

July 2010

# CLIMATE CHANGE

## The Quality, Comparability, and Review of Emissions Inventories Vary Between Developed and Developing Nations

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**GAO**

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Highlights of [GAO-10-818](#), a report to congressional requesters

## Why GAO Did This Study

Nations that are Parties to the United Nations Framework Convention on Climate Change periodically submit inventories estimating their greenhouse gas emissions. The Convention Secretariat runs a review process to evaluate inventories from 41 “Annex I” nations, which are mostly economically developed nations. The 153 “non-Annex I” nations are generally less economically developed and have less stringent inventory reporting guidelines. The Department of State (State) represents the United States in international climate change negotiations. GAO was asked to report on (1) what is known about the comparability and quality of inventories and barriers, if any, to improvement; (2) what is known about the strengths and limits of the inventory review process; and (3) views of experts on implications for current and future international agreements to reduce emissions. GAO analyzed inventory reviews and inventories from the seven highest-emitting Annex I nations and seven of the highest emitting non-Annex I nations. GAO also selected and interviewed experts.

## What GAO Recommends

GAO recommends that the Secretary of State work with other Parties to the Convention to (1) continue encouraging non-Annex I Parties to improve their inventories and (2) strengthen the inventory review process’s quality assurance framework. State agreed with GAO’s findings and recommendations.

View [GAO-10-818](#) or [key components](#). For more information, contact John Stephenson at (202) 512-3841 or [stephensonj@gao.gov](mailto:stephensonj@gao.gov).

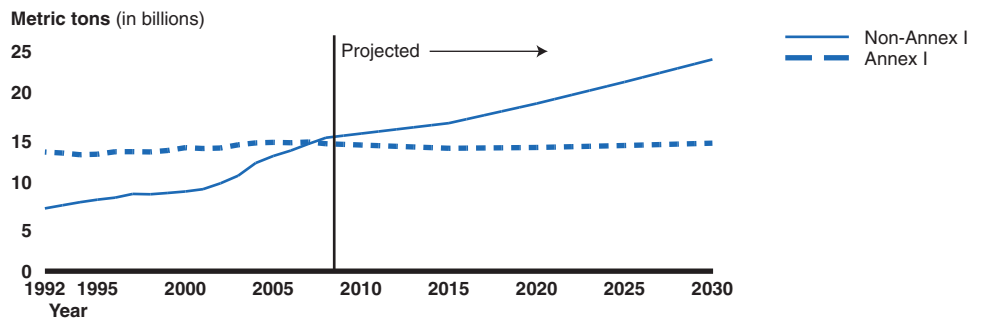
## CLIMATE CHANGE

### The Quality, Comparability, and Review of Emissions Inventories Vary Between Developed and Developing Nations

## What GAO Found

Recent reviews by expert teams convened by the Secretariat found that the 2009 inventories from the selected Annex I nations—Australia, Canada, Germany, Japan, Russia, the United Kingdom, and the United States—were generally comparable and of high quality. For selected non-Annex I nations—Brazil, China, India, Indonesia, Malaysia, Mexico, and South Korea—GAO found most inventories were dated and of lower comparability and quality. Experts GAO interviewed said data availability, scientific uncertainties, limited incentives, and different guidelines for non-Annex I nations were barriers to improving their inventories. The lack of comparable, high quality inventories from non-Annex I nations is important because they are the largest and fastest growing source of emissions, as shown in the figure, and information about their emissions is important to efforts to address climate change. There are no inventory reviews for non-Annex I nations.

**Energy-Related Carbon Dioxide Emissions in Annex I and Non-Annex I Nations, 1992-2030**



Source: GAO analysis of Energy Information Administration data.

Experts said the inventory review process has notable strengths for Annex I nations as well as some limitations. The review process, which aims to ensure nations have accurate information on inventories, is rigorous, involves well-qualified reviewers, and provides feedback to improve inventories, according to experts. Among the limitations experts identified is a lack of independent verification of estimates due to the limited availability of independent statistics against which to compare inventories’ data. Also, GAO found that the review process’s quality assurance framework does not independently assess concerns about a limited supply of reviewers and inconsistent reviews, which could pose challenges in the future.

Experts said Annex I nations’ inventories and the inventory review process are generally sufficient for monitoring compliance with current agreements to reduce emissions. For non-Annex I nations, however, experts said the current system may be insufficient for monitoring compliance with future agreements, which may require more reporting. As part of ongoing negotiations to develop a new climate change agreement, State has emphasized the need for better information on emissions from high-emitting non-Annex I nations. While improving the inventory system is important to negotiations, some experts said disagreements about emissions limits for developed and developing nations pose a greater challenge.

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## Abbreviations

|      |   |
|------|---|
| EPA  | Environmental Protection Agency           |
| IEA  | International Energy Agency               |
| IPCC | Intergovernmental Panel on Climate Change |

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United States Government Accountability Office  
Washington, DC 20548

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July 30, 2010

The Honorable Joe Barton  
Ranking Member  
Committee on Energy and Commerce  
House of Representatives

The Honorable Michael C. Burgess  
Ranking Member  
Subcommittee on Oversight and Investigations  
Committee on Energy and Commerce  
House of Representatives

The Honorable Greg Walden  
House of Representatives

High-quality information on greenhouse gas emissions is critical to domestic and international efforts to address climate change. Elevated concentrations of greenhouse gases in the atmosphere could alter the climate and adversely affect agriculture, infrastructure, ecosystems, and human health. To address these risks, Congress is considering proposals to limit greenhouse gas emissions, and the United States is participating in international negotiations to develop an international response to climate change.

In 1992, the United States and most nations of the world negotiated the United Nations Framework Convention on Climate Change (the Convention) to stabilize atmospheric concentrations of carbon dioxide and five other greenhouse gases.<sup>1</sup> As a step toward that goal, under the 1997 Kyoto Protocol to the Convention, 37 industrialized nations and the European Community agreed to binding emissions targets for 2008 through 2012.<sup>2</sup> Many nations with significant greenhouse gas emissions,

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<sup>1</sup>The Convention's objective is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous man-made interference with the climate system within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner. The five other gases are methane, nitrous oxide, and three synthetic gases—hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

<sup>2</sup>Under the Kyoto Protocol, each nation with a binding emissions target has a specified greenhouse gas emission limitation or reduction commitment.

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including China, India, and the United States, have not committed to such binding targets in the Kyoto Protocol or subsequently.<sup>3</sup> However, all nations that are Parties to the Convention agreed, among other things, to periodically provide inventories detailing their man-made emissions and removals of greenhouse gases.<sup>4</sup> These inventories, and processes for their review, play an important role in ongoing negotiations for a post-2012 agreement to extend or succeed the Kyoto Protocol. In December 2009, these negotiations resulted in the Copenhagen Accord, a nonbinding political agreement in which, among other things, certain nations announced various actions to reduce emissions and developing nations agreed to submit more frequent reports on their emissions.

Forty-one of the Convention's Parties—most of them economically developed nations—are listed in Annex I of the Convention and submit annual inventories of their greenhouse gas emissions.<sup>5</sup> Developing an inventory involves collecting data on activities across all sectors of a nation's economy that influence emissions and using numerous methods to estimate associated emissions. Annex I nations' inventories undergo a review process coordinated by the Convention's Secretariat, with reviews by teams of international experts. The review teams evaluate consistency with inventory guidelines agreed to by all Parties, including technical methods developed by the Intergovernmental Panel on Climate Change (IPCC).<sup>6</sup> An additional 153 Parties to the Convention are not listed in

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<sup>3</sup>While the United States is a Party to the Convention and signed the Kyoto Protocol in 1998, it is not bound by the protocol's terms because it has not been ratified by the Senate.

<sup>4</sup>Human activities can cause the emission of greenhouse gases as well as their removal from the atmosphere. For example, activities that promote the growth of forests can lead to the removal of carbon dioxide from the atmosphere. Such removals are also called sinks. In this report, we use the term greenhouse gas emissions to refer to both emissions and removals unless otherwise noted.

<sup>5</sup>When the Convention and its annexes were agreed to in 1992, Annex I included all members of the Organization for Economic Cooperation and Development at that time, Russia, Baltic nations, and several Central and Eastern European nations. Annex I was subsequently amended and, in 1998, several other Central and Eastern European nations, as well as Luxembourg and Liechtenstein, were added. Although Kazakhstan is not listed in Annex I of the Convention, it has expressed its intent to be bound by the Convention's reporting requirements for Annex I nations and began submitting inventories in 2009. Additionally, in December 2009, the Parties agreed to add Malta to the list of Annex I nations. This amendment will go into effect 6 months after the Convention Secretariat's communication to the Parties about the amendment's adoption.

<sup>6</sup>The IPCC is a United Nations organization that, among other things, assesses the economic, scientific, and technical aspects of climate change.

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Annex I and are known as non-Annex I nations. They are generally less economically developed, though strong economic growth since 1992 in some nations means their per-capita income now surpasses that of some Annex I nations. They are encouraged to use the same technical methods as Annex I nations in developing their inventories. However, the Parties agreed that inventories from non-Annex I nations do not need to be submitted as often, include estimates for as many gases, or undergo the same reviews as inventories from Annex I nations. In 2003, we reported that select Annex I nations varied in their adherence to reporting standards and that there was little information on inventories from select non-Annex I nations.<sup>7</sup>

The role of certain non-Annex I nations has become central to negotiations on a post-2012 agreement because their emissions have increased substantially since 1997 and are expected to continue to grow. China, a non-Annex I nation, recently overtook the United States as the world's largest emitter, according to some estimates.<sup>8</sup> According to Energy Information Administration projections, non-Annex I nations may contribute nearly all of the growth of global fossil-fuel related emissions through 2030.<sup>9</sup> Because of this expected growth, emissions reductions will be needed from high-emitting nations, including non-Annex I nations, to stabilize the concentration of greenhouse gases in the atmosphere. Recognizing this, the United States' position in international negotiations has been that a new climate change agreement should extend binding actions and strong requirements for monitoring, reporting, and verification of emissions to large non-Annex I nations. In negotiations, many non-

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<sup>7</sup>Our prior report looked at inventories from Germany, Japan, the United Kingdom, and the United States among Annex I nations, and from China, India, and Mexico among non-Annex I nations. GAO, *Climate Change: Selected Nations' Reports on Greenhouse Gas Emissions Varied in Their Adherence to Standards*, GAO-04-98 (Washington, D.C.: Dec. 23, 2003).

<sup>8</sup>See World Resources Institute, *Climate Analysis Indicators Tool (CAIT) version 7.0*, <http://cait.wri.org> (Washington, D.C., accessed May 25, 2010) and estimates from the Emission Database for Global Atmospheric Research in International Energy Agency (IEA), *CO<sub>2</sub> Emissions from Fuel Combustion, 2009 Edition* (Paris, France, 2009).

<sup>9</sup>Fossil-fuel related emissions are the largest contributor to global emissions, representing about two-thirds of global emissions in 2005. The Energy Information Administration is a statistical agency within the Department of Energy that collects, analyzes and disseminates independent information on energy issues. Energy Information Administration, *International Energy Statistics Database*, [www.eia.doe.gov/emeu/international](http://www.eia.doe.gov/emeu/international) (Washington, D.C., accessed May 11, 2010) and *International Energy Outlook 2010*, DOE/EIA-0484 (Washington, D.C., May 2010).

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Annex I nations have taken the position that Annex I nations are obliged to begin to cut their emissions more deeply because they have emitted a large share of the greenhouse gases that currently drive climate change.

In the United States, the Environmental Protection Agency (EPA) prepares the annual inventory with contributions from other agencies, including the Departments of Agriculture and Energy.<sup>10</sup> The Department of State (State) represents the United States in international negotiations to develop a post-2012 agreement to address climate change, and participates in the assessment and review of whether the Convention is being effectively implemented, including the inventory review process. State also officially submits the U.S. inventory to the Convention's Secretariat.

In response to your request, this report addresses the following questions: (1) what is known about the comparability and quality of inventories submitted by developed and developing nations and barriers, if any, to improving comparability and quality; (2) what is known about the strengths and limits of the Convention's inventory review process; and (3) what are the views of experts of the implications of the state of the inventory system for establishing or monitoring compliance with international agreements to reduce greenhouse gas emissions.

