

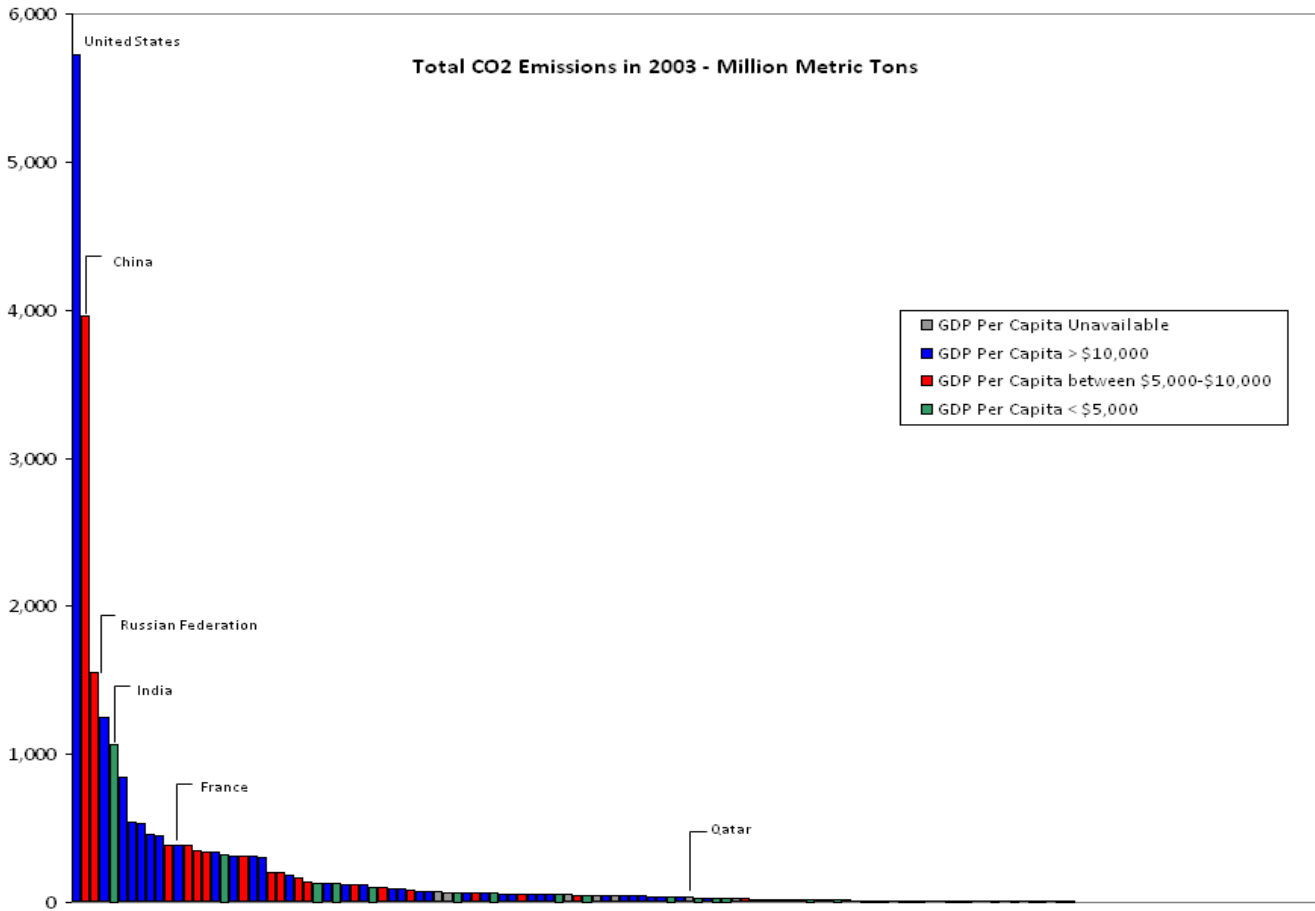
## **Whose Rules?-Terms of Discussions Around a Global Cap & Trade system**

By Vinod Khosla

Global climate change is accelerating like a runaway truck. The conventional wisdom is simple: the US does not want to participate in a global treaty, because India and China don't want to participate. But is that really an accurate assessment, or is it that they don't want to participate based on Western rules of engagement? What are the rules, and who makes them? The countries with the biggest bulk and heaviest sticks? Moral and ethical principles? If so, whose ethics and morals? Do we consider a given country's ability to pay, its natural resources, and its rate of economic development? There are many a proposal for carbon cap & trade but often without explicit consideration of the above issues, even though the issues are often included or cited in proposals. Beyond the heaviest sticks and "local ethics", is the complex matter of political reality in each country. What is locally and regionally politically acceptable becomes even more critical in the democratic world where the politics of today far outweighs the needs of the planet in 2050.

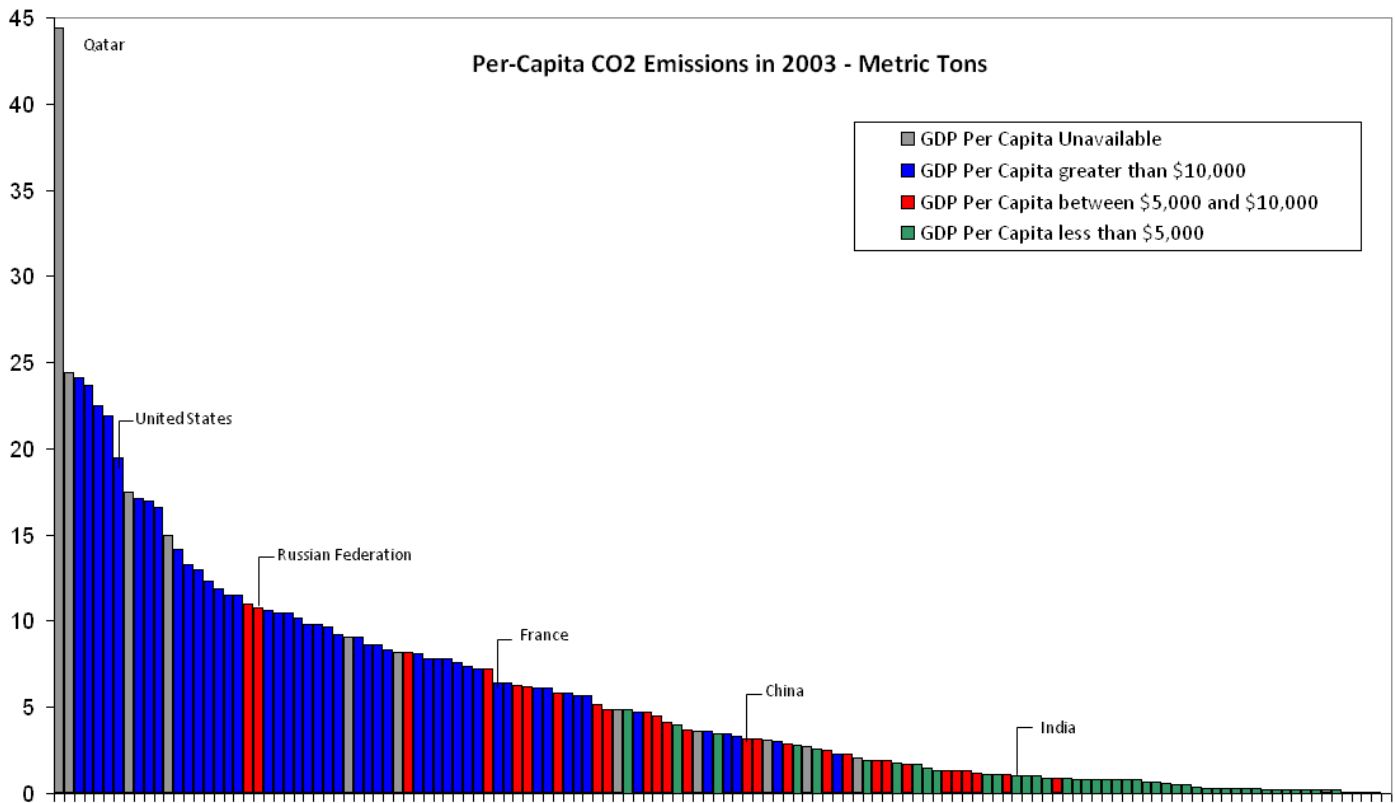
Figures 1 and 2 show (1) total annual Carbon Dioxide emissions by country and (2) Carbon Dioxide emissions per capita, by country; the series are color-coded by GDP per capita (on a purchasing power parity basis).

