.* at 277.

73. *Id.*

74. *Id.*

75. See DANIEL BODANSKY, PEW CENTER ON GLOBAL CLIMATE CHANGE: INTERNATIONAL CLIMATE EFFORTS BEYOND 2012: A SURVEY OF APPROACHES 2 (2004), <http://www.pewclimate.org/docUploads/2012%20new%20pdf>.

76. Cellulosic ethanol and space-based solar electricity are two technologies that need R&D.

drip irrigation, and a wide range of other crucial technologies need to be implemented across the globe. The international community should negotiate an international R&D technology transfer agreement as an amendment to the UNFCCC or as a freestanding instrument.⁷⁸ Bilateral and multilateral technology agreements among developing and developed countries can also enhance technology cooperation.⁷⁹ These commitments would not preclude member states from ratifying a multilateral Climate-Wise Development Treaty that would link climate and development funding.⁸⁰ It is feasible to commit to R&D, financial transfers, carbon taxes, efficiency standards, and domestic emissions reduction targets.

Carbon taxes offer certainty regarding abatement costs but uncertainty about environmental outcome.⁸¹ Global carbon tax proposals were rejected during the early stages of Kyoto negotiations in favor of a quantity-based approach, giving greater certainty regarding environmental effects.⁸² The United States and a few other countries stated that they would not commit to a global emissions tax.⁸³ The Carbon Trust suggests that market-based emission trading is optimal for large emitters while a cross-sectoral carbon tax should be directed towards smaller emitters.⁸⁴ Many sectors would not achieve necessary carbon reductions based upon a carbon tax alone according to the Carbon Trust.⁸⁵ The Carbon Trust calls for mandatory audited carbon reporting for both publicly listed organizations and larger public sector entities.⁸⁶

77. Requiring only daylight rather than direct sunlight, solar PV transforms the sun's energy into electricity. Energy Saving Trust, <http://www.est.org.uk/myhome/generating/types/solarpv/> (last visited Feb. 8, 2007).

78. BODANSKY, *supra* note 75, at 33.

79. *Id.*

80. *Id.* at 7. Daniel Bodansky suggests carrying out a Climate Marshall Plan. *Id.* at 13, 24. The "Purchase of a Global Public Good" proposal recommends that states contribute funds to an international institution. *Id.* at 13. This body would use the financial contributions to buy and retire emission permits. *Id.*

81. SWEDISH ENVTL. PROT. AGENCY, *supra* note 12, at 35.

82. *Id.*

83. *Id.*

84. *Making Business Sense of Climate Change Carbon Trust Submission to the Energy Policy Consultation*, CARBON TRUST, Sept. 2002, at 10, available at http://www.carbontrust.co.uk/NR/rdonlyres/94F54D0B-7755-413B-A051-1F890A45D685/0/Submission_Energy_Policy_Consultation.pdf.

85. "[G]iven the weight of scientific evidence it would be reasonable to expect that currently recalcitrant or sceptical countries will be forced into stronger action over time." *Id.* at 15.

86. "One of the major drivers of behavioural change in organisations is the measurement and reporting of key variables." *Id.* at 43.

Princeton University's Carbon Mitigation Initiative has developed a game that encourages strategic thinking about lowering greenhouse gas emissions. Robert Socolow and Steve Pacala's stabilization wedges help people visualize carbon reduction. The stabilization wedge game offers multiple approaches to prevent a doubling of atmospheric carbon dioxide over pre-industrial levels.⁸⁷ Teammates build a stabilization triangle using seven wedges, each representing a strategy to reduce carbon emissions.⁸⁸ Robert Socolow notes that the wedge approach "[e]stablishes a unit of action that permits quantitative discussion of cost, pace, [and] risk."⁸⁹ Quantitative trade-offs can be considered.⁹⁰ Curbing carbon emissions by roughly seven billion tons per year by 2055 would prevent roughly 175 billion tons of carbon from entering the atmosphere.⁹¹ This carbon savings is known as the stabilization triangle. A single strategy will not be able to accumulate the seven wedges needed to build the stabilization triangle. Each wedge represents one billion tons per year by 2055.⁹²

While the international community should implement long-term revolutionary mitigation technology such as space-based solar electricity, Pacala and Socolow explain that "[h]umanity can solve the carbon and climate problem in the first half of this century simply by scaling up what we already know how to do."⁹³ Princeton University's Carbon Mitigation Initiative demonstrates that our existing portfolio of tools

87. *Id.* See also Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 *SCIENCE* 968 (2004), available at http://www.princeton.edu/~cmi/resources/CMI_Resources_new_files/Wedges%20ppr%20in%20Science.pdf. The current concentration of carbon in the atmosphere is 375 ppm, up from the pre-industrial concentration of 280 ppm. *Id.*

88. Roberta Hotinski, *Stabilization Wedges: A Concept & Game*, THE CARBON MITIGATION INITIATIVE, Jan 2007, at 10, available at http://www.princeton.edu/~cmi/resources/CMI_Wedge_Game_Jan_2007.pdf.

89. Robert Socolow, Future of Energy Series Center for the Environment: Stabilization Wedges: Mitigation Tools for the Next Half-Century 25 (2006), available at <http://environment.harvard.edu/navigation2/Socolow.ppt> (based on a paper by Stephen Pacala and Robert Socolow "published in the August 13, 2004, issue of *Science*, 205 (5886), at 968–972, and its Supporting Online Material, available at <http://www.princeton.edu/~cmi>."). *Id.* at 1.

90. *Id.* at 25.

91. Carbon Mitigation Initiative, The Stabilization Triangle: Tackling the Carbon and Climate Problem with Today's Technologies 4, http://www.princeton.edu/~cmi/resources/CMI_Resources_new_files/Wedges_Concept_Game_Materials_2005.pdf (last visited Feb. 12, 2007).

92. *Id.* at 5.

93. Pacala & Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, *supra* note 87, at 968.

is sufficient to achieve the stabilization triangle.⁹⁴ For example, conservation tillage involves drilling seeds into the ground rather than plowing.⁹⁵ Expanding conservation tillage to the world's 1600 million hectares of cropland could equate to up to a wedge of carbon reduction if combined with the use of erosion control and cover crops.⁹⁶

Over the next fifty years, halting clear-cutting of primary tropical forest could achieve at least a half wedge.⁹⁷ Scaling up world ethanol production by a factor of fifty could reduce carbon by one wedge,⁹⁸ assuming the process is fossil-carbon free.⁹⁹ A quarter of a wedge could be obtained by replacing 500 million incandescent bulbs with compact fluorescent bulbs every year,¹⁰⁰ keeping in mind that wedges interact with one another.¹⁰¹ Enacting efficiency standards can push

94. Carbon Mitigation Initiative strategies include: (1) efficient vehicles, (2) reduced use of vehicles, (3) efficient buildings, (4) efficient baseload coal plants, (5) fuel shift from coal to natural gas, (6) carbon capture and storage, (7) nuclear power, (8) solar power, (9) wind generated hydrogen fuel-cell cars, (10) biomass fuel, (11) reduced deforestation, and (12) conservation tillage. *Id.* at 970.

95.

Using conservation tillage, farmers leave crop residues on their fields after harvest, instead of ploughing them in or burning them off. They plant new crops with specially designed planters. These guide the seeds down into a slot in the soil underneath the protective layer of mulch formed by rotting residues. Often farmers using conservation tillage also plant "cover" crops—underneath the main crop or between two different crops—to cover and protect the soil. Cover crops have additional benefits according to the species planted. For instance, legumes enrich the soil with nutrients, while plants with strong, deep roots break up compacted soil.

Conservation Tillage: the End of the Plough? United Nations Food and Agriculture Organization ("FAO"), at 1, available at <http://www.fao.org/News/2000/000501-e.htm>.

96. Pacala & Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, *supra* note 87, at 971.

97. *Id.*

98. Carbon Mitigation Initiative, *The Stabilization Triangle*, *supra* note 91, at 13. For other ways to achieve stabilization wedges, see Pacala & Socolow, *supra* note 87, at 971.

