Institute for Governance & Sustainable Development

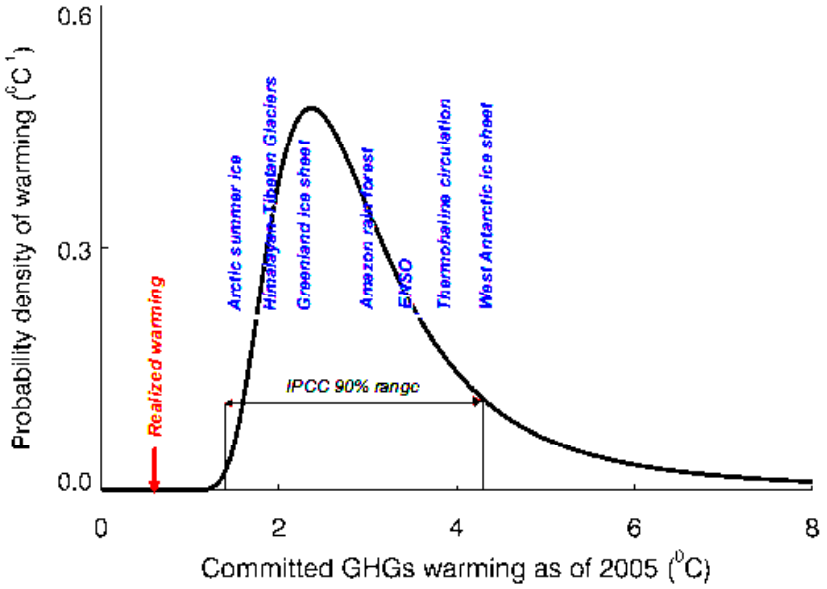
Abrupt Climate Changes Approaching Faster than Previously Predicted
Fast-Track Climate Mitigation Strategies Needed

December 2008

The paleoclimate records show that past climate changes have included both steady, linear changes as well as abrupt, non-linear changes, where small increases in global warming produced large and irreversible impacts once temperature tipping points were passed. Climate scientists now warn that anthropogenic emissions are pushing the planet's climate system toward such temperature tipping points sooner than previously expected and that impacts could be catastrophic.

Among potential impacts of passing climate tipping points are the disappearance of Arctic summer sea ice, major reduction of area and volume of Himalayan-Tibetan glaciers, deglaciation of Greenland Ice Sheet, dieback of Amazonian and boreal forests, shutdown of the Atlantic Thermohaline Circulation, and collapse of West Antarctic Ice Sheet.[1] The catastrophic impacts from these events would include many meters of sea level rise, water shortages, megadroughts, and famine and could lead to political instability and resource wars.[2] Other impacts include release of methane and other greenhouse gases (GHGs) from permafrost and ocean hydrates, which could set off runaway feedbacks.

In a recent study in the *Proceedings of the National Academy of Sciences*, V. Ramanathan and Y. Feng from the Scripps Institution of Oceanography, University of California, San Diego, calculate that GHG emissions as of 2005 have committed the planet to warming of "2.4ºC (1.4º-4.3º) above the preindustrial surface temperatures,"[3] which is within the range of predicted tipping points. See Figure.



"Probability distribution for the committed warming by GHGs between 1750 and 2005. … Shown are the tipping elements [large-scale components of the Earth's system] and the temperature threshold range that initiates the tipping.…"[4]

For further information please contact Durwood Zaelke, President, Institute for Governance & Sustainable Development, at dzaelke@igsd.org (black carbon), Elise Stull at estull@igsd.org (tipping points), Pete Grabiel at pgrabiel@igsd.org (Montreal Protocol), or Eric Meltzer at emeltzer@igsd.org (biochar). **For COP14 attendees**, please visit the side event on fast-track mitigation strategies to avoid tipping points, hosted by Sweden and the Federated States of Micronesia, on 9 Dec 08 at 19:30 in the Aesculapian Snake room, Hall 14B (light refreshments provided).