To provide information on the comparability and quality of inventories, we summarized the results of the most recent inventory reviews of the seven largest emitting Annex I nations—Australia, Canada, Germany, Japan, Russia, the United Kingdom, and the United States. For non-Annex I nations, we assessed whether inventories from seven of the largest greenhouse gas emitting nations—Brazil, China, India, Indonesia, Malaysia, Mexico, and South Korea—included estimates for all major greenhouse gases, for all economic sectors, and for various years, among other factors. In 2005, the latest year for which global estimates are available, these 14 nations represented about two-thirds of the greenhouse gas emissions that were not related to land use and forestry.<sup>11</sup> We did not independently assess the comparability or quality of inventories from

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<sup>10</sup>EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA-430-R-10-006, <http://epa.gov/climatechange/emissions/usgginventory.html> (Washington, D.C., Apr. 15, 2010).

<sup>11</sup>We report estimates of emissions not related to land use because of the lack of comparable data on land use emissions for many nations for many years. World Resources Institute, *CAIT version 7.0*.



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Annex I nations or of emissions estimates from non-Annex I nations. Though we identified some limitations with the inventory review process, we believe that the reviews provide reasonable assessments of the comparability and quality of inventories from the selected Annex I nations. Our findings are not generalizable to other nations because the selected nations are not necessarily representative. To address all three objectives, we also summarized findings in the literature and the results of semi-structured interviews with 15 experts on national emissions inventories, the Convention's inventory review process, and international agreements. We selected these experts based on recommendations from U.S. and international government officials and researchers, the relevance and extent of their publications, and their involvement in the Convention's inventory review process and related activities. We ensured that our group of experts covered key perspectives, including the views of Annex I and non-Annex I nations and the views of experts not directly involved in preparing or reviewing inventories. Experts included agency and international officials, researchers, and members of inventory review teams. Not all of the experts provided their views on all issues. We identify the number of experts providing views where relevant. Appendix I provides additional information about our scope and methodology, and appendix II lists the experts we interviewed.

We conducted this performance audit from September 2009 to July 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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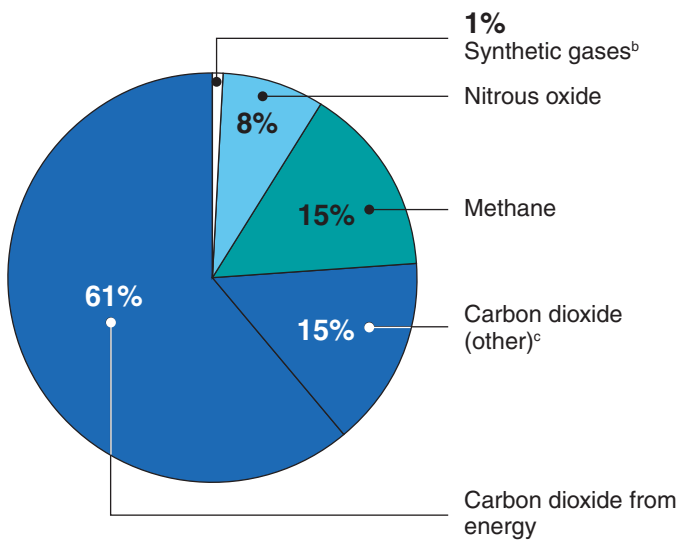
## Background

Greenhouse gases can affect the climate by trapping energy from the sun that would otherwise escape the earth's atmosphere. Various human and natural activities emit greenhouse gases, with the production and burning of fossil fuels for energy contributing around two-thirds of man-made global emissions in 2005 (see fig. 1). The remaining third includes emissions from industrial processes, such as steel production and semiconductor manufacturing; agriculture, including emissions from the application of fertilizers and from ruminant farm animals; land use, such as deforestation and afforestation; and waste, such as methane emitted from landfills. Carbon dioxide is the most important of the greenhouse gases affected by human activity, accounting for about three-quarters of

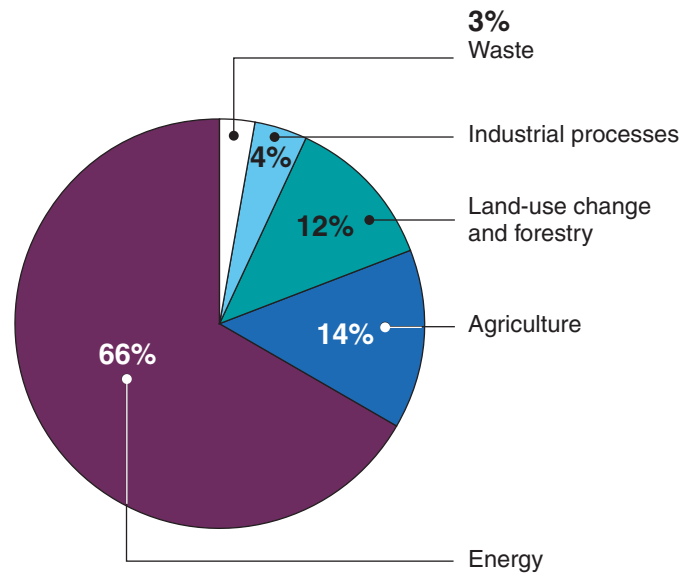
global emissions in 2005, the most recent year for which data were available.<sup>12</sup>

**Figure 1: Global Greenhouse Gas Emissions by Gas and by Economic Sector, 2005**

**Emissions by Greenhouse Gas (percent)<sup>a</sup>**



**Emissions by Economic Sector (percent)**



Source: GAO analysis of World Resources Institute data.

<sup>a</sup>Emissions are weighted by the 100-year global warming potential for each gas.

<sup>b</sup>Synthetic gases include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

<sup>c</sup>Other includes carbon dioxide emissions from industrial processes, agriculture, land-use change and forestry, and waste.

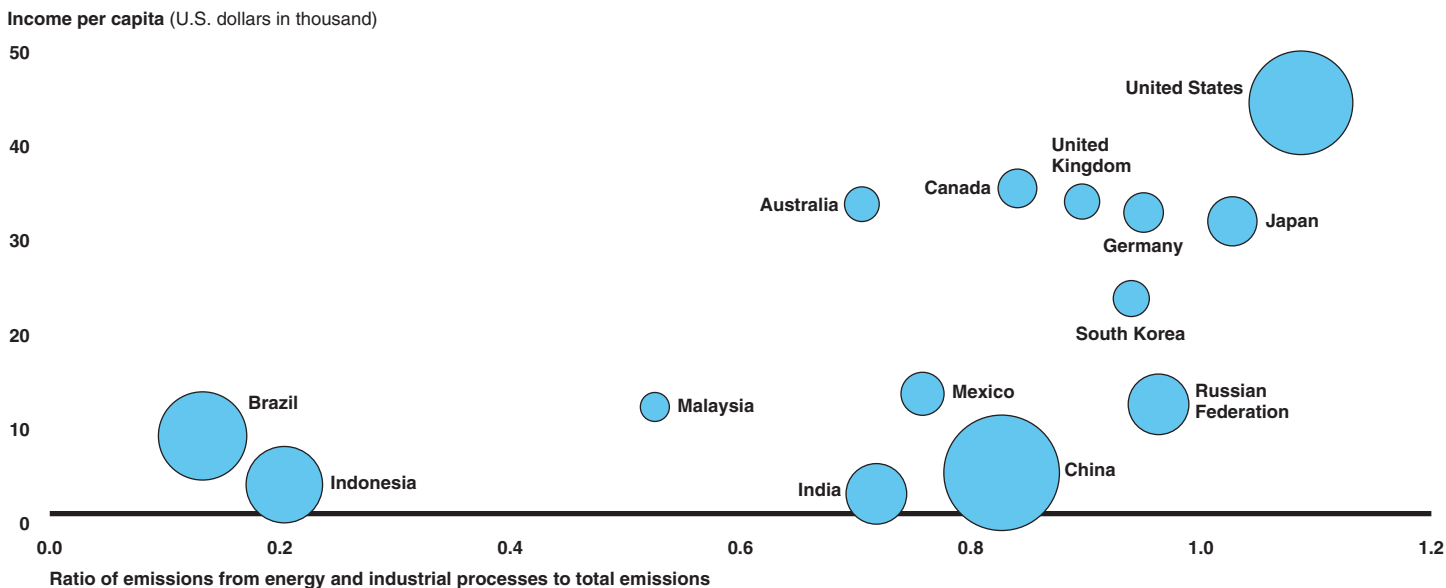
Note: Figure includes emissions and removals of greenhouse gases.

The 14 nations in our study differ greatly in the quantity of their greenhouse gas emissions, the sources of those emissions, and their per-capita incomes. Emissions in 2005 ranged from about 7 billion metric tons of carbon dioxide equivalent in China and 6 billion metric tons in the United States, to about 300 million metric tons in Malaysia. The contribution of various sectors to national emissions also differed across

<sup>12</sup>Because greenhouse gases differ in their potential to contribute to climate change, each gas is assigned a unique weight, called a global warming potential, based on its heat absorbing ability relative to carbon dioxide over a fixed period. This weighting provides a way to convert emissions of various greenhouse gases into a common measure, called carbon dioxide equivalent, which is used throughout this report.

nations, with emissions from energy and industrial processes accounting for more than 70 percent of emissions in most industrialized nations and 20 percent or less of emissions in Indonesia and Brazil (see fig. 2).

**Figure 2: Size and Structure of Greenhouse Gas Emissions and Per-Capita Income for 14 Selected Nations, 2005**



Source: GAO analysis of World Resources Institute (non-Annex I nations), Convention (Annex I nations), and World Bank data.

Notes: Size of circle represents total emissions from each nation. Since total emissions include emissions minus removals of greenhouse gases, energy and industrial process emissions are greater than total for some nations. Per capita income figures are converted from local currencies using purchasing power parities, which take into account differences in the relative prices of goods and services across nations.

The Convention established a Secretariat that, among other things, supports negotiations, coordinates technical reviews of reports and inventories, and compiles greenhouse gas inventory data submitted by nations. The Secretariat has about 400 staff, located in Bonn, Germany, and its efforts related to national inventories are funded by contributions from the Parties.<sup>13</sup> For the Secretariat’s core budget, Parties provided \$52 million for the 2008-2009 budget cycle, of which the United States contributed \$9.5 million (\$3.76 million in 2008 and \$5.75 million in 2009), excluding fees.

<sup>13</sup>The Secretariat is also funded by certain fees, which generated nearly \$77 million from 2008 to 2009.

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The Convention requires Parties to periodically report to the Secretariat on their emissions of greenhouse gases resulting from human activities.<sup>14</sup> Parties do not generally measure their emissions, because doing so is not generally feasible or cost effective, and instead estimate their emissions. To help Parties develop estimates, the IPCC developed detailed guidelines—which have evolved over time—describing how to estimate emissions. The general approach is to use statistics on activities, known as activity data, and estimates of the rate of emissions per unit of activity, called emissions factors.<sup>15</sup> For example, to estimate emissions from passenger cars, the inventory preparers could multiply the number of gallons of gasoline consumed by all cars by the estimated quantity of emissions per gallon. The IPCC guidelines allow nations to use various methods depending on their data and expertise. In some cases, with adequate data, estimates of emissions can be as accurate as direct measurements, for example for carbon dioxide emissions from the combustion of fossil fuels which contribute the largest portion of emissions for many nations.<sup>16</sup>

The Parties agreed to the following five principles for inventories from Annex I nations:

- *Transparent.* Assumptions and methodologies should be clearly explained to facilitate replication and assessment of the inventory.

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<sup>14</sup>Various natural processes also emit greenhouse gases, such as forest fires and biological emission of methane from wetlands. Though differentiating emissions from human activities versus natural emissions can pose challenges, inventories under the Convention generally include emissions from human activities.

<sup>15</sup>Three IPCC guidelines are currently being used, each addressing different aspects of inventories: *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, and *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. The IPCC has recently updated its general inventory guidelines, but the Parties have not yet agreed to start using these updated guidelines (*2006 IPCC Guidelines for National Greenhouse Gas Inventories*).

<sup>16</sup>Some nations are collecting more detailed information on emissions at major facilities. In the United States, the EPA recently issued a rule establishing mandatory greenhouse gas reporting requirements for owners and operators of certain facilities that directly emit greenhouse gases as well as for certain fossil fuel suppliers and industrial greenhouse gas suppliers. The first reports are due in 2011. In addition, about 10,500 electric power and industrial installations across 27 European nations have been calculating and reporting greenhouse gas emissions under the European Union Emission Trading System. Most of these nations indicated they have used this detailed emissions information in developing their 2010 inventories.