99. Currently corn-based ethanol requires roughly as much energy to produce as it generates, *PBS NewsHour: Emissions Exchange Program Aims to Reduce Greenhouse Gases* (PBS television June 7, 2006), available at http://www.pbs.org/newshour/bb/environment/jan-june06/globalwarming_06-07.html. See also Socolow, Hotinski, Greenblatt, & Pacala, *supra* note 16, at 13. See also Pacala & Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, *supra* note 87, at 971.

100. Roughly seven billion incandescent light bulbs can be found in the United States, Carbon Mitigation Initiative, *The Stabilization Triangle*, *supra* note 91, at 13. See also Socolow, Hotinski, Greenblatt, & Pacala, *supra* note 16, at 11 (noting that compact fluorescent light bulbs, which are four times more efficient than incandescent bulbs, have slowly gained in acceptance and reduced in price).

101. Pacala & Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, *supra* note 87, at 969. If carbon is reduced by switching from fossil fuel to renewable sources of electricity, then the same units of carbon cannot also be counted towards energy efficiency carbon reductions. *Id.*

clean technologies into the marketplace. In addition to R&D and technology standards, governments should augment pushing strategies with pulling renewable technologies across the threshold of cost-effectiveness into mass production. The latter can be accomplished via a carbon tax or emission regulation.¹⁰² Private public partnerships can occur throughout the process of basic R&D, applied R&D, demonstration, commercialization, and technology diffusion.¹⁰³

Meeting domestic demand for safe, reliable energy will require an array of energy sources.¹⁰⁴ Government support can help bring about breakthroughs in renewable energy technology.¹⁰⁵ Enacting an economy-wide cap-and-trade program for greenhouse gases will lead to the most cost-effective greenhouse gas reductions.¹⁰⁶ A United States tradable permit system would provide a clear financial incentive to reduce emissions. The transportation sector must become a priority since motor vehicles emissions are increasing more rapidly than any other sector.¹⁰⁷ As the largest source of greenhouse gas emissions, the

102. WORLD RESOURCES INST., Testimony of Dr. Jonathan Pershing before the U.S. Senate Environment and Public Works Committee Climate Roundtable: Exploring Greenhouse Gas Technologies 5 (2006), http://pdf.wri.org/pershing_ewf_testimony.pdf.

103. *Id.* at 10.

104. For a general assessment of global progress toward transition to renewable energy use, see RENEWABLE ENERGY POLICY NETWORK FOR THE 21ST CENTURY (REN21), INTERIM REPORT ON THE IMPLEMENTATION OF THE INTERNATIONAL ACTION PROGRAMME OF THE INTERNATIONAL CONFERENCE FOR RENEWABLE ENERGIES, JUNE 1–4 2004, Bonn, Germany, (2006), http://www.ren21.net/pdf/IAP_InterimReport_060601.pdf.

105. *Statement of G8 Climate Change Roundtable Convened by the World Economic Forum in Collaboration with Her Majesty's Government*, United Kingdom, WORLD ECONOMIC FORUM, June 9, 2005, at 3, http://www.weforum.org/pdf/g8_climatechange.pdf. For a discussion of the Group of Eight's ("G8") sidelining of climate change to make way for energy security, see Robin Pomeroy of Reuters, *Climate Change Evaporates from G8 Agenda*, WASH. POST, July 5, 2006, at 3, available at <http://www.washingtonpost.com/wp-dyn/content/article/2006/07/05/AR2006070500177.html>.

106. HON. EILEEN CLAUSSEN, PEW CENTER ON GLOBAL CLIMATE CHANGE, *forward to VICKI ARROYO AND KATHRYN ZYLA, AGENDA FOR CLIMATE CHANGE ACTION i* (2006), <http://www.pewclimate.org/docUploads/PCC%5FAGenda%5F2%2E08%2Epdf>.

107. Michael Janofsky, *2 Sides Do Battle in Court on Whether E.P.A. Should Regulate Carbon Dioxide*, N.Y. TIMES, Apr. 9, 2005, at 1, available at <http://www.nytimes.com/2005/04/09/politics/09emissions.html?ex=1270699200&en=7261f0439b71a6ca&ei=5090&partner=rssuserland> ("Motor vehicles account for about a quarter of the nation's carbon dioxide emissions. Yet automakers have fought efforts to force them to build more efficient engines, pointing to the extraordinary costs of altering their factories to meet any new standards."). See also KEVIN BAUMERT, TIMOTHY HERZOG, & JONATHAN PERSHING, PEW CENTER ON GLOBAL CLIMATE CHANGE, CLIMATE DATA: A SECTORAL PERSPECTIVE 17 (2005), <http://www.pewclimate.org/docUploads/ClimateData%2DSectoral%2Epdf>.

energy sector must also take precedence.¹⁰⁸ Both broad and specific policies are necessary to achieve climate stabilization.¹⁰⁹

A. Tradable Permits

The Economist explains that in a carbon-trading system, “power plants and manufacturers will be allowed to emit a certain number of tons of carbon dioxide. If they exceed that amount, they must buy ‘credits’ from companies that pollute less than their allowance.”¹¹⁰ The key to a successful tradable permit program is to determine initial emissions accurately and allocate permits wisely.¹¹¹

Tietenberg notes that a trade-off between efficiency and equity exists in tradable-permits regimes.¹¹² Governments can fail initially to allocate permits in an equitable manner, granting permits to historic users.¹¹³ When governments have placed restrictions upon permit transfers, doing so has often reduced the value of the resource.¹¹⁴ Carefully designed tradable permit systems can allocate permits in an equitable manner and lower the overall cost of climate stabilization. The Swedish Environmental Protection Agency suggests that

[d]ynamic targets are one way of bringing developing countries into a global agreement. A possible future global agreement could entail a combination of (1) fixed, binding emission reduction targets for developed countries, (2) binding dynamic targets for the wealthier developing countries and (3) voluntary targets for

108. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at vii.

109. CLAUSSEN, *forward to* VICKI ARROYO AND KATHRYN ZYLA, *supra* note 106, at i.

110. *How an American Carbon-Trading System Should Work*, *ECONOMIST*, Jan. 22, 2007, available at http://www.economist.com/daily/columns/greenview/displayStory.cfm?story_id=8578415&fsrc=RSS [hereinafter *American Carbon-trading System*]. See also Jeffrey Ball, *New Consensus: In Climate Controversy, Industry Cedes Ground; Support Grows for Caps On CO₂ Emissions; Big Oil Battles Detroit*, *WALL ST. J.*, Jan. 23, 2007, at A1, available at <http://proquest.umi.com/pqdlink?did=1199871171&sid=1&Fmt=3&clientId=44880&RQT=309&VName=PQD&cfc=1#fulltext>. Jeffrey Ball notes that “[t]he theory behind the market is to create an economy of scale that reduces everyone’s cost. Other regulatory structures are possible, including a straight tax on CO₂ emissions.” *Id.* Ball explains that tradable permits are favored over a tax since a total level of pollution can be mandated while flexibility exists to buy and sell emission permits. *Id.*

111. *Id.*

112. Carbon credits are not property rights. New Zealand’s Individual Transferable Quotas (“ITQ”) system represents a rare exception in that it allocates full property rights. Tietenberg, *supra* note 6, at 409–10. While use rights can be preferable to absolute property rights, it may be beneficial to borrow from the fishery context the notion that the “administrative cost associated with monitoring, enforcing, and administering the system will be borne by permit holders rather than by general taxpayers. These costs could be financed with a fee levied on each permit.” *Id.*

113. *Id.* at 416.