The present observed temperature increase of 0.76ºC[5] is misleading. Warming of at least another 1ºC is presently being masked by "atmospheric brown clouds" containing cooling particulates released with GHG emissions and other pollution.[6] As we continue to reduce the pollution creating these clouds, largely for health reasons, we are unmasking the 1ºC or greater temperature increase that is already committed from current emissions.[7] An additional 0.6ºC warming is temporarily delayed by ocean thermal inertia.[8] Total committed warming is 2.4ºC, with more than 50% expected to occur within decades.[9]

Impacts from this warming, Ramanathan and Feng observe, could include "widespread loss of biodiversity, widespread deglaciation of the Greenland Ice Sheet, and a major reduction of area and volume of Hindu-Kush-Himalaya-Tibetan (HKHT) glaciers, which provide the head-waters for most major river systems of Asia,"[10] including the Yellow, Yangtze, Red, Mekong, Irrawady, Ganges, and Indus.

At high latitudes and altitudes, temperatures are rising faster than the global average. The Arctic, Greenland, and the Tibetan Plateau are at particular risk.[11] Between 1965 and 2005, Arctic temperatures increased at least twice as fast as global averages.[12] The Greenland Ice Sheet is warming 2.2 times faster than global averages.[13] On the Tibetan Plateau temperature increases of up to 0.3ºC per decade, about three times the global average, have been measured for the past half-century.[14] Since the 1950's, warming in excess of 1ºC on the Tibetan side of the Himalayas has contributed to glacial retreat.[15] Melting Arctic sea ice produces positive feedbacks by reducing albedo, or reflectivity, leading to more absorption of heat by exposed Arctic waters.[16] Further darkening of polar surfaces is caused when black carbon, or soot, is deposited on snow and ice.[17] Deposition of black carbon is also a major driver of glacial retreat in the Hindu-Kush-Himalayan-Tibetan region.[18]

Scientists estimate that temperature tipping points for abrupt climate changes could be passed this century, or even in the next decade.[19] Under a "business-as-usual" scenario, where atmospheric CO_2 concentrations are increasing about 2 ppm per year, the question is not whether abrupt climate change will occur, but rather how soon.[20] Dr. James Hansen, Director of NASA's Goddard Institute for Space Studies, agrees with Ramanathan and Feng that we have already passed the threshold for "dangerous anthropogenic interference" with the natural climate system. Hansen calculates that CO_2 concentrations must be reduced from their current 385 ppm to 350 ppm maximum if we want to preserve planetary conditions similar to those where civilization developed and humanity is adapted.[21] Current projections are that CO_2 concentrations will approach 441 ppm with a corresponding committed warming of 3.1ºC by 2030 in the absence of strong countervailing mitigation.[22] By the end of the century, business-as-usual emissions could cause atmospheric concentrations of CO_2 and other long-lived GHGs to double, leading to an eventual global temperature increase of up to 6ºC.[23]

Despite the certainty that abrupt climate changes have occurred in the past and could be triggered again in the near future, current climate policy does not account for abrupt climate change.[24] In particular, abrupt climate change is not incorporated into the projections of the Intergovernmental Panel on Climate Change (IPCC), which is regarded as the most authoritative, if often conservative, source of information on climate issues.[25] While the focus must continue on mid- and long-term

mitigation strategies to reduce CO_2 emissions, we also must begin fast-track mitigation strategies that can produce immediate climate mitigation and delay the onset of tipping points.

In his commentary to the Ramanathan and Feng study, Professor Hans Joachim Schellnhuber from the Potsdam Institute for Climate Impact Research concludes that "we are still left with a fair chance to hold the 2ºC line, yet the race between climate dynamics and climate policy will be a close one. The odds . . . may be improved by aerosol management . . . (taking the warming components such as black carbon out first), and even techniques for extracting atmospheric CO_2 (like bio-sequestration) . . . . However, the quintessential challenges remain, namely bending down the global [climate emissions] . . . in the 2015-2020 window . . . and phasing out carbon dioxide emissions completely by 2100. This requires an industrial revolution for sustainability starting now."[26]

