

December 2003

CLIMATE CHANGE

Selected Nations' Reports on Greenhouse Gas Emissions Varied in Their Adherence to Standards



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Highlights

Highlights of [GAO-04-98](#), a report to the Chairman, Committee on Energy and Commerce and its Subcommittees on Energy and Air Quality and Oversight and Investigations, House of Representatives

Why GAO Did This Study

In 1992, the United States and other parties, including both developed and developing nations, agreed to try to limit dangerous human interference with the climate by participating in the United Nations Framework Convention on Climate Change. The parties agreed, among other things, to report on their emissions of carbon dioxide and five other gases whose buildup in the atmosphere is believed to affect the climate. The parties developed standards for these reports and processes for periodically evaluating the reports. Expert teams selected by the parties review the developed nations' reports; staff of the Framework Convention's administrative arm (the Secretariat) assess developing nations' reports. GAO agreed to describe the results of the most recent reviews and assessments of reports from selected economically developed and developing nations, as well as the parties' plans to improve the reports.

For the developed nations, GAO agreed to study four geographically dispersed nations with high levels of emissions—Germany, Japan, the United Kingdom, and the United States. For the developing nations, GAO studied China, India, and Mexico, which also have high emissions levels and are geographically dispersed. These nations are not representative of others; therefore, GAO's findings cannot be generalized.

www.gao.gov/cgi-bin/getrpt?GAO-04-98.

To view the full report, including the scope and methodology, click on the link above. For more information, contact John Stephenson, 202-512-3841 or stephensonj@gao.gov.

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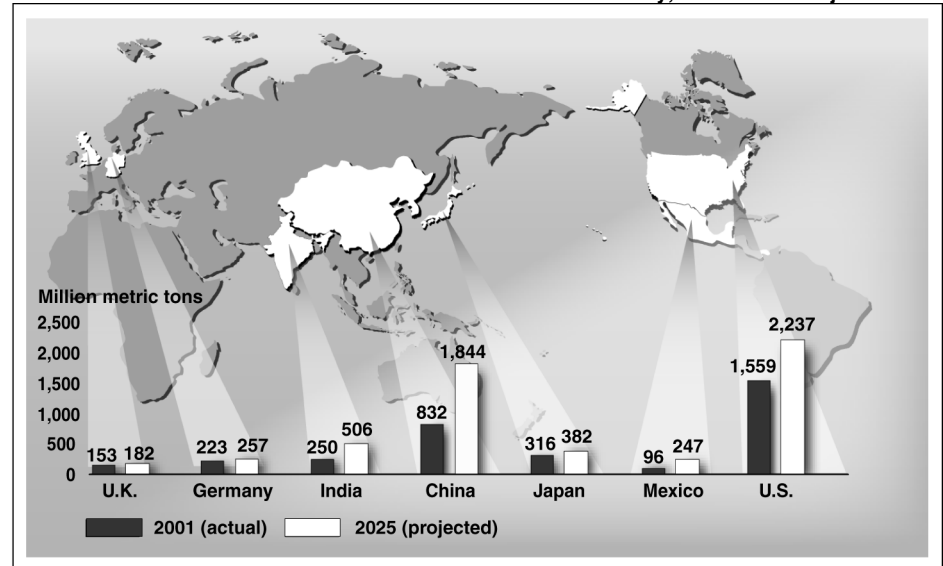
What GAO Found

In their most recent reviews, expert teams found that the United Kingdom's 2000 and 2002 reports on greenhouse gas emissions and the United States's 2000 report were largely complete, although the teams noted minor findings, such as the lack of information on quality assurance methods, which the nations were encouraged, but not required, to include in their submissions. In contrast, they found that Germany's 2001 and Japan's 2000 reports lacked critical elements, such as the required documentation that was essential to understanding them. Preliminary checks found that all four nations' 2003 reports were largely complete.

Secretariat staff have not assessed inventories from China and India because these nations have not submitted them. According to Secretariat records, China and India plan to submit inventories in February 2004 and November 2003, respectively. Secretariat staff assessed Mexico's most recent inventory, but they reported few details about it because their policy is to consolidate the findings of all the developing nations' inventories submitted during a year.

To improve the inventories, the parties are changing the reporting standards and review process. For example, starting in 2004, developed nations must present their inventory reports in a standardized format to facilitate review, and developing nations must report data for more years and gases than before. Also, in 2003, the parties began conducting more rigorous reviews of developed nations' inventories, but no such changes for developing nations are planned.

Carbon Dioxide Emissions for the Seven Nations in GAO's Study, Actual and Projected



Source: Energy Information Administration.