114. *Id.*

the least developed countries. Any future global agreement must be compatible with an international emissions trading system.¹¹⁵

The international community must frame the global warming dilemma as one requiring the simultaneous development of an array of decarbonization strategies to facilitate consensus for timely action.¹¹⁶

Emission trading allows players to choose the most cost effective approach, comparing investing in low carbon equipment, increasing energy efficiency, or buying carbon credits from a source that has lower emission reduction costs.¹¹⁷ The global cost of carbon mitigation can be minimized when emission trading facilitates reductions where they are least expensive to implement.¹¹⁸

Several countries have already implemented emissions trading programs. The Clean Air Act's cap-and-trade system for sulfur dioxide mandated that power generators cap and subsequently reduce their emissions.¹¹⁹ Electricity plants that reduced emissions beyond their required level could sell credits to those entities that went over their cap.¹²⁰ George H. W. Bush authorized the sulfur dioxide emissions trading system that has substantially reduced acid rain.¹²¹ Building upon its unified regional response to acid rain, the Regional Greenhouse Gas Initiative ("RGGI") has been created by the following eastern states to address carbon emissions from power plants: Maine, New York, New Hampshire, Vermont, Delaware, Connecticut, New Jersey, and Maryland.¹²² This regime allows for linkage with Kyoto Protocol

115. SWEDISH ENVTL. PROT. AGENCY, *supra* note 12, at 41.

116. Socolow, Hotinski, Greenblatt, & Pacala, *supra* note 16, at 19. "Over the past two centuries, the oceans have absorbed roughly half of the 250 billion tons of carbon that have been emitted from fossil fuel combustion. For the past 20 years, the oceans have been absorbing almost two billion tons of carbon per year as CO₂, and the rate is steadily increasing." *Id.* at 14.

117. AARON COSBEY ET AL., PEW CENTER ON GLOBAL CLIMATE CHANGE, WHICH WAY FORWARD? ISSUES IN DEVELOPING AN EFFECTIVE CLIMATE REGIME AFTER 2012 44 (2005), http://www.iisd.org/pdf/2005/climate_which_way_forward.pdf.

118. *Id.*

119. Senator Dianne Feinstein, Town Hall Los Angeles Speech: Global Warming: A Time to Act (Oct. 25, 2006), *available at* <http://feinstein.senate.gov/06speeches/s-global-warm-la1025.pdf>.

120. PBS NewsHour: Emissions Exchange Program Aims to Reduce Greenhouse Gases, *supra* note 99.

121. American Carbon-Trading System, *supra* note 110.

122. CAROL WERNER, ENVTL. & ENERGY STUDY INST., CLIMATE CHANGE NEWS (2006), <http://www.eesi.org/publications/Newsletters/CCNews/4.7.06%20CCnews.htm>. Such corporations as Duke Energy, Exelon, General Electric, Shell Oil, and Wal-Mart support a mandatory greenhouse gas emissions program for the United States. *Id.*

credits and other mandatory regimes.¹²³ California's Global Warming Solutions Act also has the capacity to link to other carbon markets.¹²⁴

The European Union Emissions Trading Scheme ("EU-ETS") cap-and-trade program began January 1, 2005. The first period is being implemented from 2005 to 2007. A second period will occur from 2008 to 2012, coinciding with the Kyoto Protocol's first commitment period. The EU-ETS is linked to the Kyoto Protocol's Joint Implementation ("JI") and Clean Development Mechanism ("CDM"), thus, investing in decarbonization projects in developing countries can offset domestic reductions of carbon dioxide. Companies can buy emissions reduction credits from CDM/JI projects to offset their allowances under EU-ETS.¹²⁵

Uncertainty regarding the parameters of emissions trading post-2012 hurts current carbon markets.¹²⁶ Cap-and-trade programs should be established, linked, and sustained globally in an equitable and transparent manner. By establishing a price for carbon, a cap-and-trade program helps individuals and organizations internalize the cost of emissions. Sources of carbon emissions that are capable of inexpensively reducing emissions can then sell excess carbon emission capacity to sources unable to cheaply lower carbon emissions. Project-based flexibility mechanisms allow developed countries to fund activities in developing nations that result in carbon reductions. Leakage can be avoided via transnational sectoral obligations that could be substituted for national allowances for energy-intensive industries.¹²⁷ Measuring and reporting carbon mitigation must be straightforward and economies of scale in tradable permit markets should be facilitated by smooth integration of actions taken at international, national, and sub-national levels.¹²⁸

According to the World Bank, "price signals in the carbon markets have stimulated innovation, especially in developing countries."¹²⁹ The *State and Trends of the Carbon Market 2006* report notes

123. *Id.*

124. *Id.*

125. Andrew G. Thompson & Rob Campbell-Watt, *Australia and an Emissions Trading Market—Opportunities, Costs and Legal Frameworks*, 4 I.E.L.T.R. 79, 81 (2005).

126. COSBEY ET AL., *supra* note 117, at 49.

127. *Id.* at 51.

128. *Id.*

129. WORLD BANK CARBON FINANCE UNIT KARAN CAPOOR AND WORLD BANK DEV. ECON. RESEARCH GROUP PHILIPPE AMBROSI, *STATE AND TRENDS OF THE CARBON MARKET 2006* i (2006), <http://carbonfinance.org/docs/StateoftheCarbonMarket2006.pdf>. The World Bank notes that

Carbon transactions can be grouped into two main categories:

that “[b]usiness decisions began to be made with the price of carbon as a criterion,”¹³⁰ but the report also suggests that climate stabilization will require “long-term solutions, long-term capital and long-term legally-binding constraints.”¹³¹ The World Bank points out that it is crucial for caps to be set at credible levels to enable countries to achieve Kyoto objectives and that there

be a long-term signal for post-2012 commitments from Parties to the UN Framework Convention on Climate Change (UNFCCC). In this context, we welcome other drivers of the global (if fragmented) carbon markets, such as the imminent establishment of the Regional Greenhouse Gas Initiative (RGGI) in the North-Eastern United States, the continued operation of the New South Wales carbon market in Australia and growing liquidity in the Chicago Climate Exchange (CCX), as well as corporate and retail markets.¹³²

Linking effective carbon markets would bring down the price of carbon since buyers and sellers would have a large number of other traders with which to interact.¹³³ International, state, regional, and civil society coordination must accelerate to develop procedures to enable allowances from one trading regime to be used for compliance within another system. A long-term, market-based policy framework is politically feasible. As Kofi Annan notes, “[t]he UN is a forum where sovereign states can work out common strategies for tackling global problems, and an instrument for putting those strategies into effect.”¹³⁴ Complementary regional and sectoral climate policies are not

-Allowance-based transactions, in which the buyer purchases emission allowances created and allocated (or auctioned) by regulators under cap-and-trade regimes, such as Assigned Amount Units (AAUs) under the Kyoto Protocol, or EUAs under the EU ETS. “Cap-and-trade” allowance markets have high environmental credibility because they establish a flexible structure to achieve the desired level of environmental performance established by the level of caps set.

-Project-based transactions, in which the buyer purchases emission credits from a project that can credibly and verifiably demonstrate that it reduces GHG emissions compared with what would have happened otherwise. The most notable examples of such activities are under the CDM and the JI Framework under the Kyoto Protocol, generating CERs and Emission Reduction Units (ERUs) respectively. These project-based mechanisms have strong environmental credibility because they are created using approved methodologies and benefit from being independently certified before they are issued.

Id. at 3.

130. *Id.* at ii.

131. *Id.*

132. *Id.* at iii.

133. COSBEY ET AL., *supra* note 117, at 33.

134. Secretary-General of the United Nations Kofi Annan, *An Aspiration to a Larger Freedom*, FIN. TIMES, Mar. 21, 2005, available at <http://www.un.org/News/oss/sg/stories/arti->

mutually exclusive with extending and expanding Kyoto's absolute reductions.¹³⁵ The United States should enact a mandatory reporting system and an economy-wide cap-and-trade program for greenhouse gases.¹³⁶ This will lead to the most cost-effective greenhouse gas reductions.¹³⁷ A United States cap-and-trade system would provide a clear financial incentive to reduce carbon emissions. The Group of Eight ("G8") leaders have committed to promoting "tradable certificates and trading of credits" as well as "project-based and voluntary offset mechanisms" to finance the transition to cleaner energy.¹³⁸ Internalizing the social cost of high carbon use by trading credits can compel

cleFull.asp?TID=2&Type=article. The United Nations Charter objectives involve "maintaining international peace and security; developing friendly relations among nations; achieving international cooperation in solving economic, social, cultural or humanitarian problems; and encouraging respect for human rights and fundamental freedoms for all." U.N. Charter art 1, para. 1, *available at* <http://www.un.org/aboutun/charter/>.