Black carbon may be the second largest contributor to climate warming, and because its atmospheric lifetime is days to weeks, reducing it may offer the fastest mitigation.[27] Other near-term climate mitigation strategies include reducing other short-lived forcers such as methane and tropospheric ozone precursors,[28] as well as accelerating efforts under the Montreal Protocol on Substances that Deplete the Ozone Layer to reduce ozone-depleting substances (ODSs), most of which are powerful climate gases.[29] (In November 2008, the 193 Parties to the Montreal Protocol unanimously agreed for the second year in a row to strengthen their treaty to provide additional protection for the climate system, as well as for the ozone layer.[30])

Other fast-track mitigation efforts include bio-sequestration in forests and soils. Biochar, for example, removes carbon from the carbon cycle by drawing down atmospheric concentrations of CO_2 in a carbon-negative process and provides near permanent carbon storage while also improving soil productivity and reducing the need for fossil fuel-based fertilizer.[31] Improving energy efficiency[32] and expanding renewables, especially wind, also can produce fast mitigation,[33] as can improving urban albedo.[34] Most of these near-term strategies have strong co-benefits, such as public health benefits from black carbon reductions, earlier recovery of the ozone layer from faster ODS phase-outs and from collecting and destroying ODSs in discarded products and equipment, soil enhancement and reduced fertilizer and water use from biochar, and increased energy security and green jobs from efficiency and renewables. These co-benefits provide further incentives to act now to forestall temperature tipping points visible on the horizon.

Many countries may have some existing legal authority to begin addressing some of these strategies. Where this is the case, improving compliance can help promote near-term climate mitigation.[35] The International Network for Environmental Compliance & Enforcement recently issued *Climate Compliance Alerts* on black carbon[36] and illegally harvested timber.[37]

Endnotes

[1] Timothy Lenton, Hermann Held, Elmar Kriegler, Jim Hall, Wolfgang Lucht, Stefan Rahmstorf & Hans Joachim Schellnhuber, *Tipping elements in the Earth's climate system*, 105 PROC. OF THE NAT'L ACAD. OF SCI. 1786, 1786 (2008); *see also* WORLD WILDLIFE FUND, CLIMATE CHANGE: FASTER, STRONGER, SOONER (2008) ("It is currently forecast that [Arctic] summer sea ice could completely disappear somewhere between 2013 and 2040 – a state not seen on planet Earth for more than a million years."). *See generally*, CLIMATE BRIEFING NOTE ON TIPPING POINTS & ABRUPT CLIMATE CHANGES (IGSD, forthcoming 2008).

[2] Lenton et al., *supra* note 1, at 1788; PETER SCHWARTZ & DOUG RANDALL, AN ABRUPT CLIMATE CHANGE SCENARIO AND ITS IMPLICATIONS FOR UNITED STATES NATIONAL SECURITY 18-19 (2003), http://handle.dtic.mil/100.2/ADA469325.

[3] V. Ramanathan & Y. Feng, *On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead*, 105 PROC. OF THE NAT'L ACAD. OF SCI. 14245, 14245 (2008).

[4] *Id*.

[5] *Id.* at 14247. *See also* James Hansen, Makiko Sato, Reto Ruedy, Ken Lo, David W. Lea & Martin Medina-Elizade, *Global temperature change*, 103 PROC. OF THE NAT'L ACAD. OF SCI. 14288, 14288 (2006) ("Global warming is now 0.6ºC in the past three decades and 0.8ºC in the past century.").

[6] Ramanathan & Feng, *supra* note 3, at 14246-47.

[7] *Id*. at 14245-46. *See also* V. RAMANATHAN ET AL., UNITED NATIONS ENVIRONMENT PROGRAMME, ATMOSPHERIC BROWN CLOUDS: REGIONAL ASSESSMENT REPORT WITH FOCUS ON ASIA 11-12 (2008), *available at* http://www.unep.org/pdf/ABCSummaryFinal.pdf ("[A]ir pollution regulations can have large amplifying effects on global warming. For example, using climate sensitivity recommended in IPCC-AR4, elimination of aerosols in [atmospheric brown clouds] . . . could . . . push the climate system over the 2ºC threshold value for the so-called dangerous climate change.").

[8] James Hansen, Makiko Sato, Pushker Kharecha, David Beerling, Valeris Masson-Delmotte, Mark Pagani, Maureen Raymo, Dana L. Royer & James C. Zachos, *Target Atmospheric CO_2: Where Should Humanity Aim?* 2 OPEN ATMOSPHERIC SCIENCE JOURNAL 217, 221 (2008) [hereinafter *Target Atmospheric CO_2*].