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Abbreviations

EIA	Energy Information Administration
EPA	Environmental Protection Agency
IPCC	Intergovernmental Panel on Climate Change

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United States General Accounting Office
Washington, D.C. 20548

December 23, 2003

The Honorable W.J. “Billy” Tauzin
Chairman, Committee on Energy and Commerce
House of Representatives

The Honorable Joe Barton
Chairman, Subcommittee on Energy and Air Quality
Committee on Energy and Commerce
House of Representatives

The Honorable James Greenwood
Chairman, Subcommittee on Oversight and Investigations
Committee on Energy and Commerce
House of Representatives

The Congress recently debated the need to limit U.S. emissions of the so-called “greenhouse gases”—whose buildup in the atmosphere is widely believed to adversely affect the climate. This debate dates back to at least 1992, when the United States and most of the other nations of the world took steps toward ensuring that worldwide progress in reducing greenhouse gas emissions could eventually be measured. At that time, the nations negotiated the United Nations Framework Convention on Climate Change (hereafter called the Framework Convention) with the aim of stabilizing atmospheric concentrations of carbon dioxide and five other greenhouse gases.¹ The nations also agreed to periodically report on their greenhouse gas emissions.²

¹The five other gases are methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur dioxide.

²In 1997, the United States and other parties to the Framework Convention participated in drafting the Kyoto Protocol, an international agreement to specifically limit emissions of the six greenhouse gases, and in 1998 the United States signed the protocol. However, President Clinton did not submit the protocol to the Senate for advice and consent, which are necessary for ratification. In March 2001, President Bush announced that he opposed the protocol.

As of November 2003, 188 parties had ratified the Framework Convention, including the United States.³ Of this total, 40 parties—39 nations and the European Union as a whole—are listed in Annex I of the convention. The 39 Annex I nations include the economically developed nations of the world as well as nations whose economies are in transition, including the Russian Federation, the Baltic states, and several central and eastern European nations. The Annex I nations have agreed to report annually on their emissions levels. The annual reports, called inventories, generally reflect estimated—rather than directly measured—data. The remaining 148 nations that are party to the Framework Convention but are not included in Annex I—“non-Annex I nations”—are generally classified as economically developing nations. These nations also agreed to report on their emissions, but in less detail and less frequently than the Annex I nations.

Recognizing that good-quality data on all nations’ greenhouse gas emissions are critical to determining whether the Framework Convention is successful at stabilizing greenhouse gas emissions worldwide, the parties to the convention are working in several ways to ensure the quality of the emissions data that nations report. First, with technical assistance from the Intergovernmental Panel on Climate Change (IPCC),⁴ the parties developed extensive procedures for all nations to follow when estimating and reporting their greenhouse gas emissions and removals (removals offset emissions—for example, forests absorb carbon dioxide, removing it from the air). In addition, the developed Annex I nations agreed to provide funds to help the non-Annex I nations develop their inventories. Finally, the parties agreed that nations’ estimates of their emissions, and the documentation that supports these estimates, would undergo one of two main types of review: one for Annex I nations and another for non-Annex I nations. Annex I nations’ inventories periodically undergo individual reviews performed by teams of experts assembled from the party nations. The expert reviews are extensive, examining all aspects of each inventory and its preparation to determine whether the inventory complied with the estimating and reporting procedures. The Framework Convention’s

³We use the term “ratified” to indicate that nations have ratified, accepted, approved, or acceded to the Framework Convention. The convention entered into force after it was ratified by 50 nations.

⁴Established by the World Meteorological Organization and the United Nations Environment Program in 1988, the IPCC supports the parties by providing scientific, technical, and socioeconomic advice through periodic assessments and special publications, such as the guidelines it developed on estimating emissions and removals.

administrative arm, the Secretariat, publishes a report on the findings of each nation's individual expert review. Non-Annex I nations' inventories are assessed by Secretariat staff, who examine all such inventories submitted during the year. The assessment is less extensive and evaluative than the review of Annex I nations' submissions. It focuses on identifying problems that the developing nations have had with preparing and reporting their inventories and ways to improve them. The Secretariat issues one report each year discussing its findings on the non-Annex I nations' inventories in summary format, with few nation-specific details.

We agreed with your offices to (1) describe the results of the most recent expert reviews of the greenhouse gas inventories submitted by four economically developed nations—Germany, Japan, the United Kingdom, and the United States; (2) describe the results of any assessments of the inventories of three developing nations—China, India, and Mexico; (3) determine the extent to which the developed nations have confidence in the quality of their inventory data, and describe any changes that the parties to the Framework Convention have made to requirements for assessing data confidence in the future; and (4) describe any steps that the parties to the Framework Convention are taking as a group to improve the quality of future inventories, including when such improvements might be in place.