135. COSBEY ET AL., *supra* note 117, at 8–10.

136. CLAUSSEN, *forward to* VICKI ARROYO AND KATHRYN ZYLA, *supra* note 106, at i.

137. *Id.*

138. Press Release, The World Bank, G8 Summit Statements: Chairman's Summary, Africa & Climate Change, ¶ 22(c) (July 6–8, 2005), <http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/0,,contentMDK:20576902~menuPK:258658~pagePK:2865106~piPK:2865128~theSitePK:258644,00.html>. *See also* G8 SUMMIT 2006 ST. PETERSBURG, GLOBAL ENERGY SECURITY ¶¶ 53–55 (2006), <http://en.g8russia.ru/docs/11.html>. At the St. Petersburg G8 Summit, leaders reaffirmed their commitment to implement measures set out in the Gleneagles Plan of Action. They stated that

[w]e reaffirm our intention to deliver on commitments made in Gleneagles in order to meet our shared and multiple objectives of reducing greenhouse gas emissions, improving the global environment, enhancing energy security and cutting air pollution in conjunction with our vigorous efforts to reduce poverty. We also affirm our commitment to the UNFCCC's ultimate objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system.

....

We welcome the progress made at the XI Conference of the Parties to the UNFCCC (Montreal, December 2005) where we committed to engage in a dialogue on long-term cooperative action to address climate change by enhancing implementation of the convention

....

... We look forward to the next Ministerial meeting in Mexico in October 2006, where we will continue to identify opportunities for greater collaboration to tackle climate change, while pursuing energy security and sustainable development through deployment of cleaner, more efficient and low-carbon energy technologies, finance and market mechanisms, including, as appropriate, Clean Development Mechanism, Joint Implementation, emissions trade, and adaptation.

Id. *See also* COSBEY ET AL., *supra* note 117, at 33. The G8 includes Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States. G8 Information Center, <http://www.g7.utoronto.ca/> (last visited Feb. 12, 2007).

carbon reduction and prevent further destabilization of the climate system.¹³⁹

B. Transportation Sector

In July of 2006, G8 leaders agreed that “[s]ince 2/3 of world oil is consumed by the transportation sector and its fuel consumption is outpacing general energy consumption we will pay special attention to this sector of energy demand.”¹⁴⁰ G8 leaders committed to sharing best practices to promote energy efficiency, offering incentives to consumers who purchase efficient vehicles, and supporting diversification of vehicle energy systems.¹⁴¹

Despite the auto industry’s capacity to produce clean vehicles,¹⁴² the current fuel efficiency of passenger vehicles in the United States is more than 5% lower than fuel efficiency in 1987.¹⁴³ The Pew Center on Global Climate Change calls upon the United States to replace the Corporate Average Fuel Economy (“CAFE”) program with a strengthened, corporate-average greenhouse gas emissions tradable market.¹⁴⁴ Greenhouse gas emissions from transportation are rising faster than any other sector, accounting for roughly 13% of total greenhouse gas emissions in the world.¹⁴⁵ There is one car for every eleven people in the world.¹⁴⁶ These half a billion automobiles significantly contribute to the carbon intensity of modern life. Approximately 40% of the

139. SWEDISH ENVTL. PROT. AGENCY, *supra* note 12, at 35.

140. G8, Global Energy Security, *supra* note 138, ¶ 21. See also Patricia Reaney, *Fewer Night Flights Could Cut Climate Change Impact*, REUTERS, June 14, 2006, available at http://today.reuters.com/news/newsArticle.aspx?type=TopNews&storyID=2006-06-14T170447Z_01_L13678272_RTRUKOC_0_US-ENVIRONMENT-FLIGHTS.xml&archived=false. The G8 called for an assessment of aviation contribution to greenhouse gas emissions. *Id.* Subsequent research has shown that winter and night flights have a disproportionately high contribution to the production of contrails, leading to increased greenhouse gas emissions. *Id.*

141. G8, GLOBAL ENERGY SECURITY, *supra* note 138, ¶ 21.

142. Sholnn Freeman, *GM Introduces Plug-In Electric Car*, WASH. POST, Jan. 8, 2007, at A07, available at <http://www.washingtonpost.com/wp-dyn/content/article/2007/01/07/AR2007010700904.html>.

143. Elizabeth Kolbert, *The Climate of Man—III*, *supra* note 49. “In the U.S., the average new car gets about twenty miles to the gallon; if it is driven a hundred thousand miles, it will produce almost forty-three metric tons of carbon during its lifetime.” *Id.*

144. VICKI ARROYO & KATHRYN ZYLA, PEW CENTER ON GLOBAL CLIMATE CHANGE, AGENDA FOR CLIMATE CHANGE ACTION 5 (2005), <http://www.pewclimate.org/docUploads/PCC%5FAgenda%5F2%2E08%2Epdf>.

145. BAUMERT, HERZOG, & PERSHING, *supra* note 107, at 17.

146. Steven Ferrey, *Power Future*, 15 DUKE ENVTL. L. & POL’Y J. 261, 265 (2005).

United States' daily oil demand goes to gasoline use.¹⁴⁷ Reuters notes that

[n]ew vehicles in the United States are the fastest and heaviest in three decades, with the fleet's fuel efficiency no better than the figure for 1994—about 21 miles per gallon The mileage estimate for 2006 passenger vehicles—cars, sports utilities, pickups and minivans—continues a recent trend even though gasoline prices have risen steadily and now average \$3 per gallon, the Environmental Protection Agency said in an annual efficiency report.¹⁴⁸

According to the United States Bureau of Transportation Statistics, the average driver in the United States “[s]pends 55 minutes a day behind the wheel” and “[d]rives 29 miles a day.”¹⁴⁹ With Stanford Ovshinsky's nickel-metal hydride (“NiMH”) battery, an electric car travels between 100 and 120 miles per charge.¹⁵⁰ Lithium-ion batteries produce five times the energy of lead-acid batteries, allowing an electric car to travel 250 miles before needing to recharge the battery.¹⁵¹ Mass production could reduce the extremely high price of this technology.¹⁵² Further battery research and development should be a high priority.¹⁵³

Low-carbon electricity should replace fossil fuels.¹⁵⁴ Electricity is not a per se clean energy source. It is crucial to compare the varying environmental impacts of the energy sources used to produce electricity. As single-source polluters, electric plants are easier to regulate than millions of vehicles.¹⁵⁵ Yet, the fact that “[i]ndling strategies alone have the potential to save 1 billion gallons of diesel fuel per year”

147. *Cars Heavier, Faster but US Fuel Economy Unchanged*, REUTERS, July 17, 2006, available at http://today.reuters.com/stocks/QuoteCompanyNewsArticle.aspx?view=CN&storyID=2006-07-17T225744Z_01_N17325630_RTRIDST_0_AUTOS-FUEL.XML&rpc=66 (last visited July 17, 2006).

148. *Id.*

149. *National Household Travel Survey*, BUREAU OF TRANSPORTATION STATISTICS (2001–2002), http://www.bts.gov/programs/national_household_travel_survey/daily_travel.html.

150. WHO KILLED THE ELECTRIC CAR? (Sony Pictures Classics 2006), available at <http://www.sonyclassics.com/whokilledtheelectriccar/electric.html>.

151. *Id.* See generally Linda Hales, *An Electric Car, Booted: Museum Removes EV1 as Film Gears for Release*, WASH. POST, June 16, 2006, at C1, available at <http://www.washingtonpost.com/wp-dyn/content/article/2006/06/15/AR2006061502052.html>.

152. WHO KILLED THE ELECTRIC CAR?, *supra* note 150.

153. Robert Goldschmidt, *Massive Battery Power*, WALL ST. J., July 15, 2006, at A9, available at <http://proquest.umi.com/pqdlink?did=1077540201&sid=2&Fmt=3&clientId=44880&RQT=309&VName=PQD>.