Figure 1: Total Annual Carbon Dioxide Emissions- 2003, Million Metric Tons<sup>1</sup>



<sup>1</sup> [World Resource Institute](#), citing IEA data

Figure 2: Per Capita Carbon Dioxide Emissions – 2003, Metric Tons<sup>2</sup>



Professor John Holdren (Co-chair of the National Commission on Energy Policy) summarized the current situation in a recent talk<sup>3</sup>: we have a global climatic disruption and serious harm is already occurring. Mitigation, adaption and suffering are our only options and the more we have of the former two, the less we will have of the latter. The key question is whether we can we avoid catastrophic interference. Seventy-five percent of the carbon emissions in question come from energy use, oil, coal and natural gas, and approximately twenty-five percent come from deforestation and burning in the tropics.

It is widely recognized that mitigation must happen everywhere to make a material difference. But should the burden of mitigation be allocated? The proposals so far have been dominated by Western points of view and principally comprised of tradeoffs between the various western constituencies like business, labor, agricultural and environmental groups. The proposals don't work with the priorities of many developing countries like India and China. Is it possible to craft a set of proposals that are more likely to be acceptable?

In line with the questions above, there are two metrics serve as a useful starting point: the total carbon emissions by country (Figure 1) and the carbon emissions per capita by country (Figure 2).

<sup>2</sup> Ibid

<sup>3</sup> “Action on Climate Change: How Much is Needed, How Fast”, John P Holdren , Aspen Ideas Festival – July 1, 2008

## DRAFT

However, is it reasonable to compare the total carbon emissions of a country with a billion people with that of a country with a million people? At this point, the discussion often turns to the idea of carbon reduction in percentage terms, but questions crop up again - is it reasonable to have a country with per capita income of \$1,000 be asked to meet the same percentage carbon reduction as a country with per capita income of \$40,000? Is it reasonable to ask a country with a per capita income of \$1,000 and a growth rate of 2% in the economy to achieve the same reduction as a country with a per capita income of \$1,000 and a 10% growth rate? Who decides where to draw the line? What protocols are used to assess fairness? Whose standards should we use to evaluate fairness?

Even if a definition of fairness can be determined, “what is fair” and “what is pragmatic” are often inconsistent with each other. Perhaps the only morally defensible “fair thing” to do is to give every human being an equal right to pollute the air. That means an equal per capita emissions quota. Extending this argument, being strictly fair, using the closest thing to a universal moral code would suggest that the per capita allocation should be done based on total cumulative carbon emissions “stock” through history rather than an equal current annual “flow” of carbon emissions per capita. Developed nations would include their historical emissions (potentially starting at the dawn of the industrial revolution in 1750 or so) in computing the stock of carbon emissions they have emitted per capita over time. Though carbon calculations can get convoluted, it is important to realize that emissions during the last fifty years are the dominant culprits by virtue of their magnitude. As of 2006, the approximately 1 billion person population of the OECD emits roughly as much carbon dioxide equivalent as the remaining 5.5 billion people<sup>4</sup>. Developing nations argue that it is only fair that they [the OECD and the developed world] bear the principal burden for reductions, especially since they have the highest incomes and greatest capability to invest in the reduction of their carbon footprint. Unfortunately this fair formulae does not work well for the planet, or for the politics, heavyweight clout and self interest of the United States which would have to radically change its carbon emissions and hence its energy use profile dramatically, draining investment funds and causing significant business dislocations. Moreover, the common refrain (including environmental circles) is that that India and China don't want to do their part in global carbon emissions reduction, and that any coordinated action without them is doomed to failure. Of course, every country wants to continue its development priorities while offsetting the burden of carbon abatement to the “commons” – the classic “free rider” problem. However, we believe that most countries will participate in a scheme that can be sold as “fair” to their populace.

