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Greenhouse Gases and Economic Development: An Empirical Approach to Defining Goals

John Blodgett and Larry Parker, Resources, Science, and Industry Division

February 4, 2005

Abstract. This analysis identifies those nations that have combined the highest per capita GDPs with the lowest intensities of greenhouse gas emissions. Taking those nations as exemplars, it then examines possible outcomes from pursuing competing goals economic growth and development versus constraining greenhouse gases that are confounding efforts, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, to address global climate change.

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Summary

This analysis identifies those nations that have combined the highest per capita GDPs with the lowest intensities of greenhouse gas emissions. Taking those nations as exemplars, it then examines possible outcomes from pursuing competing goals — economic growth and development versus constraining greenhouse gases — that are confounding efforts, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, to address global climate change.

Eight nations — Austria, France, Italy, Iceland, Luxembourg, Norway, Sweden, and Switzerland — combine high per capita GDP (among the top-20 nations) with the lowest intensity of greenhouse gas emissions of all nations (between 107 and 70 tons per million $ GDP). Taking the lower level of their per capita GDP ($23,500) and an intensity of 100, this analysis examines the greenhouse gas emission implications of a world achieving those levels of economic activity and greenhouse gas intensity.

The relationship of population, economic growth, and emissions is defined by:

(population) x (per capita GDP) x (intensity) = emissions

This relationship can be applied globally, to individual nations, or to groups of nations. One can calculate the implications of different population levels, different economic development levels, different emissions targets, etc. Obviously if population rises, emissions will rise unless per capita GDP and/or intensity decrease enough to offset the rise; likewise, if per capita GDP rises, emissions will rise unless intensity (and/or population) decrease enough to offset it.

With the formula, one could test numerous variations; this analysis focuses on the one empirically-based set, a global per capita GDP of $23,500, an intensity of 100, and the 2000 world population of 6 billion. With those assumptions, greenhouse gas emissions would be 14.1 billion tons per year, about 55% more than the 9.1 billion tons actually emitted in 2000.

Whether global greenhouse gas emissions of 14.1 billion tons per year (or more as population increases) would pose a threat of global warming sufficient to justify impeding that economic development and/or stimulating even more aggressive action to improve greenhouse gas intensity awaits growing scientific understanding and the decisions of world leaders — and the manifestation of events.

For some, the finding that one can construct an empirically based approach that achieves a standard of living for 6 billion people equal to several European nations while not increasing global greenhouse gas emissions by more than about 55% will be optimistic. For others, the emissions level may appear unacceptable — implying either constraints on economic growth or even more aggressive improvements in intensity. For still others, any worry about greenhouse gas emissions is misdirected.

This report will not be updated.

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Greenhouse Gases and Economic Development: An Empirical Approach to Defining Goals

Introduction

Long-term international efforts to address future global climate change have had to struggle with significant country and region-specific differences in possible policy responses related to differing economic, technical, and political circumstances. Foremost among these regional differences is the divide between developed and less-developed nations in terms of contributions to current and future annual greenhouse gas emissions and the related possible global climate change.

How to treat in a fair way the implications of significantly different material standards of living between developed and developing countries is a key conflict arising in international negotiations to slow the growth of, or even to reduce, future global greenhouse gas emissions. The conflict arises because any pressure to reduce emissions comes up against the increases in emissions likely to result from economic development and rising standards of living in developing economies — which contain a large share of the world's population.

This report explores what future world economic growth and development means for proposals to constrain total annual global greenhouse gas emissions. This analytical exercise uses international data for the three country-specific variables that will determine future annual greenhouse gas emissions: population, per capita gross domestic product (GDP), and greenhouse gas emissions per million dollars of GDP (intensity).

The analysis presents scenarios showing what levels of greenhouse gas emissions would be if the world population was at a benchmark per capita GDP comparable to several European nations that currently have the lowest greenhouse gas emissions per million dollars of GDP among all developed nations. The paper analyzes a benchmark based on the interactions of economic activity, population, and greenhouse gas-emitting activities exemplified by the selected nations, but does not deal with the time involved to transition to the higher level of development. The empirically-derived benchmark is an analytical construct designed to illustrate the dynamics involved in designing global greenhouse gas emissions goals; the report does not present a set of projections or predictions.

Background

The current international approach to controlling greenhouse gas emissions, as contained in the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, is to limit emissions of designated, developed nations (listed in an Annex I) relative to a baseline of 1990. For the UNFCCC, the target was for Annex I nations voluntarily to return emissions to 1990 levels; there was no penalty for failure. For the Kyoto Protocol, which amends the UNFCCC, the target is for Annex I nations to hold 2008-2012 emissions to a specified percentage of the 1990 baseline; sanctions for failure have not yet been defined.

This approach has a two-fold logic: (1) the Annex I nations, having achieved development and having contributed the most to cumulative greenhouse gas emissions, are generally considered rich enough to make investments in controlling greenhouse gases; and (2) the Annex II nations, undergoing development, are exempted from greenhouse gas emission limits so as not to constrain their opportunities to expand activities that may be essential to their economic growth. The success of this approach is problematic. Except for the former Soviet bloc countries, the UNFCCC voluntary targets generally were not achieved.[1] Likewise, many signatories to the Kyoto Protocol are anticipated not to meet their targets; and further, the world's largest emitter of greenhouse gases, the United States, has refused to join. Finally, this approach, even if valid as a first step, could have little long-term effect on cumulative emissions, since it lacks long-term limits for any nation; and leaving developing nations free to develop without greenhouse gas limits likely means that their emissions will, at some time in the future, exceed any diminution of emissions from developed nations.

To illustrate, if one were to assume that in 2000 all nations equaled the United States in per capita economic activity, then the global GDP would have been about $204 trillion; at the U.S. greenhouse gas intensity[2] of 195, then global emissions would have been nearly 40 billion tons of carbon equivalents per year, compared to actual emissions of about 9.1 billion tons in 2000.

So, are the twin objectives of holding down greenhouse gas emissions and of fostering economic growth compatible? Can one visualize a world in which all peoples achieve a comfortable standard of living without greenhouse gas emissions causing unacceptable global warming?

Two alternative views of the situation avoid the conflict analyzed in this report. First, the apparent conflict in objectives can be mooted if one concludes that greenhouse gases do not cause global warming. For those who hold this position, growth can proceed without concern for emissions. Second, the apparent conflict might also be mooted if one concludes that economic activity can be delinked from fossil fuel energy use within an acceptable time period. For those who believe that many opportunities exist to save energy at little or no cost with appropriate technical fixes, the conflict can be avoided — at least for some time — and economic development can proceed without increasing emissions rates (and other societal benefits can also be achieved, such as reduced air pollution).