154. Pacala & Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, *supra* note 87, at 11.

155. WHO KILLED THE ELECTRIC CAR?, *supra* note 150.

indicates that drivers have a role to play in greenhouse gas reduction.¹⁵⁶

C. Energy Efficiency and Clean Electricity Generation

Decision makers at all levels should maximize energy efficiency and minimize the environmental impact of energy generation. Environmentally clean technology should be supported through the enactment of governmental subsidies for renewable energy and the removal of subsidies for energy generation that poses high risks to human health and the environment.

1. Clean Energy Regulation

Globally, the energy sector contributes roughly 80% of greenhouse gas emissions.¹⁵⁷ The World Bank estimates a 60% increase in global energy production carbon emissions by 2030,¹⁵⁸ noting that

[e]nergy sector policy reform is urgently required to stimulate the investments needed for developing and transition economies to meet their energy needs. Much of the investment need is unmet because of policy constraints: addressing these problems through joint public and private participation and working across the spectrum of public and private interventions are required. Actions needed include removal of broad-based subsidies and targeting the poor who may need income support; establishment of credible legal and regulatory frameworks; development of enabling policy environments through regulatory interventions such as appliance energy efficiency standards, mandated utility demand side management programs, and mandatory energy audits; creation of market-based approaches such as emissions trading, energy service companies, energy performance contracts, and credit guarantees; and information dissemination regarding energy savings and clean energy options.¹⁵⁹

Regulatory interventions such as appliance energy efficiency standards and labeling systems can reduce energy demand.¹⁶⁰ Yet, the United

156. Press Release, Env'tl. Prot. Agency Newsroom, EPA Denies Petition to Regulate Greenhouse Gas Emissions from Motor Vehicles (Aug. 28, 2003), <http://yosemite.epa.gov/opa/admpress.nsf/b1ab9f485b098972852562e7004dc686/694c8f3b7c16ff6085256d900065fdad!OpenDocument>. For an overview of the litigation to date see *Massachusetts v. Env'tl. Prot. Agency*, <http://www.law.duke.edu/publiclaw/supremecourtonline/certgrants/2006/masvenv.html> (last visited Feb. 17, 2007).

157. The agricultural sector accounts for much of the remaining 20% not generated by the energy sector. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at vii.

158. *Id.* at 7.

159. *Id.* at vi.

160. *Id.* at viii. See also INCUBATOR PROGRAMME, CARBON TRUST (2006), <http://www.carbontrust.co.uk/technology/incubator/>. Early stage, low carbon technologies can benefit from business accelerators that aid researchers in bringing their work to market. *Id.* See also

States still emits 24% of worldwide carbon emissions,¹⁶¹ contributing more greenhouse gases per person than any other nation.¹⁶² The EPA notes that

[a]s an individual, you can affect the emissions of about 4,800 pounds of carbon equivalent, or nearly 32% of the total emissions per person, by the choices you make in three areas of your life. These areas are the electricity we use in our homes, the waste we produce, and personal transportation. The other 68% of emissions are affected more by the types of industries in the U.S., the types of offices we use, how our food is grown, and other factors.¹⁶³

Power plants are responsible for 40% of the carbon emitted by the United States.¹⁶⁴ The Executive Director of the International Energy Agency, Claude Mandil, notes that emission reductions “can be achieved with technologies that not only are readily available in the market but economically-competitive during the life cycle of the product.”¹⁶⁵ Governments should enact legislation to provide incentives for the use of such energy efficient technologies as light-emitting diodes (“LEDs”), which last longer and consume less electricity than many other kinds of lights.¹⁶⁶ End-use efficiency in the commercial, industry, residential, and transport sectors can substantially reduce en-

GRANGER MORGAN ET AL., PEW CENTER ON GLOBAL CLIMATE CHANGE, THE U.S. ELECTRIC POWER SECTOR AND CLIMATE CHANGE MITIGATION 26 (2005), <http://www.pewclimate.org/docUploads/Electricity%5FFinal%2Epdf> (noting that energy efficiency standards have led to a decrease in the electricity needed to run a United States refrigerator by 74% over the past two decades). Using Energy Star labeled home appliances can lower home energy bills. *Id.*

161. Press Release, World Bank News Release No:2006/401/ESSD, Kristyn Schrader, Little Green Data Book 2006, <http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/0,,contentMDK:20915429~menuPK:176751~pagePK:64020865~piPK:149114~theSitePK:244381,00.html>.

162. ENVTL. PROT. AGENCY, GLOBAL WARMING EMISSIONS: INDIVIDUAL (2000), <http://yosemite.epa.gov/oar/globalwarming.nsf/webprintview/EmissionsIndividual.html>. On average, each person in the United State emits roughly 6.6 tons of carbon annually. *Id.*

163. *Id.*

164. NATURAL RES. DEF. COUNCIL, ENERGY DOWN THE DRAIN: THE HIDDEN COST OF CALIFORNIA'S WATER SUPPLY 4 (2004), <http://www.nrdc.org/water/conservation/edrain/edrain.pdf>.

165. Press Release, Int'l Energy Agency, Light's Labour's Lost—Policies for Energy-Efficient Lighting (June 29, 2006), http://www.iea.org/Textbase/press/pressdetail.asp?PRESS_REL_ID=182. See generally INT'L ENERGY AGENCY, LIGHT'S LABOUR'S LOST—POLICIES FOR ENERGY-EFFICIENT LIGHTING (2006), available at <http://www.iea.org/w/bookshop/add.aspx?id=302>.

166. Evan Ramstad & Kathryn Kranhold, *Changing the Light Bulb; No Joke: LED Technology Fuels Fast Growth in Once-Staid Industry*, WALL ST. J., June 8, 2006, at B1, available at <http://proquest.umi.com/pqdlink?did=1050797721&sid=2&Fmt=3&clientId=44880&RQT=309&VName=PQD>.

ergy demand.¹⁶⁷ Beyond consumer conservation, a carbon market would facilitate the transition to clean energy generation.

Coal power plants function at a 32% efficiency rate, emitting roughly one quarter of all carbon emissions.¹⁶⁸ Kris Maher of the Wall Street Journal notes that approximately half of the electricity produced in the United States comes from coal.¹⁶⁹ Electricity generated by coal should not be seen as comparable to electricity produced by sources that have less of an environmental impact. Electricity contributes a third of the United States greenhouse gas emissions.¹⁷⁰ The carbon emissions of United States power plants have risen by 25% in the last two decades.¹⁷¹ Effective decarbonization of the United States' electricity sector over the next fifty years is instrumental to reducing greenhouse gas emissions.

Reasonable and equitable water management can reduce greenhouse gas emissions. Water efficiency can increase energy efficiency since less energy is needed to treat and deliver smaller quantities of water.¹⁷² The California State Water Project requires more energy than any other entity in the state, using 2% to 3% of the entire electricity consumption in California to pump water over the Tehachapi Mountains to Southern California.¹⁷³ Water systems and wastewater systems consume 3% of the electricity used in the United States every year—an amount equal to the energy demand of California—and excluding additional heating and cooling of water at the residential level.¹⁷⁴

Water resource management will become increasingly challenging due to climate change.¹⁷⁵ Climate change means more than a simple five degree increase in local temperatures. Rainfall is increasingly concentrated in heavy downpours according to The National Oceanic and Atmospheric Administration, and the EPA notes that precipita-

167. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at vii.

168. Pacala & Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, *supra* note 87, at 969.

169. Kris Maher, Coal Sector Tightens Belt Amid Soft Spot, Wall St. J., Jan. 24, 2007, at A6, available at <http://proquest.umi.com/pqdlink?did=1200825961&sid=1&Fmt=4&clientId=44880&RQT=309&VName=PQD>.

170. HON. EILEEN CLAUSSEN, PEW CENTER ON GLOBAL CLIMATE CHANGE, *forward to* GRANGER MORGAN ET AL., *supra* note 160, at ii.