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- *Consistent.* All elements should be internally consistent with inventories of other years. Inventories are considered consistent if a Party uses the same methodologies and data sets across all years.
  - *Comparable.* Estimates should be comparable among Parties and use accepted methodologies and formats, including allocating emissions to the six economic sectors defined by IPCC—energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, and waste.
  - *Complete.* Inventories should cover all sources and sinks and all gases included in the guidelines.
  - *Accurate.* Estimates should not systematically over- or underestimate true emissions as far as can be judged and should reduce uncertainties as far as practical.<sup>17</sup>

Annex I nations are to submit inventories annually consisting of two components—inventory data in a common reporting format and a national inventory report—both of which are publicly available on a Web site maintained by the Secretariat.<sup>18</sup> The common reporting format calls for emissions estimates and the underlying activity data and emissions factors for each of six sectors—energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, and waste. It also calls for data on the major sources that contribute to emissions in each sector. The inventory data are to reflect a nation’s most recent reporting year as well as all previous years back to the base year, generally 1990.<sup>19</sup> The 2010 reporting format called for nearly 150,000 items of inventory data and other information from 1990 through 2008. The common format and underlying detail facilitate comparisons across nations and make it easier to review the data by, for example, enabling automated checks to ensure emissions were properly calculated and to flag inconsistencies in data reported over time.

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<sup>17</sup>The Convention, *Guidelines for the Preparation of National Communications by Parties Included In Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories*, FCCC/SBSTA/2006/9 (Bonn, Germany, Aug. 18, 2006).

<sup>18</sup>See [http://unfccc.int/national\\_reports/annex\\_i\\_ghg\\_inventories/national\\_inventories\\_submissions/items/5270.php](http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/5270.php).

<sup>19</sup>Five Annex I nations with economies in transition—Bulgaria, Hungary, Poland, Romania, and Slovenia—are allowed to use other years as baselines.

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The national inventory report should explain the development of the estimates and data in the common reporting format and should enable reviewers to understand and evaluate the inventory. The report should include, among other things, descriptions of the methods used to calculate emissions estimates, the rationale for selecting the methods used, and information about the complexity of methods and the resulting precision of the estimates; information on quality assurance procedures used; discussion of any recalculations affecting previously submitted inventory data; and information on improvements planned for future inventories.

The Secretariat coordinates an inventory review process that, among other things, assesses the consistency of inventories from Annex I nations with reporting guidelines. The purposes of this process are to ensure that Parties are provided with (1) objective, consistent, transparent, thorough, and comprehensive assessments of the inventories; (2) adequate and reliable information on inventories from Annex I Parties; (3) assurance that inventories are consistent with IPCC reporting guidelines; and (4) assistance to improve the quality of inventories.

In supporting the inventory review process, the Secretariat provides scientific and technical guidance on inventory issues and coordinates implementation of Convention guidelines. Inventory reviews are supervised by the head of the reporting, data, and analysis program within the Secretariat. By June each year, the Secretariat checks each inventory for completeness and format, called an initial check, and conducts a preliminary assessment before submitting it to an inventory review team for examination. The Secretariat assembles inventory review teams composed of scientists and other experts from around the world to review inventories from all Annex I Parties according to the Convention's review guidelines. The inventory review teams assess inventories in September by reviewing activity data, emissions factors, methodologies, and other elements of an inventory to determine if a nation has employed appropriate standards, methodologies, and assumptions to compute its emission estimates. From February through March, the inventory review teams develop inventory review reports outlining their findings.

In accordance with the Convention's principle of common, but differentiated responsibilities, non-Annex I nations' inventories' format and frequency differ from those for Annex I nations. The reporting guidelines, which have evolved over time, encourage non-Annex I nations to use the IPCC methodological guidelines in developing their inventories, but do not specify that they must be used. While they submit inventories to the Secretariat, non-Annex I nations' inventories are not stand-alone

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documents. Rather, a non-Annex I nation's inventory is a component of its national communication, a report that discusses steps the nation is taking or plans to take to implement the Convention. Non-Annex I nations do not have to use the common reporting format or submit a national inventory report. Moreover, they do not submit an inventory each year, but instead the Parties to the Convention determine the frequency of their submissions. Parties have not agreed on a regular frequency for non-Annex I nations to submit their inventories.

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## Inventories From Seven Annex I Nations Were of Higher Comparability and Quality than Those From Seven Non-Annex I Nations Because of Several Barriers

According to expert inventory review teams, the 2009 greenhouse gas inventories of seven Annex I nations were generally comparable and of high quality, although some of their emissions estimates have substantial uncertainty. In contrast, we found that the most recent inventories from seven non-Annex I nations, although they met reporting guidelines, were of lower quality and generally not comparable. Finally, experts identified several barriers to improving inventory comparability and quality.

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## Recent Reviews Found That Selected Annex I Nations' Inventories Were Comparable and of High Quality, but Some Estimates Have Substantial Uncertainty

All of the inventories submitted in 2009 by the seven selected Annex I nations were generally comparable and of high quality, according to the most recent inventory reviews conducted by expert review teams under the Convention. The reviews found that six of the seven nations—Australia, Canada, Japan, Russia, the United Kingdom, and the United States—used appropriate methodologies and data, employed reasonable assumptions, and did not systematically either over- or underestimate emissions in their 2009 inventories (covering data from 1990 through 2007). The one exception to this was Germany's 2009 inventory, which the review team said did not follow guidelines for its agricultural emissions, in part because of its attempt to use newer methods. The change significantly reduced estimated emissions from agriculture, though the sector is a relatively small contributor to Germany's total emissions. One inventory reviewer familiar with Germany's 2009 inventory said its overall quality was fairly good. In addition, Germany appears to have addressed the issue of its agricultural emissions in its 2010 inventory submission by returning to its previous methods, which had the effect of increasing its estimates of

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emissions from agriculture.<sup>20</sup> Experts said that the seven selected inventories were generally comparable, which means they generally used agreed-upon formats and methods. In addition, nine experts we interviewed said they were of high quality and did not have major flaws.

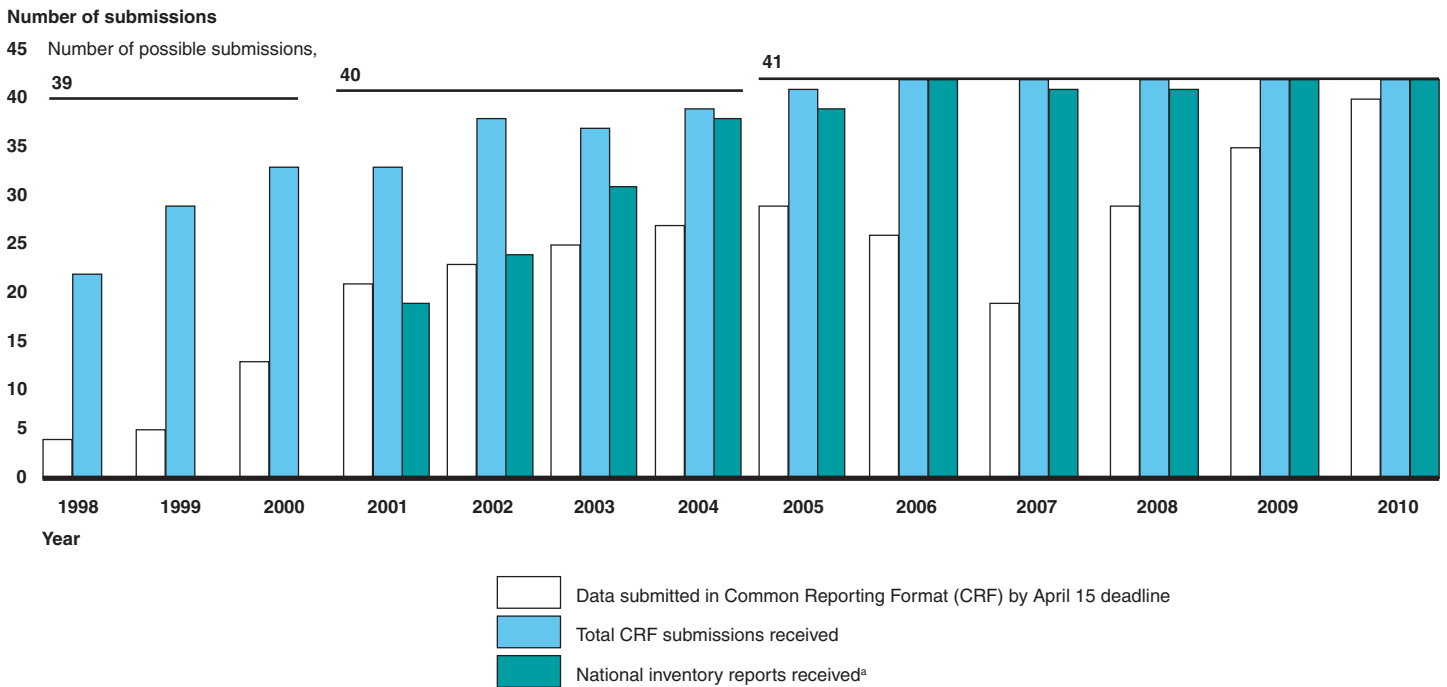
These findings show significant improvement in the seven nations' inventories since our 2003 report. For example, we reported in 2003 that both Germany's 2001 submission (covering data through 1999) and Japan's 2000 submission (covering data through 1998) lacked a national inventory report, a critical element that explains the data and methods used to estimate emissions. Nearly all Annex I nations—including Germany and Japan—now routinely submit this report. In addition, the review team found Russia's 2009 inventory showed major improvements. For example, Russia included a full uncertainty analysis for the first time and improved its quality assurance and quality control plan. Since our 2003 report, these 7 selected nations, and 34 other Annex I Parties, have submitted about seven inventories, which were generally on time and more comprehensive than previous inventories (see fig. 3).

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<sup>20</sup>In its 2009 inventory, Germany used updated guidance and emission factors to estimate emissions from agriculture, but it did not justify the changes, as the Parties have agreed to do. For 2006 emissions, the 2009 changes to methodology for agriculture reduced emissions by about 1.2 percent of the national total. The 2010 revisions have essentially reversed that.



**Figure 3: Inventory Submissions from Annex I Parties, 1998-2010**



Source: GAO analysis of Convention Secretariat information.

Notes: In 2007, Parties submitted initial reports under the Kyoto Protocol. The effort to compile and review these reports may have contributed to the decline in on-time inventory submissions for surrounding years.

<sup>a</sup>Reporting guidelines called for the preparation of national inventory reports beginning in 2000, but they were not collected prior to 2001.

The inventory review reports noted several potential problems that, while relatively minor, could affect the quality of emissions estimates. For example, the review of the 2009 U.S. inventory noted that assumptions about the carbon content of coal are outdated because they are based on data collected between 1973 and 1989. The effect on emissions estimates is not clear, but the carbon content of the coal burned as fuel may change over time, according to the inventory review report. Any such change would affect emissions, since coal is the fuel for about half of all U.S. electricity generation.<sup>21</sup> The U.S. inventory also used a value from a 1996 agricultural waste management handbook to estimate nitrous oxide emitted from livestock manure. The inventory review noted that livestock

<sup>21</sup>The 2010 U.S. inventory submission includes updated carbon content assumptions.

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productivity, especially for dairy cows, has increased greatly since 1996, which would also increase each animal's output of nitrous oxide emissions. Using the IPCC's methodology for calculating emissions from excreted nitrogen, we estimated that this would lead to an underestimate of roughly 4.7 percent of total nitrous oxide emissions and 0.2 percent of total greenhouse gas emissions.<sup>22</sup> Finally, the review of Russia's 2009 inventory noted that it did not include carbon dioxide emissions from organic forest soils, which the inventory review report said could be significant. The inventory reviews and one expert we interviewed attributed many of the potential underestimations to a lack of data or an adequate IPCC-approved methodology and said that nations were generally working to address the issues.

Even though the review teams found these seven inventories generally comparable and of high quality, the nations reported substantial uncertainty in many of the emissions estimates in their inventories. The term "uncertainty" denotes a description of the range of values that could be reasonably attributed to a quantity.<sup>23</sup> All of the Annex I nations' inventories we reviewed contained quantitative estimates of uncertainty. As shown in table 1, six of the seven nations reported uncertainties for their overall estimates between plus or minus 1 and 13 percent, and Russia reported overall uncertainty of about plus or minus 40 percent. That equates to an uncertainty of 800 million metric tons of carbon dioxide equivalent, slightly more than Canada's total emissions in 2007. Russia's relatively large uncertainty estimate could stem from several factors, such as less precise national statistics. In addition, Russia generally used aggregated national data rather than data that account for variation within the nation. This would increase uncertainty because aggregated data do not account for important differences that affect emissions, such as different types of technology used in the energy sector. Japan and Australia reported very low uncertainty in 2009. The inventory review report noted that Japan's estimate was lower than estimates from other nations, but neither the report nor Japan's inventory provides a full

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<sup>22</sup>EPA officials said they will include updated figures for the 2011 inventory submission.

