Establishing an Equitable Global Carbon Budget To Prevent Catastrophic Climate Change

by Bruce Hodge

Introduction

Mitigating climate change is a complex task. It will require a concerted cooperative international effort that spans more than a hundred years. Many policymakers have proposed various carbon emission reductions over various time spans. It's difficult to evaluate or compare the various proposals because their impact upon the concentration of atmospheric carbon dioxide is rarely stated explicitly.

This paper proposes two broad international policy objectives which taken together, establish concrete and equitable targets for mitigating climate change. Together they form a framework against which proposals for various countries and timescales can be evaluated.

Peak Carbon Dioxide Concentrations

Effectively mitigating catastrophic climate change will require sharp reductions in the global emissions of carbon dioxide and other greenhouse gases over the next 100 years. The strength and timing of these reductions will in turn determine the peak atmospheric concentrations of these gases. [1]

Several years ago, climate scientists thought that peaking atmospheric carbon dioxide concentrations at 500-550 ppm would avoid the worst impacts of climate change. Recent studies including the Stern review[2] and the Sigma XI/UN report[3] indicate that peaking atmospheric carbon dioxide concentrations at 450 ppm would be a highly desirable target to attain in order to avoid catastrophic climate change.

In the EU, much attention has been focused on limiting the temperature increase to 2ºC above pre-industrial levels. Several recent studies have concluded that we need to peak emissions within the decade at even lower concentrations (e.g. 420 ppm) to avoid dangerous climate change.[4]

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[1] This paper examines carbon dioxide emissions only, although the same approach could be used for the other greenhouse gases.
[2] Stern Review on the economics of climate change (http://tinyurl.com/ye5to7)
[3] UN Foundation and Sigma Xi report: "Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable" (http://www.unfoundation.org/SEG)
[4] "Designing emissions pathways to reduce the risk of dangerous climate change", Institute for Public Policy Research, http://tinyurl.com/2wq27t

Carbon Equity

As has been noted repeatedly, a survey of per-country carbon emission rates[5] around the world reveals gross differences between countries.

The United States is the top emitter of carbon (23% in 2003), closely followed by China (16%), then by Russia (6%). The next 19 countries are above 1% emissions; the remaining 190 countries are all below 1%. Not only is the US the top net emitter, but also ranks highest in emissions per capita among the top ten emitters.

Table 1 - Top 10 Countries Ranked by Carbon Emissions [6]
(as a % of global emissions in 2003)

	GtC/yr [7]	% of global carbon emissions	tC/capita/year [8]
UNITED STATES OF AMERICA	1.58	22.8%	5.43
CHINA (MAINLAND)	1.13	16.3%	0.86
RUSSIAN FEDERATION	0.41	5.9%	2.85
INDIA	0.35	5.0%	0.33
JAPAN	0.34	4.9%	2.64
GERMANY	0.22	3.2%	2.66
CANADA	0.15	2.2%	4.88
UNITED KINGDOM	0.15	2.2%	2.56
REPUBLIC OF KOREA	0.12	1.8%	2.59
ITALY (INCLUDING SAN MARINO)	0.12	1.8%	2.10

Attempts to set reduction goals on a country by country basis have met with varying degrees of success because of heated debate over carbon equity concerns, notably Kyoto[9] and recent G8 talks on climate change[10].

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[5] Carbon emissions in this paper refer to the emissions from the combustion of carbon-based fuels and from the manufacture of cement.
[6] National Carbon Dioxide Information Analysis Center (CDIAC) (http://cdiac.esd.ornl.gov)
[7] GtC = Gigatonne carbon = 1 billion metric tons of carbon = ~3.66 billion metric tons of carbon dioxide
[8] tC = tonne carbon = 1 metric ton of carbon = ~3.66 metric tons of carbon dioxide
[9] Kyoto Protocol, Dec. 1997 (http://ec.europa.eu/environment/climat/kyoto.htm)
[10] "U.S. odd man out in climate consensus", 17-Mar-2007 (http://news.yahoo.com/s/nm/20070317/ts_nm/group_dc_2)

Policy Recommendations

This paper proposes two broad international policy recommendations:

- ***Set a target for the peak of atmospheric carbon dioxide concentrations at 420 ppm (or alternatively peaking at a 2ºC average global temperature increase over pre-industrial average temperature)***

- ***Set a target of achieving uniform per capita carbon emissions – each global citizen is entitled to emit the same amount–by the end of 50 years.***

Together, these two targets would allow planners to implement and track carbon reduction strategies over an extended period, with the understanding that all countries are marching towards a common, shared goal with a known outcome. Diplomatic efforts may create special cases for certain countries and perhaps allow for trading of carbon offsets.