171. MORGAN ET AL., *supra* note 160, at 16.

172. NATURAL RES. DEF. COUNCIL, ENERGY DOWN THE DRAIN: THE HIDDEN COST OF CALIFORNIA'S WATER SUPPLY, *supra* note 164, at 1.

173. *Id.*

174. MORGAN ET AL., *supra* note 160, at 16.

175. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at viii.

tion in the United States has risen by an average of 5% to 10% over the past century.¹⁷⁶ Northern states have experienced an increase in rainfall of 10% to 15%.¹⁷⁷ Over the past thirty years, the United States has experienced a 7% increase in rainfall.¹⁷⁸ Heavy rainstorms leaving more than two inches within a single day have risen by 14% and those producing more than four inches a day were up by 20%.¹⁷⁹ “The number of Category four and five hurricanes worldwide has nearly doubled over the past 35 years,” according to a National Science Foundation funded study.¹⁸⁰ In addition to increased precipitation, development has led to more people living in areas vulnerable to flooding. This trend is occurring globally as the world’s population continues to grow at a rapid pace. Wallace Broecker of the Lamont-Doherty Earth Observatory notes that “[i]f current trends continue, carbon in the atmosphere may triple by the end of the century.”¹⁸¹ Atmospheric water vapor may be amplifying temperature increases in Europe.¹⁸² Greenhouse gases such as carbon dioxide and methane lead to increased evaporation of water, which in turn becomes a greenhouse gas in the atmosphere. This water vapor feedback may be occurring over the United States as well.¹⁸³

Though scientists agree that even the best case climate change scenario will be disastrous, uncertainty remains regarding how soon and to what degree a slowdown of the ocean’s thermohaline circula-

176. ENVTL. PROT. AGENCY, GLOBAL WARMING—IMPACTS: PRECIPITATION, <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ClimateTrendsPrecipitation.html#tab7> (last visited Feb. 10, 2007).

177. *Id.*

178. Jason Szep, *Northeast Floods Stir Global Warming Debate*, REUTERS, June 30, 2006, http://today.reuters.com/news/newsarticle.aspx?type=ScienceNews&storyid=2006-06-30T093507Z_01_N29246217_RTRUKOC_0_US-WEATHER-USA-WARMING.xml&src=rss (last visited June 30, 2006).

179. *Id.*

180. David Terraso, *Hurricanes Are Getting Stronger, Study Says*, Georgia Tech Institute Communications and Public Affairs, Sept. 15, 2005, <http://www.gatech.edu/news-room/release.php?id=654>. The study was conducted by Peter Webster of Georgia Tech’s School of Earth and Atmospheric Sciences who notes that hurricanes “cool the oceans by evaporating the water and then redistributing the oceans’ tropical heat to higher latitudes.” *Id.*

181. *PBS NewsHour: Researchers Scramble to Create CO₂-Busting Technologies* (PBS television broadcast June 8, 2006), available at http://www.pbs.org/newshour/bb/environment/jan-june06/globalwarming_06-08.html.

182. Black, *Water Builds the Heat in Europe*, *supra* note 33.

183. Richard Black, *Air Trends “Amplifying” Warming*, BBC NEWS, Apr. 7, 2006, <http://news.bbc.co.uk/1/hi/sci/tech/4880328.stm>.

tion will lead to cataclysmic consequences.¹⁸⁴ As the ocean absorbs atmospheric carbon, seawater becomes more acidic, which in turn lowers the marine concentrations of carbonate and reduces the ocean's ability to absorb carbon in the future. A slowing of the thermohaline circulation may lead to a collapse of North Atlantic plankton stocks, the foundation of the marine food pyramid.¹⁸⁵

While seas become more acidic, freshwater supplies will become more salty. Doubling carbon levels will likely create severe drought conditions in the United States.¹⁸⁶ Rising salinity levels will impact water supplies in such locations as California's Central Valley, Miami, New York, and Philadelphia.¹⁸⁷ Despite hopes that higher carbon concentrations permit plants to use water more efficiently, a hotter and drier climate will reduce water availability.¹⁸⁸ As irrigation and the total area of land under cultivation increases, the EPA predicts that water users in the Colorado Basin will likely lose \$200–300 million annually if water flow decreases by the expected 15% to 20%.¹⁸⁹ A 10% reduction in the runoff from the Colorado River's lower basin would reduce hydropower production by 36%.¹⁹⁰ Governments

184. Klaus Keller et al., *Avoiding Dangerous Anthropogenic Interference with the Climate System*, 73 CLIMATIC CHANGE 227, 235 (2005), http://www.princeton.edu/~cmi/research/Integration/Papers/Keller_et_al_cc_05.pdf (last visited Feb. 12, 2007).

185. Schiermeier, *Climate Change: A Sea Change*, *supra* note 26, at 258.

186. Kolbert, *The Climate of Man—II*, *supra* note 20.

187. ENVTL. PROT. AGENCY, GLOBAL WARMING—IMPACTS: WATER SUPPLY AND DEMAND, <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ImpactsWaterResourcesWaterSupplyandDemand.html> (last visited Feb. 10, 2007). See also Michael Byrnes, *Killer Salinity Rings Australia's Desert Heart*, REUTERS, July 13, 2006, http://today.reuters.com/news/newsarticle.aspx?type=ScienceNews&storyid=2006-07-13T160638Z_01_SYD96776_RTRUKOC_0_US-ENVIRONMENT-AUSTRALIA-SALINITY.xml&src=rss (last visited July 13, 2006). Australians have begun a tree-planting campaign and are using salt-tolerant plants to counter desertification of Australia's farmlands as underground salt rises to the surface. *Id.*

188. ENVTL. PROT. AGENCY, GLOBAL WARMING—IMPACTS: WATER SUPPLY AND DEMAND, *supra* note 187. "Scientists at NASA have suggested that in the long run, a worldwide expansion of deserts is likely." *Id.*

189. *Id.* For a discussion of drought subsidy policy gone awry, see Gilbert M. Gaul, Dan Morgan & Sarah Cohen, *No Drought Required for Federal Drought Aid: Livestock Program Grew to Cover Any "Disaster"*, WASH. POST, July 18, 2006, at A1, available at http://www.washingtonpost.com/wp-dyn/content/article/2006/07/17/AR2006071701237.html?nav=rss_politics. See also NATURAL RES. DEF. COUNCIL, ENERGY DOWN THE DRAIN: THE HIDDEN COST OF CALIFORNIA'S WATER SUPPLY, *supra* note 164 at 5. "Many California farmers still pay the government \$2 to \$20 per acre-foot for water, which represents as little as 10 percent of the 'full cost' of the water, although some farmers are paying more as contracts are revised (e.g., \$35 per acre-foot)." *Id.*

190. ENVTL. PROT. AGENCY, GLOBAL WARMING—IMPACTS: WATER SUPPLY AND DEMAND, *supra* note 187.

should ensure the equitable allocation of diminishing water resources while decreasing greenhouse gas emissions.

2. Clean Energy Subsidization

It is clear that building consensus to link emissions trading systems requires political will. As information dissemination raises public awareness about clean energy options and current climate trends, support grows for legally binding incentives to transition to clean energy. Governments should subsidize clean energy, facilitate energy audits, and link viable emissions trading systems.