[9] Ramanathan & Feng, *supra* note 3, at 14247.

[10] *Id.* at 14245.

[11] Lenton et al., *supra* note 1, at 1788 ("Transient warming is generally greater toward the poles and greater on the land than in the ocean."); *see also* Jane Qiu, *The Third Pole*, 454 NATURE 393 (2008).

[12] P. LEMKE ET AL., INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *Observations: Changes in Snow, Ice and Frozen Ground*, *in* CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 339 (S. Solomon et al. eds., 2007) ("Recent decreases in ice mass are correlated with rising surface air temperatures. This is especially true for the region north of 65°N, where temperatures have increased by about twice the global average from 1965 to 2005.").

[13] Petr Chylek & Ulrike Lohmann, *Ratio of the Greenland to global temperature change: Comparison of observations and climate modeling results*, 32 GEOPHYS. RES. LETT. L14705 (2005).

[14] Qiu, *supra* note 11, at 393.

[15] V. Ramanathan & G. Carmichael, *Global and regional climate changes due to black carbon*, 1 NATURE GEOSCIENCE 221, 224 (2008); *see also* Qiu, *supra* note 11, at 393 ("The Tibetan plateau gets a lot less attention than the Arctic or Antarctic, but after them it is Earth's largest store of ice. And the store is melting fast. In the past half-century, 82% of the plateau's glaciers have retreated. In the past decade, 10% of its permafrost has degraded. As the changes continue, or even accelerate, their effects will resonate far beyond the isolated plateau, changing the water supply for billions of people and altering the atmospheric circulation over half the planet . . . . The melting seasons on the plateau now begin earlier and last longer . . . . If current trends hold, two thirds of the plateau glaciers could be gone by 2050."). In the Tibetan Plateau Steppe, where the headwaters of the Yangtze, Mekong, and Indus are located, there is concern both for short-term flood and long-term reductions in water supplies. *See, e.g.*, *id.* at 395 ("The risk of floods, though, is but a short-term danger far exceeded by long-term issues with water supplies atop the [Tibetan plateau].").

[16] Lenton et al., *supra* note 1, at 1788.

[17] Ramanathan & Carmichael, *supra* note 15, at 221. *See also* M.G. Flanner, C.S. Zender, J.T. Randerson & P.J. Rasch, *Present-day climate forcing and response from black carbon in snow*, 112 J. GEOPHYS. RES. D11202 (2007) (noting that "the 'efficacy' of BC/snow forcing is more than three times greater than forcing by CO_2").

[18] RAMANATHAN ET AL., *supra* note 7, at 6 ("The present report adds that soot in [atmospheric brown clouds] is another major cause of the retreat of [Hindu-Kush-Himalayan-Tibetan] glaciers and snow packs. The warming of the elevated atmospheric layers due to greenhouse warming is amplified by the solar heating by soot at elevated levels and an increase in solar absorption by snow and ice contaminated by the deposition of soot."); *see also id.* at 25 ("Decreased reflection of solar radiation by snow and ice due to black carbon deposition is emerging as another major contributor to the melting of snow packs and glaciers."); *see also* Ramanathan & Carmichael, *supra* note 15, at 224.

[19] Lenton et al., *supra* note 1, at 1786; COMMITTEE ON ABRUPT CLIMATE CHANGE & NATIONAL RESEARCH COUNCIL, ABRUPT CLIMATE CHANGE: INEVITABLE SURPRISES 107-08 (2003).

[20] *Target Atmospheric CO_2*, *supra* note 8, at 218; *see also* James Hansen, *Climate Catastrophe*, 195 NEW SCIENTIST 30, 32 (2007).

[21] *Target Atmospheric CO_2*, *supra* note 8, at 217.

[22] Ramanathan & Feng, *supra* note 3, at 14247-49.

