Order Code RL32721

CRS Report for Congress

Greenhouse Gas Emissions: Perspectives on the Top 20 Emitters and Developed Versus Developing Nations

Updated January 31, 2008

Larry Parker
Specialist in Energy and Environmental Policy
Resources, Science, and Industry Division

John Blodgett
Deputy Assistant Director
Resources, Science, and Industry Division

Congressional Research Service

Prepared for Members and Committees of Congress

Greenhouse Gas Emissions: Perspectives on the Top 20 Emitters and Developed Versus Developing Nations

Summary

Using the World Resources Institute (WRI) database on greenhouse gas emissions and related data, this report examines two issues. The first issue is the separate treatment of developed and developing nations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. This distinction has been a pivotal issue affecting U.S. climate change policy. The second issue is the continuing difficulty of the current approach designed to address climate change through limiting greenhouse gas emissions to a specified percentage of baseline emissions (typically 1990). The data permit examination of alternative approaches, such as focusing on per capita emissions or the greenhouse gas emission intensity (measured as emissions per unit of economic activity). Key findings include:

- A few countries account for most greenhouse gas emissions: in 2000, the United States led by emitting 20% of the world total, followed by China with 15%; no other country reached 6%; the top nine emitters accounted for 60% of the 185 nations' emissions.
- Land-use effects (e.g., deforestation) on emissions are negligible for most nations, but they cause emissions to rise sharply for certain developing nations, for example, Brazil and Indonesia.
- While oil- and gas-producing Gulf States have the highest per capita greenhouse gas emissions, in general developed nations rank high in per capita emissions (in 2000, Australia, the United States, and Canada ranked 5, 7, and 9, respectively, in the world), while developing nations tend to rank low (China, India, and Indonesia ranked 99, 146, and 123, respectively).
- The greenhouse intensity of the economy — the metric by which the Bush Administration is addressing climate change — varies substantially among developed countries (the Ukraine emits 651 tons/million international $GDP, while France emits 94 tons/million $GDP, with the United States at 196 tons/million $GDP; developing nations show less variance unless land use is taken into account.
- The time frame adopted for defining the climate change issue and for taking actions to address greenhouse gas emissions has differential impacts on individual nations, as a result of individual resource endowments (e.g., coal versus natural gas and hydropower) and stage of economic development (e.g., conversion of forest land to agriculture occurring before or after the baseline).

Differentiating responsibilities between developed and developing nations — as the UNFCCC does — fails to focus efforts on some of the largest emitters. Moreover, many developed countries have not achieved stabilization of their emissions despite the UNFCCC. Given the wide range of situations illustrated by the data, a flexible strategy that allows each country to play to its strengths may be appropriate if diverse countries like the United States and China are ever to reach agreement.

Contents

List of Tables

Greenhouse Gas Emissions: Perspectives on the Top 20 Emitters and Developed Versus Developing Nations

Climate change is a global issue[1]; however, greenhouse gas emissions data on a global basis are incomplete. Some developing countries have no institutions for monitoring greenhouse gas emissions and have never reported such emissions to the United Nations Framework Convention on Climate Change (UNFCCC).[2] In a similar vein, data on individual greenhouse gases, sources, and land-use patterns vary greatly in quality. Despite shortcomings in the data, the emerging picture of emissions has implications for considering alternative policies for controlling emissions. First, the picture outlines the estimated contributions of individual countries. Second, evaluating those emissions in terms of socio-economic characteristics (e.g., population and economic activity) provides insights on the potentially divergent interests of differing groups of nations — especially concerning developed nations versus developing ones.[3]

The World Resources Institute (WRI) has compiled greenhouse gas emissions and related data from a variety of sources into a database that is available for analysis.[4] Covering 185 nations (plus a separate entry combining the members of the European Union),[5] the database includes total emissions, per capita emissions, and

---

[1] This paper does not explore the underlying science of climate change nor the question of whether action is justified. See CRS Report RL33849, *Climate Change: Science and Policy Implications*, by Jane Leggett, for more information.

[2] For the most recent developments on submissions to the UNFCCC by non-Annex 1 countries, see [http://unfccc.int/national_reports/non-annex_i_natcom/submitted_natcom/items/653.php].

[3] The UNFCCC divides nations into two groups, nations listed in Annex I (which under the Kyoto Protocol would have specified reduction targets), encompassing "developed" nations including Eastern Europe and the former Soviet Union; and non-Annex I nations (which do not have specified reduction targets), including the rest of the world.

[4] Called the Climate Analysis Indicators Tool (CAIT), the database uses a variety of data sources to provide information on greenhouse gas emissions, sinks, and other relevant indicators. Full documentation, along with caveats, is provided on the WRI website at [http://cait.wri.org/].

[5] Both the individual countries of the European Union and the European Community as an entity are Parties to the Kyoto Protocol. Within the EU, the differing situations of each constituent nation have resulted in differing emissions targets and policies for each country. While this analysis focuses on the implications of individual nations' situations, the EU nations are authorized to meet their goals collectively.

greenhouse gas (or carbon) intensity,[6] selected socio-economic indicators, and other measures. Emissions data for all six greenhouse gases[7] identified by the UNFCCC are available for 1990, 1995, and 2000; data for carbon dioxide (CO_2) are available back to 1850 and up to 2004, but the effects of land use on CO_2 are only available from 1950.