[1] Following the breakup of the former Soviet Union, various Eastern European and former Soviet republics' economies contracted in the 1990s, such that their emissions declined between 1990 and 2000.

[2] Emissions (tons) divided by economic activity (GDP); see discussion below.

Analytical Approach

Identifying Benchmark Countries. Given concerns about greenhouse gas emissions and the risk of global warming on the one hand, and the desire for and impetus of economic growth on the other, the challenge of finding a way to merge the objectives persists. The approach of this report is to identify nations that have best combined economic growth and low greenhouse gas emissions. Their accomplishment becomes a benchmark for examining implications for greenhouse gas emissions if all nations equaled their achievements in balancing economic activity and greenhouse gas emissions.

This study compares a hypothetical world of economic activity and greenhouse gas emissions based on the benchmarks to the actual situation in 2000. The report does not explore whether all nations could in fact achieve the benchmarks, nor deal with technological or other changes that might be relevant.

Table 1 presents data[3] on per capita national GDP,[4] per capita emissions,[5] and intensity[6] for the 20 highest GDP nations. Intensities range from 70 (Switzerland) to 277 (Australia). Eight of the top-20 per capita GDP nations achieve greenhouse intensities below 110. No other developed nation in the data bank achieves an intensity of 110 or lower.[7] These eight thus become the focus for defining a benchmark conjoining economic growth and emission goals.

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[3] The analysis in this report is based on the Climate Analysis Indicators Tool (CAIT) created by the World Resources Institute. The database uses a variety of data sources to provide information on greenhouse gas emissions and other relevant indicators. Full documentation, along with caveats, is provided on the WRI website at [http://cait.wri.org/].

The database includes 186 nations with a 2000 population of 6.032 billion. This compares to 191 members of the United Nations, and to a 2000 world population count of 6.080 billion by the U.S. Census Bureau, [http://www.census.gov/ipc/www/worldpop.html].

See also CRS Report RL32721, *Greenhouse Gas Emissions: Conflicting Situations, Conflicting Perspectives*, by Larry Parker and John Blodgett; and Kevin Baumert and Jonathon Pershing, *Climate Data: Insights and Observations* (World Resources Institute: Prepared for the Pew Center on Global Climate Change, December 2004).

[4] CAIT uses international $ of purchasing power parity (PPP).

[5] The six greenhouse gases measured are carbon dioxide, nitrous oxide, methane, perfluorocarbons, hydrofluorocarbons, and sulfur hexafluoride. Emissions data are typically given in millions of metric tons of carbon equivalents (MMTCE). Absolute figures are emissions per year (globally, 9,125.9 MMTCE or 9.1 billion tons). In the text, unless otherwise explicitly stated, “tons” of emissions means “metric tons of carbon equivalents.”

[6] Unless otherwise noted, throughout this analysis intensity is defined as (metric) tons of total greenhouse gases in carbon equivalents (CE) divided by GDP; in CAIT, intensity is defined as (metric) tons of carbon from energy use and cement manufacture divided by GDP.

[7] A number of the world’s very poorest nations have very low emissions and intensities.

Table 1. Greenhouse Gas Intensity of 20 Highest Per Capita GDP Nations (2000)

	Per Capita GDP ($ PPP)	Per Capita Emissions (Tons)	Intensity (Tons/million$GDP)
Switzerland	$ 27,780	1.9	70
Sweden	$ 23,650	2.0	83
France	$ 23,490	2.3	99
Austria	$ 26,420	2.6	99
Iceland	$ 28,910	2.7	99
Italy	$ 24,280	2.5	104
Norway	$ 29,200	3.1	105
Luxembourg	$ 53,410	5.7	107
Japan	$ 25,280	2.9	114
Denmark	$ 28,680	3.4	120
Germany	$ 25,100	3.3	128
United Kingdom	$ 23,580	3.2	130
Netherlands	$ 26,910	3.7	139
Finland	$ 24,160	3.6	150
Ireland	$ 30,380	4.8	156
Belgium	$ 25,220	4.0	159
Singapore	$ 23,700	4.4	184
United States	$ 33,960	6.6	195
Canada	$ 26,840	6.3	236
Australia	$ 24,550	6.8	277

Source: World Resource Institute; CAIT; CRS calculations.

Defining the Relationship of the Goals. For this analysis, the relationships of population, economic activity, and emissions are expressed by the following formula:

$$(Population) \times (percapitaGDP) \times (Intensity) = Emissions$$

[Equation 1]

GDP data are presented on a per capita basis to provide comparability across nations or categories of nations.

The implication for the two goals of economic growth and of constrained emissions is clear: if economies grow and population is stable or rises, emissions will rise unless intensity decreases enough to offset the rise. Thus intensity becomes a focus of analysis. Factors affecting intensity include amounts of and technologies involved in fossil fuel use (combustion of fossil fuels releases carbon dioxide, the dominant greenhouse gas); agricultural practices (livestock release methane and nitrogen fertilizers release nitrous oxide, both also greenhouse gases); and the production, use, and release of certain chemicals (including hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride). (In addition, certain land use practices affect greenhouse gases — e.g., forest growth can sequester carbon and deforestation can release it.)[8]

Defining an Economic Benchmark

As shown by **Table 1**, eight nations combined a greenhouse gas intensity of less than 110 tons per million dollars GDP with per capita GDPs of $23,490 or better. While six of the eight are relatively small (in terms of both geography and total GDP), the other two, Italy and France, are among the top 15 nations in terms of both size of total economy and amount of greenhouse gases emitted. This shows that substantial economies can rank low in greenhouse gas intensity and that such efficiency is not restricted to only small countries/economies. From the perspective of global economic development, a benchmark of a per capita GDP of $23,500 — at the low end of the eight, falling between France and Sweden — could be taken as a reasonable starting point for analysis.

With $23,500 as the parity GDP benchmark, the world's nations can be categorized into three groups: a "Parity Income Group" defined as nations with per capita GDPs of $23,500 plus or minus 10% ($21,150 - $25,850), an "Above-Parity GDP" group with GDPs greater than $25,850, and a "Below-Parity GDP" group with GDPs lower than $21,150 (see **Table 2**). Appendices A, B, and C provide additional data on these nations.