Also as agreed with your offices, in examining these issues, we did not independently review the nations' inventories to assess their quality. Instead, we examined the guidance developed for the nations and the requirements they are to meet in preparing and reporting their greenhouse gas inventories and believe the guidance provides reasonable parameters for ensuring good-quality inventory data. We also examined the methodology for the reviews of developed nations' inventories and believe it provides reasonable help to reviewers in evaluating the quality of inventories. We relied on the findings of the reviews as reported by the Secretariat. Regarding the Annex I nations, we agreed to study the two European Union nations and the two non-European Union nations with the highest levels of emissions that are developed nations, according to the most recent data available to the United Nations (2001). Although some nations that are considered Annex I nations have economies in transition and emit significant levels of greenhouse gases, as agreed, we did not include them in our study. Regarding the non-Annex I nations—developing nations—we agreed to study China, India, and Mexico because of their high levels of greenhouse gas emissions and geographic dispersion. These seven nations are not necessarily representative of other parties to the

Framework Convention; accordingly, our findings are not generalizable to the other parties. Although we spoke with U.S. officials who are responsible for assembling and managing the U.S. inventory, we did not speak with comparable officials in the other six nations. It is our policy to contact foreign government officials through the U.S. Department of State, and we asked the department to facilitate that contact; however, the department did not arrange for those contacts during our review. State Department officials asserted that issues of reporting and review under the Framework Convention have been particularly sensitive for the developing nations; also, foreign governments might not readily grasp the different roles of the General Accounting Office and the State Department. As a result, according to State Department officials, some governments might view a request of this nature from the United States as intrusive, raising suspicions about the underlying purpose of such a study.

Results in Brief

The most recent expert reviews of the greenhouse gas inventories submitted by Germany, Japan, the United Kingdom, and the United States found that the U.K. and U.S. submissions were largely complete, while Germany's and Japan's submissions lacked certain critical elements. At the time of our study, the most recent expert reviews were for inventories submitted by Japan, the United Kingdom, and the United States in 2000; by Germany in 2001; and by the United Kingdom in 2002. The reviews of the U.K. and U.S. inventories found they contained nearly all of the required information and noted only relatively minor problems, such as not providing information on the quality assurance procedures used. Accordingly, the experts' suggestions for improving those submissions were not substantial; for example, the expert review report for the 2000 U.K. submission suggested that the United Kingdom archive all of the documentation supporting its inventory in one location or on the Web. In contrast, the reviews of Germany's and Japan's inventories found that both were missing some important elements. For example, both submissions lacked the required report explaining how the emissions estimates were developed. The experts suggested fundamental improvements for future inventories, such as submitting all of the required information. The Secretariat's preliminary examination of all four nations' 2003 submissions found that they were largely complete and contained national inventory reports.

Neither China nor India has submitted an inventory to the Secretariat; Mexico submitted an inventory as recently as 2001, which the Secretariat assessed. According to the Secretariat, China and India are preparing their

initial inventories, which, under the Framework Convention, are due within 3 years of when the convention entered into force for that nation or when the financial assistance provided by the developed nations to help with reporting becomes available. According to the Secretariat, China's inventory is due by November 2004 and India's by July 2004. Regarding the Secretariat's assessment of Mexico's 2001 submission, little information that could be directly tied to Mexico was released. Instead, the Secretariat consolidated the results with those of the 51 other non-Annex I nations that it examined at the same time, as is its usual practice for the assessments.

The four developed nations reported generally high confidence in the emissions data presented in their most recent submissions; however, future assessments of confidence in these data must be quantified to produce more useful information. For the 2003 and previous submissions, developed nations were required to assess as high, medium, or low their confidence in their inventory data for each major emission source and removal. The developed nations could use either qualitative or quantitative methods for making those assessments, and no criteria existed for determining which of the three categories was the most appropriate. In their 2003 submissions, all four developed nations reported that they had high confidence in at least 75 percent of their total emissions data, largely because most emissions are carbon dioxide, which is relatively easy to estimate with a high degree of accuracy. Effective next year, the developed nations are required to assess their confidence in their data using quantitative methods and to report numerical ratings instead of reporting by the three categories (high, medium, or low). The parties consider using quantitative methods to be the better practice because the resulting numerical ratings give a more precise assessment of nations' confidence in their data and make it easier for the nations to set priorities when deciding how to improve the accuracy of the inventories.