In practice, there will be a range of carbon emissions among individuals in each country. The per-capita target allows each country to calculate it's allowable emissions and makes allowances for population growth. Countries that are already below the per-capita target are allowed to grow their per-capita emissions up to the target. Care must be taken in those cases to level off the growth in per-capita emissions, since the next 50-year period will have an even lower per-capita target.

Finally, it's not necessary for all countries to agree on the target before action is taken. Particularly if the United States unilaterally announced it's intent to achieve carbon equity in 50 years – it would send a powerful signal to the rest of the world. That would make it more likely that both China and India–the two other big players over the next 50 years–would agree to similar or identical equity goals.

This is not a new idea - a very similar approach was first proposed in 1990 by Aubrey Meyer of London's Global Commons Institute, and given the term "*Contraction and Convergence*" - C&C for short[11]. Since then, other proposals designed to overcome some of the limitations of C&C have been put forth: notably "*Greenhouse Development Rights*" by Paul Baer, *et al.* of the organization *EcoEquity*[12].

The *Greenhouse Development Rights* framework is more sophisticated than either C&C or the approach described in this paper, and argues convincingly for increased equity for developing countries.

Impacts of Implementing the Policy Recommendations

Once a target has been set, it is possible to work backwards and determine the amount of carbon that can be emitted over the next 50 years. There are many possible emission trajectories. For illustrative purposes, let us select one that appears reasonable and feasible. Today, global industrial carbon emission rates are almost 8 GtC/year and land

[11] http://www.gci.org.uk/
[12] http://www.ecoequity.org/GDRs/GDRs_Nairobi.pdf

use emissions are about 1.5 GtC/year. Roughly speaking if we can peak by around 2010 and drop total emissions (including land-use) to around 2 GtC/year by 2050, then atmospheric carbon dioxide concentrations will peak at about 420 ppm. [13] That allows each person to emit about 0.22 tC/year, assuming a global population of about 9 billion in 2053 and absolute carbon equity.[14]

Given the 0.22 tC/capita/year target, and by combining per country emissions data from CIDAC and projected per country population data from the UN[15], it is possible to compute the target carbon emissions per year (GtC/year) for each country in Year 50.

Table 2 shows the top 10 countries as ranked by their projected average emissions over a 50 year period assuming that their emissions are linearly reduced to 022 tC/capita/year. Chart A shows the per capita emissions trajectories for these countries.

Table 2 - Countries Ranked by Average Carbon Emissions over the Next 50 Years[16]
(as a % of global emissions)

	Projected % reduction of current emission rate by Year 50	Projected GtC/yr in Year 50	Projected % of global emissions (50 year average)	Projected Total GtC over 50 year period	Projected % of global emissions in Year 50
UNITED STATES OF AMERICA	94%	0.09	18.7%	41.70	4.4%
CHINA (MAINLAND)	73%	0.31	16.1%	36.01	15.4%
INDIA	-2%	0.35	7.8%	17.54	17.6%
RUSSIAN FEDERATION	94%	0.02	4.8%	10.81	1.2%
JAPAN	93%	0.02	4.0%	9.03	1.2%
GERMANY	92%	0.02	2.7%	5.93	0.9%
UNITED KINGDOM	90%	0.01	1.9%	4.18	0.7%
CANADA	94%	0.01	1.8%	4.10	0.5%
MEXICO	73%	0.03	1.6%	3.61	1.5%
INDONESIA	21%	0.06	1.6%	3.59	3.1%

[13] Note that these calculations make some assumptions about the global carbon sinks (both terrestrial and oceanic) over the next 50 years. Currently, the sinks are absorbing about 4 GtC/year.
[14] The latest UN data (2007) are now projecting a global population of 9.1 billion in 2050. This paper uses 2004 data showing ~9 billion.
[15] 2004 UN data: http://www.un.org/esa/population/publications/WPP2004/POP-R2004-DATA_Web.xls
[16] Based on CDIAC data and UN projected population data. Year 1 of the 50-year period is 2003 because the latest CDIAC dataset is from 2003. Assumes a linear per country ramp to 0.22 tC/capita/year by Year 50.

Despite a 94% reduction in emissions, the United States would still emit more than any other country over the next 50 years, with China a close second. India's 50-year emissions would be roughly 40% of US emissions. Thus, if all countries commit and hold to a per-capita equity goal, the impact of US emissions will not be overshadowed by the emissions from China and India.

India would maintain its current emissions per capita, but would increase its total emissions due to projected population growth.