This parity benchmark of $23,500 is more than triple the actual world per capita GDP of $7,333 in 2000, and is more than 5.5 times the "Below-Parity GDP" nations' per capita GDP of $4,120 in 2000.

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[8] Land use effects on greenhouse gases are *not* accounted for in this analysis; the data tend to be highly uncertain. Including it would not substantively affect most countries' intensity (but Brazil and Indonesia would be; see CRS Report RL32721, cited in footnote 3.)

Table 2. Nations Categorized by a Parity Per Capita GDP of $23,500 in the Year 2000

"Above-Parity GDP" Nations, 2000 per capita GDP > $25,850	"Parity-GDP" Nations, 2000 per capita GDP $23,500 ± 10% ($25,850 - $21,150)	"Below-Parity GDP" Nations, 2000 per capita GDP < $21,150
Austria Canada Denmark Iceland Ireland Luxembourg Netherlands Norway Switzerland United States	Australia Belgium Finland France Germany Italy Japan Singapore Sweden United Arab Emirates United Kingdom	*All other nations*, e.g., Argentina Brazil China India Indonesia Iran Korea (South) Mexico Pakistan Poland Russian Federation Thailand Turkey Ukraine Uzbekistan

Source: World Resource Institute; CAIT; CRS calculations.

Table 3 presents the shares of world population, GDP, and greenhouse gas emissions by each of the three parity-defined groups of nations. It also shows average per capita emissions and intensity for the three groups; for details on individual nations, see Appendices A, B, and C. Obviously, most of the world's population (87%) lives in "Below-Parity GDP" nations, sharing about half the GDP (49%) and emitting over half (60%) of the greenhouse gases. The "Below-Parity GDP" nations tend to be low per capita emitters, but relatively high intensity emitters. The "Above-Parity GDP" and "Parity-GDP" nations include just 13% of the world's population but account for about half the GDP (51%) and produce 40% of the emissions; and, with some significant exceptions, have relatively high per capita emissions. Also, while the "Above-Parity GDP" and "Parity-GDP" nations include low intensity emitters, these categories also include some quite high intensity emitters.

It should be noted that the United States dominates the figures in the "Above-Parity GDP" category (see Appendix A). Of that category, the United States accounts for 79% of the population, 82% of the GDP and 85% of the emissions.

Table 3. Shares of GDP and Greenhouse Gas Emissions by Parity-Defined Category (2000)

	Share of Global Population	Share of Global GDP	Share of Global Greenhouse Gas Emissions	Per Capita Emissions (Tons)	Intensity (Tons/ million$ GDP)
"Above-Parity GDP" Nations	6.0%	26.8%	24.5%	6.2	190
"Parity-GDP" Nations	7.2%	24.2%	14.8%	3.1	126
"Below-Parity GDP" Nations	86.8%	49.0%	60.8%	1.1	257

Source: World Resource Institute; CAIT; CRS calculations.

Defining a Greenhouse Gas Emissions Benchmark

The UNFCCC and Kyoto Protocol define the emissions goal in terms of specific nations' emissions compared to an historic baseline. Per capita emissions and greenhouse gas intensity (emissions per unit of economic activity) have also been discussed as metrics for defining emissions goals.[9] In this analysis, we look at empirical benchmarks to define what appear to be currently feasible targets. In 2000, Sweden and France combined intensities below 100 with per capita GDPs near $23,500; they achieved per capita rates of emissions of 2.0 and 2.3 tons, respectively (see **Table 1**). If these per capita rates were combined with the parity GDP as a global target, what would the emissions implications be?

Per Capita Emissions. If annual per capita emissions ranged from 2.0 to 2.3 tons then the 2000 global population of 6 billion[10] would have emitted 12 to 13.8 billion tons of greenhouse gases, or about a third more than actually were emitted. However, the distribution of emissions would be dramatically different: the United States' emissions would be about 70% less than actually emitted in 2000, while China's emissions would be about 80% greater, making it the world's largest emitter. Appendices A and B indicate that all "Above-Parity GDP" and "Parity" nations

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[9] For an overview of different approaches, see Daniel Bodansky, *International Climate Efforts beyond 2012: A Survey of Approaches*, (Pew Center on Global Climate Change, December 2004).

[10] Throughout this report we round the 2000 population to 6.0 billion, since it is being used in conjunction with emissions data that are rounded because of estimates and uncertainties. Rounding may result in minor discrepancies in figures and in totalling.

would emit less under the scenario, except for Switzerland, France, and Sweden. Appendix C indicates that some "Below-Parity GDP" nations would emit less (e.g., South Korea, the Russian Federation, and Ukraine), while others would emit substantially more. **Table 4** lists large emitters (>100 million tons) that emit more than under the scenario of 2.0 - 2.3 tons per capita (left column) and those that emit less (right column).

Table 4. Per Capita Greenhouse Emissions for Selected Nations

Nations, >2.3 Tons Carbon Equivalents per capita and > 100 Million Tons Total	(tons)	Nations, 2.0 - 2.3 Tons Carbon Equivalents per capita	(tons)	Nations, <2.0 Tons Carbon Equivalents per capita and > 100 Million Tons Total	(tons)
Australia	6.8	France*	2.3	Iran	1.9
United States	6.6	Slovakia	2.3	Mexico	1.4
Canada	6.3	Suriname	2.3	Brazil	1.3
Russian Federation	3.6	Hungary	2.2	China	1.1
Germany	3.2	Argentina	2.1	Indonesia	0.7
United Kingdom	3.1	Uruguay	2.1	India	0.5
S. Korea	3.1	Malaysia	2.0		
Ukraine	2.9	Sweden	2.0		
Japan	2.9	Uzbekistan	2.0		
Poland	2.7				
S. Africa	2.6				
Spain	2.6	*Only France emits >100 Million Tons Total			
Italy	2.5				

Source: World Resource Institute; CAIT; CRS calculations.

Greenhouse Gas Intensity. The eight benchmark nations exhibited a range of intensities from 70 to 107 (see **Table 1**). The nation closest to the parity per capita GDP had an intensity of 99 (France), a level also shared by Austria and Iceland. An intensity of 100 would seem a reasonable (and convenient) starting point for analysis.

If each nation achieved a greenhouse gas intensity of 100 tons per million dollars GDP, then at the world's 2000 level of economic activity ($44 trillion), greenhouse gas emissions that year would have been about 4.4 billion tons, or a little less than half actual emissions. As can be seen from Appendices A, B, and C, achieving an intensity of 100 would be a substantial challenge for the vast majority of nations, including nations in each income category.