[23] INTERNATIONAL ENERGY AGENCY [IEA], WORLD ENERGY OUTLOOK 45-46 (2008) ("The projected rise in emissions of greenhouse gases in the Reference Scenario puts us on a course of doubling the concentration of those gases in the atmosphere by the end of this century, entailing an eventual global average temperature increase of up to 6°C. The Reference Scenario trends point to continuing growth in emissions of CO_2 and other greenhouse gases. Global energy-related CO_2 emissions rise from 28 Gt in 2006 to 41 Gt in 2030 - an increase of 45%. The 2030 projection is only 1 Gt lower than that projected in last year's *Outlook*, even though we assume much higher prices and slightly lower world GDP growth. World greenhouse-gas emissions, including non-energy CO_2 and all other gases, are projected to grow from 44 Gt CO_2-equivalent in 2005 to 60 Gt CO_2-eq in 2030, an increase of 35% over 2005."); *see id.* at 401 ("The total CO_2-equivalent concentration of all long-lived greenhouse gases, taking into account land-use change, is currently around 455 ppm. This is around 60% higher than the level in pre-industrial times.") (footnote omitted).

[24] Peter Read & Jonathan Lermit, *Bio-Energy with Carbon Storage (BECS): a Sequential Decision Approach to the threat of Abrupt Climate Change*, 30 ENERGY 2654, 2654 (2005) ("Abrupt Climate Change is an issue that 'haunts the climate change problem' (IPCC, 2001) but has been neglected by policy makers up to now, maybe for want of practicable measures for effective response, save for risky geo-engineering."); *see also* Lenton et al., *supra* note 1, at 1792 ("Society may be lulled into a false sense of security by smooth projections of global change. Our synthesis of present knowledge suggests that a variety of tipping elements could reach their critical point within this century under anthropogenic climate change."). *But see*, *Science Daily*, *Abrupt Climate Change Focus Of U.S. National Laboratories* (2008), http://www.sciencedaily.com/releases/2008/09/080918192943.htm (The initial focus is on four types of ACC: instability among marine ice sheets, particularly the West Antarctic ice sheet; positive feedback mechanisms in subarctic forests and arctic ecosystems, leading to rapid methane release or large-scale changes in the surface energy balance; destabilization of methane hydrates (vast deposits of methane gas caged in water ice), particularly in the Arctic Ocean; and feedback between biosphere and atmosphere that could lead to megadroughts in North America.).

[25] *See*, *e.g.*, James Hansen, *Scientific reticence and sea level rise*, ENVIRON. RES. 2, 5 (2007).

[26] Hans Joachim Schellnhuber, *Global Warming: Stop worrying, start panicking?*, 105 PROC. OF THE NAT'L ACAD. OF SCI. 14239, 14239-40 (2008).

[27] Ramanathan & Carmichael, *supra* note 15, at 222 ("The BC forcing of 0.9 W m^{-2} (with a range of 0.4 to 1.2 W m^{-2}) . . . is as much as 55% of the CO_2 forcing and is larger than the forcing due to the other GHGs such as CH_4, CFCs, N_2O or tropospheric ozone."); *see also* Mark Jacobson, *Control of Fossil-Fuel Particulate Black Carbon and Organic Matter, Possibly the Most Effective Method of Slowing Global Warming*, 107 J. GEOPHYS. RES. D19 (2002); and Qiu, *supra* note 11, at 396 ("Reducing emissions of greenhouse gases and black carbon should be the top priority," according to Xu Baiqing of the Institute of Tibetan Plateau Research.).

[28] *Role of Black Carbon on Global and Regional Climate Change: Hearing on the role of black carbon as a factor in climate change Before H. Comm. on Oversight and Gov't Reform*, 110th Cong. 4 (2007) (testimony of V. Ramanathan).