To improve the quality of data on greenhouse gas emissions, the parties to the Framework Convention are refining their requirements for nations' inventories and bolstering their review processes, with the changes to take effect over the next few years. Changes to the inventory requirements affect both Annex I and non-Annex I nations. For example, in addition to the new requirement for performing a quantified assessment of data confidence, Annex I nations will be required to structure the documentation that explains the inventories according to a standardized format beginning with their 2004 submissions. For non-Annex I nations, the revised requirements are intended to encourage more of the nations to submit inventories as well as to improve the quality of the inventories. For

example, as of 2003, non-Annex I nations that have not yet submitted their first inventories must submit data for either 1990 or 1994 in their first submissions, and all non-Annex I nations must include data for 2000 when they submit their second inventories. This is in contrast to the requirement that Annex I nations annually report data for all years, from 1990 to the present. In addition, the parties plan to bolster the expert review process for Annex I nations. For example, until this year, only a portion of the 39 Annex I nations underwent an expert review each year; however, beginning with the 2003 submissions, each of the 39 nations will be subject to an annual expert review. The changes to the review process are intended to standardize it and to ensure that reviews are conducted effectively and consistently. According to the Secretariat, the parties have no plans to change the assessment process for non-Annex I nations' inventories, but the new reporting guidance for non-Annex I nations is designed to facilitate any assessment process changes that the parties might institute in the future.

The Environmental Protection Agency (EPA), which is responsible for preparing the U.S. submission, provided clarifying comments on a draft of this report, which we incorporated as appropriate. We also requested comments from the State Department and the Framework Convention Secretariat, but none were provided.

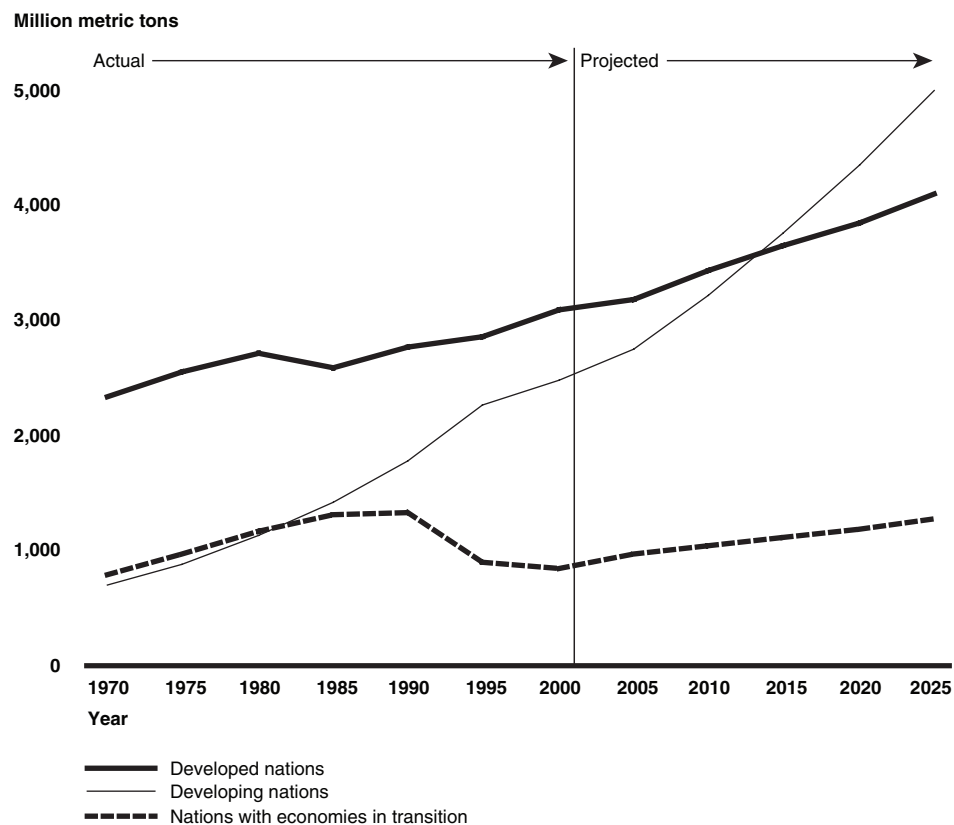
Background

Scientists have discovered that changes in the earth's climate are induced by the increasing concentrations of certain gases in the earth's atmosphere—some naturally occurring, others human-induced—that have the potential to significantly alter the planet's heat and radiation balance. These so-called "greenhouse gases" trap some of the sun's energy and prevent it from returning to space. The trapped energy warms the earth's climate, much like glass in a greenhouse. Over the past century, humans have contributed to the greenhouse effect, particularly by burning fossil fuels, which increased atmospheric carbon dioxide and other greenhouse gases. The effects of a warmer climate could have important consequences for human health and welfare by, among other things, altering weather patterns, changing crop yields, and leading to the flooding of coastal areas.

According to the Department of Energy's Energy Information Administration (EIA), in 2001, the most recent year for which data are available, the United States and other developed nations accounted for just under half (47 percent) of the world's emissions of carbon dioxide—the most prevalent greenhouse gas. The other emissions came from

economically developing nations, including China, India, and Mexico (40 percent), and from nations with economies in transition (13 percent) in Europe and the Former Soviet Union. EIA projects that, over the next 2 decades, carbon dioxide emissions from each of the three nation groups will increase; however, carbon dioxide emissions from developing nations will increase most dramatically, surpassing those of developed nations by 2015, as shown in figure 1.