This report uses the data compiled by WRI to examine a pivotal and long-running issue surrounding U.S. climate change policy: the appropriate roles of developed and developing countries in addressing climate change.

The UNFCCC states as its first principle in Article 3:

> The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.[8]

The United States has struggled with the "common but differentiated responsibilities" of developing countries and with the pledge for the developed countries to "take the lead in combating climate change...." The resulting debate concerns what actions to address greenhouse emissions should be "common" responsibilities (i.e., undertaken by all nations) and what actions should be "differentiated" (i.e., undertaken only by developed ones). Under the UNFCCC and the subsequent Kyoto Protocol, common actions include the responsibility to monitor and report emissions; differentiated actions include the commitment to reduce emissions to a 1990 baseline for designated developed nations, listed on Annex I to the UNFCCC (and hence known as Annex I nations).

Thus the UNFCCC, the Kyoto Protocol, and much of the current debate about actions to control greenhouse gas emissions focus on individual nations' amounts of emissions. As a result, primary attention falls on current greenhouse gas emissions, past greenhouse gas emissions, and projected greenhouse gas emissions. In this context, addressing global climate change has in effect meant reducing greenhouse gas emissions — for Annex I countries. (A complicating factor is that land use activities can affect net emissions, and the Kyoto Protocol provides methods for taking land use effects into account.) For the UNFCCC, the differentiated control action was for Annex I countries to take voluntary actions to ensure that their greenhouse gas emissions in 2000 did not exceed 1990 levels.[9] For the Kyoto Protocol, the differentiated control action was for Annex I countries to control emissions to individually specified percentages of baseline emissions, averaged over

---

[6] Carbon intensity is the ratio of a country's emissions to its gross domestic product (GDP), measured in international dollars (purchasing power parity).

[7] Carbon dioxide, nitrous oxide, methane, perfluorocarbons, hydrofluorocarbons, and sulfur hexafluoride.

[8] *United Nations Framework Convention on Climate Change*, Article 3.1.

[9] The United States and many other countries failed to meet this voluntary goal. It was this general failure that gave impetus to the Kyoto Protocol to mandate reductions.

the period 2008-2012.[10] Under both the UNFCCC and the Kyoto Protocol, non-Annex I nations would be exempt from these specified control requirements — although they could voluntarily join in. This split in responsibilities — with the consequent lack of greenhouse gas control requirements for major emitting non-Annex I countries — played a key role in the United States' refusal to agree to the Kyoto Protocol.

Justifications for the differential treatment of the developed, Annex I nations compared to the developing nations are both environmentally and economically based.

- Environmentally, the Annex I nations account for about 72% of total carbon dioxide emissions that accumulated in the atmosphere between 1950 and 2000.[11] Thus, to the extent cumulative CO_2 may be contributing to global warming, the Annex I nations bear the preponderant responsibility.

- Economically, as the UNFCCC explicitly recognizes, the development being pursued by the non-Annex I nations depends importantly on expanded use of energy, including fossil fuels, which are the main source of carbon dioxide, the dominant greenhouse gas. From this perspective, a logic for the differing treatment of the two groups is that the developed, Annex I countries can afford to control emissions because they have achieved a relatively high standard of living, while the developing nations have the right and should have the opportunity to expand energy use as necessary for their economic development.

This distinguishing of the responsibilities of the Annex I and non-Annex I nations generates crucial and interrelated tensions:

- First, this approach means that Annex I nations pay an economic price for addressing global climate change;

- Second, non-Annex I nations retain the opportunity to develop their economies using least-cost energy regardless of greenhouse gas emissions; this in turn means that from the perspective of the Annex I nations, developing nations — which may be competing in certain economic sectors — appear to be getting a free ride;

- And third, despite investments in controls and resulting tensions between competing economies, actual global emissions will continue to rise if the increase in emissions from non-Annex I nations exceeds any decrease in emissions achieved by Annex I ones.

---

[10] Generally the baseline was 1990; the individual Annex I commitments were negotiated, with the U. S. commitment — *if* the United States had agreed to the Kyoto Protocol — being a 7% reduction.

[11] Climate Analysis Indicators Tool (CAIT) Version 4.0 (Washington, DC: World Resources Institute, 2007).

The intensity of these tensions that arise from focusing on emissions levels is clear when one examines emissions data (see **Appendices A, B, and C**). To frame this discussion, CRS focuses on the 20 individual nations that emitted the most greenhouse gases in 2000.[12] The top 20 were chosen because they represent about three-quarters of the estimated greenhouse gas emissions in the year 2000 (latest available data from CAIT for all six greenhouse gases). In addition, data for the 25-member European Union are included, as the Kyoto Protocol allows the EU to address its greenhouse gas emission obligations collectively. In 2000, the 25-nation EU was the third-largest emitter of greenhouse gases, after the United States and China.