[29] *See* Guus J. M. Velders, Stephen O. Andersen, John S. Daniel, David W. Fahey & Mack McFarland, *The importance of the Montreal Protocol in protecting climate*, 104 PROC. NAT'L. ACAD. SCI. 4814, 4814-19 (2007), *available at* http://www.pnas.org/cgi/content/abstract/104/12/4814 (From 1990 to 2010, the Montreal Protocol will have reduced climate emissions by a net of 135 billion tonnes of CO_2-eq., delaying climate forcing by up to 12 years. This is ~ 13% of the forcing due to accumulated anthropogenic emissions of CO_2 and several times the reductions sought under the first phase of Kyoto Protocol.). In 2007, the Montreal Protocol was further strengthened to accelerate the phase-out of HCFCs; that adjustment has the potential to produce mitigation up to 16 billion tones of CO_2-eq. *See* U.S. EPA 2008 Climate Award Winners, Team Award Winners, http://www.epa.gov/cppd/awards/2008winners.html ("The U.S. EPA estimates that, through 2040, the HCFC agreement could reduce emissions by up to 16 billion metric tonnes of carbon dioxide-equivalent. This is equal to the greenhouse gas emissions from the electricity use of more than 70 million U.S. households over the next 30 years."); TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL [TEAP], UNITED NATIONS ENVIRONMENT PROGRAMME, RESPONSE TO DECISION XVIII/12, REPORT OF THE TASK FORCE ON HCFC ISSUES (WITH PARTICULAR FOCUS ON THE IMPACT OF THE CLEAN DEVELOPMENT MECHANISM) AND EMISSIONS REDUCTIONS BENEFITS ARISING FROM EARLIER HCFC PHASE-OUT AND OTHER PRACTICAL MEASURES 8 (2007) [hereinafter TEAP RESPONSE], *available at* http://ozone.unep.org/teap/Reports/TEAP_Reports/TEAP-TaskForce-HCFC-Aug2007.pdf.

[30] At the 20th Meeting of the Parties to the Montreal Protocol, the Parties agreed to begin collecting and destroying unwanted ODSs in existing stockpiles and discarded products and equipment. *See* The Eighth Meeting of the Conference of the Parties to the Vienna Convention and the Twentieth Meeting of the Parties to the Montreal Protocol, Doha, Qatar, Nov. 16-20, 2008, *Advance Report*, at Decision XX/7 (Nov. 27, 2008) [hereinafter *Advance Report*], *available at* http://ozone.unep.org/Meeting_Documents/mop/20mop/MOP-20-9E.pdf. Without immediate action to prevent emissions of ODSs from banks, these sources will release 6 billion tonnes or more of CO_2–eq. into the

atmosphere before 2015 and a further 15 billion tonnes of CO_2–eq. thereafter, and will otherwise cancel the hoped for gains of the current climate treaty. *See* TEAP RESPONSE, *supra* note 29, at 12, 27; *see also* IPCC & TEAP, *Technical Summary*, *in* SPECIAL REPORT ON SAFEGUARDING THE OZONE LAYER AND THE GLOBAL CLIMATE SYSTEM: ISSUES RELATED TO HYDROFLUOROCARBONS AND PERFLUOROCARBONS [SPECIAL REPORT] 9 (2005), *available at* http://arch.rivm.nl/env/int/ipcc/pages_media/SROC-final/SpecialReportSROC.html.

The Parties also decided to start discussions on moving hydrofluorocarbons, or HFCs, from the climate treaty to the stricter Montreal Protocol, where HFCs with high global warming potential could be phased-out. *See Advance Report*, *supra*, at Decision XX/8. HFCs have global warming potentials hundreds to thousands of times that of CO_2 and are one of the six GHGs included in the Kyoto Protocol; they are used primarily as a replacement for ODSs phased-out under the Montreal Protocol. *See* IPCC & TEAP, *Summary for Policy Makers*, *in* SPECIAL REPORT, *supra*, at 3. The Parties also provided USD $490 million over three years to assist developing countries to meet their commitments, including the commitment last year to accelerate the phase-out of HCFC, which has the potential to prevent up to 16 billion tonnes of CO_2-eq. emissions if the Parties ensure climate friendly alternatives are used, and not high GWP HFCs. *See id.*; *see also* TEAP RESPONSE, *supra* note 29.

[31] Johannes Lehmann, John Gaunt & Marco Rondon, *Bio-char Sequestration In Terrestrial Ecosystems – A Review*, 11 MITIGATION AND ADAPTATION STRATEGIES FOR GLOBAL CHANGE 403, 404 (2006).