Figure 1: Carbon Dioxide Emissions by Developed and Developing Nations and Nations with Economies in Transition, 1970 through 2025, Actual and Projected

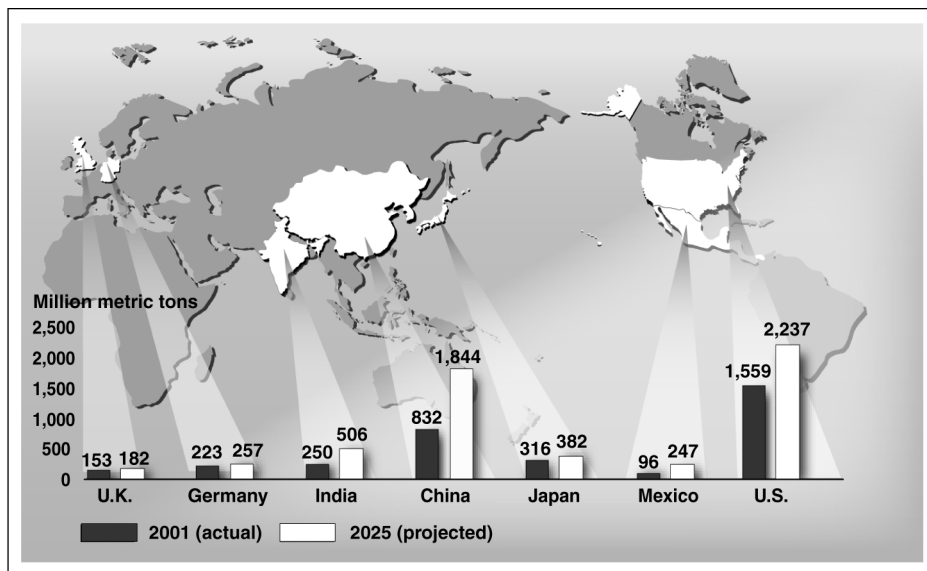


Source: GAO analysis of Energy Information Administration data.

Note: The Energy Information Administration includes data on Croatia's and Slovenia's emissions with those of the developed nations, rather than with emissions data from the other nations with economies in transition.

More specifically, figure 2 shows actual and projected carbon dioxide emissions for the seven nations in our study. Growth in emissions between 2001 and 2025 is projected to range from 29 million metric tons for the United Kingdom to 1,012 for China.

Figure 2: Carbon Dioxide Emissions for the Seven Nations in Our Study, Actual and Projected



Source: Energy Information Administration.

The seven nations in our study also differ greatly in terms of their population and per capita income (an indicator of economic development). For example, population ranged from about 60 million in the United Kingdom to nearly 1.3 billion in China, and per capita income ranged from \$2,540 in India to \$36,300 in the United States. (See table 1.)

Table 1: Comparative Statistics of the Seven Nations in Our Study

Nation	Estimated population, 2002 (millions)	Per capita income, 2001 or 2002
Economically developed nations		
Germany	83.3	\$26,600 (2002)
Japan	127.0	28,000 (2002)
United Kingdom	60.0	25,300 (2002)
United States	281.0	36,300 (2001)
Economically developing nations		
China	1,284.3	4,600 (2002)
India	1,045.8	2,540 (2002)
Mexico	103.4	9,000 (2001)

Source: Central Intelligence Agency, *The World Fact Book* (2002).

Notes:

Some figures have been rounded.

Estimated per capita income is based on purchasing power parity rates. Purchasing power parity is based on the assumption that a unit of currency, such as a dollar, should be able to buy the same bundle of goods in all countries.

Under the Framework Convention, the United States and the other parties generally agreed to implement policies and measures aimed at returning “individually or jointly to their 1990 levels these anthropogenic [human-caused] emissions” of greenhouse gases not covered by another treaty, the Montreal Protocol.⁵ The six primary gases covered by the Framework Convention are carbon dioxide, nitrous oxide, methane, and three synthetic gases—sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons. Emissions of these gases are generally not measured because doing so would be too costly; consequently, they must be estimated.⁶ In this regard, the IPCC, at the parties’ request, developed detailed guidance on methodologies for nations to use when estimating their emissions and revised that guidance twice, most recently in 1999. Both developed and developing nations are required to follow this guidance—*Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*—when preparing their inventories. In addition, in 2000, the IPCC published—also at the parties’ request—its *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, which contains information on prioritizing tasks to arrive at the best possible estimates using finite resources as well as advice on establishing quality assurance programs, among other things. The nations have been encouraged, but not required, to follow the good practice guidance.

⁵The Montreal Protocol, ratified by the United States in 1988, aims to reduce the use of substances that deplete stratospheric ozone. Among these substances are chlorofluorocarbons, which are also potent greenhouse gases.