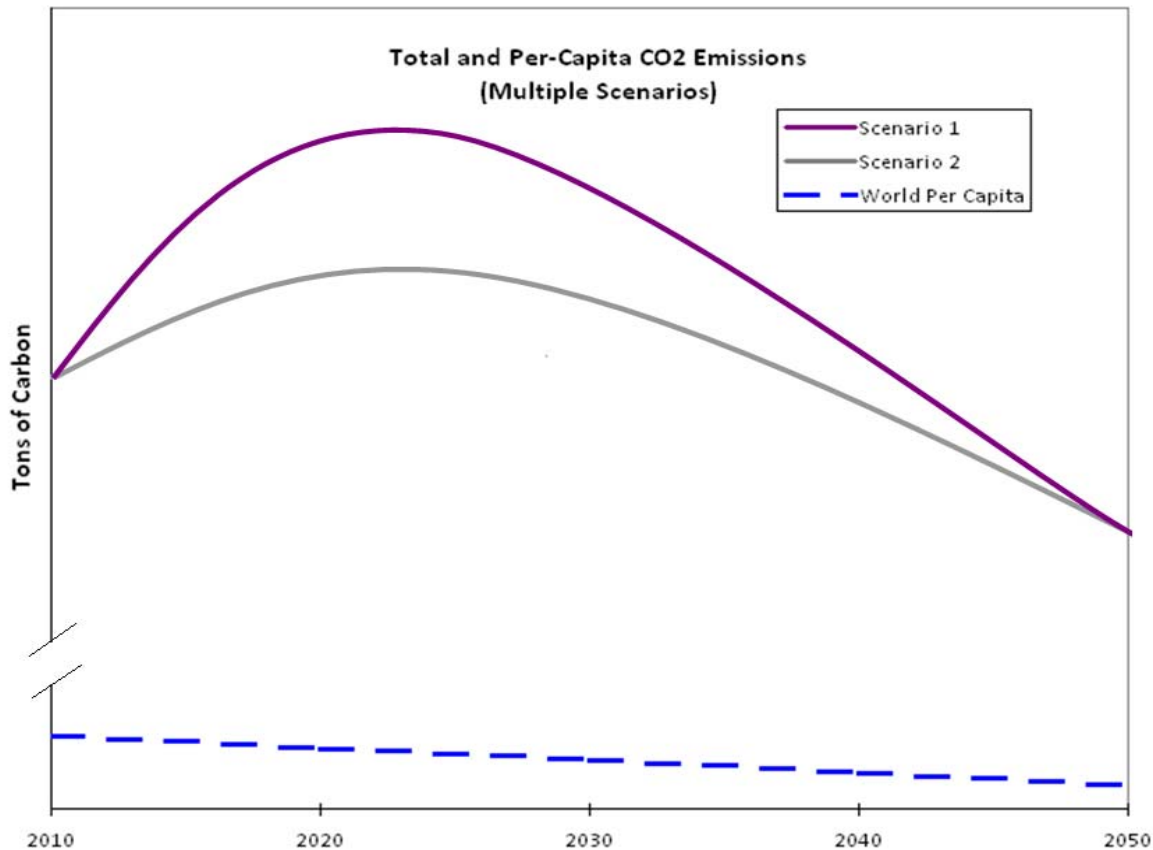
In that vein, India’s Prime Minister Manmohan Singh has stated categorically that India would sign up to a cap & trade system that allocates equal carbon emissions to every human being. Realistically, it is the US that will not sign up to a system that allocates an equal right to pollute to every human being (In fact, India has gone forth and stated that its per capita carbon emissions will never exceed that of the developed world). What India and China have refused to sign up for is a system stacked against them, a system devised by the developed world that makes it more difficult for them to get to the same level of per capita GDP as the developed world and its concomitant energy consumption (assuming they get to similar levels of energy efficiency per dollar of GDP). India and China are not currently at the level of energy efficiency per dollar of GDP that the developed world achieves, and would have to work harder and invest more than they currently do to get to similar levels of energy/carbon efficiency of GDP.

---

<sup>4</sup> <http://www.eia.doe.gov/oiaf/ieo/pdf/highlights.pdf>

The question is not whether India and China would participate, but rather on what terms they can do so. The United States will have its own ideas of what works system works best. Europe, which has lower per capita emissions than the US may be the most flexible and committed to carbon reductions (with significantly greater political support for reductions). Russia may have other geopolitical interests, including the use of its strategic energy assets. Brazil may be most focused on its land assets (and with its recent discovery of large oil fields of the coast, could change its priorities). Africa may de-prioritize the issue given the various other challenges it faces. Clearly, some country specific considerations will have to be accounted for— as many critics have outlined, the larger landmass (and subsequent distance to travel), and lower density population of the US will by its very nature use more fossil fuels to travel than its more tightly packed European counterpart. It is not hard to conclude that the basic terms of the discussion around carbon cap & trade need to change and new formulas have to be devised to share the pain of carbon emissions reductions between the world’s citizens, with allowances to deal with factors such as density, climate (i.e., a colder country is going to use more fossil fuel in heating than its temperate counterpart) and others. There is a general consensus that emissions reductions are needed – our responsibility is to avoid the tragedy of the commons. What is the carbon reduction responsibility allocation that might be acceptable to most countries whether they are developed or developing?

Figure 3: Annual Total and Per Capita Global Carbon Emissions Scenarios



## DRAFT

The hypothetical scenarios shown in Figure 3 are approximate trend lines; two potential pathways of achieving the most accepted (though not universally so) per capita emissions target of 2tc/yr/person (and reduce carbon emissions on different trajectories and achieve different levels of carbon in the atmosphere). The long-term goal, though still subject to considerable to debate, is often set at stabilizing atmospheric carbon at approximately 450ppm of carbon dioxide equivalent by 2050 (which the Intergovernmental Panel on Climate Change (IPCC) says would give us a 50% probability of limiting temperature increases to about 2 degrees Celsius<sup>5</sup>) though experts have suggested ranges between 350ppm (James Hansen at NASA<sup>6</sup>) and 550ppm. The simplest way to look at these trajectories is that each level of carbon in the atmosphere results in a different level of risk of catastrophic or runaway climate change – the higher that atmospheric carbon content, the greater the risk we face. The science on the magnitude of the change at each level of carbon in the atmosphere is uncertain but recent indications point to “safe levels” being lower than was generally accepted even a few years ago. The critical learning from recent experience is for prudent global climate risk management; we not only need to achieve the above targets but be willing and able to respond to changing targets quickly as new information comes becomes available. What we know about the impact of climate change is important, but what we don’t know (and will learn over the next few years) is even more so. As such, the principles behind a global cap & trade deal should allow for easy adjustment, as opposed to a new multi-year Kyoto style negotiation among almost 200 countries. The need for flexibility of our response to changing information on climate change and carbon emissions is evidenced by the inaccuracy in the global carbon emission trajectories.