An analysis of how these few nations have combined high GDP and relatively low intensity of greenhouse gas emissions is beyond the scope of this paper. A few observations may be indicative, however. Over 90% of the gross electricity production of four (France, Norway, Sweden, and Switzerland) comes from greenhouse gas-free hydropower and nuclear facilities.[11] For Iceland, over half (56%)

[11] International Energy Agency, *Electricity Information 2002* (OECD/IEA, 2002).

of its total primary energy supply is geothermal.[12] All eight nations rank among the highest in the world on transportation fuel prices.[13]

Merging Goals: Results

Two scenarios are used to express the results of this analysis. The first, called the Global Parity Scenario, assumes the benchmark parity GDP of $23,500, the benchmark greenhouse gas intensity of 100, and the 2000 world population of 6 billion. The second, called the Parity with Grandfathering Scenario, makes the same assumptions as the Global Parity Scenario, but maintains (grandfathers) higher-than-parity GDPs (and the associated emissions) for those nations whose 2000 per capita GDPs exceeded the benchmark of $23,500. The results are presented below.

Global Parity Scenario. Combining the values of intensity equaling 100 and a $23,500 parity GDP will result in higher emissions: with the higher GDPs of developing nations, emissions will be higher. Thus, if in 2000 the 6 billion inhabitants of the planet each shared per capita GDP of $23,500 (a decline for 19 developed nations (listed in **Table 5**), a substantial increase for much of the rest of the world), then the global economy would have been about $141 trillion and at an intensity of 100 annual greenhouse gas emissions would have been about 14.1 billion tons.[14] This compares to actual 2000 world GDP of $44 trillion and emissions of 9.1 billion tons.

Under this scenario of universal parity of GDP and an intensity of 100, the nations with (by far) the largest changes in emissions are the United States, for whom emissions are 1.22 billion tons less (-64%), India, for whom emissions are 1.88 billion tons more (+372%), and China, for whom emissions are 1.61 billion tons more (+118%). (See the first two numeric columns in **Table 6**.)

[12] Ibid.

[13] See "Diesel & Gasoline Prices in 165 Countries, Global Country Ranking" in [http://www.zietlow.com/docs/Fuel-Prices-2003.pdf] , at pages 58 and 59.

[14] Setting per capita income at $23,500 and carbon intensity at 100 gives per capita emissions of 2.35. At intensity = 100, per capita emissions of 2.0 or 2.3 represent per capita incomes of $20,000 and $23,000, respectively.

Table 5. Total Actual GDP and Parity GDP at $23,500 Per Capita (2000)

	Population (thousands)	Total GDP (million $)	Parity GDP (million $)	Amount of Total Exceeding Parity (million $)
United States	286,303	$ 9,680,850	$ 6,728,121	$ 2,952,730
Japan	126,870	$ 3,207,344	$ 2,981,445	$ 225,899
Germany	82,210	$ 2,063,536	$ 1,931,935	$ 131,601
Canada	30,770	$ 825,745	$ 723,095	$ 102,650
Netherlands	15,919	$ 428,356	$ 374,097	$ 54,260
Italy	57,690	$ 1,400,835	$ 1,355,715	$ 45,120
Switzerland	7,180	$ 199,471	$ 168,730	$ 30,741
Denmark	5,340	$ 153,134	$ 125,490	$ 27,644
Ireland	3,794	$ 115,249	$ 89,159	$ 26,090
Norway	4,491	$ 131,149	$ 105,539	$ 25,611
Austria	8,110	$ 214,240	$ 190,585	$ 23,655
Australia	19,182	$ 470,916	$ 450,777	$ 20,139
Belgium	10,252	$ 258,606	$ 240,922	$ 17,684
Luxembourg	438	$ 23,391	$ 10,293	$ 13,098
United Kingdom	58,720	$ 1,384,896	$ 1,379,920	$ 4,976
Finland	5,172	$ 124,961	$ 121,542	$ 3,419
Iceland	280	$ 8,095	$ 6,580	$ 1,515
Sweden	8,869	$ 209,740	$ 208,422	$ 1,319
Singapore	4,018	$ 95,246	$ 94,423	$ 823
Total	735,608	$ 20,995,760	$ 17,286,788	$ 3,708,972

Source: World Resource Institute; CAIT; CRS calculations.

Parity with "Grandfathering" Scenario. However, it seems highly unlikely that nations with per capita GDPs in 2000 above $23,500 would find a scenario that decreased their GDP levels very appealing. An alternative scenario to strict parity is one that grandfathers any GDP above parity.

Grandfathering changes Equation 1 by an additive factor; it is not a multiplier:

$$(Population_w) \times (percapitaGDP_p) \times (Intensity) + \sum_{n>p} (Population_n) \times [(percapitaGDP_n) - (percapitaGDP_p)] \times (Intensity) = Emissions$$

[Equation 2]

in which $_w$ is world, $_n$ is nation(s), $_p$ is parity, and $_{n>p}$ is nations of greater-than-parity GDP; in this exercise, intensity = 100 throughout

Combining the assumptions of —

- maintaining GDPs above the parity level at their 2000 level,
- all other nations' economies rising to per capita GDPs of $23,500, and
- a greenhouse gas intensity of 100 for all nations,

then emissions would be approximately 14.5 billion tons. This is nearly 60% higher than actual 2000 emissions. (The last column of **Table 5** shows grandfathered GDPs.)

Of the 14.5 billion tons, about 370 million tons would result from the grandfathered nations' extra economic activity. Thus, in this scenario, maintaining GDPs higher than $23,500 adds less than 3% to emissions compared to the scenario with *all* nations having the parity GDP and an intensity of 100. (Note that "grandfathering" above-parity GDPs means that the world per capita GDP ($24,167) is higher than the parity level. This scenario could be called a minimum per capita GDP standard of living of $23,500.)

Of that grandfathered 370 million tons, the United States would emit about 295 million tons, or 80%. However, because the scenario assumes an intensity of 100 (rather than the actual U.S. intensity of 195), the total emissions under the scenario are still 942 million tons less than the United States' 2000 actual emissions of 1,892 million tons.

However, even assuming GDPs above $23,500 are maintained, the emissions could be kept at a base level — say, the 14.1 billion tons at parity — by constructing a scenario in which those nations with higher-than-parity GDPs had greenhouse gas intensities below 100. In this variation, all nations with per capita GDPs of $23,500 would be at an intensity of 100, while those with higher GDPs would have lower intensities such that the calculations of equation 1 produced global greenhouse gas emissions at 14.1 billion tons. This scenario, offsetting the emissions attributable to the amount of GDP grandfathered would particularly affect the United States, which accounts for 80% of the grandfathered GDP.