A Look at the Historic Data

Current (2000) and Baseline (1990) Emissions Data. A compelling fact to emerge from the database is that a few countries account for most of the emissions. **Appendices A, B, and C** present data concerning the top 20 greenhouse gas-emitting nations in 2000. They accounted for approximately 75% of global emissions. Excluding land use data, the United States led in emitting greenhouse gases (1,876 million metric tons of carbon equivalent, MMTCE)[13] at 20% of the total, followed by China (1,355 MMTCE) at about 15%. No other country reached 6% of total emissions (although the collective 25-member EU accounted for 14%); overall, only nine countries emitted 2% or more. These top nine emitters accounted for 60% of global emissions and the next 11 top emitters accounted for another 15% of emissions.

Thus one implication of these data is that greenhouse gas control in the short term depends mainly on the actions of a relatively few nations; if the top 20 emitters (or even the top 10) all acted effectively, the actions of the remaining 160-plus nations would be of little import, at least for years.

A second compelling fact about those top emitters is that they represent very different types and situations.[14] The top 20 nations include:

- Developed (Annex I) nations whose emissions *grew* between 1990 and 2000: the United States, Japan, Canada, Italy, Australia, and Spain (ranked 1, 5, 8, 10, 15, and 19, respectively). These six nations accounted for 30.6% of global greenhouse gas emissions in 2000.

---

[12] For a more general discussion of the top 25 emitters, see Kevin Baumert and Jonathan Pershing, *Climate Data: Insights and Observations* (Pew Center on Climate Change, December 2004).

[13] The UNFCCC provides a methodology for calculating the greenhouse gas contributions of nations and converting them to equivalent units — Million Metric Tons of Carbon Equivalents (MMTCE).

[14] For a discussion of these situations, see CRS Report RL33970, *Greenhouse Gas Emission Drivers: Population, Economic Development and Growth, and Energy Use*, by John Blodgett and Larry Parker.

- Developed (Annex I) nations whose emissions *declined* between 1990 and 2000, largely as a result of the collapse of the Eastern European and USSR socialist economies during the decade: Russian Federation, Germany,[15] Ukraine, and Poland (ranked 3, 6, 16, and 20, respectively).[16] These four nations accounted for 11.2% of global greenhouse gas emissions in 2000.

- Developed (Annex I) nations with free-market economies whose emissions *declined* between 1990 and 2000, largely because of a combination of low population growth, modest economic growth, and the displacement of high-emitting fuels (coal) with alternatives: the United Kingdom and France (ranked 9 and 13, respectively). These two nations accounted for 3.5% of global greenhouse gas emissions in 2000.

- Developing (non-Annex I) nations, all of whose emissions rose during the decade: China, India, Brazil, Mexico, South Korea, Indonesia, Iran, and South Africa (ranked 2, 4, 7, 11, 12, 14, 17, and 18, respectively). These eight nations accounted for 30.1% of global greenhouse gas emissions in 2000.

For the year 2000, then, 12 of the top 20 countries were Annex I countries, including 7 of the top 10 emitters. In 2000, the Annex I countries accounted for about 60% of the top-20 group's greenhouse emissions, compared with 40% for the developing, non-Annex I countries; in 1990, the relative shares were 68% and 32%, respectively, so the developing countries have been increasing their share. Highlighting the tension between Annex I and non-Annex I perspectives, the number-one emitters of each group were the top two emitters overall: At the top was the leading developed, free-market economy, the United States; in the number-two position was the leading developing, non-Annex I country, China.[17] Combined, these two countries accounted for over one-third of total global emissions.

Longer-Term Historical Data (1950-2000). The impact of emissions on climate change is believed to be cumulative over decades and even centuries. Thus a longer-term examination of data provides an important perspective, and is one reason for the differing treatments of the Annex I and non-Annex I nations. Available data (see **Appendices A, B, and C**) give emissions estimates of energy-related CO_2 emissions back to 1950.[18] The period 1950-2000 represents the re-industrialization

---

[15] Germany falls into this category as a result of its incorporation of East Germany. The pre-merger West Germany was of course not a centrally planned economy.

[16] The only change in the top 20 between 1990 and 2000 was the dropping out of Kazakhstan, whose coal-based industries collapsed; it was replaced by Iran.

[17] China is likely to pass the United States in greenhouse emissions in the near future — if it hasn't already done so. However, data are not available to verify current emissions.

[18] As noted earlier, CAIT has data back to 1850; however, the earlier the data, the more (continued...)

of developed countries after World War II and the emergence of some major third-world countries.

This longer-term view of emissions underscores the contribution of the Annex I nations:

- Annex I countries' share of energy-related emissions over the half-century is over 70% of global emissions of carbon dioxide. The energy and materials needed to power industrialization after World War II put Russia ahead of China as the second-largest emitter over the time period.

- The relative rankings of several developing countries, including Brazil, South Korea, Indonesia, and Iran, drop substantially using a longer historical baseline for emissions: from the 2000 rank to the 1950-2000 cumulative rank, from 7th to 18th, 12th to 19th, 14th to 27th, and 17th to 22rd, respectively.

Greenhouse gas emissions, particularly energy-related emissions, are closely tied to industrialization. As "developed" is considered by many to be synonymous with "industrialized," it is not surprising that those countries entering the 1950-2000 period with an industrial base (even a war-damaged one) would have higher cumulative emissions than those countries that only began to industrialize during this period.