<sup>23</sup>This is the statistical meaning of uncertainty. According to the IPCC, the term is sometimes used more generally and imprecisely when referring to greenhouse gas inventories—see IPCC, *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, p. A3.19 (Geneva, 2000). An uncertainty percentage is often given as "plus or minus," meaning that the actual value could be either above or below the estimate by that percentage. Ranges reported here are for the 95 percent confidence interval.

explanation. The review team for Australia said that its uncertainty ranges were generally consistent with typical uncertainty ranges reported for its sectors. Despite high levels of uncertainty in some instances, the inventory review teams found the seven inventories to be generally of high quality because the teams judge quality based on consistency with guidelines rather than strictly on the precision of the estimates.

**Table 1: Estimates of Uncertainty Reported in Seven Annex I Nations' 2009 Inventories for Emissions in 2007**

| Nation              | Lower bound (percent) | Upper bound (percent) |
|---------------------|-----------------------|-----------------------|
| Australia           | -2%                   | +2%                   |
| Canada <sup>a</sup> | -3                    | +6                    |
| Germany             | -10                   | +10                   |
| Japan               | -1                    | +1                    |
| Russia              | -40                   | +40                   |
| United Kingdom      | -13                   | +13                   |
| United States       | -3                    | +7                    |

Source: National Inventory Reports of seven selected nations; inventory review report for Russia.

<sup>a</sup>Canada's uncertainty analysis does not include uncertainty from the land-use, land-use change, and forestry sector.

The uncertainty of emissions estimates also varies among the different sectors of a nation's economy. For example, uncertainty is relatively low for estimates of carbon dioxide emissions from the combustion of fossil fuels because the data on fuel use are generally accurate and the process that generates emissions is well understood. Uncertainty is much higher for certain categories within agriculture and land-use. For example, some nations report that the uncertainty in their estimates of nitrous oxide emissions from agricultural soils is greater than 100 percent, in some cases much greater. According to a March 2010 report by a National Research Council committee, this results from scientific uncertainty in emission factors.<sup>24</sup> Table 2 shows the contribution of the most important sources of uncertainty in the U.S. inventory. The sources of uncertainty in the other six Annex I nations' inventories follow a broadly similar pattern: the largest sources of uncertainty are either large sources of emissions—such

<sup>24</sup>National Research Council, *Verifying Greenhouse Gas Emissions: Methods to Support International Climate Agreements* (Washington, D.C., National Academies Press, 2010).

as fossil fuel combustion and land use—or small but highly uncertain categories—such as agricultural soils.

**Table 2: Greenhouse Gas Emissions and Uncertainty for Selected Categories from the 2009 U.S. Inventory for Emissions in 2007**

| <b>Emissions category</b>  | <b>Emissions estimate (in millions of metric tons of carbon dioxide equivalent)</b> | <b>Uncertainty of the estimate (percent)</b> |
|--|---|--|
| Carbon dioxide from combustion of fossil fuels                     | 5,736   | -2% to +5%                                   |
| Carbon dioxide from land use, land-use change, and forestry        | -1,063<br>(removal of carbon dioxide)   | -15 to +18                                   |
| Nitrous oxide from agricultural soil management                    | 208   | -22 to +53                                   |
| Methane from fermentation from digestion by livestock <sup>a</sup> | 139   | -11 to +18                                   |
| Methane from landfills   | 133   | -39 to +33                                   |
| Methane from natural gas systems                                   | 105   | -24 to +43                                   |

Source: GAO analysis of 2009 U.S. inventory.

<sup>a</sup>The technical term for this is enteric fermentation.

Shortcomings in inventory reporting guidelines may decrease the quality and comparability of emissions estimates for land use, according to two experts we interviewed. For example, the guidelines state that nations should report all emissions from “managed forests,” but they have broad latitude in assigning forested land to this category. This choice may have a major effect on emissions; one expert said that it would be possible for some nations with large forested areas, such as Brazil, to offset all their emissions from deforestation by designating large areas of protected forest as managed and taking credit for all of the carbon dioxide absorbed by those forests. To address this potential inconsistency, the National Research Council committee report recommended taking inventory of all land-based emissions and sinks for all lands, not just man-made emissions on managed lands. Others said that designating land as managed forest remains the most practical way to estimate man-made emissions and removals because other methods are not well developed.

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**Inventories From Selected Non-Annex I Nations Met Guidelines but Were of Lower Quality and Generally Not Comparable**

Inventories from the non-Annex I nations we reviewed met the Convention's relevant reporting guidelines. All of the seven non-Annex I nations we reviewed—Brazil, China, India, Indonesia, Malaysia, Mexico, and South Korea—had submitted their first inventories. In addition, Mexico submitted its second, third, and fourth inventories, and South Korea submitted its second.<sup>25</sup> Secretariat officials said the other selected nations could submit their second inventories, as part of their national communications, over the next few years. The reporting guidelines call for non-Annex I nations to estimate emissions for 1990 or 1994 in their first submission, and for 2000 in their second submissions, and to include estimates for carbon dioxide, methane, and nitrous oxide in all submissions. We found that all selected non-Annex I nations reported for relevant years and these three gases, but we did not assess whether nations used appropriate methodologies and assumptions to develop these estimates.

However, the seven inventories were generally not comparable and were of lower quality than inventories from Annex I nations in four ways:

1. *Inventories from select non-Annex I nations were outdated.* The most recent inventories from selected Annex I nations estimate emissions for 1990-2008. However, except for Mexico and South Korea, the most recently submitted inventories from selected non-Annex I nations are for emissions for 1994.<sup>26</sup> (See figure 4.)

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<sup>25</sup>Of all 153 non-Annex I nations, only 24 have submitted more than their first inventories.

<sup>26</sup>Brazil and Indonesia estimated annual emissions for 1990 through 1994. These inventories were included in nations' national communications submitted on the following dates: Brazil, December 2004; China, December 2004; India, June 2004; Indonesia, October 1999; Malaysia, August 2000; Mexico, December 2009; and South Korea, December 2003.

**Figure 4: Comparison of Most Recent Greenhouse Gas Emissions Inventories Submitted by Selected Annex I and Non-Annex I Nations**

| Groups of nations selected by GAO  | Year(s) covered in inventory         | Coverage of gases |         |               |                 | Estimate of uncertainty (percent) |
|--|--------------------------------------|-------------------|---------|---------------|-----------------|-----------------------------------|
|  |                                      | Carbon dioxide    | Methane | Nitrous oxide | Synthetic gases |                                   |
| <b>Annex I</b><br>Australia, Canada, Germany, Japan, Russia, United Kingdom, and the United States | 1990 92 94 96 98 00 02 04 06 08 2010 | •                 | •       | •             | •               | 1-40                              |
| <b>Non-Annex I</b><br>Mexico   |                                      | •                 | •       | •             | •               | 7 <sup>a</sup>                    |
| S. Korea   |                                      | •                 | •       | •             | •               | Not estimated                     |
| Brazil   |                                      | •                 | •       | •             | •               | 22                                |
| Indonesia  |                                      | •                 | •       | •             |                 | Not estimated                     |
| China, India, Malaysia   |                                      | •                 | •       | •             |                 | Not estimated                     |

Source: GAO analysis of inventories.

Note: We selected the seven largest emitting Annex I nations and seven of the largest emitting non-Annex I nations

<sup>a</sup>This uncertainty estimate is from Mexico's 2006 submission. Mexico did not include an uncertainty analysis in its latest inventory submitted in 2009.

2. *Some selected non-Annex I nations' inventories do not estimate emissions of all gases.* As shown in figure 4, inventories from China, India, Indonesia, and Malaysia did not include estimates of the emissions of synthetic gases. Independent estimates show that while synthetic gases were only 1 percent of global emissions in 2005, the emissions of synthetic gases increased by 125 percent between 1990 and 2005. Their emissions have also grown substantially in some non-Annex I nations, such as China, which had the largest absolute increase in synthetic gas emissions among all non-Annex I nations between 1990 and 2005, according to information from the International Energy Agency (IEA).<sup>27</sup>
3. *Select non-Annex I nations' inventories, to varying degrees, lacked critical elements.* We assessed inventories for several elements that, according to reporting guidelines, can improve the quality and transparency of inventories. First, only Brazil and Mexico provided a quantitative analysis of the uncertainty of their estimates.<sup>28</sup> Second, we found that all inventories lacked adequate documentation of

<sup>27</sup>IEA, *CO<sub>2</sub> Emissions from Fuel Combustion, 2009 Edition*.

<sup>28</sup>Mexico's quantitative uncertainty analysis was a part of its third National Communication, but not in the fourth National Communication.

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methodologies, emission factors, and assumptions and that most lacked descriptions of quality assurance and quality control measures. Third, none of the select nations reported in a comparable format, instead using different formats and levels of aggregation.<sup>29</sup> For example, China estimated some methane emissions from various agricultural subsectors but grouped some of these estimates into only one category. In contrast, South Korea estimated these same emissions but reported them in separate categories. Overall, the lack of documentation and of a common reporting format limited our ability to identify and compare estimates across nations. Finally, only Mexico included an analysis of its key categories of emissions.<sup>30</sup>

4. *National statistics from some select non-Annex I nations are less reliable.* According to three experts we interviewed and literature, some non-Annex I nations have less reliable national statistics systems than most Annex I nations. These systems are the basis for emissions estimates, and experts noted that the estimates are only as good as the underlying data. For example, researchers estimated that the uncertainty of carbon dioxide emissions from China's energy sector was as high as 20 percent.<sup>31</sup> In contrast, reported uncertainties in estimates of carbon dioxide emissions from fossil fuel use in many developed nations are less than 5 percent. In addition, the International Energy Agency noted a relatively large gap between its energy statistics and those used in the national inventories of some non-Annex I nations, highlighting a need for better collection of data and reporting of energy statistics by some non-Annex I nations.<sup>32</sup>

The lack of comparable, high quality inventories from non-Annex I nations is important because they represent the largest and the fastest growing portion of the world's emissions, and information about their emissions is important to international efforts to address climate change. (See figure 5.) For example, annual emissions from the seven selected non-Annex I nations grew by about 5 billion metric tons of carbon dioxide equivalent

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<sup>29</sup>Unlike for Annex I nations, the reporting guidelines only encourage non-Annex I nations to use a common format.

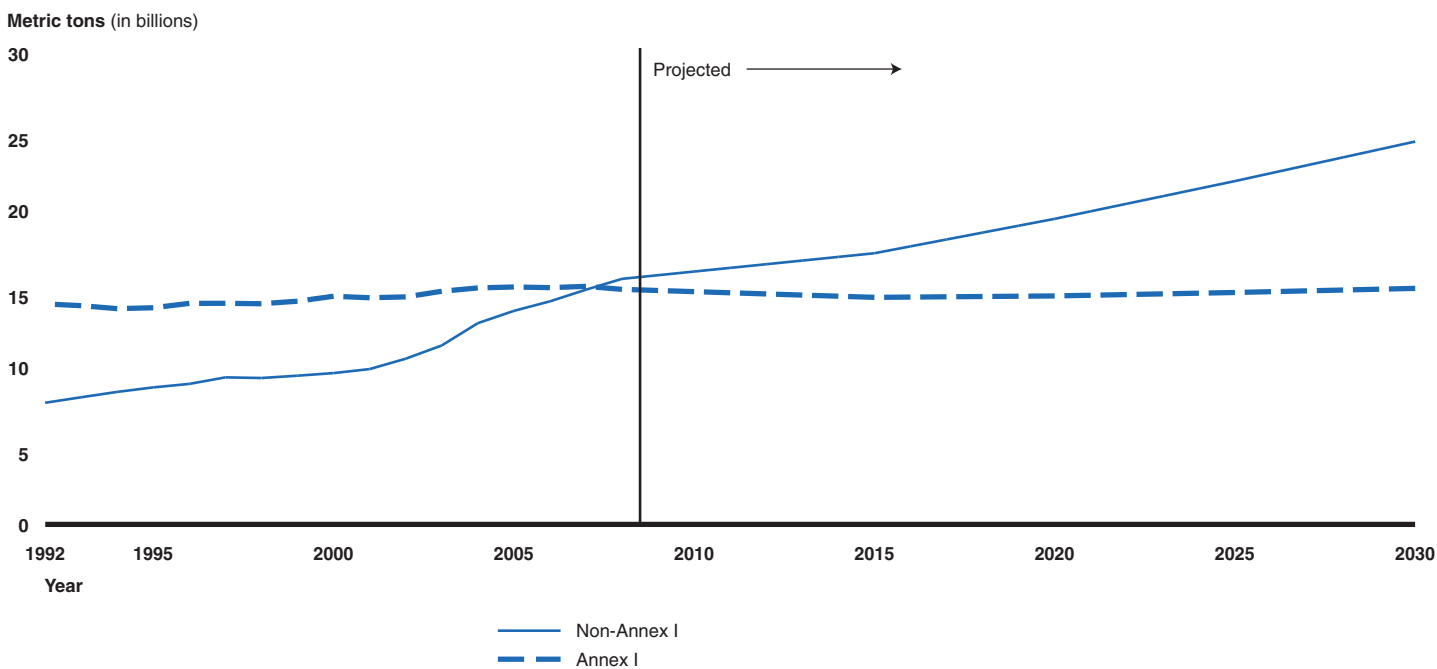
<sup>30</sup>Mexico's key source analysis was a part of its third National Communication.