As **Table 6** shows, Switzerland and Sweden already are offsetting their higher-than-parity GDPs. France, with a per capita GDP just $20 less than parity and an intensity of 99, effectively defines the parity GDP. Austria, Luxembourg, and Iceland have such modest "excess" emissions that they are lost in rounding.

Table 6. Greenhouse Gas Emissions in a World of Parity GDP and Intensity = 100 (Selected Nations)

Nations, (in order of % change in greenhouse gas emissions)	2000 Emissions MMTCE	Parity Emissions @ $23,500 per capita GDP (MMTCE)	Parity Emissions + Grandfath'd GDP >$23,500 per capita (MMTCE)	Difference, 2000 Emissions *versus* Parity + Grandfath'd (MMTCE)	%
India	506	2,387	2,387	1,881	372%
Indonesia	135	485	485	350	259%
China	1,356	2,967	2,967	1,611	119%
Brazil	230	400	400	170	74%
Mexico	139	230	230	91	65%
Switzerland	14	17	20	6	43%
Iran	120	150	150	30	25%
Sweden	17	21	21	4	24%
France	137	138	138	1	1%
Austria	21	19	21	0	0%
Luxembourg	2	1	2	0	0%
Iceland	1	1	1	0	0%
Italy	146	136	140	-6	-4%
Norway	14	11	13	-1	-7%
Spain	104	95	95	-9	-9%
Poland	102	91	91	-11	-11%
South Africa	113	101	101	-12	-11%
Japan	364	298	321	-43	-12%
Denmark	18	12	15	-3	-17%
Ukraine	143	116	116	-27	-19%
Germany	265	193	206	-59	-22%
Korea (South)	143	110	110	-33	-23%

Nations, (in order of % change in greenhouse gas emissions)	2000 Emissions MMTCE	Parity Emissions @ $23,500 per capita GDP (MMTCE)	Parity Emissions + Grandfath'd GDP >$23,500 per capita (MMTCE)	Difference, 2000 Emissions *versus* Parity + Grandfath'd (MMTCE)	%
United Kingdom	181	138	138	-43	-24%
Netherlands	60	37	43	-17	-28%
Ireland	18	9	12	-6	-33%
Russian Fed.	520	342	342	-178	-34%
Belgium	41	24	26	-15	-37%
Finland	19	12	12	-7	-37%
Singapore	18	9	10	-8	-44%
United States	1,892	672	968	-924	-49%
Canada	195	72	83	-112	-57%
Australia	130	45	47	-83	-64%

Source: World Resource Institute; CAIT; CRS calculations.

Implications of Analysis

The relationships of population, economic growth, and emissions as defined by Equation 1,

$$(Population) \times (percapitaGDP) \times (Intensity) = Emissions$$

have been used to evaluate diverse assumptions about each factor. This analytical construct could be applied globally, to individual nations, or to groups of nations. One can calculate the implications of different population levels, different economic development levels, different emissions goals, etc.

For analytic purposes, this report has treated the variables of equation 1 as an illustrative tool, not a prediction of future growth or distribution. The analysis has compared scenarios to the 2000 situation. In reality, economic development is and will be a continuing process, with nations exhibiting differing growth rates depending on starting points, resource endowments, institutional structures, and so on. Any attempt to translate the results and insights of this exercise into an enforceable agreement would extend beyond the issue of appropriate emission targets (in whatever form) to issues of implementation strategy and compliance timetables. Those considerations are beyond the scope of this paper.

However, the implications of differing growth rates could be analyzed by incorporating growth rates into equation 1. This would allow evaluation of policies that affect the rates of growth for the variables.

Incorporating growth, equation 1 becomes:

$$(Population)e^{k_p t} \times (percapitaGDP)e^{k_g t} \times (Intensity)e^{k_i t} = (Emissions)e^{k_e t}$$

[Equation 3]

in which k_p = population growth rate, k_g = per capita growth rate, k_i = intensity growth rate, and k_e = emissions growth rate; t = time, and e = a constant 2.71828 [the base of natural logarithms]

The exponents of multiplicands are added, so

$$(k_p + k_g + k_i) = k_e \qquad \text{[Equation 3a]}$$

If the sum of the three growth rate variables on the left is positive, emissions are rising; if the sum is negative, emissions are declining.

Obviously, if any one of the three variables on the left increases more than the sum of the other two decreases, emissions rise. Since population is rising globally and national and international efforts are fostering the development of "Below-Parity GDP" nations, intensity is the variable of focus for constraining emissions.

Outcomes and Sensitivity to Alternative Values. One could test numerous assumptions; this analysis has focused on one set, a parity GDP of $23,500 (with and without grandfathering), an intensity of 100, and the 2000 world population. **Table 7** summarizes the results, and for illustrative purposes, includes further variations as described below.

Equation 1 shows that even at a global intensity of 100 — which would in 2000 be considered a "best performance standard" — greenhouse gas emissions will be rising in the future as economic activity increases.

- At a population of 6 billion, achieving a parity GDP of $23,500 *and* an intensity of 100, global greenhouse gas emissions would be 14.1 billion tons (+55%).
- With the same assumptions plus grandfathering[15] above-parity 2000 GDPs, emissions would be 14.5 billion tons (+59%).

[15] This is grandfathering only the amount of GDP above parity in 2000 for the population at that time. In fact, "Above-Parity GDP" nations' GDPs will presumably continue to grow over time, and thus the amount that could be grandfathered will grow. This analysis ignores that growth in order to avoid having to project growth. As a result, if future above-parity growth is grandfathered, the analysis *understates* emissions growth. (However, it should be remembered that grandfathering is an add on to emissions, not a multiplier; and in the scenario of parity GDPs with global intensity at 100, grandfathering above-parity GDPs in 2000 increased emissions less than 3%.)

One can also explore the implications of other values for the variables. **Table 7** includes some *illustrative* variations. For example, if one thought that population were going to increase to a level of 9 billion, then:

- At a population of 9 billion, the parity per capita GDP of $23,500 plus grandfathering,[16] and an intensity of 100, emissions would be 21.5 billion tons (+136%).

Or, if one thought that a parity level of $23,500 were too high, one could calculate the implications of a lower level, say an average per capita GDP of $15,000 (slightly more than double the 2000 world average per capita GDP):

- At the 2000 population of 6 billion, an intensity of 100, an average per capita GDP of $15,000 (and ignoring grandfathering), emissions would be 9 billion tons, slightly lower than the 2000 level.
- But at a population of 9 billion, an intensity of 100, and an average per capita GDP of $15,000 (and ignoring grandfathering), emissions would be 13.5 billion tons.