Policy recommendations such as Al Gore's call for 90% reductions in U.S. emissions by 2050 can be placed within the proposed framework. In broad brushstrokes, we can say that if other countries match the target per-capita emissions of the U.S., then globally we're on track to peak carbon emissions at 420 ppm.

A 90+% reduction may seem like an insurmountable goal; however a recent study researched mainly by scientists from the US National Renewable Energy Laboratory and published by the American Solar Energy Society[17] conservatively estimates that we can achieve a 70% reduction by vastly improved energy efficiency and ramping up renewable energy sources.

Carbon Emissions in 50 Years

At the end of the 50 year period, both China and India will have roughly equal emissions and account for a third of global emissions for that year. See Table 3. Note that the ranking is equivalent to a ranking based on population alone. Chart B shows the emissions trajectory for each of these countries.

Table 3 - Countries Ranked by Carbon Emissions[18]
(as a % of global emissions in 2053)

	GtC/yr	% of global carbon emissions
INDIA	0.35	17.6%
CHINA (MAINLAND)	0.31	15.4%
UNITED STATES OF AMERICA	0.09	4.4%
PAKISTAN	0.07	3.4%
INDONESIA	0.06	3.1%
NIGERIA	0.06	2.9%
BRAZIL	0.06	2.8%
BANGLADESH	0.05	2.7%
ZAIRE	0.04	2.0%
ETHIOPIA	0.04	1.9%

[17] ASES Report "Tackling Climate Change in the U.S.": http://www.ases.org/climatechange

[18] Based on CDIAC data and UN projected population data. Year 1 of the 50-year period is 2003 because the latest CDIAC dataset is from 2003. Assumes a linear per country ramp to 0.22 tC/capita/year by Year 50.

The second half of this century will challenge all countries to lower the per capita emissions even further below the 0.22 tC/capita/year goal to achieve a peak at about 420 ppm of atmospheric carbon dioxide. Chart C shows the projected carbon dioxide concentrations for this scenario.

Conclusion

In summary, this paper advocates establishing an international goal of achieving a peak of 420-ppm atmospheric carbon dioxide concentrations, and setting a goal of achieving uniform per capita carbon emissions – each global citizen is entitled to emit the same amount – by the end of 50 years. Establishing international consensus on both of these goals will provide a framework for carbon emissions policy–a roadmap of where we need to go and a means of measuring our progress towards achieving significant carbon reductions.

Chart A – Projected Per Capita Carbon Emissions by Country (0.22 tC/capita/year in 2053)