<sup>31</sup>Gregg, Jay S.; Andres, Robert J.; and Marland, Gregg, "China: Emissions Pattern of the World Leader in Carbon Dioxide Emissions from Fossil Fuel Consumption and Cement Production," *Geophysical Research Letters*, vol. 35 (2008).

<sup>32</sup>IEA, *CO<sub>2</sub> Emissions from Fuel Combustion, 2009 Edition*, I.5.

between 1990 and 2005, which was about the annual emissions of Canada, Germany, Japan, and Russia in 2005 combined.<sup>33</sup> Recognizing the importance of information from non-Annex I nations, in March 2010, a National Research Council committee recommended that Framework Convention Parties extend regular, rigorous inventory reporting and review to developing nations.<sup>34</sup>

**Figure 5: Energy-Related Carbon Dioxide Emissions in Annex I and Non-Annex I Nations, 1992 through 2030, Actual and Projected**



Source: GAO analysis of Energy Information Administration data.

Note: Does not include Monaco or Lichtenstein, which are both Annex I nations. These accounted for less than one percent of Annex I nations' emissions in 2007 according to inventory data submitted to the Convention Secretariat.

<sup>33</sup>Emissions for selected non-Annex I nations are from World Resources Institute, and from inventories submitted to the Secretariat for Canada, Germany, Japan, and Russia.

<sup>34</sup>National Research Council, *Verifying Greenhouse Gas Emissions*, 6.



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## Experts Identified Several Barriers to Improving the Comparability and Quality of Inventories

Experts we interviewed identified several barriers to improving the comparability and quality of inventories. First, 10 of the 12 experts who provided views about barriers said that a lack of data and scientific knowledge makes some types of emissions difficult to estimate for both Annex I and non-Annex I nations.<sup>35</sup> For example, current estimates of emissions related to biological processes, such as those from agriculture and land use, can be uncertain because of limited data. Specifically, nations do not always collect data on livestock nutrition, which can affect methane emissions. In addition, emissions related to some biological processes are difficult to estimate because they are not fully understood or are inherently variable. Emissions related to agriculture, for example, depend on the local climate, topography, soil, and vegetation. In March 2010, a National Research Council committee recommended further scientific research and data collection to reduce the uncertainties in estimates of agriculture, forestry, and land-use emissions.<sup>36</sup> Such emissions are important, contributing about one quarter of total global emissions in 2005, the most recent year for which global data were available. They are particularly important for some non-Annex I nations, where they can be the largest sources of emissions. In Brazil and Indonesia, for example, agriculture and land-use emissions accounted for about 80 percent of total emissions in 2005.

Second, 11 experts said that non-Annex I nations have limited incentives to produce better inventories. The current international system encourages Annex I nations with commitments under the Kyoto Protocol to improve their inventories.<sup>37</sup> This is because their ability to participate in the Kyoto Protocol's flexibility mechanisms—which provide a cost-effective way to reduce emissions—is linked to, among other things, the

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<sup>35</sup>Some of the experts we interviewed did not provide views on barriers to improving inventories. Twelve experts provided the views discussed in this section.

<sup>36</sup>The committee recommended the production of global land-use and land cover maps every 2 years and the development of a research program to improve methods for estimating agriculture, forestry, and land-use emissions. See National Research Council, *Verifying Greenhouse Gas Emissions*, 9.

<sup>37</sup>Belarus, Turkey, and the United States do not have binding emissions targets or commitments under the Kyoto Protocol, though all are included in the Convention's Annex I.

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quality of certain aspects of their inventories.<sup>38</sup> Late submissions, omissions of estimates, or other shortcomings can all affect nations' eligibility to use these mechanisms.<sup>39</sup> Therefore, low-quality inventories can affect nations' ability to lower the costs of achieving their emissions targets. While four experts we interviewed said that this linkage between inventories and the flexibility mechanisms in the Kyoto Protocol has driven improvements in many Annex I nations' inventories, incentives for non-Annex I nations are limited. Furthermore, four experts said that some non-Annex I nations may avoid additional international reporting because they see it as a first step toward adopting commitments to limit emissions.

In addition, experts and the national communications of selected non-Annex I nations identified several other barriers to improving the quality and comparability of inventories from non-Annex I nations, including:

- *Less stringent reporting guidelines and lack of review.* Reporting guidelines differ between Annex I and non-Annex I nations. Non-Annex I nations do not need to annually submit inventories or to report on as many gases, for as many years, with as much detail, or in the same format as Annex I nations. They also do not have to follow all IPCC methodological guidelines, although they are encouraged to do so. Six experts said that this less stringent reporting regime has contributed to the lack of quality and comparability in inventories from non-Annex I nations. In addition, non-Annex I nations have not benefited from the feedback of technical reviews of their inventories, according to one expert.

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<sup>38</sup>The Kyoto Protocol established three mechanisms that provide cost-effective ways for industrial nations to reduce their emissions. Emissions trading allows nations with emissions lower than their Kyoto targets to sell excess allowances to nations with emissions exceeding their targets. The Clean Development Mechanism and Joint Implementation allow nations with binding targets to implement projects that reduce or avoid emissions—such as the construction of renewable energy infrastructure—in developing nations that do not have binding emissions targets or industrialized nations respectively. These projects can earn credits, which industrial nation sponsors can use for compliance with their Kyoto targets.

<sup>39</sup>When inventory review teams find that a Kyoto Protocol Annex I nation's inventory is incomplete or not consistent with applicable guidelines, they may suggest "adjustments" to correct the shortcoming. Nations are ineligible if, for example, their inventory (1) is not submitted within 6 weeks of the due date, (2) omits an estimate for certain categories of emissions, or (3) annual adjusted emissions for a single year in the commitment period exceeds reported emissions by more than 7 percent. See, *Guidelines for the Preparation of the Information Required Under Article 7 of the Kyoto Protocol*, FCCC/KP/CMP/2005/8 Add.2, Decision 15/CMP.1, par 3.

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- *Financial and other resource constraints.* Though eight experts generally said that many non-Annex I nations may lack needed financial and other resources, they differed on the magnitude and importance of additional international support. Non-Annex I nations may lack resources to improve data collection efforts, conduct additional research, or establish national inventory offices. The developed nations of Annex I provided the majority of about \$80 million that has been approved for the latest set of national communications, which include inventories, from non-Annex I nations. However, one expert said that this has not been sufficient to fully support the activities needed. In their national communications, China and India indicated needing funding to, for example, improve data collection. Two experts said that improving non-Annex I nations' inventories may require significant resources. On the other hand, others said that the funds involved may be relatively small, or that financial constraints may not be significant, at least for major non-Annex I nations. For example, according to a report from a National Research Council committee, significant improvements in inventories from 10 of the largest emitting developing nations could be achieved for about \$11 million over 5 years.<sup>40</sup> While experts disagreed about the importance of additional funding, three said that international funding should support capacity development in each nation. They said that more continuous support would improve on the current, project-based method of funding, which encourages nations to assemble ad-hoc teams that collect data, write a report, and then disband.
  - *Lack of data and nation-specific estimates of emissions factors.* According to four experts and the Convention Secretariat's summary of constraints identified by non-Annex I nations in their initial national communications, the lack or poor quality of data or a reliance on default emissions factors limit the quality of inventories. Most non-Annex I nations identified that missing or inadequate data was a major constraint for estimating emissions in at least one sector. For example, Indonesia reported that it did not estimate carbon emissions from soils because the data required were not available. Though inventory guidelines encourage the use of nation-specific emissions factors that reflect national circumstances, most non-Annex I nations use default values provided by the IPCC. The reliance on default values can increase uncertainties of estimates because national circumstances can differ significantly from the defaults. For example, Denmark's nation-specific emission factor for methane emissions from sheep is twice as large as the default. Thus, if

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<sup>40</sup>National Research Council, *Verifying Greenhouse Gas Emissions*, 6.

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Denmark had used the default value, it would have underestimated its emissions from sheep by half.

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## The Inventory Review Process for Annex I Nations Has Several Strengths and Some Limitations, and No Comparable Process Exists for Non-Annex I Nations

Experts said that the process for reviewing inventories from Annex I nations has several notable strengths. They also identified three limitations, which may present challenges in the future. Moreover, we found that although the review process includes steps to help ensure the quality of reviews, there is no independent assessment of the process' operations. Finally, there is no review process for inventories from non-Annex I nations.

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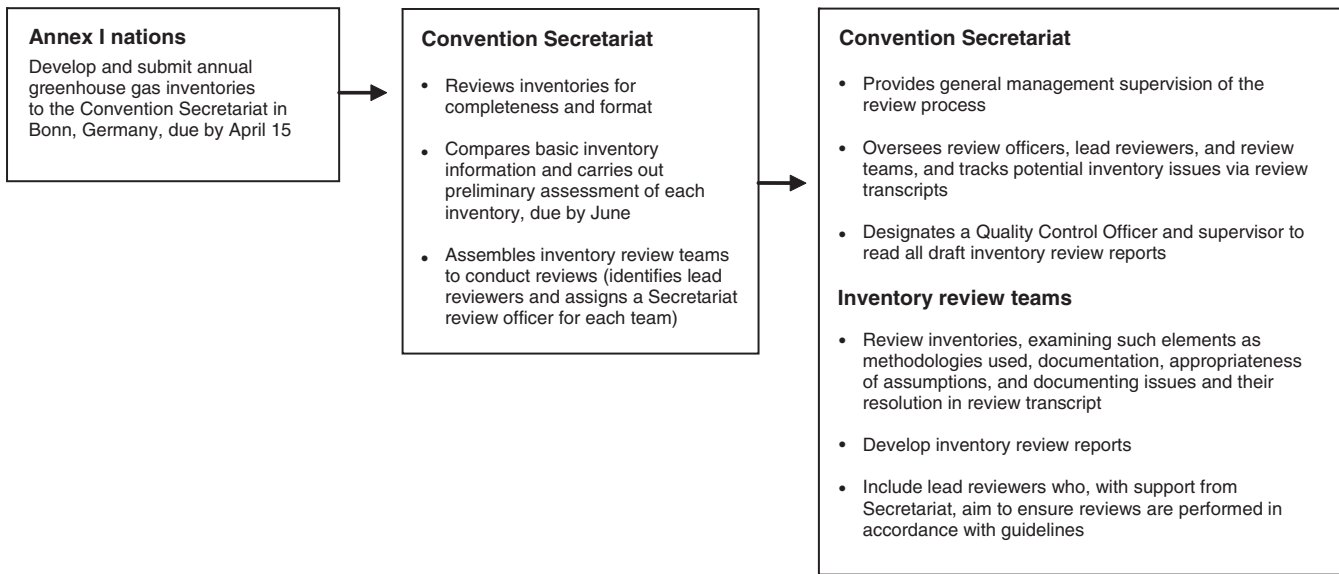
## The Process for Reviewing Inventories from Annex I Nations Has Several Strengths

Eight of the experts we interviewed said the process for reviewing inventories from Annex I nations has several notable strengths that enable it to generally meet its goals of providing accurate information on the quality of inventories and helping nations improve their inventories.<sup>41</sup> (Figure 6 below depicts the inventory review process.)

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<sup>41</sup>Some of the experts did not provide views on the strengths and limitations of the inventory review process. Twelve experts provided the views discussed in this section.