Impact of Land Use. Changes in land use can significantly affect net levels of emissions. In general, deforestation increases CO_2 emissions and afforestation decreases them. However, data on land-use changes and their conversion into equivalent units of greenhouse gas emissions are even more uncertain than the emissions data. Therefore, this discussion (see **Appendices A, B, and C**) is at best illustrative.

Unlike the cumulative energy-related emissions data, including land use in the calculations focuses discussion on certain developing countries.

- Land-use practices in certain developing countries, notably Brazil and Indonesia, are having the effect of substantially upping their relative emissions ranks: The ranking of their cumulative net emissions from 1950 to 2000 rise from 18th to 5th, and 27th to 4th, respectively, when land use is taken into account.

- For Annex I nations and many non-Annex I nations, including land use has relatively little effect on their emissions, and for many their net emissions decline. Among the top 20 emitters in 2000, the impact of accounting for land use on emissions is small for Western European and North American nations, Russia, China, and India.

---

[18] (...continued)
uncertain the quality; and land-use data are only available back to 1950.

The United States' relative rank (as number 1) does not change when land use is taken into account, although its net emissions in 2000 drop by 110 MMTCE (nearly 6%).

What the land-use data reflect are the relatively stable land-use patterns of countries where most land-clearing and agricultural development occurred before 1950. The Western developed nations and China and India, for example, have long-established agricultural practices; in contrast, Brazil and Indonesia have over the past few decades been clearing large regions of forest and jungle for timber and/or conversion to agriculture, releasing greenhouse gases (or removing sinks). In terms of the UNFCCC and the Kyoto Protocol, including land use in the equation for controlling emissions disadvantages certain countries whose exploitation of resources and development of agriculture are occurring at a particular moment in history.

Implications of Focusing on Emissions Levels for International Actions

The data on greenhouse gas emissions highlight issues of both effectiveness and fairness in the effort to address global climate change. Differentiating responsibilities between Annex I and non-Annex I nations, as the UNFCCC has, does not focus efforts on all of the largest emitters. As **Table 1** shows, the emissions of all Annex I nations currently account for just over half of 2000 emissions. Comparing 1990 to 2000 emissions, it is apparent that the share of emissions by non-Annex I nations has been growing.

Moreover, contradictory issues of fairness arise. For Annex I countries, the present scheme of controlling greenhouse gases requires them to bear essentially all the direct economic costs. For non-Annex I countries, to the extent that development is linked to increasing greenhouse gas emissions, imposing controls on them could slow their development and hold down their standards of living vis-a-vis the developed nations.

Finally, the focus on emissions levels at specific times (e.g., a baseline of 1990) has differential and arbitrary impacts on individual nations.

- Looking at the industrialization process, to the extent that fossil fuel use is a necessary ingredient of economic development, as acknowledged by the UNFCCC, the emergence of the global climate change issue at this time effectively determines the distinction between the developed, Annex I nations and the developing, non-Annex I nations. For Annex I nations, that energy exploitation has been incorporated into their economies and is part of their baseline for considering any controls on greenhouse gases. For developing, non-Annex I nations, however, economic development will require expanded energy use, of which fossil fuels can be the least costly. Thus imposing limits on fossil energy use at this time could result in developing countries being relegated to a lower standard of living than those nations that developed earlier.

Table 1. Shares of Global Emissions by the Industrialized (Annex I), Developing (non-Annex I), and Top 20 Countries

Indicator	Industrialized (Annex I) Countries n = 38[a]	Developing (non-Annex I) Countries n = 147	Top 20 Nations
1990 GHG Emissions (excl. land use)	58.7%	40.1%	75.8%
2000 GHG Emissions (excl. land use)	51.5%	47.2%	75.4%
2000 GHG Emissions (with land use)	41.3%	57.6%	70.4%
Cumulative Energy-Related CO_2 Emissions 1950-2000 (excl. land use)	71.6%	26.4%	80.6%
Cumulative Energy-Related CO_2 Emissions (with land use)	51.5%	46.7%	73.9%

Source: Climate Analysis Indicators Tool (CAIT) Version 4.0 (Washington, DC: World Resources Institute, 2007).

a. Counting the European Union countries individually, excluding the EU as a collective member.

- Similarly, certain land-use activities, such as clearing land for agriculture and exploiting timber, affect net greenhouse gas emissions. Nations that are currently exploiting their resource endowments, such as Brazil and Indonesia, could find themselves singled out as targets for controls. Yet developed nations, like the United States and most European countries, which exploited such resources in the past, have those greenhouse gas implications embedded in their baselines.

- Also, the focus on 1990 as a baseline means that the Eastern European and former Soviet Union nations have the advantage of reductions in emissions from their subsequent economic contractions, which will allow them room for growth. Likewise, the discovery and exploitation of North Sea gas has allowed Great Britain to back out coal and thereby reduce emissions since the baseline.