⁶According to EPA officials, because of the way carbon dioxide emissions are estimated, the results are as accurate as they would be if they were measured.

The parties to the Framework Convention also agreed to report periodically to the Secretariat on their levels of greenhouse gas emissions. For Annex I nations, those reports are extensive. Annually, each Annex I nation is required to submit inventory data—in a common reporting format the parties themselves agreed to—as well as a national inventory report that explains how the data in the common reporting format were derived. The common reporting format calls for data for each of the six emissions sectors—energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, and waste—as well as for the data on the major sources that contribute to emissions from 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, which is 1990.⁷ For each year, the common reporting format calls for 42 tables containing over 8,100 items that are sector-specific numbers; data summarized across sectors; and other information, such as trends from the base year to the current reporting year, recalculations of prior years’ data, and reasons certain emissions were not estimated. The parties require that data be submitted in the common reporting format to facilitate comparison across nations and to make it easier to review the data. Because an inventory contains data from the base year to the most recent reporting year, each year’s submission is larger than the last. The 2003 reporting format called for approximately 98,000 items of inventory data and other information from 1990 through 2001.

The national inventory report, the second component of the submission, should be detailed and complete enough to enable reviewers to understand and evaluate the inventory. The report should include, among other things, descriptions of the methods used to estimate the data, 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.

Each year, when Secretariat staff receive Annex I nations’ submissions, they perform an initial check to determine whether the submissions are complete and then synthesize the information to facilitate comparison across nations. Teams of expert reviewers—comprising members chosen

⁷Five Annex I nations with economies in transition—Bulgaria, Hungary, Poland, Romania, and Slovenia—are allowed to use other years as baselines.

by the parties for their sector expertise as well as to achieve broad geographic representation—also use this synthesized information to identify issues requiring clarification during their reviews of individual submissions.

From 2000 through 2002, the parties tested the usefulness of three methods of conducting expert reviews on selected submissions from Annex I nations. The first type of review, called a desk review, consists of about 10 experts spending about 4 weeks in their respective nations reviewing information on the same three nations' inventories. For this type of review, the experts communicate with each other and the nation being reviewed via the Internet and telephone. The second type of review, called a centralized review, involves about 10 experts spending about a week at the Secretariat's headquarters in Bonn, Germany, jointly reviewing between four and six nations' inventories. The third review type, called an in-country review, consists of a team of about 5 experts spending a week in the nation whose inventory is being reviewed, jointly examining the nation's inventory and supporting information. The Secretariat chose inventories of different levels of completeness to undergo desk and centralized reviews; only nations that volunteered for an in-country review received one.

During the 3-year test period, the experts examined the data and supporting information the nations used to prepare the inventories via all three types of reviews. For example, the experts determined whether a nation calculated its emissions estimates using formulas from published data sources or formulas specified by the parties. The experts also verified the information provided in response to questions raised in previous reviews. Finally, the experts summarized the inventories' strengths and weaknesses; made recommendations for improvement, if warranted; and presented their findings in reports that were both published and posted on the Internet.

For Annex I nations' submissions to be reviewed by the experts, the submissions must meet two criteria. Since 2000, the experts have reviewed only submissions that presented their data in the common reporting format, and, beginning with the 2003 submissions, the experts will review only submissions that include the national inventory report. According to the parties to the Framework Convention, the goal of the expert reviews is to identify areas in the inventories needing improvement; for this reason, the experts' reports do not rate the overall quality of the submissions, and the reports do not identify some findings as being more important than

others. According to the Secretariat, since 1998, Annex I nations' submissions have steadily and substantially improved in their timeliness and completeness, and the expert review process has contributed to the improved quality of recent submissions.

Non-Annex I nations' requirements for format and frequency of reporting differ from those for Annex I nations. Although all parties to the Framework Convention are to develop their inventories using the revised 1996 IPCC guidelines and submit the inventories to the Secretariat, non-Annex I nations' inventories are not stand-alone documents. Rather, a non-Annex I nation's inventory is a component of its national communication, which is a report it must submit to the Secretariat that discusses all of the steps the nation is taking or plans to take to implement the Framework Convention.⁸ In addition, non-Annex I nations are not required to use the common reporting format or to submit a national inventory report. Moreover, non-Annex I nations are not required to submit an inventory each year but may instead negotiate the frequency of their submissions. To date, most non-Annex I nations negotiated a deadline for only one inventory.⁹ To help the non-Annex I nations develop and report their inventories, the developed nations of Annex I provide financial assistance that is disbursed through the convention's financial mechanism, the Global Environment Facility. The facility, which funds various types of environmental projects in developing nations,¹⁰ disburses the funds, including those to assist non-Annex I nations with their emissions reporting, through implementing agencies, such as the United Nations Development Program. The implementing agencies, in turn, disburse the funds to the nations on a schedule and according to terms negotiated by the agency and each nation.