**Figure 6: Review Process for Inventories from Annex I Nations**



Source: GAO analysis of Convention documents and interviews with Secretariat officials.

Experts identified four broad categories of strengths:

- *Rigorous review process.* Five experts said the rigorous review process gives them confidence that review teams can identify major problems with inventory estimates. For example, the Secretariat and review teams compare data, emission factors, and estimates from each inventory (1) from year to year, (2) with comparable figures in other inventories, and (3) with data from alternative sources, such as the International Energy Agency (IEA) and the United Nations Food and Agriculture Organization. Reviewers also ensure methods used to estimate emissions are appropriate and meet accepted guidelines. In addition, IEA officials inform the inventory review process by reviewing energy data in inventories and independently identifying issues for review teams to consider further.
- *Qualified and respected reviewers.* Three experts we interviewed said that well-qualified and widely respected inventory reviewers give the process credibility. Secretariat officials told us that a relatively small number of people in the world have the expertise to evaluate inventories without further training. Parties nominate reviewers, including leading scientists and analysts, many of whom are also inventory developers in their home nations. Reviewers must take training courses and pass examinations that ensure they understand inventory guidelines and

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appropriate methodologies before serving on a review team. Two experts said reviewers' experience and qualifications allow them to assess the strengths and weaknesses in inventories, including whether nations use appropriate methodologies. This is particularly important because some nations use advanced or nation-specific approaches, which can be difficult to assess.

- *Capacity building.* Three experts said the inventory review process builds expertise among reviewers from developed and developing nations. Specifically, they said the review process brings inventory specialists together from around the world, where they learn from each other and observe how various nations tackle challenges in compiling their inventories. Two experts said that reviewers return home and can use the knowledge and contacts gained from their review team experiences to improve their national inventories.
- *Constructive feedback.* Two experts said that the inventory reviews provide constructive feedback to improve inventories from Annex I nations. This feedback includes identifying both major and minor shortcomings in inventories. Secretariat officials said that review teams, when they identify issues, must also offer recommendations for addressing them. For example, reviewers noted Russia's 2009 use of default assumptions for much of its uncertainty analysis, and recommended that Russia develop values that better match the methods and data used in making the emissions estimates.

For these and other reasons, three experts we interviewed said that the review process has helped improve the quality of inventories from Annex I nations. Secretariat officials said that when review teams point out discrepancies or errors, many nations revise and resubmit estimates to correct problems. For example, Australia revised its estimates of carbon dioxide emissions from croplands after a review team pointed out that changes in croplands management affect emissions. Australia's revisions decreased estimated emissions from croplands in 1990 by 138 percent, meaning the revisions had the effect of moving croplands from an estimated source of greenhouse gas emissions to a sink removing greenhouse gases from the atmosphere. For nations with Kyoto Protocol commitments, review teams may adjust estimates if they are not satisfied

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with a response to their findings.<sup>42</sup> For example, the team reviewing Greece's 2006 inventory concluded that estimates in several categories were based on methods, data, and emissions factors that did not adhere to reporting guidelines. The review team was not satisfied with Greece's response, and recommended six adjustments to Greece's estimates. These adjustments lowered Greece's official baseline energy sector emissions by 5 percent, from 82 million to 78 million metric tons of carbon dioxide equivalent.<sup>43</sup>

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## The Process for Reviewing Inventories from Annex I Nations Has Some Limitations

Experts, literature, and several nations identified some limitations of the review process, which may present challenges in the future if, for example, the process is expanded to incorporate non-Annex I nations. First, six experts we interviewed said the process does not independently verify emissions estimates or the quality of the underlying data. Review teams primarily ensure the consistency of inventories with accepted standards but do not check underlying activity data, such as the amount of fuel burned. Review teams do compare underlying data with those reported in other sources, but these other sources are not fully independent because they also come from the nations that supply the inventories. Two experts said that more thorough verification might involve comparing estimates to observed measurements or independently constructing estimates from raw data.

However, such approaches may be costly and, as a National Research Council committee reported, the other methods currently available do not allow independent verification of estimates. Furthermore, one expert said that the review of emissions estimates from agricultural soils and land-use sectors may be especially limited because of a lack of data and the inherent difficulty in measuring these emissions. The inability to more thoroughly assess inventories may reduce the reliability of review findings. For example, the inventory review process may have overlooked a significant shortcoming in at least one review. Specifically, in 2009, the national audit office of one Annex I nation found that its national inventory estimates may understate actual emissions by about a third

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<sup>42</sup>Because the authority for the review teams to make adjustments is provided by the Kyoto Protocol, the review teams cannot adjust estimates for Belarus, Turkey, or the United States, the Annex I nations that do not have Kyoto Protocol commitments.

<sup>43</sup>The Convention, *Report of the Review of the Initial Report of Greece*, FCCC/IRR/2007/GRC (Bonn, Germany, Dec. 28, 2007).

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because the inventory preparers used questionable statistics. The relevant agencies in that nation generally agreed with the audit office's recommendations based on its assessment. The review for that inventory, however, did not identify this issue.

Second, four experts we interviewed and several nations have expressed concerns about inconsistency across reviews, though the magnitude of this potential problem is unclear. The concerns relate to the potential for review teams to inconsistently apply standards when assessing an inventory. Secretariat officials said the process of reviewing inventories involves some degree of subjectivity, since reviewers use professional judgment in applying inventory review guidelines to a specific inventory. As a result, review teams might interpret and apply the guidelines differently across nations or over time. Four experts we spoke with, as well as several nations, have raised such concerns. For example, the European Community reported that some nations have received, on occasion, contradictory recommendations from inventory review teams.<sup>44</sup> Secretariat officials said lead reviewers are ultimately responsible for consistent reviews but that Secretariat staff assist the review teams during the process, and two Secretariat staff read through all draft inventory reports, in part to identify and resolve possible inconsistencies. In addition, lead reviewers develop guidance on consistency issues at annual meetings. The magnitude of this potential problem is unclear, in part because it has not been evaluated by an independent third party.

Third, three experts and officials we interviewed said there are not enough well-qualified reviewers to sustain the process. Three experts and Secretariat officials said that they did not know whether this shortage of available experts has affected the overall quality of reviews. The Secretariat has, in the past, reassigned staff and reviewers from work on national communications to the review of inventory reports, and it provides training to all reviewers to increase capacity and retain qualified reviewers. However, Secretariat officials said it may be difficult to sustain the quality of reviews in the future if the inventory review process is expanded to include inventories from non-Annex I nations without receiving additional resources, since this would substantially increase the demands on the review process.

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<sup>44</sup>France, "Submission by France on Behalf of The European Community and Its Member States," *Experiences With and Lessons Learned From the Review of Initial Reports Under the Kyoto Protocol, Including Recommendations for Improvements*, FCCC/SBI/2008/MISC.7 (Bonn, Germany, 2008) 7.



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## The Review Process Does Not Have an Independent Assessment of Its Operations

The review process includes steps to help ensure the quality of reviews, but we found that its quality assurance framework does not independently assess the process. Secretariat officials said that lead reviewers oversee the drafting of review reports, and review officers, lead reviewers, and review teams maintain a review transcript to keep track of potential issues they have identified with inventories, of nations' responses to those issues, and of their resolution. However, lead reviewers, in the report of their 2009 meeting, expressed concern that these review transcripts are sometimes incomplete and are not always submitted to the Secretariat. In providing information on their experience with the review process and recommendations for improvements, the nations of the European Community suggested in late 2008 that the review process would benefit from establishing clear quality assurance and quality control procedures as well as from an annual analysis of its performance in relation to its objectives.<sup>45</sup> Secretariat officials said they designated a Quality Control Officer who, along with the supervisor of the review process, reads all draft review reports and may identify problems and check underlying information in reports. Furthermore, Secretariat officials said that lead reviewers meet annually to discuss the review process, assess and prepare guidance about specific issues or concerns about the review process, and develop summary papers to report to Parties.

Nonetheless, the review process lacks an independent assessment of its operation. We examined several other review processes and found that periodic external assessments by independent entities can provide useful feedback to management and greater assurance that the review processes are working as intended.<sup>46</sup> Inventory guidelines call for Annex I nations to carry out quality assurance activities for their own inventories, including a planned system of reviews by personnel not directly involved in the

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<sup>45</sup>France, *Experiences With and Lessons Learned From the Review of Initial Reports*, 7.

<sup>46</sup>Though neither the Secretariat nor review teams are required to follow them, we examined the standards, descriptions or guidelines of the review processes in the following: (1) International Standard Organization (ISO) guidance for verifying greenhouse gas assertions (ISO, *Greenhouse gases—Part 3: Specification with Guidance for the Validation and Verification of Greenhouse Gas Assertions*, ISO 14064-3 (Geneva, Switzerland, 2006).), (2) the study process used by the National Academies, (3) Government Auditing Standards (GAO, *Government Auditing Standards July 2007 Revision*, [GAO-07-731G](#) (Washington, D.C.: July, 2007).), and (4) the Institute for Internal Auditors standards (The Institute of internal Auditors, *International Professional Practices Framework* (Altamonte Springs, Florida, January 2009).).

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process.<sup>47</sup> Though some United Nations and Framework Convention oversight bodies have the ability to assess the inventory review process, none have done so.<sup>48</sup> The Secretariat has internal auditors, but they have not audited the inventory review process and Secretariat officials said they did not know of any plans to do so. Although the Compliance Committee of the Kyoto Protocol has reviewed aspects of the review process, issuing a report with information on consistency issues, this report was not a systematic review and was not developed by people independent of the review process.

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## No Inventory Review Process Exists for Non-Annex I Nations

As stated earlier, inventories from non-Annex I nations do not undergo formal reviews. The Secretariat compiled a set of reports summarizing inventory information reported by non-Annex I nations, such as inventory estimates, national circumstances, and measures to address climate change.<sup>49</sup> However, Secretariat officials said they had not assessed the consistency of non-Annex I nations' inventories with accepted guidelines. These officials also said that they did not plan to compile another report covering non-Annex I nations' second inventories because the Parties have not agreed to this. An expert we interviewed said that the quality of inventories from non-Annex I nations is unknown because their inventories have not been formally reviewed. Two experts said that some non-Annex I nations have resisted increased scrutiny of their inventories because of sovereignty concerns, meaning that nations do not want to disclose potentially sensitive information or data to other political bodies. The growth in greenhouse gas emissions along with lower quality inventories in some non-Annex I nations is likely to increase the pressure for a public review of their inventories in the future.

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<sup>47</sup>IPCC, "Quality Assurance and Quality Control," *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (2000).

<sup>48</sup>The Framework Convention's Subsidiary Body for Implementation assists the Parties in assessing and reviewing the effective implementation of the Convention, and the Subsidiary Body for Scientific and Technological Advice provides the Parties with information and advice on scientific and technological matters, including matters that relate to inventories.

<sup>49</sup>The Convention, *Sixth Compilation and Synthesis of Initial National Communications from Parties Not Included in Annex I to the Convention*, FCCC/SBI/2005/18 (Bonn, Germany, 2005).

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## Experts Said the Inventory System Is Generally Sufficient for Monitoring Compliance with Current Agreements, but Future Agreements with Non-Annex I Nations Could Pose Challenges

Most experts we interviewed said that the inventory system for Annex I and non-Annex I nations is generally sufficient for monitoring compliance with current agreements. However, they said that the system may not be sufficient for monitoring non-Annex I nations' compliance with future agreements that include commitments for them to reduce emissions.

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## Experts Said the Inventory System Supports Current Agreements and International Negotiations

Eleven of the experts we interviewed said the inventory system—inventories and the process for reviewing them—is generally sufficient for monitoring compliance with current agreements, though five raised some concerns. All 11 of the experts who provided their views on the implications of the inventory system expressed confidence that inventories and the Convention's inventory review process are suitable for monitoring Annex I nations' compliance with existing commitments to limit emissions.<sup>50</sup> In part, this is because emissions in many Annex I nations primarily relate to energy and industrial activity, which can be more straightforward to estimate and monitor than emissions from land use and agriculture.

Nevertheless, five experts raised at least one of two potential challenges facing the current system. First, three said they were cautious until they see how the system performs under the more demanding conditions of submitting and reviewing inventories that will show whether nations have

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<sup>50</sup>Some of the experts we interviewed did not provide views on the implications for international agreements because, for example, they felt they were not experts in these issues. Eleven experts provided views discussed in this section.