In all these cases, the time frame adopted for defining the climate change issue and for taking actions to address greenhouse gas emissions has differential impacts on individual nations, as a result of their individual resource endowments[19] and stage of economic development. The differential impacts give rise to perceived inequities. Thus the effort to find a metric for addressing greenhouse gas emissions baselines and targets that will be perceived as equitable is challenging.

---

[19] E.g., the availability of natural gas and/or coal, and when each has been or is being exploited; or the extent of deforestation and/or afforestation, and when either has occurred.

Alternative Perspectives

The problems raised above prompt the question: What alternatives to controls derived from historically based emissions levels are available? Alternative metrics for taking into account greenhouse gas emissions and economic development include per capita emissions and economic intensity of emissions.[20]

Per Capita Emissions. The socioeconomic differences between the developed, Annex I nations and the developing nations lead to considerations about emissions other than simply their absolute amounts. One alternative is to consider per capita emissions: All else equal, populous nations would emit more greenhouse gases than less populated ones. On this basis, the difference between developed, Annex I countries and non-Annex I ones is apparent.

Appendix B shows that of the top 20 emitters, the highest ranked by per capita greenhouse gas emissions[21] are developed countries (Australia, United States, and Canada, ranked 5, 7, and 9, respectively). Their per capita emissions (7.0, 6.6, and 6.1 tons per person, respectively) are double the emissions of the highest-ranked developing country in the top 20 (South Korea, at 3.0), and six times that of China (1.1). The rankings for the non-Annex I countries in the top 20 emitters range from 32 (South Korea) to 146 (India), with China ranked 99. In contrast, Annex I countries range from 5 (Australia) to 47 (Italy), with the United States at 7. Reasons the United States, Australia, and Canada are so high on this measure include their dependence on energy-intensive transport to move people and goods around countries of large size and relatively low population density, the use of coal for power generation, and the energy requirements for resource extraction industries.

Thus, if one were considering how to control greenhouse gas emissions, one way of trying to bridge the different interests of the developed, Annex I nations and the developing ones would be to focus on per capita emissions as a way of giving each nation an equitable share of energy use. For the United States compared to the developing world, this metric could imply constraints, depending on the compliance time frame and future technological advancements. Likewise, this approach could permit most less-developed countries to increase their emissions to accommodate expanding economies.

Greenhouse Gas Intensity of Economy. Another alternative for evaluating a nation's contribution to greenhouse gas emissions is to consider how efficiently that nation uses energy (and conducts other greenhouse gas-emitting activities) in producing goods and services. This concept is captured by greenhouse

---

[20] For other analyses bearing on this question, see CRS Report RL32762, *Greenhouse Gases and Economic Development: An Empirical Approach to Defining Goals*, by John Blodgett and Larry Parker; and CRS Report RL33970, *Greenhouse Gas Emission Drivers: Population, Economic Development and Growth, and Energy Use*, by John Blodgett and Larry Parker.

[21] The top four by this measure are oil- and gas-producing Gulf States.

gas intensity — or carbon intensity[22] — measured as the amount of greenhouse gases emitted per million dollars of gross domestic product, measured in international dollars (parity purchasing power) (see **Appendices A, B, and C**). Carbon intensity as a greenhouse gas indicator has been receiving considerable attention since President Bush decided to use it as a benchmark for his voluntary climate change program.[23] Also, the World Resources Institute has advocated its use as an appropriate index for developing, non-Annex I nations.[24]

A nation's greenhouse gas intensity reflects both its resource endowment and the energy-intensiveness of its economy. In terms of energy resources, countries with rich resources in coal would tend to be higher emitters, while countries with rich resources in hydropower or natural gas would tend to be lower emitters. In terms of economic activity, countries with major heavy industry, major extractive industries, and extensive transportation systems tend to be higher emitters, while countries without these and/or dominated by service industries would tend to be lower emitters. As noted in terms of emissions, taking into account land use sharply increases the greenhouse gas intensity of Brazil and Indonesia.

These variables do not differentiate nations simply; overall, the top 20 emitters (see **Appendices A, B, and C**) range widely in greenhouse gas intensity: from 651 tons per million international $GDP (Ukraine, which relies heavily on coal) to 94 tons/million international $GDP (France, which relies heavily on nuclear power for generating electricity). These are both Annex I nations; non-Annex I nations have a narrower range, from 183 tons/million international $GDP (Brazil) to 350 tons/million international $GDP (Iran). Taking into account land use, however, jumps Brazil to 478 tons/million international $GDP (+ 161%) and Indonesia to 1,340 tons/million international $GDP (+ 509%); the next largest increase from land use is Mexico at 18%.

As a metric for considering how to control greenhouse gas emissions, intensity focuses attention on the efficient use of energy and on the use of alternatives to fossil fuels. Thus, a greenhouse gas intensity metric would reward the use of renewables, hydropower, and nuclear power in place of fossil fuels; and among fossil fuels it would reward natural gas use and penalize coal use (with oil use falling in between).

For greenhouse gas intensity, the United States ranks number 96 in the world, making this a more favorable metric than absolute emissions (the United States ranks number 1 in the world) and per capita emissions (the United States ranks number 7).