[32] Group of Eight Summit, Heiligendamm, Ger., June 6-8, 2007, *Growth and Responsibility in the World Economy: Summit Declaration*, ¶ 46 (June 7, 2007) ("Improving energy efficiency worldwide is the fastest, the most sustainable and the cheapest way to reduce greenhouse gas emissions and enhance energy security.").

[33] The IPCC has predicted that renewable energy sources, which have "a positive effect on energy security, employment and on air quality," will be able to provide 30-35% of the world's electricity by 2030. IPCC, *Summary for Policymakers*, *in* CLIMATE CHANGE 2007: MITIGATION 13 (B. Metz et al. eds., 2007). The IPCC has also found that "wind is the fastest growing energy supply sector." IPCC, IPCC SCOPING MEETING ON RENEWABLE ENERGY SOURCES 4 (Olav Hohmeyer & Tom Trittin eds., 2008); *see also* GREENPEACE & GLOBAL WIND ENERGY COUNCIL, GLOBAL WIND ENERGY OUTLOOK 2006, at 38 (2006) ("Under the Advanced wind energy growth projection, coupled with ambitious energy saving, wind power could be supplying 29.1% of the world's electricity by 2030 and 34.2% by 2050."). In its most recent report, the International Energy Agency concludes "[p]reventing catastrophic and irreversible damage to the global climate ultimately requires a major decarbonisation of the world energy sources . . . . The energy sector will have to play the central role in curbing emissions – through major improvements in efficiency and rapid switching to renewable and other low-carbon technologies . . . ." *See* IEA, *supra* note 23, at 37-38.

[34] *See* Hashem Akbari, Surabi Menon & Arthur Rosenfeld, *Global Cooling: Increasing Worldwide Urban Albedos to Offset CO_2*, CLIMATIC CHANGE (forthcoming 2008) (If 100 large urban areas switched their roofs and pavement to highly reflective materials, the authors calculate this would "induce a negative radiative forcing of $4.4x10^{-2}$ Wm^{-2} equivalent to offsetting 44 Gt of emitted CO_2. A 44 Gt of emitted CO_2 offset resulting from changing the albedo of roofs and paved surfaces is worth about $1100 billion. Assuming a plausible growth rate of 1.5% in the world's CO_2-equivalent emission rate, we estimate that the 44 Gt CO_2-equivalent offset potential for cool roofs and cool pavements would counteract the effect of the growth in CO_2-equivalent emission rates for 11 years."); *see also* Hashem Akbari, Leader, Heat Island Group, Presentation at the Fifth Annual California Climate Change Conference: Global Cooling: Increasing World-wide Urban Albedos to Offset CO_2 (Sept. 9, 2008), *available at* http://www.climatechange.ca.gov/events/2008_conference/presentations/2008-09-09/Hashem_Akbari.pdf. In California, which sets strict energy budgets for new construction, residential and some non-residential buildings can receive energy credits toward their energy budgets for installing "cool roofs." Cool roofs can lower roof temperatures up to 100 degrees Fahrenheit, reducing energy use for air conditioning and associated urban heat islands and smog. CAL. CODE REGS. tit. 24 § 118 (2007). Cool roof and reflective pavement are two of California's early action measures implementing California Assembly Bill Number 32, the Global Warming Solutions Act. *See* AIR RESOURCES BOARD, CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY, EXPANDED LIST OF EARLY ACTION MEASURES TO REDUCE GREENHOUSE GAS EMISSIONS IN CALIFORNIA RECOMMENDED FOR BOARD CONSIDERATION, at C-14 (2007).

[35] See Eighth International Conference on Environmental Compliance and Enforcement, Cape Town, S. Afr., Apr. 5-11, 2008, *Cape Town Statement*, for an affirmation of the benefits of environmental compliance and enforcement.

[36] Int'l Network for Environmental Compliance and Enforcement [INECE], *Jump-Starting Climate Protection: INECE Targets Compliance with Laws Controlling Black Carbon* (June 12, 2008), *available at* http://inece.org/climate/INECEClimateComplianceAlert_BlackCarbon.pdf.

[37] INECE, *Recent Amendments to U.S. Lacey Act Should Help Protect Forests Worldwide*, *available at* http://www.inece.org/climate/ClimateComplianceAlert_LaceyAct.pdf.