Or, if one thought that a global average intensity of 100 were too aggressive an improvement, one could substitute a higher value, say 150:

- At the population of 6 billion, an intensity of 150, an average per capita GDP of $23,500 (and ignoring grandfathering), emissions would rise to 21.2 billion tons.
- And at a population of 9 billion, an intensity of 150, an average per capita GDP of $23,500 (and ignoring grandfathering), emissions would be 31.7 billion tons.

Finally, one could set a value for total emissions, and solve equation 1 for another of the variables. For example, suppose one "capped" emissions at 150% of current emissions, for a total of 13.7 billion tons. Then —

- At the population of 6 billion and a parity per capita GDP of $23,500, ignoring grandfathering and holding emissions at 13.7 billion tons (50% above 2000 emissions) intensity would be 96.
- And at a population of 9 billion and a parity per capita GDP of $23,500, ignoring grandfathering and holding emissions at 13.7 billion tons (50% above 2000 emissions) intensity would be 65 — a level below the developed world's 2000 intensity leader — Switzerland at 70.

These scenarios are only illustrative. Readers may wish to assign their own values to the variables to explore the implications of their own assumptions.

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[16] The United Nations has projected a population of 8.9 billion for 2050, down from a previous forecast of 9.3 billion. See U.N. Population Division, *World Population Prospects: The 2002 Revision Highlights* (ESA/P/W. 180, 26 February 2003), at [http://www.un.org/esa/population/unpop.htm].

Table 7. Global GDP and Emissions under Various Scenarios

Scenario	Population (billions)	Per Capita GDP (million $)	Total GDP (trillion $)	Per Capita Emissions (tons)	Intensity (tons/ million$ GDP)	Emissions (billion tons/year)
Actual, 2000	6.032	$ 7,333	$ 44	1.5	207	9.1
Parity	6	$ 23,500	$ 141	2.35	100	14.1
Parity w/ grandfather	6	$ 24,167	$ 145	2.4	100	14.5
Ditto + population @ 9 billion	9	$ 23,889	$ 215	2.4	100	21.5
Per capita GDP @ $15,000	6	$ 15,000	$ 90	1.5	100	9.0
Ditto + population @ 9 billion	9	$ 15,000	$ 135	1.5	100	13.5
Intensity @ 150 + parity GDP	6	$ 23,500	$ 141	3.5	150	21.2
Ditto + population @ 9 billion	9	$ 23,500	$ 211.5	3.5	150	31.7
Parity GDP + emissions @ 150% of 2000 actual	6	$ 23,500	$ 141	2.3	97	13.7
Ditto + population @ 9 billion	9	$ 23,500	$ 211.5	1.5	65	13.7

Source: World Resource Institute; CAIT; CRS calculations.
Note: Rounding may cause minor discrepancies.

(Note in **Table 7** that average global per capita GDP rises above the parity level when nations with higher per capita GDP are grandfathered.)

Transitional Implications. One of the problems with the UNFCCC and Kyoto Protocol is that they do not resolve emissions implications of the transitional situation.[17] While the complexity of an implementation strategy is beyond the scope of the paper, the analysis does suggest one method for understanding the challenges involved in moving to a world of economic growth for "Below-Parity GDP" nations within the context of constrained greenhouse gas emissions.

Those few countries that have achieved parity GDPs with the lowest intensity may be considered a benchmark for defining "excess" emissions. This can be combined with the current interest in economic mechanisms for achieving efficient constraints on the growth of greenhouse gases. As shown by the last column of **Table 6**, this metric provides a calculation of "shortfall" or "excess" of current emissions compared to the emissions that result from the $23,500 parity income times the 100 intensity goal.

The implications of this scenario for selected nations are shown in the far right hand column of **Table 6**. A "plus" means that the scenario results in higher emissions than actual emissions in 2000; a "minus" means that the scenario results in lower emissions than actual 2000 emissions. The growth implication is that a "plus" nation could increase its emissions by the plus amount as its GDP grows and still be within the scenario. The implication of a "minus" nation is the opposite — that under the scenario emissions would be less by the minus amount.

This gives rise to various possibilities: One would be to tax excess emissions, and the monies raised could be used, for example, to further economic development or to finance efforts at reducing intensity. Another possibility would be to create "allowances" out of the shortfalls, which could be "sold" to countries with excessive emissions, transferring monies to those "shortfall" nations while providing offsets to "excess" emitters.

Also, a global "trading" scheme or a global "excess emissions" tax deals with "leakage," in which greenhouse gas-intensive economic activities may be shifted from "controlled" to "uncontrolled" nations.

Policy Implications: Importance of Greenhouse Gas Intensity. The metrics of total emissions, per capita emissions, and intensity interrelate: per capita GDP times intensity [divided by one million] equals per capita emissions; population times per capita emissions equals total emissions. But in considering tradeoffs between economic growth and greenhouse gas emissions, intensity is a more useful metric than per capita emissions. Multiplying population times per capita emissions to get total emissions would say nothing about per capita (or national) GDP. Intensity, on the other hand, directly relates economic activity to total emissions (emissions divided by GDP equals intensity); using per capita GDP permits both comparisons among nations and incorporation of population into the calculation.

The Bush Administration has focused its greenhouse gas policies on intensity rather than emissions per se. So far, this policy relies on voluntary actions. It

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[17] See CRS Report RL32721, cited at footnote 3, p. 10.

focuses on the decline in intensity, and suggests that this "path" will lead to an intensity decline of 17% over a decade ending in 2012.[18] (Total emissions are nonetheless projected to rise.) No ultimate intensity goal is set, nor is the rate of intensity decline tied to rates of growth in population or economic activity.

Finally, if climate change concerns were ever to lead nations to set an upper bound ("cap") on greenhouse gas emissions, this analysis brings out the implications for economic growth and intensity of that "cap." When emissions are "capped," the rate of growth of emissions is 0; so equation 3a becomes:

$$(k_p + k_g + k_i) = 0$$

With a cap, then, if any of the three left-hand variables is positive, at least one of the others must be negative. Currently, world population is growing, although a few individual countries have negative population growth rates. Growth in GDP is a goal both globally and for individual nations. On a year by year basis, various nations' GDPs and even world GDP may contract, but globally and for individual nations, over time, GDP has been growing. When population and economic activity are growing, then, a cap on emissions globally or for an individual nation implies a decline in intensity at a rate equal to the sum of the rates of growth of population and of per capita GDP.