---

[22] While the term "greenhouse gas intensity" encompasses all six greenhouse gases, the term "carbon intensity" is sometimes used identically and implicitly means "carbon equivalents intensity" and other times is used more narrowly to refer only to carbon emissions. The discussion in this analysis focuses on "greenhouse gas intensity," unless otherwise noted (e.g., in the discussion of cumulative emissions).

[23] Papers outlining the Administration's climate change initiative are available on the White House website: [http://whitehouse.gov/news/releases/2002/02/climatechange.html].

[24] See Kevin A. Baumert, Ruchi Bhandari, and Nancy Kete, *What Might A Developing Country Climate Commitment Look Like?* World Resources Institute Climate Notes, May 1999.

Of the indicators examined here, the United States gets the most favorable results from this one. Nevertheless, in absolute terms, the United States is relatively inefficient with respect to intensity compared with Western European countries (the EU-25 would rank 134 and Japan ranks 143. In addition, the United States is less efficient than non-Annex I emitters South Korea, Brazil, and Mexico, but it is more efficient than China, India, South Africa, Indonesia, and Iran.

Discussion

As stated above, the data on greenhouse gas emissions highlight issues of both effectiveness and fairness with respect to current efforts to address global climate change. Differentiating responsibilities between Annex I and non-Annex I countries fails to focus efforts on all the largest emitters. In addition, contradictory issues of fairness arise, as Annex I countries bear essentially all the direct economic costs of reducing emissions, and non-Annex I countries are granted the right to increase emissions to meet developmental needs. Finally, the focus on historical emissions as a baseline for regulation has differential and arbitrary impacts on individual nations.

The result of the UNFCCC and Kyoto Protocol's setting emissions targets for only developed nations and focusing on returning their emissions to a specific baseline is twofold: (1) the current regime has had little effect on global emissions, and will have little effect in the near future; and (2) the largest emitters, the United States and China, have not found it in their interests to join in the international effort to a significant degree. Indeed, the United States has pulled completely out of the Kyoto process. Proponents of the Kyoto Protocol assert that although it is only a first step, it is one that must be taken.

This history of the UNFCCC and the Kyoto Protocol raises serious questions about how to develop greenhouse gas targets, time frames, and implementation strategies. With respect to targets, the UNFCCC recognized the right of developing countries to develop and the responsibility of all countries to protect the global climate. These goals of the UNFCCC suggest that if there is to be any permanent response to climate change that involves controlling greenhouse gases, then a regime that combines some measure reflecting the right of developing countries to develop, such as per capita emissions, and some measure reflecting the need to be efficient, such as carbon intensity, may be necessary to move the world toward a workable and effective climate change framework.

As shown above, globally, a target focused on per capita emissions generally rewards developing nations,[25] providing them room for economic growth, with the target's balance between limiting emissions and permitting growth determining the individual winners and losers. For example, based on **Appendix B**, a target of 3 tons carbon per person would allow all the developing nations in the top 20 emitters except South Korea growth room, while six developed nations (United States, Russian Federation, Germany, United Kingdom, Canada, and Australia) would have

---

[25] An exception is several Gulf States that are high emitters due to exploitation of their oil reserves.

to make cuts. In contrast, a target focused on greenhouse gas intensity would have more diverse implications for developing nations. Several major developing nations produce considerably higher greenhouse gas emissions per million dollars of GDP than some developed nations. For example, China's carbon intensity is over twice that of Japan's (273 tons/million international $GDP versus 111). Thus a greenhouse gas intensity goal could be a counterforce to the economic development process for some countries, meaning that the winners and losers of a regime combining per capita and carbon intensity measures could be highly dynamic and contentious. Adding land-use implications would further complicate the regime, and selectively affect certain nations, especially those just now at the point of exploiting forests (notably Indonesia and Brazil).

For the United States, a regime containing some mix of per capita and greenhouse gas intensity measures[26] would likely imply a need to constrain emissions over some time frame. The U.S. greenhouse gas intensity is declining, as is the case with most nations, but the decrease currently does not completely offset increased emissions resulting from the growth of population and of the economy. The extent to which targets could translate into economic costs would depend on the other two features of the regulatory scheme: (1) time frame (specifically, whether it would accommodate technological advances in less-carbon-intensive technology or accelerated commercialization of existing technologies such as nuclear power); (2) implementation strategy (specifically, whether it encourages least-cost solutions and development of advanced technologies).

With respect to time frame, the data indicate two things: (1) most countries that achieved a significant reduction during the 1990s did so as a result of either an economic downturn or a substantial realignment in energy policy; (2) many countries have not been able to stabilize their emissions despite the UNFCCC, much less reduce them. Using economic contraction as an emission reduction strategy can scarcely be considered an option. Instead, the substantial development and/or deployment of less-carbon-intensive technology, improved land-management strategies, and other actions would be necessary to achieve stabilized emissions. As noted above, greenhouse gas emissions are closely tied to industrialization — a synonym for "developed." With few exceptions, improvement in efficiency has been gradual. A permanent transformation of the global economy necessary to ensure a long-term stabilization of greenhouse gas emissions may involve a multi-stage, long-term time frame.