Figure 4: Shifts in Forecasts of Carbon Emissions<sup>7</sup>

	2008 Estimated Emissions – GT CO <sub>2</sub> e	2050 BAU* Emissions – GT CO <sub>2</sub> e	2050 target Emissions – GT CO <sub>2</sub> e
(1) Original Globe Report – 450 ppmv, no overshoot	42	85	10
(2) Updated baseline and target – 450 ppmv, no overshoot	55	85	13
(3) MGI Report – 450 ppmv with overshoot to 500 ppm; updated baseline and target	55	85	20
<p>* Business as Usual</p> <p>(1) Emissions baseline from IEA (2002)</p> <p>(2) Emissions baseline from IPCC (2008); 2050 target based on Stern Review 450 ppmv scenario</p> <p>(3) 2050 target based on Meinshausen (2007) and consistent with G8 proposals</p>			

<sup>5</sup> [http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041007131717/IAssessment1201517963441/view\\_content](http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041007131717/IAssessment1201517963441/view_content)

<sup>6</sup> <http://www.washingtonpost.com/wp-dyn/content/article/2007/12/27/AR2007122701942.html>

<sup>7</sup> “The Carbon Productivity Challenge”, McKinsey Global Institute, June 2008

## DRAFT

Figure 4 shows the shifts in the forecast of carbon emissions by two such reputable sources. It notes that in 2002 (in the GLOBE report), the IEA forecast that emissions in 2008 would be 42 Gt per year with a 2X increase from 2008 to 2050 (under business as usual scenarios). An updated IPCC report only five years later (relying on 2004 data) forecasts 2008 emissions at 55 GT or more than 30% higher in the short span of five years. Why? Because in addition to growth, there are large uncertainties around measurement, and the projected growth rates for India and China have increased dramatically thus changing their energy consumption and carbon emissions forecasts. Econometric models are only as good as the research and assumptions upon which they are based- and in our view, the assumptions to this point are extremely tenuous. Projecting India's or Russia's growth rate in 2040 is akin to projecting the 2008 growth rate in the early 1900's. With the accelerating rate of change in society and heightened global dynamics, it is nearly impossible to make accurate predictions. The correct response is thus to estimate but not rely solely on the numbers. The global response has to be dynamic and flexible – a system that adapts as the results come in, and not requiring political negotiations at each stage. Technology development to allow for rapid response is critical but in addition we must also allow for a rapid, maybe even automatic, policy response.

Forecasting is an inexact science as multiple examples over the years have shown us. In particular, a lot of economic forecasting is essentially a regression of old data; it cannot account for technological evolution, shifts, and shocks because these cannot be predicted. One of the more famous examples is McKinsey's 1980 estimation of the mobile phone market in the 2000 (for AT&T) – in which a market size of approximately 1 million phones was forecast. The actual market in 2000 exceeded 100 million – an error of approximately 10,000%. Similarly, the EIA's Energy outlook retrospective noted that on average, the EIA's forecast of average oil prices was off by 52%; natural gas prices were off by 64%, and coal prices were off by 47%.<sup>8</sup> The goal is not to criticize McKinsey or the EIA, but rather to highlight the risks prevalent in forecasting technology potential as a whole and recognizing when technology has the potential to be a "Black Swan". As the author of "The Black Swan", Nassim Taleb defines it – a Black Swan event is: 1) an outlier – it lies outside the realm of traditional expectations, as evidence from the past does not predict the future event 2) it carries a significant impact and 3) In spite of its outlier status, it is justified on an ex-post basis – explanations are derived and accepted after the fact. To summarize: "rarity, extreme impact, and retrospective (though not prospective) predictability."<sup>9</sup> Technology shocks are one of the best examples of this maxim in action – ranging from the internet, the agricultural revolution, to the rise (and demise) of the traditional telecommunications infrastructure. Forecasting is an inexact science; its errors are further compounded by dramatic changes in inputs and assumptions, often rendering history a poor base to extrapolate from.

To summarize, we see a few key criteria that any carbon emissions control system must achieve

- Meet Global CO2 reduction targets – any scheme must converge upon this target value, be it 350, 450, or 550PPM worldwide.

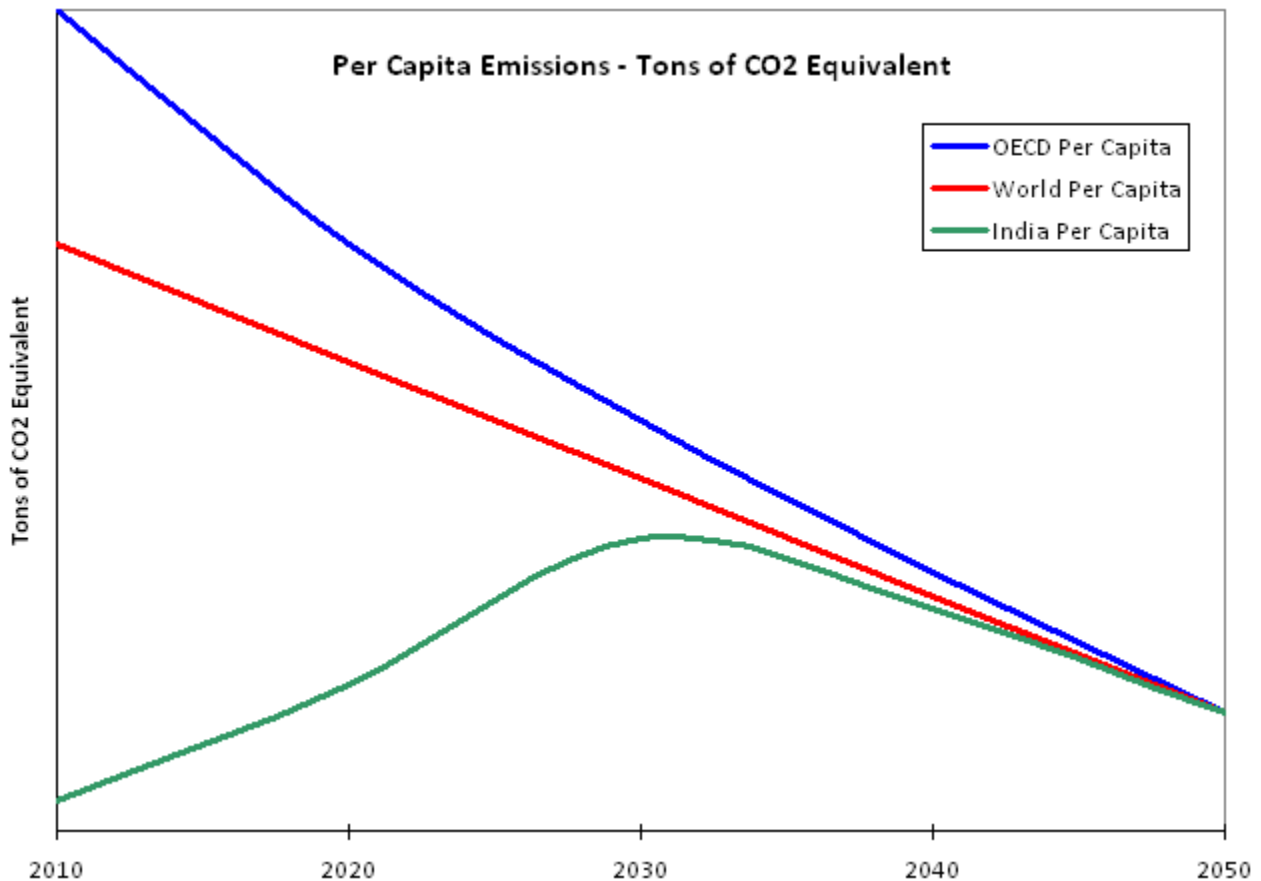
<sup>8</sup> "Annual Energy Outlook: Retrospective Review", EIA, April 2007