⁸Annex I nations also submit national communications discussing their efforts to implement the Framework Convention in addition to submitting stand-alone inventories, but the format and frequency of the national communications are different for Annex I and non-Annex I nations.

⁹According to the EPA official who managed the 2003 U.S. inventory, the parties to the Framework Convention plan to discuss increasing the frequency of non-Annex I nations' inventory reporting during the next conference of the parties in December 2003.

¹⁰In addition to funding climate change projects, the Global Environment Facility also funds projects related to biodiversity, international waters, land degradation, ozone depletion, and persistent organic pollutants.

The inventory reviews and the extent to which the results are reported also differ for Annex I and non-Annex I nations. Reviews of Annex I nations' submissions focus on compliance with reporting standards, and the results are made publicly available in considerable detail. In contrast, because non-Annex I nations are generally in the early stages of developing their inventories and have limited resources to do so, assessments of their submissions, and the resulting reports, focus largely on providing a forum for the non-Annex I nations to exchange information on common reporting problems and best practices. Consequently, while the Secretariat makes reports on the results of non-Annex I assessments publicly available, it does so in summary format and provides only a few nation-specific details in tables that accompany the aggregated reports.

Recent Reviews Found That U.K. and U.S. Inventories Were Largely Complete, but German and Japanese Inventories Lacked Critical Elements

The most recent expert reviews of inventories submitted by the four developed nations found that the U.K. and U.S. inventories contained most of the required elements, but the German and Japanese inventories were missing certain critical elements. Experts reviewed inventories variously submitted from 2000 through 2002 by each of the four developed nations in our study. The inventories submitted by Japan and Germany in 2000 and 2001, respectively, each received a centralized review. Two U.K. inventories were reviewed: the one submitted in 2000 received an in-country review, and the one submitted in 2002 received a desk review. The inventory that the United States submitted in 2000 received both an in-country review and a desk review. Although the experts planned to conduct reviews of all Annex I nations' inventories submitted in 2003, no results were available at the time of our study.

The reviews of the submissions of the United Kingdom and the United States found they were largely complete and noted only relatively minor problems. For example, the reviews of the two nations' 2000 submissions noted that neither submission included information on quality assurance procedures. Although the good practice guidance calls for including such information in the national inventory report, the nations were encouraged, but not required, to follow the good practice guidance for the 2000 submissions. Nonetheless, the experts included the lack of quality assurance documentation as a finding of the reviews. Because the problems noted were relatively minor, the suggestions for improving future submissions constituted refinements rather than recommendations for large-scale changes. For example, the experts' report on the 2000 U.K. submission suggested archiving the documentation supporting the national inventory report in one location or on the Web. Similarly, the report on the

desk review of the 2000 U.S. submission suggested that more details on the methods and factors used to estimate emissions for the land-use change and forestry sector would allow more complete assessment of that sector's data.

In contrast, the reviews of the German and Japanese submissions found them to be missing some critical components, and the experts' reports made suggestions for improvement that were fundamental in nature. For example, the review of Germany's 2001 submission found it contained only summary-level and trend data; it did not include any of the sector-specific data tables or recalculations of prior years' data called for by the common reporting format. Furthermore, the national inventory report was missing, so the reviewers could not determine whether problems noted in previous inventories had been addressed. Although the review of the Japanese 2000 submission found most of the data required by the common reporting format was included, like the German submission, this one lacked the national inventory report. As a result of these shortcomings, the experts suggested that Germany submit a complete set of data for all of the required years and sectors and that both nations submit the national inventory report. Additional details on the findings of the six expert reviews are contained in appendix I.

Although none of the four Annex I nations' latest submissions—for 2003—had undergone an expert review as of November 2003, Secretariat staff had performed initial completeness checks on each of them. They found that all four nations' submissions contained most of the required data as well as the required national inventory reports.

Little Nation-Specific Inventory Information Is Available for the Three Developing Nations

The Secretariat has not assessed any inventories from China and India because, as of November 2003, neither nation had submitted one. The Secretariat assessed Mexico's 2001 submission, but the Secretariat's practice is to issue one report on the findings of its assessments of all the inventories submitted during the year, with few nation-specific details. Therefore, the Secretariat made public little information about the results of its assessments that could be directly tied to Mexico.

According to the Secretariat, China and India are preparing their initial inventories, to be submitted as part of their first national communications. Under article 12, paragraph 5, of the Framework Convention, non-Annex I nations' first inventories are due to the Secretariat "within three years of the entry into force of the Framework Convention or of the availability of

financial resources” from the developed nations in Annex I. According to the Secretariat, funding was approved for China in May 2000 and for India in December 1999, and the first disbursements of funds took place in November 2001 for China and in July 2001 for India. According to the Secretariat, the due dates for their first greenhouse gas inventories are no later than November 2004 for China and July 2004 for India.