The difficulty in implementing the UNFCCC suggests implementation and compliance are still an open issue. The United States submitted climate action plans during the 1990s indicating it would achieve the UNFCCC goal of returning emissions to 1990 levels. It did not. There were no sanctions. Likewise, some Kyoto signatories may not achieve their reduction targets in 2008-2012. The sanctions are unclear. Given the wide range of situations illustrated by the data, a flexible strategy that permits each country to play to its strengths may make it easier

---

[26] See CRS Report RL33970, *Greenhouse Gas Emission Drivers: Population, Economic Development and Growth, and Energy Use*, by John Blodgett and Larry Parker.

for diverse countries like the United States and China to reach some acceptable agreement.

The extent of flexibility would depend on the balance between emission reductions and economic cost designed into the targets, time frame, and implementation strategy. Market-based mechanisms to reduce emissions focus on specifying either the acceptable emissions level (quantity), or compliance costs (price), and allowing the marketplace to determine the economically efficient solution for the other variable. For example, a tradeable permit program sets the amount of emissions allowable under the program (i.e., the number of permits available caps allowable emissions), while permitting the marketplace to determine what each permit will be worth. Conversely, a carbon tax sets the maximum unit (per ton of CO_2) cost that one should pay for reducing emissions, while the marketplace determines how much actually gets reduced.

Hence, a major implementation question is whether one is more concerned about the possible economic cost of the program and therefore willing to accept some uncertainty about the amount of reduction received (i.e., carbon taxes), or one is more concerned about achieving a specific emission reduction level with costs handled efficiently, but not capped (i.e., tradeable permits). Of course, combinations of these approaches are possible, depending on the flexibility desired.[27] The data presented here portray a very wide range of situations and conditions among the 20 top countries that represent 75% of total emissions. Significant flexibility may not only be desirable but necessary for them to reach any significant agreement.

---

[27] See CRS Report RL33799, *Global Climate Change: Design Approaches for a Greenhouse Gas Reduction Program*, by Larry Parker; CRS Report RL30024, *U.S. Global Climate Change Policy: Evolving Views on Cost, Competitiveness, and Comprehensiveness*, by Larry Parker and John Blodgett; and CRS Report RS21067, *Global Climate Change: Controlling CO2 Emissions — Cost-Limiting Safety Valves*, by Larry Parker.

Appendix A. Relative Ranking of 20 Top Emitters (Plus EU-25) of Greenhouse Gases Based on 2000 Greenhouse Gas Emissions

Country	Annex 1	2000 Emissions	1990 Emissions	2000 Per Capita	2000 GHG Intensity	2000 Emissions w/ Land-use	1950-2000 Cumulative Energy CO_2 Emissions	1950-2000 Cumulative Energy CO_2 w/land-use
United States	Yes	1	1	7	96	1	1	1
China	No	2	2	99	68	2	3	2
European Union-25	*Yes*[a]	*[3]*[b]	*[2]*	*[38]*	*[134]*	*[3]*	*[2]*	*[2]*
Russian Federation	Yes	3	3	22	29	5	2	3
India	No	4	4	146	90	6	8	14
Japan	Yes	5	6	35	143	7	5	7
Germany	Yes	6	5	26	131	8	4	6
Brazil	No	7	9	87	101	4	18	5
Canada	Yes	8	10	9	84	10	10	9
United Kingdom	Yes	9	8	34	141	11	6	8
Italy	Yes	10	12	47	149	13	12	15
Mexico	No	11	14	80	114	12	14	16
Korea (South)	No	12	19	32	99	14	19	24

Country	Annex 1	2000 Emissions	1990 Emissions	2000 Per Capita	2000 GHG Intensity	2000 Emissions w/ Land-use	1950-2000 Cumulative Energy CO_2 Emissions	1950-2000 Cumulative Energy CO_2 w/land-use
France	Yes	13	11	48	156	15	9	12
Indonesia	No	14	16	123	86	3	27	4
Australia	Yes	15	15	5	65	17	15	19
Ukraine	Yes	16	7	42	141	19	7	11
Iran	No	17	21	57	50	18	22	31
South Africa	No	18	17	45	66	20	13	20
Spain	Yes	19	20	46	138	24	17	25
Poland	Yes	20	13	44	74	25	11	14

Source: Climate Analysis Indicators Tool (CAIT) Version 4.0 (Washington, DC: World Resources Institute, 2007).

a. European Union members, listed in Annex I, signed the Kyoto Protocol individually and, collectively, as the EU. The Protocol gave explicit authority to the original 15 member European Union to meet its obligations collectively; the EU has in effect expanded that authority as it has incorporated new members.

b. The bracketed numbers would be the ranking of the EU; if the EU ranking were counted, equal and lower rankings would increase by one (e.g., Poland would rank 21st in 2000 emissions and 46th in 2000 per capita emissions, but remain at 90th in 2000 GHG intensity).