<sup>9</sup><http://www.nytimes.com/2007/04/22/books/chapters/0422-1st-tale.html>

DRAFT

- Be politically acceptable in most countries – no scheme is likely to find global acceptance, but we must strive for an approach that is politically viable for most sovereign entities and thus minimizes opt-outs or “free riders”.
- Morally acceptable – while the concept of “fairness” is open to debate, any system must be fair in assigning the responsibility for the problem in rough proportion to the primary polluters. Pragmatically, fairness will have to be defined to be maximally but not universally acceptable.
- Dynamic – working towards carbon reductions now is important, but the primary goal is to work towards significant carbon reduction capability in the future (even at some marginal cost in terms of emissions today), and an ability to react more quickly as research improves and safe “targets” get defined with increasing certainty. In other words, investing in capital stock for future carbon emission reductions offers greater benefits than the “consumption” of carbon emission reductions today.

Figure 5: Hypothetical Scenario of Per Capita Carbon Emissions Trends Required



How might the carbon emissions reduction proceed? Figure 5 shows one hypothetical pathway, with the OECD working to reduce its per-capita emissions, while countries like India experience a

## DRAFT

temporary increase in per capita emissions of CO<sub>2</sub>, but leveling of around an acceptable per capita emissions level (likely to be around 2 tons CO<sub>2</sub>e equivalent per year). In this vein, countries like India and China could offer to go beyond their responsibility to equal per capita emissions and agree in addition to not exceed the per capita emissions of the OECD countries (as shown above), thus accepting an additional constraint. India's Prime Minister has offered just such a constraint, but that is not sufficient to achieve global carbon reduction targets. Current developed country thought (as highlighted in the recent Stern report<sup>10</sup>) is that one would require the developed world to reduce carbon emissions by an agreed upon percentage relative to 1990 levels by 2050 with some interim goals set for 2020. Extrapolating this somewhat arbitrary date, (since we would still need the developing world to reduce its emissions to meet the per capita global target of 2tc/yr/person) one approach is to give the developing world until 2020 to start making reductions in absolute carbon emissions.

Is the basic approach outlined above "fair"? It may or may not be, depending upon the country involved. Should the same date for capping carbon emissions be used for all countries even if they are in very different stages of development, just because the developed world needs them to cap emissions? If we concede that different countries are on different developmental trajectories, who decides what the date should be for each country to start capping total carbon emissions? We need an objective criteria that is smooth and continuous in its demand on countries for investment in carbon reductions. It needs to apply to every country as close to uniformly as possible as they reach the levels of capability to invest in the carbon commons. It may be fair for China but not for India; it may be fair to require India to reduce emissions but not Bangladesh. It is clear we need concrete measures from countries like India and China because very soon, if not already, they will constitute a majority of the carbon emissions "flow" (As per some reports, China may already be the world's largest CO<sub>2</sub> emitter<sup>11</sup> - another point of contention for many in the West who see any scheme without Chinese reductions as essentially useless). Even if they have substantially lower per capita emissions and a lesser ability to respond to the need for carbon mitigation because of their lower per capita incomes, should we still require them to reduce carbon emissions? While noting the room for forecasting discrepancy, it is still clear that by 2050, almost every country must approach the global per capita target of 2tc/yr/person. If India and China are outside a cap trade treaty, fairness will not matter. Total worldwide carbon emissions would potentially condemn the world to Professor Holdren's "suffering" option (outlined earlier). Is there an option that better fulfills most of our criteria, while still offering enough incentives for the heavyweights (developing and developed) to participate?

We believe that such an approach exists. Pragmatically, the developed world has been the primary cause of greenhouse gas (GHG) emissions, and will require higher per capita emissions than the per capita quota. To do so, it can afford to pay the developing world for this privilege. One such instrument to facilitate this is the clean development mechanism (CDM). The CDM sets up a trading contract where the developed world pays the developing countries to execute carbon reduction projects. The developing world gets credits for reducing emissions beyond the business as usual scenarios, but is not penalized if they don't achieve specific targets. This is a win-win— the developed world is able to reduce their carbon footprint by reducing emissions in the developing world where it

---

<sup>10</sup> "Key Elements of a Global Deal on Climate Change," Nicholas Stern,

<sup>11</sup> <http://www.guardian.co.uk/environment/2007/jun/19/china.usnews>

## DRAFT

might be cheaper to do (essentially “outsourcing” their carbon mitigation responsibilities) and the developing world gets more carbon efficient investment opportunities accelerating their development. Many will agree in the equity of this arrangement, but it isn’t likely to be enough. There is a need for additional approaches.

What could the world offer in addition to CDM’s, to allow for greater incentives to reduce carbon emissions to the developing countries? What could the developing world offer the developed world that would not be too costly to their development goals? Before discussing additional options, it is important to look back at previous efforts such as the Kyoto protocol. The Kyoto protocol divides the world into Annex 1 countries (Members of the OECD, as well as countries with economies in transition including members of the former Soviet Union and several other Central and Eastern European states) and non-Annex 1 countries. The criteria for what is a “developed” country (Annex 1 country) and what is “developing” are somewhat arbitrary. Where should the cutoff be in per capita GDP? Absolute carbon caps based on 1990 carbon emissions penalize fast growing countries, especially unfairly for the ones with low per capita carbon emissions. They are even worse for the slow growth, very poor economies in some of the African nations. Should a country like Eritrea with per capita emissions that are 1% of the US per capita emissions (0.2 tons of CO<sub>2</sub> per capita)<sup>12</sup> and with per capita income of \$900<sup>13</sup> be responding in any way to the need for carbon mitigation? As a result of western “country politics”, internal negotiations with “environmental groups” (which accounted-prioritize the aspirations of the poor), and a failure to understand local politics and values, impractical solutions (more suited to fast developing countries) are often proposed. Economics is a principal driver of adoption of technology and business practices – as the cost of capital (due to risk-adjustments) in the developing world is generally higher than the developed world, many solutions that work in the latter are not viable in the former. But in the problem of defining Annex 1 or developed countries and in the cost of capital may lie solutions that meet the developed and developing world’s separate and common goals. The most often cited “fairness” questions are the need for shared pain and wanting countries like India and China to do more than just commit to good intentions. What could fairly and flexibly quantify this effort of emissions reduction and make it measurable?