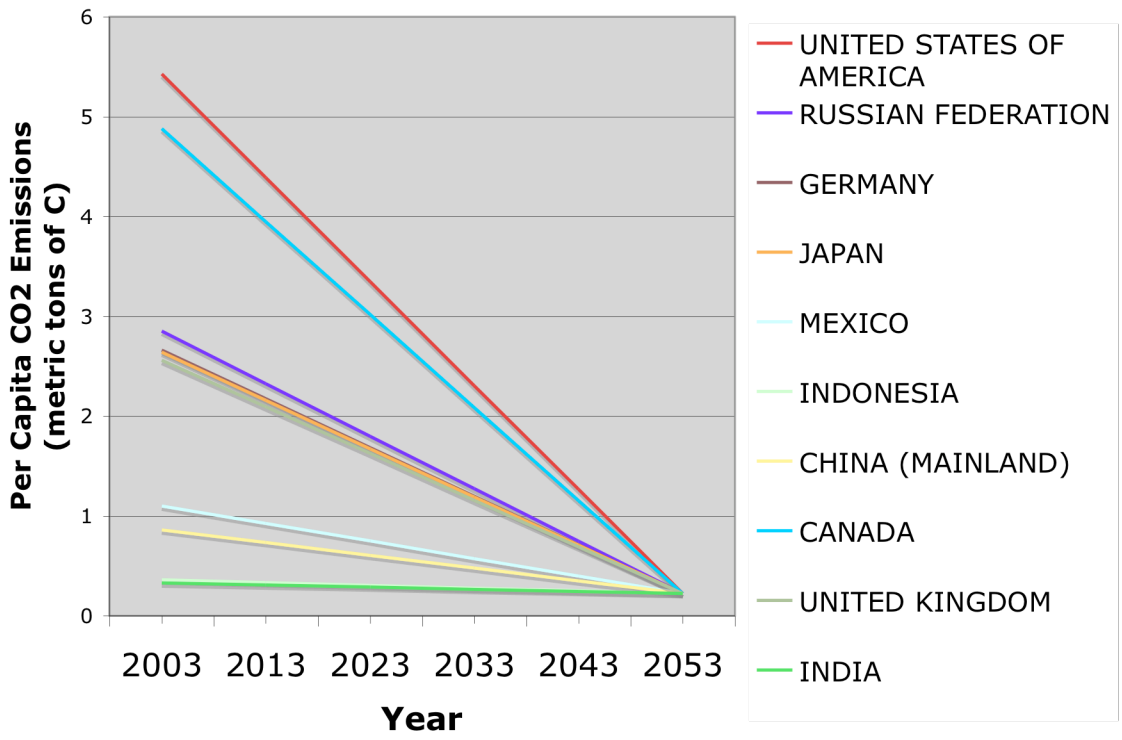

Chart B – Projected Emissions by Country

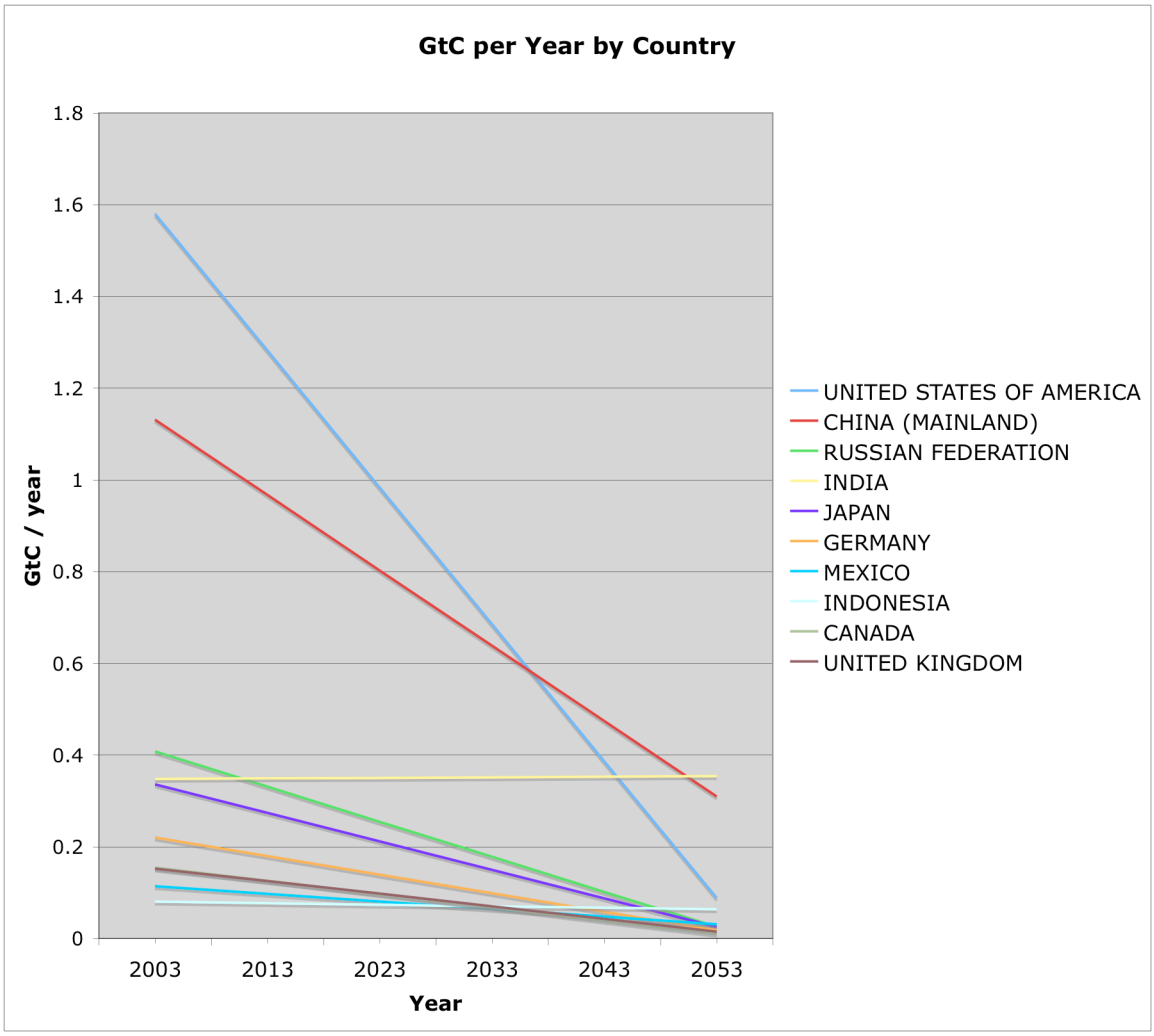

Chart C – Projected Atmospheric CO2 Concentrations (0.22 tC/capita in 2053)

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