Appendix B. Emissions and Other Climate Change-Related Indicators for 20 Largest Emitters

2000 Rank	Country	Annex 1	2000 MMTCE	2000 % of World	1990 MMTCE	1990-2000 Difference MMTCE	Difference %	2000 Per Capita GHG Emissions (tons C/person)
1	United States	Yes	1,876	20.4%	1,631	245	13.1%	6.6
2	China	No	1,355	14.7%	1,029	326	24.1%	1.1
[3]	*European Union-25*	*Yes*[a]	*1,294*	*14.1%*	*1,369*	*-75*	*-5.8%*	*2.9*
3	Russian Federation	Yes	523	5.7%	780	-257	-49.1%	3.6
4	India	No	516	5.6%	366	150	29.1%	0.5
5	Japan	Yes	369	4.0%	328	41	11.1%	2.9
6	Germany	Yes	277	3.0%	332	-55	-19.9%	3.4
7	Brazil	No	232	2.5%	187	45	19.4%	1.3
8	Canada	Yes	187	2.0%	154	33	17.6%	6.1
9	United Kingdom	Yes	180	2.0%	198	-18	-10.0%	3.0
10	Italy	Yes	145	1.6%	132	13	9.0%	2.5
11	Mexico	No	144	1.6%	118	26	18.1%	1.5
12	Korea (South)	No	142	1.5%	79	63	44.4%	3.0
13	France	Yes	142	1.5%	150	-8	-5.6%	2.4

2000 Rank	Country	Annex 1	2000 MMTCE	2000 % of World	1990 MMTCE	1990-2000 Difference MMTCE	Difference %	2000 Per Capita GHG Emissions (tons C/person)
14	Indonesia	No	138	1.5%	97	41	29.7%	0.7
15	Australia	Yes	134	1.5%	111	23	17.2%	7.0
16	Ukraine	Yes	132	1.4%	253	-121	-91.7%	2.7
17	Iran	No	130	1.4%	79	51	39.2%	2.0
18	South Africa	No	114	1.2%	97	17	14.9%	2.6
19	Spain	Yes	104	1.1%	79	25	24.0%	2.6
20	Poland	Yes	102	1.1%	119	-17	-16.7%	2.6
Total[b]			6,942	75.4%	6,319	623	9.0%	
	WORLD		9,201		8,335	866	9.4%	1.5

a. The Kyoto Agreement gave explicit authority to the original 15 member European Union to meet its obligations collectively; the EU has in effect expanded that authority as it has incorporated new members. If the EU-25 were ranked in terms of its 2000 GHG emissions, it would place 3rd.

b. Total is of the 20 individual nations; it does not include the European Union.

Appendix C. Additional Emissions and Other Climate Change-Related Indicators for 20 Largest Emitters

2000 Rank	Country	2000 Emissions with Land-use (MMTCE)	1950-2000 Cumulative Energy CO_2 Emissions (MMTCE)	1950-2000 Cumulative Energy with Land-use (MMTCE)	GDP (millions of international $)	2000 GHG Intensity (tons/million intl. $GDP)	2000 GHG Intensity with Land-use (tons/million intl. $GDP)
1	United States	1,766	58,107	50,957	$9,587,197	196	184
2	China	1,342	19,587	30,206	$4,960,067	273	270
[3]	*European Union-25*[a]	*1,288*	*48,018*	*48,190*	*$10,379,307*	*125*	*124*
3	Russian Federation	538	21,048	24,716	$1,038,121	504	518
4	India	505	5,123	4,798	$2,453,549	210	206
5	Japan	370	10,193	11,559	$3,326,505	111	111
6	Germany	277	12,918	12,970	$2,094,828	132	132
7	Brazil	606	2,031	18,665	$1,269,311	183	478
8	Canada	204	4,757	6,175	$839,682	222	243
9	United Kingdom	179	8,122	8,116	$1,573,155	114	114
10	Italy	144	3,926	3,924	$1,441,942	101	100
11	Mexico	170	2,564	3,737	$886,227	162	192
12	Korea (South)	142	1,892	2,129	$760,234	186	187

2000 Rank	Country	2000 Emissions with Land-use (MMTCE)	1950-2000 Cumulative Energy CO_2 Emissions (MMTCE)	1950-2000 Cumulative Energy with Land-use (MMTCE)	GDP (millions of international $)	2000 GHG Intensity (tons/million intl. $GDP)	2000 GHG Intensity with Land-use (tons/million intl. $GDP)
13	France	140	5,100	5,115	$1,513,498	94	92
14	Indonesia	837	1,253	21,925	$624,627	220	1,340
15	Australia	135	2,508	2,868	$486,820	275	278
16	Ukraine	132	5,668	5,668	$202,048	651	651
17	Iran	132	1,627	1,782	$370,949	350	356
18	South Africa	114	2,784	2,798	$414,441	275	276
19	Spain	102	2,099	2,067	$881,471	118	116
20	Poland	101	4,336	4,350	$401,992	253	252
Total[b]		7,936	175,643	224,525	$34,467,455		
	WORLD	11,280	217,820	303,825	$44,319,514	208	254

Source: Climate Analysis Indicators Tool (CAIT) Version 4.0 (Washington, DC: World Resources Institute, 2007).

a. The Kyoto Agreement gave explicit authority to the original 15 member European Union to meet its obligations collectively; the EU has in effect expanded that authority as it has incorporated new members. If the EU-25 were ranked in terms of its 2000 GHG emissions, it would place 3rd.
b. Total is of the 20 individual nations; it does not include the European Union.