This leads us into our primary proposal – the carrot and stick for the developed world beyond CDM’s. For the developed world, an approach based on CDM’s carries significant advantage, primarily in the degree of control over the funds that are allocated through it. This leverage can be directed towards requiring a hard, measurable commitment from the recipient nations on carbon emissions. Any approach must meet developing world needs/goals of not limiting their growth, while at the same time providing actual incentives towards carbon emission reduction. What measurable makes sense? We think that the single best way to measure progress is not based on CO<sub>2</sub> emissions as a whole, but rather on incentivizing the developing world to increase its carbon productivity of GDP - producing more, but reducing the carbon emissions associated with each marginal dollar in growth. This is the concept of **carbon efficiency**.

---

<sup>12</sup> <http://www.iaea.org/inisnkm/nkm/aws/eedrb/data/ER-enemc.html>

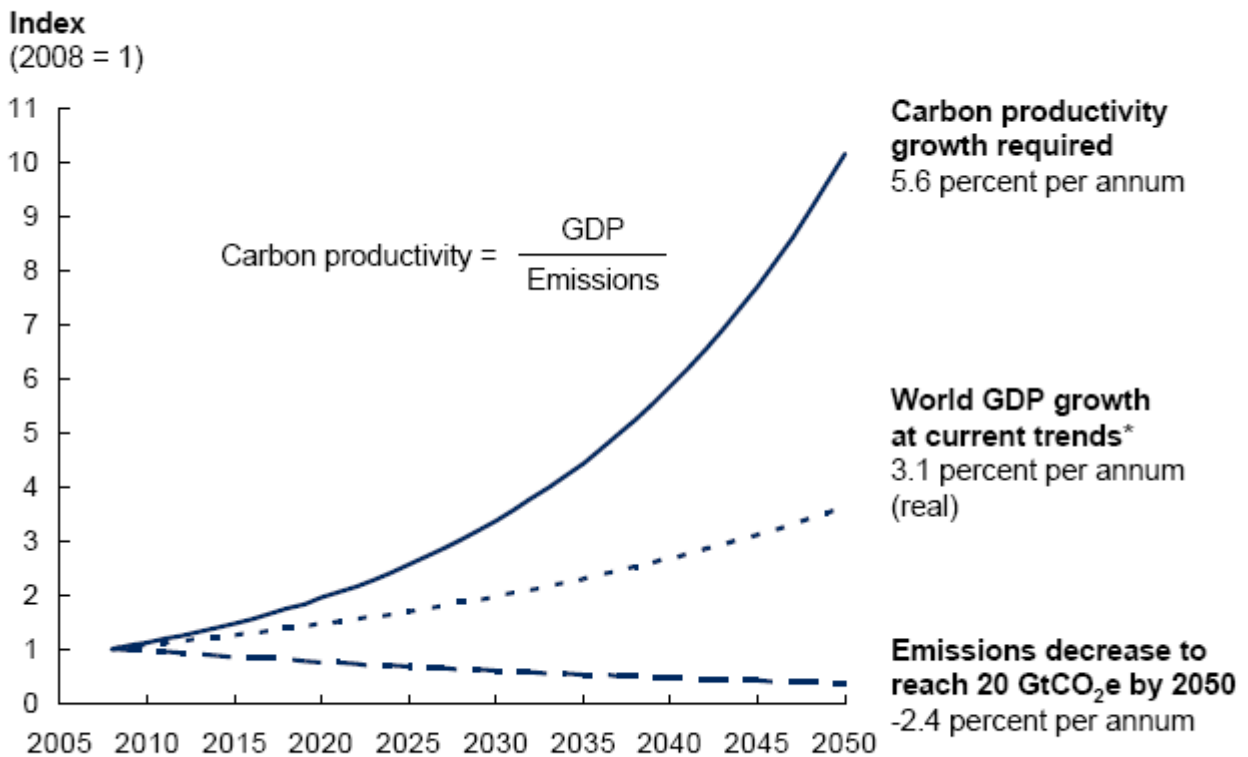
<sup>13</sup> Ibid

DRAFT

Given a 3.1% world GDP growth rate<sup>14</sup>, McKinsey has estimated that the carbon efficiency of the world GDP needs to grow at about 5.6% per annum to meet their recommended set of global reduction targets– this increase in efficiency can become the measurable that CDM’s and any other “gives” from the developed world can “ask” for in return. As Figure 6 shows, a moderate increase in efficiency sustained over time bears exponential benefits. Such an approach is a significantly easier and more politically palatable “give” for the developing world – it does not ask them to slow their growth (as a hard carbon emissions cap might), but rather to improve the efficiency of their growth. From a fairness standpoint, it does not unduly punish nations (like the Eritrea example cited previously) that are not achieving stratospheric levels of growth, but rather aligns incentives - efficiency and growth become common goals. With the developed nations working towards this goal themselves, and the developing nations incentivized to do the same through the mechanisms discussed, we would have a clear pathway towards meeting GHG emissions targets worldwide.

Figure 6: Scale of Emissions Productivity Required<sup>15</sup>

**REDUCING EMISSIONS AND MAINTAINING GROWTH IMPLIES CARBON PRODUCTIVITY MUST INCREASE BY TEN TIMES**



Accepting the postulate that increasing carbon efficiency is the key, the next question is as to where and how the developing nations can work towards this goal and how the CDM mechanism can be used to guide it. Looking back, we’ve noted that access to cheap capital (and lower financing costs) is vital; in fact, perhaps the most critical tool in developing a lower carbon GDP economy is the cost of

<sup>14</sup> McKinsey Global Institute, June 2008 – projection through 2037 from Global Insight, extrapolated to 2050