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met their binding emission targets under the Kyoto Protocol.<sup>51</sup> When inventories are for years included in the Protocol's commitment period, nations may be more concerned about meeting emissions targets, and review teams may face pressure to avoid negative findings. Second, three experts said that flexibilities in the current inventory system or difficulties in measuring and verifying emissions from some agriculture and land-use segments could create complications for international emissions trading under the Kyoto Protocol. Emissions trading under the Kyoto Protocol allows nations with emissions lower than their Kyoto targets to sell excess allowances to nations with emissions exceeding their targets. Though Parties to the Kyoto Protocol developed and agreed to the current system, three experts indicated that ensuring greater comparability of estimates between nations and types of emissions might be useful for emissions trading.<sup>52</sup> For non-Annex I nations, eight experts said that their lower quality inventories and lack of review do not present a current problem since these nations do not have international commitments to limit their emissions.

Seven of the experts said that the inventory system is sufficient to support international negotiations. To develop agreements, two experts said, negotiators need information on current and historic emissions from the nations involved. Annex I nations submit this information in their annual emissions inventories, the most recent of which cover emissions from 1990 to 2008. Although emissions estimates in most non-Annex I nations' inventories are outdated, seven experts said that there are enough independent estimates to provide negotiators with adequate information.<sup>53</sup> State officials said that independent estimates are useful, but official national inventories would be preferable because they can lead to more

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<sup>51</sup>Inventories that Annex I Parties with Kyoto commitments submitted in 2010, which are currently being reviewed, are the first to include emissions estimates for years included in the Kyoto Protocol's 2008-2012 commitment period, though inventories to establish baseline emissions have already been reviewed.

<sup>52</sup>Under the Kyoto Protocol, nations can only use certain emissions from land-use change and forestry to meet the Protocol's targets.

<sup>53</sup>For example, IEA publishes yearly estimates of carbon dioxide emissions from the combustion of fossil fuels, the most recent of which includes estimates from 1971 to 2007 for 140 nations. In addition, the Emission Database for Global Atmospheric Research, developed by the European Commission's Joint Research Centre and the Netherlands Environmental Assessment Agency, estimates other sources of carbon dioxide and other greenhouse gases emissions. See IEA, *CO<sub>2</sub> Emissions from Fuel Combustion, 2009 Edition* and <http://edgar.jrc.ec.europa.eu/>.

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constructive discussions and can help create capacity in nations to better measure emissions. In international negotiations, State has emphasized the need for better information on emissions from all high-emitting nations, including non-Annex I nations.

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### Experts Said the Inventory System May Not Be Sufficient for Monitoring Non-Annex I Nations' Compliance with Future Agreements, Though Other Barriers Pose Greater Challenges

Different types of commitments would place different demands on the inventory system. Thus, the implications of the state of the inventory system for a future agreement will largely depend on the nature of that agreement. For Annex I nations, eight experts said that future commitments were likely to resemble current commitments and therefore the inventory system is likely to be sufficient. However, for non-Annex I nations, if future agreements include commitments to limit emissions, the current system is not sufficient for monitoring their compliance, according to nine experts. This is because non-Annex I nations do not submit inventories frequently, the quality of their inventories varies, and they do not undergo an independent technical review. Additional reporting and review could pose challenges since it could take time for non-Annex I nations to improve their inventories and Secretariat officials said that adding non-Annex I nations to the current inventory review process could strain the capacity of that system.

Some types of commitments by non-Annex I nations could be especially difficult to monitor and verify, according to experts. In the nonbinding 2009 Copenhagen Accord, many nations submitted the actions they intended to take to limit their greenhouse gas emissions, with Annex I nations committing to emissions targets for 2020 and non-Annex I nations announcing various actions to reduce emissions. Experts identified several challenges with monitoring the implementation of some of the actions proposed by non-Annex I nations (see table 3). For example, two experts said that monitoring emissions reductions from estimates of future business-as-usual emissions may prove challenging. They said this is because such actions may require Parties to estimate reductions from a highly uncertain projection of emissions that would have otherwise occurred. Parties would also have to develop and agree on guidelines to estimate and review business-as-usual emissions in addition to actual emissions. Similarly, monitoring reductions in the intensity of greenhouse gas emissions—emissions per unit of economic output, or gross domestic product—could pose challenges because of uncertainties in estimates of gross domestic product. One expert said that these challenges arise because the Parties to the Convention created the current inventory system to monitor compliance and evaluate progress among Annex I nations with national targets. This expert added that Parties to a new

agreement may need to supplement the system to support the types of actions under consideration by non-Annex I nations.

**Table 3: Select Actions Submitted Under the Copenhagen Accord and Potential Challenges Identified by Experts**

| Type of action   | Examples   | Potential challenges identified by experts   |
|--|--|--|
| <b>Annex I nations</b>   |  |  |
| National emissions targets   | <ul style="list-style-type: none"> <li>5-25 percent reduction from 2000 levels by 2020 (Australia)<sup>a</sup></li> <li>17 percent reduction from 2005 levels by 2020 (Canada)<sup>a</sup></li> <li>15-30 percent reduction from 1990 levels by 2020 (European Union, Japan, and Russia)<sup>a</sup></li> <li>In the range of a 17 percent reduction from 2005 levels by 2020 (United States)<sup>a</sup></li> </ul> | <ul style="list-style-type: none"> <li>Some issues to be resolved related to reporting land-use, land-use change, and forestry emissions.</li> <li>Some concerns about using current inventories to support international emissions trading.</li> </ul>  |
| <b>Non-Annex I nations—nationally appropriate mitigation actions</b> |  |  |
| Reductions from business-as-usual                                    | <ul style="list-style-type: none"> <li>Up to 30 percent reduction from business-as-usual by 2020 (Mexico)</li> <li>30 percent reduction from business-as-usual by 2020 (South Korea)</li> <li>36-39 percent reduction from projected emissions by 2020 (Brazil)</li> </ul>   | <ul style="list-style-type: none"> <li>Would require new guidelines, reporting, and review for business-as-usual emissions projections.</li> <li>Non-Annex I inventories are infrequent, less comprehensive, and are not reviewed.</li> <li>Additional reviews could strain capacity of current system.</li> </ul> |
| Sector-level targets and timetables                                  | <ul style="list-style-type: none"> <li>Reduction in emissions related to deforestation (Brazil)</li> </ul>   | <ul style="list-style-type: none"> <li>May require new guidelines if sectors are not the same as defined in current guidelines.</li> <li>Would require reporting and review of sector-level emissions.</li> <li>Focus on forestry may present additional challenges.</li> </ul>                                    |
| Intensity targets  | <ul style="list-style-type: none"> <li>40-45 percent reduction in carbon dioxide emissions per unit of gross domestic product (GDP) by 2020 compared to 2005 (China)</li> <li>20-25 percent reduction in emissions intensity of GDP by 2020 compared to 2005 (India)</li> </ul>  | <ul style="list-style-type: none"> <li>Would require new guidelines, reporting, and reviewing for GDP figures.</li> <li>Non-Annex I inventories are infrequent, less comprehensive, and are not reviewed.</li> <li>Additional reviews could strain capacity of current system.</li> </ul>                          |
| Policies and measures  | <ul style="list-style-type: none"> <li>Promotion of energy efficiency (Indonesia)</li> </ul>   | <ul style="list-style-type: none"> <li>Would require new guidelines, reporting, and review.</li> </ul>   |

Source: GAO analysis based submissions to the Convention Secretariat and interviews with experts.

Note: This list represents challenges identified by one or more experts.

<sup>a</sup>All listed Annex I actions are conditional on actions by others, or, for the United States, on anticipated energy and climate legislation.

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Eight of the experts we interviewed said that Parties to a future agreement could overcome or mitigate many of the challenges related to inventories. For example, two experts said that Parties could design agreements that rely less on emissions estimates that are inherently uncertain or difficult to verify. For example, quantitative targets could apply only to sectors or gases that are relatively easy to measure and verify, such as carbon dioxide emissions from the burning of fossil fuels.

Three experts said that barriers other than the inventory system pose greater challenges to designing and reaching agreements on climate change. For example, nations disagree on the appropriate emissions limits for developed and developing nations. According to three experts, such disagreements were more of an obstacle to a comprehensive agreement in the latest round of negotiations in Copenhagen than were inventory issues. In addition, one expert pointed out that Parties to international agreements generally have limited ability to get other Parties to comply. For example, at least one nation with a binding emissions target under the Kyoto Protocol is unlikely to meet its target based on current inventory estimates and policies, according to this expert. Nations may be reluctant to agree to an international agreement until they have some assurance that other nations will follow through on their commitments.

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## Conclusions

High quality and comparable information on national greenhouse gas emissions is critical to designing and implementing international responses to climate change. The nations we reviewed meet their inventory reporting obligations, and review reports indicate this has resulted in generally high quality inventories from the seven highest emitting Annex I nations. However, the current inventory system does not request high quality emissions information from non-Annex I nations, which account for the largest and fastest growing share of global emissions. We found that the inventories from seven selected high emitting non-Annex I nations were generally outdated, not comparable, and of lower quality than inventories from Annex I nations. The existing gap in quality and comparability of inventories across developed and developing nations makes it more difficult to establish and monitor international agreements, since actions by both developed and developing nations will be necessary to address climate change under future international agreements. As a recent National Research Council committee study pointed out, extending regular reporting and review to more nations may require external funding and training, but the resources needed for the largest emitting developing nations to produce better inventories is relatively modest.

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While our work suggests that the current inventory review process has notable strengths, we identified limitations that may present challenges in the future. For example, some experts and nations have reported concerns about inconsistent reviews and that resources may not be sufficient in the future. Stresses on the review process are likely to increase as review teams begin to review inventories that cover years in which some nations have binding emissions targets and if inventories from non-Annex I nations are subjected to inventory review under a future agreement. The Convention Secretariat has internal processes in place to help ensure quality reviews, but no systematic independent review to assess the merits of concerns about the consistency of reviews or to assess the need for additional qualified reviewers in the future. Addressing these issues could benefit the Secretariat by further enhancing confidence in its processes and ensuring that it has the resources necessary to maintain high quality reviews.

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## Recommendations for Executive Action

We are making two recommendations to the Secretary of State:

1. Recognizing the importance of high quality and comparable data on emissions from Annex I and non-Annex I Parties to the Convention in developing and monitoring international climate change agreements, we recommend that the Secretary of State continue to work with other Parties to the Convention in international negotiations to encourage non-Annex I Parties, especially high-emitting nations, to enhance their inventories, including by reporting in a more timely, comprehensive, and comparable manner, and possibly establishing a process for reviewing their inventories.
2. To provide greater assurance that the review process has an adequate supply of reviewers and provides consistent reviews, we recommend that the Secretary of State, as the U.S. representative to the Framework Convention, work with other Parties to the Convention to explore strengthening the quality assurance framework for the inventory review process. A stronger framework could include, for example, having an independent reviewer periodically assess the consistency of inventory reviews and whether the Secretariat has sufficient resources and inventory reviewers to maintain its ability to perform high quality inventory reviews.



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## Agency Comments and Third-Party Views

We provided State, the Convention Secretariat, and EPA with a draft of this report for review and comment. State agreed with our findings and recommendations and said that the department has been working with international partners in negotiations and through bilateral and multilateral partnerships to support and promote improved inventory reporting and review. State's comments are reproduced in appendix III.

The Convention Secretariat provided informal comments and said that it appreciated our findings and conclusions. The Secretariat said that the report provided a comprehensive overview of the existing system for reporting and reviewing inventories under the Convention and the Kyoto Protocol, as well as very useful recommendations on how this system could evolve in the future and steps to be taken to that end. The Secretariat noted our acknowledgement of the strengths of the inventory review process for Annex I nations. In addition, the Secretariat commented on our discussion of the limited availability of statistics against which to compare inventory data, saying that this lack of data does not imply that its review process lacks independent verification and that its review teams rely on available statistics in conducting their reviews. The Secretariat also said that the disparities in inventory quality across Annex I and non-Annex I nations should be viewed in the context of the "common but differentiated responsibilities" of developed and developing nations under the Convention.

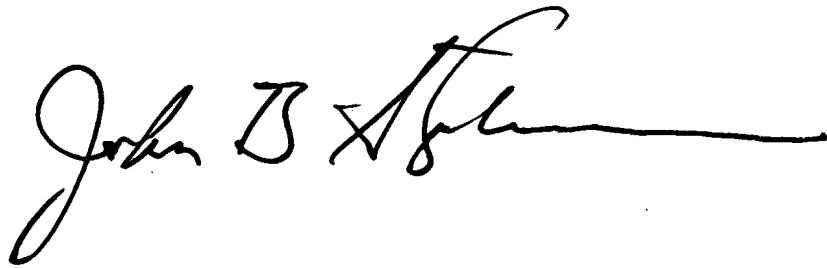
In addition, EPA and the Convention Secretariat provided technical comments and clarifications, which we incorporated as appropriate.