Solar energy represents a promising clean energy ripe for government subsidies. While desertification increases sandstorms around the globe, the solar energy industry cannot obtain enough sand in the form of silicon with which to meet demand for solar PV modules. Solar PV panel sales are increasing by approximately 35% annually.¹⁹¹ As a result, supply is struggling to meet demand. Microchip manufacturers are willing to pay a higher price for silicon since they need a higher level of purity than that needed for solar PV panels.¹⁹²

Faced with a silicon shortage, solar PV manufacturers have developed thinner wafers.¹⁹³ Window tinting that generates electricity is possible through the use of semi-transparent solar cells.¹⁹⁴ While thin-

191. Georgina Prodhan, *Solar Silicon Shortage to End in 2008: Executives*, REUTERS, June 26, 2006, http://today.reuters.com/news/newsarticle.aspx?type=ScienceNews&storyid=2006-06-26T105545Z_01_L23462123_RTRUKOC_0_US-SOLAR-SILICON.xml&src=rss. See also China's "Roof of the World" Glaciers Melting Fast, REUTERS, May 2, 2006, available at http://www.chinadaily.com.cn/china/2006-05/03/content_582276.htm ("Dust and sandstorms are a growing problem, particularly in North China, due to deforestation, drought and the environmental depredations of China's breakneck economic growth."); Joseph Kahn, *A Sea of Sand Is Threatening China's Heart*, N.Y. TIMES, June 8, 2006, available at <http://www.nytimes.com/2006/06/08/world/asia/08desert.html?ex=1307419200&en=d5f429665b38f5d6&ei=5088&partner=rssnyt&cem=rss> (stating that "an ever-rising tide of sand has claimed grasslands, ponds, lakes and forests, swallowed whole villages and forced tens of thousands of people to flee as it surges south and threatens to leave this ancient Silk Road greenbelt uninhabitable"); *News Feature*, 438 NATURE 276 (2005) (noting that rapidly melting Himalayan glaciers are impacting water availability in China, India, and Nepal. Nepal's shrinking glaciers are flooding mountain lakes, endangering downstream villages. The Netherlands has drained one of Nepal's most dangerous glacial lakes.); Jeffrey Sachs, *Can Extreme Poverty Be Eliminated?*, 293 SCI. AM. 3, 60 (2005). "As Asia boomed, Africa stagnated. Special geographic factors have played a crucial role. Foremost among these is the existence of the Himalaya Mountains, which produce southern Asia's monsoon climate and vast river systems." *Id.*

192. Prodhan, *supra* note 191.

193. *Id.* The unavailability of silicon has fostered innovation that has made solar power portable, a feature that will give it a competitive edge in the backup-power market. *Id.*

194. ENERGY SAVING TRUST, *supra* note 77.

film requires less silicon, the efficiency of current thin cells is 7% to 10%, compared to the standard silicon solar PV efficiency of 15%.¹⁹⁵ Peter Woditsch of Deutsche Solar notes that “[s]ilicon is available in twenty-five percent of the earth’s crust, so there is no need for a silicon shortage.”¹⁹⁶ While thin wafers can increase the flexibility of materials, there is no need to lower solar efficiency due to the availability of silicon.

The energy needs of 85% of humanity are not being met as nearly two billion people lack an energy supply and three billion live with an inadequate supply.¹⁹⁷ Solar and small-scale wind technologies are ingredients of peace via decentralized energy generation.¹⁹⁸ By decentralizing control over power, renewable energy can become a factor in sustaining good governance.¹⁹⁹ The Navajo Tribe has set up one hundred stand-alone solar PV power systems for remote Navajo Nation homes.²⁰⁰ Similarly, solar power plants in remote villages are beginning to provide residential lighting, vaccine refrigeration, and water pumping systems.²⁰¹ Sri Lanka is using solar powered drip irrigation systems to raise crop yields, cut water use, and reduce ero-

195. Christopher Scinta, *Silicon Shortage Dims Outlook For Solar Stocks*, WALL ST. J., June 7, 2006, available at <http://proquest.umi.com/pqdlink?did=1050085971&sid=2&Fmt=3&clientId=44880&RQT=309&VName=PQD>.

196. Prodhan, *supra* note 191.

197. GREEN CROSS INT’L, *DIALOGUES ON ENERGY AND SUSTAINABLE DEVELOPMENT: WHERE ARE WE GOING?* (2004), http://www.greencrossitalia.it/ita/pdf/energy_barcellona2004.pdf.

198. *Id.*

199. Ferrey, *supra* note 146, at 293. See also PAUL WOLFOWITZ, *WORLD BANK NEWS & BROADCAST, GOOD GOVERNANCE AND DEVELOPMENT: A TIME FOR ACTION* (2006), available at <http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:20883752~pagePK:34370~piPK:42770~theSitePK:4607,00.html>. World Bank President Paul Wolfowitz notes that

transparent and accountable institutions, strong skills and competence, and a fundamental willingness to do the right thing. Those are the things that enable a government to deliver services to its people efficiently. An independent judiciary, a free press, and a vibrant civil society and important components of good governance. They balance the power of governments, and they hold them accountable for delivering better services, creating jobs, and improving living standards. Some countries can achieve growth for many years without all of those factors.

Id.

200. ANDREW ROSENTHAL, WILES, THOMAS, & DANIELS, *SOUTHWEST TECHNOLOGY DEVELOPMENT INSTITUTE, SANDIA NATIONAL LABORATORIES, NAVAJO TRIBAL UTILITY AUTHORITY, TECHNICAL SUPPORT FOR THE NAVAJO PHOTOVOLTAIC PROGRAM 1*, http://www.sandia.gov/pv/docs/PDF/rose_prm.pdf (last visited Feb. 12, 2007).

201. *ALTERNATIVE ENERGY POWERED BY BP, SOLAR: ACCESS TO ENERGY*, <http://www.bp.com/sectiongenericarticle.do?categoryId=9013391&contentId=7026235> (last visited Feb. 12, 2007).

sion.²⁰² Indoor air pollution impacts the survival of people who use traditional biomass fuels for heating and cooking.²⁰³ Renewable sources supply over 10% of Germany's electricity, due in part to an array of financial incentives.²⁰⁴

The Natural Resources Defense Council notes that "[s]olar energy is produced here in the United States, employing about 20,000 men and women in high-tech, high-earning jobs. This domestic industry helps reduce our dependence on foreign oil, coal and natural gas for heating or powering our homes."²⁰⁵ Mass production of solar PV modules will bring the cost of solar energy down substantially as people buy more panels.²⁰⁶ Homeowners can install roof tiles that are solar panels. Use of roofs and walls to produce solar electricity greatly reduces the space requirements of solar power.²⁰⁷ While access to such technology is now as easy as a call to Home Depot, costs are still prohibitive without government incentive programs.²⁰⁸

In the United States, people can obtain a 30% federal tax credit up to \$2000 for installing a solar PV system on their homes.²⁰⁹ The Database of State Incentives for Renewable Energy ("DSIRE") hosts a website that informs people about further incentives available on a state-by-state basis.²¹⁰ Local property tax rebates are also available in an increasing number of towns and cities.²¹¹ Power companies are giving incentives in the form of net metering programs that allow electricity customers to run their meters backwards, receiving credit for sending electricity back to the grid.²¹² Title XII, section 1251 of the Energy Policy Act of 2005 mandates that utilities offer net metering,

202. *Id.*

203. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at iii.

204. Richard Black, *Pioneers Look Forward to Solar Future*, BBC NEWS, Feb. 10, 2006, <http://news.bbc.co.uk/1/hi/sci/tech/4685150.stm>.

205. NATURAL RES. DEF. COUNCIL, WIND, SOLAR AND BIOMASS ENERGY TODAY: SOLAR POWER, <http://www.nrdc.org/air/energy/renewables/solar.asp> (last visited Feb. 12, 2007).

206. Richard Black, *Energy Gap: Crisis for Humanity?*, *supra* note 9 (stating that solar electricity costs up to five times that of coal and gas and noting that storing energy is still rudimentary).

207. Socolow, Hotinski, Greenblatt, & Pacala, *supra* note 16, at 12.

208. ALTERNATIVE ENERGY POWERED BY BP, *supra* note 201.

209. U.S. ENERGY STAR PROGRAM OF THE ENVTL. PROT. AGENCY AND THE U.S. DEP'T. OF ENERGY, FEDERAL TAX CREDITS FOR ENERGY EFFICIENCY: THE ENERGY POLICY ACT OF 2005, http://www.energystar.gov/index.cfm?c=products.pr_tax_credits (last visited Feb. 12, 2007).

210. DATABASE OF STATE INCENTIVES FOR RENEWABLE ENERGY, State by State Incentives, <http://www.dsireusa.org/aboutus.cfm> (last visited Feb. 12, 2007).