Concluding Discussion

This analysis assumes a minimum standard of living of $23,500 per capita GDP (in 2000 $ purchasing power parity) based on benchmark countries. The analysis identifies the differing actual starting points of individual nations in terms of GDP, population, and greenhouse gas intensity, but not other factors such as their resource endowments, where the capital for development would come from, etc., which mean that economic development occurs unevenly and dynamically over time.

In looking at the interaction of the countervailing forces of economic growth and constrained greenhouse gas emissions, these other factors will be important. Moreover, differing rates of economic growth among nations and the continuing economic growth among "Above-Parity GDP" nations makes any degree of achieving parity GDPs and constraining emissions more complicated and raises the issue of maintaining above-parity GDPs. Without grandfathering, parity implies some transfer of wealth from richer to poorer nations (through emissions trading or other mechanisms), while accepting grandfathering implies higher emissions — or even further improvements in intensity.

(A world of a minimum $23,500 per capita GDP and constrained emissions is an analytic construct: it is not a prediction. It is conceivable that a goal of a

[18] Papers outlining the Administration's climate change initiative are available on the White House website: [http://www.whitehouse.gov/news/releases/2002/02/climatechange.html]. (Note: the Administration's intensity figures include land use and are not directly comparable to the intensities used in this paper.)

comfortable standard of living for everyone (however defined) will prove as difficult to achieve as the related goal of adequate nutrition for every person.)

Over time, diverse forces and human choices will be affecting global economic activity and emissions of greenhouse gases. Some of these forces and choices will have the effect of increasing emissions, others will have the opposite effect.

- **Population growth**, currently about 1.2% per year,[19] means that economic activity must grow just to keep per capita GDP constant. If world population were to level off at, say, 9 billion (a 50% increase over 2000), then at annual per capita greenhouse emissions of 2 to 2.3 tons, total emissions would be 18 to 20.7 billion tons, or double those of 2000.
- **Economic growth** must exceed population growth if per capita GDPs are to grow. But growth per se may not meet the distributional requirements to address poverty, i.e., economic betterment of those at the bottom of the economic ladder.
- **Greenhouse gas (carbon) intensity** improved in many countries and globally between 1950 and 2000 (see **Table 8**). While those improvements were, overall, smaller than the rate of economic growth, the examples of a few nations, such as France and Sweden, suggest that high-intensity nations could improve.
- **Public Policy initiatives** at global and national levels are addressing all three forces. On population, for example, U.N. programs regarding health, children, and family planning all impact population; individual nations also have programs affecting population, some explicitly to encourage childbearing, others the opposite. On economic development, the United Nations has underway a set of programs to improve the standards of living of the world's poorest,[20] including a goal to halve the number of persons living on less than one dollar per day by 2015; and many nations have or contribute to foreign aid programs to foster economic growth. On greenhouse gas emissions, initiatives include actions under the UNFCCC and Kyoto Protocol, together with national programs to improve energy efficiency, to encourage energy conservation, to develop carbon sinks, and otherwise to reduce emissions of greenhouse gas emissions.

With international policies and programs to alleviate poverty and foster development, together with increasing population, this analysis indicates that the crux of any goal of constraining greenhouse gas emissions is the level of intensity. This in turn implies substantial decoupling of energy use and economic activity — although not to an impossible level. The analyzed level of 100 has been achieved by nations that rank in the top-20 for both per capita GDP and total annual greenhouse gas emissions.

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[19] U.N. Population Division, *World Population Prospects: The 2002 Revision Highlights* (ESA/P/W. 180, 26 February 2003), at [http://www.un.org/esa/population/unpop.htm] .

[20] See U.N. Millennium Development Goals, at [http://www.un.org/millenniumgoals/] .

Greenhouse gas intensity has been improving globally, and in many nations. For 1990 to 2000, the global carbon intensity declined about 13%; for various nations, see **Table 8**. But over the same decade, world population grew 13.7% and per capita GDP grew 30%, so emissions rose.[21]

A goal of all nations equaling or bettering an intensity of 100 would represent a very substantial challenge for most nations. Some studies have suggested that improving intensity could be achieved at low cost — even in some cases at a profit.[22] But the assumption that many "no regrets" opportunities[23] exist to reduce carbon emissions has not been borne out so far in practice, as evidenced by the failure of most countries to meet the UNFCCC goal (and likely problems in meeting the Kyoto Protocol limits).

From a policy perspective, if constraining greenhouse gases were determined to be an appropriate action for all nations, the question would be the relationships of, and the relative efforts to be devoted to, international and domestic policies and programs that affect population; economic growth and development; and intensity. At present, the first two are clearly demanding proportionately more attention and resources than intensity is.

The purpose of this analysis has been to give some tangible sense of a possible outcome from pursuing competing goals — economic growth and development versus constraining greenhouse gases — that are confounding efforts, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, to address global climate change. For some, the finding that one can construct an empirically based approach that achieves a standard of living for the existing population equal to that of several European nations while not increasing global greenhouse gas emissions by more than 60% will be optimistic. However, this calculation ignores population growth, and assumes a level of intensity that may appear daunting to many. For others, the emissions may appear unacceptable despite the improvement in intensity — which could imply even more aggressive improvements in intensity and/or constraints on economic growth. For still others, worry about greenhouse gas emissions is misdirected.

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[21] Kevin Baumert and Jonathon Pershing, *Climate Data: Insights and Observations* (World Resources Institute: Prepared for the Pew Center on Global Climate Change, December 2004), 7-8. Note that *carbon* intensity includes only emissions of carbon dioxide from energy use and cement manufacture.

[22] E.g., Interlaboratory Working Group, *Scenarios for a Clean Energy Future*, ORNL/CON-476 (November 2000). See CRS Report 98-738 ENR *Global Climate Change: Three Policy Perspectives*, pp. 5-10.

[23] The phrase was used by the George H. W. Bush Administration: C. Boyden Gray and David B. Rivkin, Jr., "A 'No Regrets' Environmental Policy," *Foreign Policy*, summer 1991, pp. 47-65. See also CRS Report RL30024 *Global Climate Change Policy: Cost, Competitiveness, and Comprehensiveness*, pp. 8-10.