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As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, Secretary of State, Administrator of EPA, Executive Secretary of the Convention Secretariat, and other interested parties. In addition, the report will be available at no charge on GAO's Web site at <http://www.gao.gov>.

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If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or [stephensonj@gao.gov](mailto:stephensonj@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.

A handwritten signature in black ink, reading "John B. Stephenson". The signature is written in a cursive style with a long horizontal flourish at the end.

John B. Stephenson  
Director, Natural Resources and Environment

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# Appendix I: Scope and Methodology

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Our review provides information on: (1) the comparability, quality, and barriers to improving inventories submitted by developed and developing nations to the United Nations Framework Convention on Climate Change (the Convention); (2) the strengths and limitations of the Convention's inventory review process; and (3) the views of experts on the implications for agreements to reduce greenhouse gas emissions. To address all of these objectives, we reviewed relevant literature and Convention documents; met with officials from the Environmental Protection Agency (EPA), Department of State (State), the Convention Secretariat, and others to understand inventories, the inventory review process, and international negotiations; and summarized the views of experts on these issues.

Specifically, to address the first objective, we selected a nonprobability sample of 14 nations, seven Annex I nations—Australia, Canada, Germany, Japan, Russia, the United Kingdom, and the United States—and seven non-Annex I nations—Brazil, China, India, Indonesia, Malaysia, Mexico, and South Korea—based on the size of their emissions (including emissions from land-use and land-use change and forestry). We selected the largest emitting Annex I nations. For non-Annex I nations, we selected the largest emitting nations who had submitted inventories based on data available at the time.<sup>1</sup> We omitted Myanmar because it did not submit an inventory to the Convention. We also ensured coverage of major variations in selected nation's income and sectoral structure of their economies. To illustrate this variation, we used the World Bank's data on per capita income levels, and data from the World Resources Institute and Convention Secretariat on emissions from the energy and industrial processes sectors. The selected 14 nations represented about two thirds of the world's greenhouse gas emissions not related to land use and forestry in 2005. Our findings are not generalizable to other nations because the selected nations are not necessarily representative.

To assess the comparability and quality of inventories from Annex I nations, we summarized the results of the Convention's 2009 reviews of inventories from selected Annex I nations, the most recent reviews available. We did not independently assess the validity of data, assumptions, or methodologies underlying the inventories we reviewed. Though we identified some limitations with the inventory review process,

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<sup>1</sup>Based on more recent data, Malaysia is no longer one of the seven highest emitting non-Annex I nations.

we believe that reviews provide reasonable assessments of the comparability and quality of inventories from selected Annex I nations. For non-Annex I nations, we assessed whether the latest inventories from selected nations included estimates for all major greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, sulfur hexafluoride, and perfluorocarbons), for all sectors (energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, and waste) and various years, and checked for inclusion of key inventory characteristics, including descriptions of uncertainty and quality assurance and quality control measures, adequate documentation to support estimates, a comparable format, and analysis to identify emissions from key sources. Though inventory guidelines do not call for all of these from non-Annex I nations, we believe they are indicative of the quality and comparability of inventories. We did not independently assess emissions estimates from non-Annex I nations. We used the quality principles agreed to by Parties for Annex I nations—transparency, consistency, comparability, completeness, and accuracy—as the basis of our review of all inventories and in our discussions with experts.<sup>2</sup> We also provide information on the reported uncertainty of emissions estimates, a more objective indicator of their precision, and on the timeliness of inventory submissions. To identify barriers to improving inventories, we reviewed relevant literature, including national communications from the seven selected non-Annex I nations, and summarized the views of our expert group.

To address the second objective, we summarized the results of semi-structured interviews with experts and Secretariat officials. We reviewed Convention documentation about the inventory review process, including Compliance Committee and Subsidiary Body for Implementation reports.

To address all three objectives, we summarized findings in the literature and the results of semi-structured interviews with experts. First, we identified 285 experts from our review of the literature and recommendations from U.S. and international government officials and researchers. From this list, we selected 15 experts based on (1) the relevance and extent of their publications, (2) recommendations from others in the inventory field, and (3) the extent to which experts served in

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<sup>2</sup>The Convention, *Guidelines for the Preparation of National Communications by Parties Included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories*, FCCC/SBSTA/2006/9 (Bonn, Germany, Aug. 18, 2006).

the Consultative Group of Experts (a group assembled by the Convention to assist non-Annex I nations improve their national communications), as lead reviewers in the Convention's inventory review process, or were members of the National Research Council's committee on verifying greenhouse gas emissions. Finally, to ensure coverage and range of perspectives, we selected experts who had information about key sectors, like the agriculture and energy sectors, came from both Annex I and non-Annex I nations and key institutions, and provided perspectives from both those who were involved in the inventory review process and from those not directly involved in preparing or reviewing inventories. Appendix II lists the experts we interviewed, which included agency and international officials, researchers, and members of inventory review teams. We conducted a content analysis to assess experts' responses and grouped responses into overall themes. The views expressed by experts do not necessarily represent the views of GAO. Not all of the experts provided their views on all issues. We identify the number of experts providing views where relevant.

During the course of our review, we interviewed officials, researchers, and members of inventory review teams from State, EPA, and the Department of Energy in Washington, D.C.; the Convention Secretariat's office in Bonn, Germany; and from various think tanks, nongovernmental organizations, and international organizations.

We conducted this performance audit from September 2009 to July 2010 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

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# Appendix II: List of Experts

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Scott Barrett, Columbia University

Clare Breidenich, Independent Consultant

Jane Ellis, Organisation for Economic Co-operation and Development

Thelma Krug, Inter American Institute for Global Change Research, Brazil

Bill Irving, Environmental Protection Agency

Bo Lim, United Nations Development Programme

Gregg Marland, Oak Ridge National Laboratory

Julia Martinez, Climate Change Program, Mexico

Sebastian Oberthür, Vrije University Brussels

Riitta Pipatti, Head of the Greenhouse Gas Inventory Unit at  
Statistics Finland

Helen Plume, Ministry for the Environment, New Zealand

Michael Prather, University of California, Irvine

Kristin Rypdal, Office of the Auditor General of Norway

Karen Treanton, International Energy Agency

David Victor, University of California-San Diego

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# Appendix III: Comments from the Department of State

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United States Department of State

*Chief Financial Officer*

Washington, D.C. 20520

JUL 20 2010

Ms. Jacquelyn Williams-Bridgers  
Managing Director  
International Affairs and Trade  
Government Accountability Office  
441 G Street, N.W.  
Washington, D.C. 20548-0001

Dear Ms. Williams-Bridgers:

We appreciate the opportunity to review your draft report, "CLIMATE CHANGE: The Quality, Comparability, and Review of Emissions Inventories Vary Between Developed and Developing Nations," GAO Job Code 361122.

The enclosed Department of State comments are provided for incorporation with this letter as an appendix to the final report.

If you have any questions concerning this response, please contact Kate Larsen, Foreign Affairs Officer, Bureau of Oceans, International Environmental and Scientific Affairs at (202) 647-1863.

Sincerely,

A handwritten signature in black ink, appearing to read "James L. Millette".

James L. Millette

cc: GAO – Mike Hix  
OES – Dr. Kerri-Ann Jones  
State/OIG – Tracy Burnett

**Department of State Comments on GAO Draft Report**

**CLIMATE CHANGE:**  
**The Quality, Comparability, and Review of Emissions Inventories Vary**  
**Between Developed and Developing Nations**  
**(GAO-10-818, GAO Code 361122)**

Thank you for the opportunity to comment on your draft report entitled "*CLIMATE CHANGE: The Quality, Comparability, and Review of Emissions Inventories Vary Between Developed and Developing Nations.*" The Department of State recognizes the central importance of accurate greenhouse gas emissions inventories as a first step to addressing the problem of climate change and has long been a strong supporter of improving the quality of inventories and enhancing international review.

The Department of State endorses the main findings and conclusions of the GAO report. We believe that GAO's assessment of the current state of inventory reporting and review for both developed and developing countries and the implications for the effectiveness of future agreements under the UNFCCC is both accurate and balanced.

The Department of State agrees fully with the recommendations contained in the report and has been working with our international partners in the negotiations and through bilateral and multilateral partnerships to support and promote improved inventory reporting and review. The Department of State will continue to encourage non-Annex I Parties, especially the major-emitting economies, to submit regular, comprehensive and comparable national emissions inventories and will work through the UNFCCC process to ensure that such inventories undergo a process of international consultation and analysis, as agreed in the Copenhagen Accord.

The Department of State also agrees that there is a need to ensure an effective and efficient inventory review process, including through the exploration of strengthening quality assurance to ensure consistency and a high quality of inventory reviews. Providing the necessary transparency on greenhouse gas emissions and efforts to control them is a fundamental objective of the Department of State in any future international agreement under the UNFCCC.



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# Appendix IV: GAO Contact and Staff Acknowledgments

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## GAO Contact

John B. Stephenson, (202) 512-3841 or [stephensonj@gao.gov](mailto:stephensonj@gao.gov)

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## Staff Acknowledgments

In addition to the contact named above, Michael Hix (Assistant Director), Russell Burnett, Colleen Candrl, Kendall Childers, Quindi Franco, Cindy Gilbert, Jack Hufnagle, Michael Kendix, Thomas Melito, Kim Raheb, Ben Shouse, Jeanette Soares, Kiki Theodoropoulos, Rajneesh Verma, and Loren Yager made key contributions to this report.

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# Related GAO Products

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*Climate Change: Observations on Options for Selling Emissions Allowances in a Cap-and-Trade Program.* [GAO-10-377](#). Washington, D.C.: February 24, 2010.

*Climate Change Policy: Preliminary Observations on Options for Distributing Emissions Allowances and Revenue under a Cap-and-Trade Program.* [GAO-09-950T](#). Washington, D.C.: August 4, 2009.

*Climate Change Trade Measures: Estimating Industry Effects.* [GAO-09-875T](#). Washington, D.C.: July 8, 2009.

*Climate Change Trade Measures: Considerations for U.S. Policy Makers.* [GAO-09-724R](#). Washington, D.C.: July 8, 2009.

*Climate Change: Observations on the Potential Role of Carbon Offsets in Climate Change Legislation.* [GAO-09-456T](#). Washington, D.C.: March 5, 2009.

*Climate Change Science: High Quality Greenhouse Gas Emissions Data are a Cornerstone of Programs to Address Climate Change.* [GAO-09-423T](#). Washington, D.C.: February 24, 2009.

*International Climate Change Programs: Lessons Learned from the European Union's Emissions Trading Scheme and the Kyoto Protocol's Clean Development Mechanism.* [GAO-09-151](#). Washington, D.C.: November 18, 2008.

*Carbon Offsets: The U.S. Voluntary Market is Growing, but Quality Assurance Poses Challenges for Market Participants.* [GAO-08-1048](#). Washington, D.C.: August 29, 2008.

*Climate Change: Expert Opinion on the Economics of Policy Options to Address Climate Change.* [GAO-08-605](#). Washington, D.C.: May 9, 2008.

*International Energy: International Forums Contribute to Energy Cooperation within Constraints.* [GAO-07-170](#). Washington, D.C.: December 19, 2006.

*Climate Change: Selected Nations' Reports on Greenhouse Gas Emissions Varied in Their Adherence to Standards.* [GAO-04-98](#). Washington, D.C.: December 23, 2003.

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*Climate Change: Information on Three Air Pollutants' Climate Effects and Emissions Trends.* [GAO-03-25](#). Washington, D.C.: April 28, 2003.

*International Environment: Expert's Observations on Enhancing Compliance With a Climate Change Agreement.* [GAO/RCED-99-248](#). Washington, D.C.: August 23, 1999.

*International Environment: Literature on the Effectiveness of International Environmental Agreements.* [GAO/RCED-99-148](#). Washington, D.C.: May, 1999.

*Global Warming: Difficulties Assessing Countries' Progress Stabilizing Emissions of Greenhouse Gases.* [GAO/RCED-96-188](#). Washington, D.C.: September 4, 1996.

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## Congressional Relations

Ralph Dawn, Managing Director, [dawnr@gao.gov](mailto:dawnr@gao.gov), (202) 512-4400  
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## Public Affairs

Chuck Young, Managing Director, [youngc1@gao.gov](mailto:youngc1@gao.gov), (202) 512-4800  
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