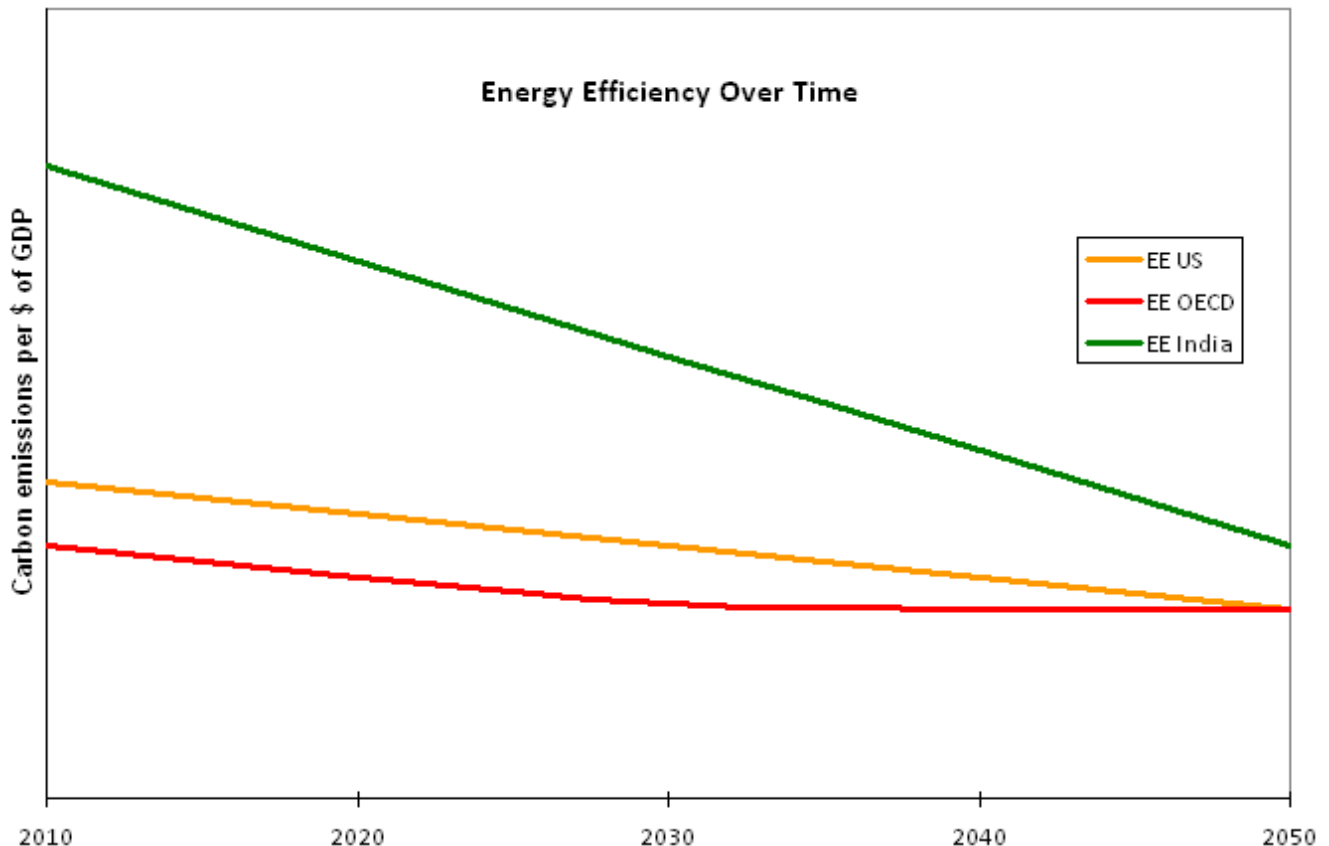
<sup>15</sup> McKinsey Global Institute, June 2008

## DRAFT

capital since the amortized cost of energy or an energy producing service (like cost per mile driven for transportation) often depends materially on the cost of capital. Paying an additional fee up front (for solar power capital costs or an electric car) can realize significant fossil fuel savings over time; the effective cost of a Killo watt-hour or for a mile driven depends materially on the cost of capital (a point that has been made previously by others). One approach towards lowering this cost of capital for developing nations may be leveraging the relatively low-interest sovereign loans granted to developing nations to apply towards the capital costs of low-carbon power generation (be it electricity or biofuels) – essentially utilizing the cheaper access to capital of a developed nation to develop lower-cost energy in the developing world. For example it has been estimated that the cost of solar thermal power in 2013 would drop from \$0.169/KWh to \$0.136/KWh if the cost of capital dropped from 8% to 3%, a rate not uncommon in sovereign lending. Alternatively, institutions like the World Bank or the IMF could become facilitators of the move to low carbon GDP growth in the developing world. One could even demand that under the CDM, the developing world (for projects that depend on these lower cost “low carbon” loans) utilizes the best available low carbon technology that can be economically justified. Recognizing that technology is rapidly expanding the art of the possible and the technologies we are likely to use in 2030 have probably not been invented or potentially even thought of today makes this an even more attractive proposition. Accepting these low carbon loans becomes voluntary for the developing countries based of the condition the loan-providing institution (like the IMF, World Bank, or Asian Development Bank) sets.

How might efficiency improve? Figure 7 (for illustrative purposes) shows the gains in efficiency over time from the perspective of the US, the OECD, and India –with more rapid improvement to come from countries (like India and China) where relatively easy marginal gains can be had.

Figure 7: Hypothetical Scenario of Energy Efficiency Improvements Required



## DRAFT

If the world economic growth increased beyond 3%, the world “need” for carbon efficiency improvements would increase but that increase would apply equally to all countries without major new negotiations (again, going back to a dynamic response capability). Ideally, we would still keep the other constraints like caps on total carbon emissions in the developed world so all Annex 1 countries accept the constraints of an agreed upon reduction (many scientists recommend at least a 75% reduction) from 1990 levels by 2050 and hopefully add 2020 targets to ensure that we are on course to meet our 2050 targets. It would also behoove us to require that the “non-Annex 1” countries do not exceed the average per capita carbon emissions of the Annex 1 or OECD countries (as offered by India already) and remain below the hopefully declining per capita emissions of the developed countries. “Fair” is clearly in the eye of the beholder, but this approach comes as close as possible using a definition of fairness that is likely to appeal to a majority of the world’s population. A carbon efficiency of GDP “improvement” materially (but not perfectly) uncouples the requirement for carbon reductions from GDP per capita and GDP growth rates. This is critical to the politics of the developing world, and an important first step but it may not be enough by itself. For selected global industries, additional constraints such as sector specific caps may be needed to make the system politically acceptable in the developed world (Stern notes steel and cement as possibilities<sup>16</sup>). Political realities in the West will forestall the adoption of policies that cause widespread employment losses, especially if the jobs in question are outsourced to the developing world - the sector-based approach offers an alternative by encouraging innovation across the spectrum, instead of encouraging industry to find the country that is most willing to turn a blind-eye to the pollution.