Table 8. Average Annual Change in Carbon Intensity, by Decade, for Top-20 Emitting Countries (1960-2000)

	1960-70 average annual growth (%)	1970-80 average annual growth (%)	1980-90 average annual growth (%)	1990-2000 average annual growth (%)	1960-2000 average annual growth (%)
Australia	0.0	0.0	-0.9	-1.2	-0.5
Brazil	0.2	0.4	-1.0	1.6	0.3
Canada	na	-1.6	-2.8	-0.8	na
China	-3.6	0.9	-3.9	-6.1	-3.2
France	-0.6	-2.2	-4.9	-2.2	-2.5
Germany	na	na	-3.2	-3.3	na
India	1.2	1.4	1.4	-0.4	0.9
Indonesia	0.4	0.7	0.3	2.7	1.0
Iran	na	na	2.5	0.6	na
Italy	4.8	-1.1	-1.6	0.9	0.3
Japan	0.3	-2.1	-2.7	-0.2	-1.2
Mexico	-1.3	2.2	0.2	-1.2	0.0
Poland	na	na	na	-5.1	na
Russ. Fed.	na	-1.4	-1.2	0.3	na
S. Africa	-1.9	0.5	1.8	-0.2	0.0
S. Korea	6.7	2.0	-1.8	0.2	1.7
Spain	0.5	2.1	-2.0	0.4	0.2
Ukraine	na	na	na	2.5	na
U.K.	-1.5	-2.8	-2.8	-2.6	-2.4
U.S.	0.2	-2.0	-2.9	-1.6	-1.6

Source: World Resources Institute, CAIT.
na = not available
Note: Intensity based on carbon emissions from energy use and cement manufacture.

Appendix A. "Above-Parity GDP" Nations — 2000 Per Capita GDPs Greater Than $25,850

"Above-Parity GDP" Nations: 2000 per capita GDP > $25,850	Population in 2000 (thousands)	Per Capita GDP (2000 $ PPP)	GDP (Millions 2000 $ PPP)	Emissions in 2000 (MMTCE)	Per Capita Emissions (Tons)	Intensity (Tons/million$ GDP)
Austria	8,110	$ 26,420	$ 214,240	21.3	2.6	99
Canada	30,770	$ 26,840	$ 825,745	194.7	6.3	236
Denmark	5,340	$ 28,680	$ 153,134	18.3	3.4	120
Iceland	280	$ 28,910	$ 8,095	0.8	2.7	99
Ireland	3,794	$ 30,380	$ 115,249	18.0	4.8	156
Luxembourg	438	$ 53,410	$ 23,391	2.5	5.7	107
Netherlands	15,919	$ 26,910	$ 428,356	59.5	3.7	139
Norway	4,491	$ 29,200	$ 131,149	13.8	3.1	105
Switzerland	7,180	$ 27,780	$ 199,471	13.9	1.9	70
United States	286,303	$ 33,960	$ 9,680,850	1,891.8	6.6	195
Total, "Above-Parity GDP" nations	362,625	$ 32,490	$ 11,781,680	2,234.6	6.2	190

Source: World Resource Institute; CAIT; CRS calculations.

Appendix B. "Parity GDP" Nations — 2000 Per Capita GDPs $23,500 ± 10% ($25,850 - $21,150)

"Parity" Nations: 2000 per capita GDP $23,500 ± 10% ($25,850 - $21,150)	Population in 2000 (thousands)	Per Capita GDP (2000 $ PPP)	GDP (Millions 2000 $ PPP)	Emissions in 2000 (MMTCE)	Per Capita Emissions (Tons)	Intensity (Tons/million$ GDP)
Australia	19,182	$ 24,550	$ 470,916	130.4	6.8	277
Belgium	10,252	$ 25,220	$ 258,606	41.2	4.0	159
Finland	5,172	$ 24,160	$ 124,961	18.7	3.6	150
France	58,893	$ 23,490	$ 1,383,340	137.2	2.3	99
Germany	82,210	$ 25,100	$ 2,063,536	265.2	3.2	129
Italy	57,690	$ 24,280	$ 1,400,835	145.9	2.5	104
Japan	126,870	$ 25,280	$ 3,207,344	364.1	2.9	114
Singapore	4,018	$ 23,700	$ 95,246	17.5	4.4	184
Sweden	8,869	$ 23,650	$ 209,740	17.4	2.0	83
United Arab Emirates	2,905	$ 22,800	$ 54,000	29.4	10.1	544
United Kingdom	58,720	$ 23,580	$ 1,384,896	180.6	3.1	130
Total, "Parity" nations	436,781	$ 24,502	$ 10,653,420	1347.6	3.1	126

Source: World Resource Institute; CAIT; CRS calculations.

Appendix C. “Below-Parity GDP” Nations — 2000 Per Capita GDPs Smaller Than $21,150

“Below-Parity GDP” nations, 2000 per capita GDP < $21,150	Population in 2000 (thousands)	Per Capita GDP (2000 $ PPP)	GDP (Millions 2000 $ PPP)	Emissions in 2000 (MMTCE)	Per Capita Emissions (Tons)	Intensity (Tons/million $GDP)
Argentina	37,032	$ 11,880	$ 439,897	79.1	2.1	180
Brazil	170,100	$ 7,250	$ 1,233,633	229.5	1.3	186
China	1,262,460	$ 3,740	$ 4,724,163	1,355.6	1.1	287
India	1,015,923	$ 2,730	$ 2,772,730	506.0	0.5	182
Indonesia	206,265	$ 2,970	$ 613,299	135.0	0.7	220
Iran	63,664	$ 5,720	$ 364,399	119.7	1.9	328
Korea (South)	47,008	$ 14,720	$ 691,772	143.4	3.1	207
Mexico	97,966	$ 8,570	$ 839,150	139.4	1.4	166
Pakistan	138,080	$ 1,870	$ 258,024	77.9	0.6	302
Poland	38,648	$ 9,320	$ 360,114	102.4	2.7	284
Russian Federation	145,555	$ 6,760	$ 983,864	519.9	3.6	528
Thailand	60,728	$ 6,230	$ 378,476	71.3	1.2	188
Turkey	67,420	$ 6,300	$ 411,418	98.9	1.5	240
Ukraine	49,501	$ 3,980	$ 197,005	142.5	2.9	723
Uzbekistan	24,746	$ 2,360	$ 58,521	49.4	2.0	844
Other	1,811,328	$ 3,996	$ 7,236,999	1774.7	1.0	245
Total, “<Parity GDP”	5,238,424	$ 4,119	$ 21,565,464	5,544.7	1.1	257

Source: World Resource Institute; CAIT; CRS calculations.