211. *Id.*

212. *Id.*

reimbursing customers for renewable energy that can be fed back into the grid.²¹³ This allows people who have installed wind and solar systems to run their meters backwards, reducing their monthly bills and contributing power to the grid.²¹⁴

In the United States, the renewable energy sector has experienced unnecessary fluctuation in tax credits, leading to alternating periods of investment followed by instability when the federal credit terminates.²¹⁵ Growth in renewable capacity has been significantly impacted by this political inertia and future uncertainty.²¹⁶ Given the history of the United States 1990 Clean Air Act Amendments, which set sulfur dioxide allowance too low to make renewable energy competitive with lower-sulfur coal, states are wary about federal legislation. In its race to the top analysis, the Pew Center on Global Climate Change suggests establishing a national framework that can run parallel to state regimes that set renewable targets above the federal level.²¹⁷ Beyond carbon mitigation, states enact renewable portfolio standards because doing so leads to substantial economic development. Supporting renewable energy strengthens local energy generation, creating in-state jobs and enhancing the reliability of electrical supply.²¹⁸ Currently, twenty-two states and the District of Columbia have implemented Renewable Portfolio Standards.²¹⁹ Similarly, a European Union target of 21% of renewable sources for electricity has been set for 2010, and ten developing countries have established targets to be met between 2010 and 2020.²²⁰ China's Renewable Energy Law target must generate 15% of the country's electricity from

213. Energy Policy Act of 2005, Pub. L. 109-58, Stat 594 (signed into law by President Bush on August 8, 2005).

214. DEP'T OF ENERGY, ANNUAL ENERGY OUTLOOK 2006 WITH PROJECTIONS TO 2030, DOE/EIA-0383 (2006), [http://www.eia.doe.gov/oiaf/aeo/pdf/0383\(2006\).pdf](http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2006).pdf).

215. BARRY G. RABE, PEW CENTER ON CLIMATE GLOBAL CHANGE, RACE TO THE TOP: THE EXPANDING ROLE OF U.S. STATE RENEWABLE PORTFOLIO STANDARDS 26 (2006), <http://www.pewclimate.org/docUploads/RPSReportFinal%2Epdf>.

216. *Id.*

217. *Id.*

218. *Id.* at v.

219. Press Release by Katie Mandes, Pew Center on Global Climate Change, The Expanding Role of State Renewable Energy Policy (June 14, 2006), http://www.pewclimate.org/press_room/sub_press_room/2006_releases/rps_release.cfm.

220. DEV. COMM. OF THE WORLD BANK GROUP, *supra* note 1, at 15.

renewable sources by 2020.²²¹ Sweden plans to end its dependency on oil entirely by 2020.²²²

Since its creation in 1991, the Global Environment Facility ("GEF") has allocated \$6.2 billion for projects in 140 developing countries.²²³ As the financial mechanism of the UNFCCC, the GEF distributes money for energy efficiency, renewable energies, and sustainable transportation. It also manages the Least Developed Countries Fund and the Special Climate Change Fund under the UNFCCC as well as the Adaptation Fund under the Kyoto Protocol.²²⁴ Noting that G8 countries emit 47% of global carbon emissions, Green Cross International points out that we no longer have time for studies without subsequent implementation of efficiency measures, renewable energy systems, and clean energy policies.²²⁵ Green Cross International proposes establishing a Global Solar Fund; redirecting \$50 billion over ten years from the \$210 billion World Bank estimate of annual global subsidies for fossil fuels.²²⁶ For comparison, the United States spent \$553 billion on national defense in 2004.²²⁷ International peace and security measures must encompass climate change stabilization and adaptation.

V. Conclusion

The international community can overcome political and economic disparity to achieve climate stabilization. The OECD urges countries to come to terms with the inadequacy of response to reliable climate projections by putting "mitigation and adaptation on the agenda for Poverty Reduction Strategy Papers and other development strategies."²²⁸ Domestic and international climate policy must be implemented without further delay. Sir Nicholas Stern suggests that

221. GREEN CROSS INT'L, ENERGY SECURITY: G8 LEADERS MUST LIVE UP TO THEIR GLOBAL RESPONSIBILITIES 2006, <http://www.greencrossinternational.net/indexmac.htm>. (report prepared for the G8 Summit in St. Petersburg, July 15–17, 2006).

222. *Id.*

223. This funding has been supplemented by \$20 billion in co-financing. GLOBAL ENV'T FACILITY, GEF ANNUAL REPORT 7 2005, http://www.gefweb.org/Whats_New/documents/Draft_AR_2005_text.pdf (July 8, 2006/Council Version).

224. GLOBAL ENV'T FACILITY, CLIMATE CHANGE, http://www.thegef.org/projects/Focal_Areas/climate/climate.html (last visited Jan. 28, 2007).

225. *Id.*

226. GREEN CROSS INT'L, ENERGY SECURITY: G8 LEADERS MUST LIVE UP TO THEIR GLOBAL RESPONSIBILITIES, *supra* note 221.

227. *Id.*

228. *Id.* at 16–18.

global warming could lower the global economy by 20%.²²⁹ To mitigate the greatest market failure to date, Stern urges the international community to spend 1% of world GDP.²³⁰ Stern notes that “with strong, deliberate policy choices, it is possible to ‘decarbonise’ both developed and developing economies on the scale required for climate stabilisation, while maintaining economic growth in both.”²³¹ He concludes that “[i]t requires a partnership between the public and private sector, working with civil society and with individuals. It is still possible to avoid the worst impacts of climate change; but it requires strong and urgent collective action.”²³² Decarbonization must occur on a vast scale across economic and political fault lines.

The emerging carbon market is an efficient and transparent mechanism for pricing carbon emissions. Transportation and energy measures need to occur on both an individual and collective basis. As NASA climate scientist Gavin Schmidt notes, “you have to think on all the scales at once, and even that will only help you avoid the worst scenarios.”²³³ Emissions trading, carbon taxation, and such financial incentives as rebates are among the array of economic instruments available to lower carbon emissions. Regulations could entail certification and performance standards. Voluntary agreements could include industry-good practice guidelines to reduce emissions. International cooperation could strengthen participation in the Clean Development Mechanism and initiate ventures such as a solar fund. Countries should increase research, development, and demonstration of low and no-carbon renewable energy. Governments need to facilitate widespread deployment of existing low and no-carbon technologies. Decision makers at all levels should work together to establish and link carbon cap-and-trade markets to achieve global participation.

229. *Climate Change Fight “Can’t Wait,”* BBC NEWS, Oct. 31, 2006, <http://news.bbc.co.uk/2/hi/business/6096084.stm>.

230. Robert Peston, *Report’s Stark Warning on Climate*, BBC NEWS, Oct. 29, 2006, <http://news.bbc.co.uk/2/hi/business/6096594.stm>.

231. SIR NICHOLAS STERN, STERN REVIEW: THE ECONOMICS OF CLIMATE CHANGE EXECUTIVE SUMMARY XI., available at http://news.bbc.co.uk/1/shared/bsp/hi/pdfs/30_10_06_exec_sum.pdf (HM Treasury Oct. 30, 2006) (noting that “stabilisation of greenhouse gases at levels of 500–550ppm CO₂ will cost, on average, around 1% of annual global GDP by 2050. This is significant, but is fully consistent with continued growth and development, in contrast with unabated climate change, which will eventually pose significant threats to growth”). *Id.* at xiii.

232. *Id.* at xxvii.

233. Michael Powell, *Gore Unveils Global-Warming Plan Cutting Emissions, Restructuring Industry and Farming Urged*, WASH. POST, Sept. 19, 2006, at A2, available at http://www.washingtonpost.com/wp-dyn/content/article/2006/09/18/AR2006091801125.html?nav=rss_politics.

Linking effective carbon markets would bring down the price of carbon since buyers and sellers would have a large number of other traders with which to interact.²³⁴ Subsidies supporting carbon intensive activities should be replaced with sustainable low and no-carbon incentives and governments should enact renewable portfolio standards to increase use of renewable energy. We must move beyond international indecision regarding choice of policy instruments. Avoiding catastrophic climate change requires genuine multilateral cooperation immediately.

234. COSBEY ET AL., *supra* note 117, at 33.