Any such overarching global cap-and-trade scheme will not be easy, either from a political perspective or an economic one. In Tom Friedman’s words: “We’re having a Green Party, not a Green Revolution.”<sup>17</sup> In a revolution there are dislocations, there are winners and losers and people and institutions get hurt. It is complicated further by the basic drive of the capitalistic system to economic efficiency. But in fact, this very drive can be turned on its head and the capitalist system can be used to achieve the goals of a carbon constrained world more efficiently. Many aspects of this will not be appealing to the environmental community - they have been key in identifying and alerting the world to this potentially catastrophic problem, but has also been a source of non-pragmatic solutions. Economics, not environmental whims must drive global solutions – given the scale of capital needed, public funding is not enough and attracting private capital (motivated by profit as opposed to “social goodwill”) is key. We must be pragmatic. For example, for every nuclear plant the community “stopped” it is likely that the plant was replaced with an even environmentally dirtier coal power plant. The environmentalists may be responsible for causing more coal plants to be built and carbon emissions to increase than the power industry (nuclear energy has close to zero carbon emissions)! Today, we must again be wary of uneconomic solutions to significant problems, such as the idea of parallel hybrids as a large scale solution (A recent McKinsey report noted that hybrids have a carbon abatement cost of approximately \$90 per ton<sup>18</sup>, making it the most expensive of any other large-scale solution). Are hybrids or some other low-carbon transportation technology likely to be adopted in 50-80% of the next billion cars we ship on this planet? Economics will be the determining factor. In

---

<sup>16</sup> Stern et al

<sup>17</sup> “Hot, Flat, and Crowded: Why We Need a Green Revolution--and How It Can Renew America”, Thomas Friedman

<sup>18</sup> Reducing U.S Greenhouse Gas Emissions: How Much at What Cost?”, McKinsey, December 2007

## DRAFT

a world with limited investment dollars, the case for green tech has to make economic and environmental sense, and “adoption risk” (including, but not limited to consumer preferences) must be low.

There is another source of carbon emissions that must be included in a “fair” compromise – deforestation. We must have a carrot and stick approach, rewarding a reduction in deforestation with carbon credits that have at least equal economic value to the land holders, and penalizing countries that don't achieve deforestation targets. Ideally, under a regime like WTO, in addition to the carbon incentives to preserve forests, we might prohibit agricultural exports, or at least biofuels exports, from countries that don't meet deforestation reduction targets.

Fundamentally, technology is in the business of “expanding the art of the possible” – making what was perceived as impossible into the possible, and further making the possible probable. Sir Arthur C. Clarke noted that “Every revolutionary idea seems to evoke three stages of reaction. They may be summed up by the phrases: 1) It's completely impossible. 2) It's possible, but it's not worth doing. 3) I said it was a good idea all along.” When evaluating the ability of a technology to make the “Black Swan” impact, we utilize the following rules:

- Attack manageable but material problems
- Technologies that can achieve unsubsidized market competitiveness quickly
- Technologies that scale - If it isn't cheaper it doesn't scale
- Technologies that have manageable startup costs and short innovation cycles
- Technologies that have declining cost with scale – cost and technology trajectory matters

As highlighted earlier, we believe the focus should be on encouraging innovative, out of the box solutions – finding the technology and economic “Black Swans ” that are potentially available (and will continue to be), even if they are not always recognized immediately.

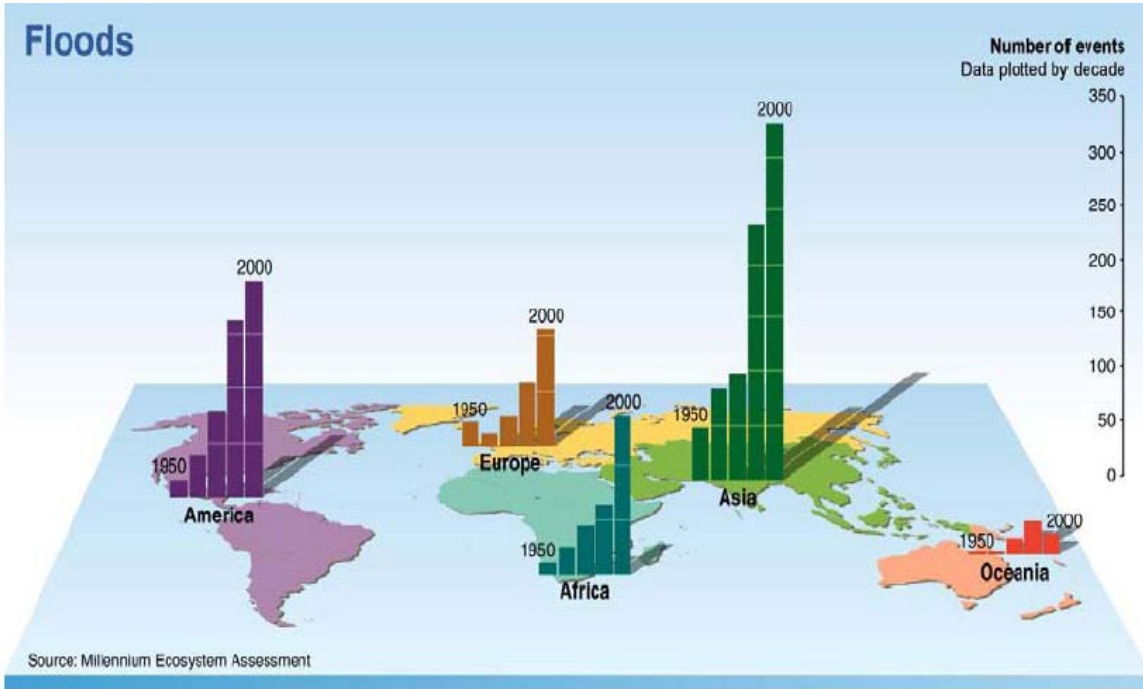
But as Tom Friedman said, it will not be easy. We spend 2.5% of world gross product on defense and countries like the USA spend as much as 5% of GDP on defense. Avoiding the catastrophic consequences of climate change and (re)creating a low carbon world will not be free though estimates<sup>19</sup> (The Stern report estimated approximately 1-2% of Gross World Product (GWP); mid-range IPCC estimates are about 0.5-1% of GWP ) suggest it will be lower cost than our “impact weighted” defense costs. With the relatively high probability of catastrophic change and the rapidly rising cost of extreme weather related events (the US GAO noted that “...claims paid on weather-related losses totaled more than \$320 billion between 1980 and 2005...”<sup>20</sup> and that “...climate change may increase losses by altering the frequency or severity of weather-related events...” ) the cost may feel like a bargain if we act in a timely manner. Figure 8 below shows the effect of one specific weather-related event over time.

---

<sup>19</sup> Holdren et al.

<sup>20</sup> <http://www.gao.gov/new.items/d07285.pdf>

Figure 8: Number of Flood Events by Continent and Decade Since 1950



In our opinion, Climate change is a far more critical and potentially more catastrophic problem than national defense, terrorism or nuclear proliferation, even though all those problems are urgent and potentially catastrophic. Some “insurance” costs (much like defense and anti-terrorism costs) are warranted to mitigate the risk of calamitous damage that we face. The implementation of a global mechanism to work towards the reduction of carbon emissions is vital – a working cap-and-trade system offers one such tool towards aligning the interests of a disparate group of countries, industries, and people.