Mexico submitted inventories in 1997 and 2001. Although 106 developing nations had submitted their initial inventories as of November 2003, Mexico is the only nation to have submitted more than one. Secretariat staff assessed Mexico’s 2001 inventory, along with those of 51 other non-Annex I nations that submitted inventories that year. In keeping with its practice of reporting on its assessments of non-Annex I nations’ inventories as a group, the report for 2001 contained only limited details that could be linked specifically to Mexico’s inventory. In particular, the Secretariat reported that Mexico had improved its estimates of emissions from the energy, agriculture, and land-use change and forestry sectors. It also reported that Mexico could further improve its inventory by establishing systematic procedures for preparing the inventory annually and by including estimates for the solvent-use sector. Otherwise, the Secretariat reported only generally on the results of the assessments of submissions of the 52 non-Annex I nations’ inventories.

Mexico’s 2001 submission contained estimates for 1994, 1996, and 1998. According to an EPA official who is knowledgeable about Mexico’s inventory, the 2001 Mexico inventory is of reasonably high quality, especially considering the limited resources Mexico has dedicated to developing it. According to its submission, Mexico followed the IPCC estimating guidelines and good practice guidance in preparing the inventory. The EPA official further commented that Mexico’s 2001 submission is among the best of those of the developing nations, and in some cases—for example, in presentation of its carbon dioxide emissions data—is equal to those of some developed nations. On the other hand, according to that official, Mexico did not (1) comply with the IPCC estimating guidelines in developing the land-use change and forestry sector data, (2) adequately estimate data for the three synthetic gases, or (3) provide adequate documentation explaining the inventory. Furthermore, Mexico developed its two inventories independent of each other, without establishing a process that would systematically make documentation and data additions and revisions as needed. Consequently, in the opinion of the EPA official, it was difficult for Mexico to build upon its previous efforts when preparing its second inventory.

The Four Developed Nations Reported Generally High Confidence in Their Latest Emissions Data, but Future Assessments of Confidence Must Be More Precise

As required for the 2003 submissions, the four developed nations categorized their confidence in their emissions data as either high, medium, or low. All four nations reported their confidence in the data as generally high. To improve the usefulness of nations' assessments of data confidence, however, beginning with the 2004 submissions, developed nations must quantify their confidence assessments.

The Four Developed Nations Rated Their Confidence in Their Most Recent Emissions Data as Generally High

As previously explained, the parties to the Framework Convention have constructed an extensive system of estimating and reporting requirements, buttressed by periodic reviews, to help nations produce inventory data that are of high quality. The parties do not attempt, on the basis of the reviews or any other means, to assign a grade or otherwise rate any nation's success in producing high-quality data. However, as one means of helping developed nations identify areas where their data can be strengthened, the parties require each nation to assess its confidence in the accuracy of its own data. Specifically, the nations are required annually to analyze the quality of the data they report (called an uncertainty analysis) for each gas and for each major source of emissions and removals in each of the six sectors. To do this, the nations have been encouraged, but not required, to use the quantitative methods of uncertainty analysis included in the IPCC good practice guidance. Alternatively, they could rely on qualitative means to determine their confidence in these data. In either case, they have been required to report whether they had high, medium, or low confidence in each estimate of emissions of each of the six gases by each major source of those emissions. The nations have not been required to report on their confidence in the accuracy of the inventory data as a whole. The parties did not provide further criteria for nations to use when determining which of the three categories was most appropriate.¹¹

¹¹According to EPA officials, the confidence a nation has in the accuracy of its inventory depends on the predominant sources of its emissions, as well as on the completeness of the inventory and the quality of the methods it uses to estimate emissions. For example, a nation such as New Zealand, whose greenhouse gas emissions' sources are predominantly in the agriculture and land-use change and forestry sectors, may have lower confidence in the accuracy of its inventory data as a whole than a nation such as the United States, whose emissions originate predominantly from the energy sector, even though both nations might be using state-of-the-art estimation methods. This is because emissions estimates from the agriculture and land-use change and forestry sectors are inherently less accurate than those originating from fossil fuels that produce energy.

As required, all four developed nations reported high, medium, or low ratings of confidence in their estimates for their 2001 emissions by source. To determine the confidence each nation had in its inventory data as a whole, we calculated the proportion of each nation's data that corresponded to each of the three rating categories. According to our calculations, all four nations rated their confidence in their inventory data as a whole as generally high, with the high-confidence ratings ranging from about 75 percent for the United States to about 96 percent for Japan. The high-confidence ratings occurred largely because the lion's share of each nation's total emissions is carbon dioxide from fuel combustion, which can be estimated with a relatively high level of confidence. Table 2 shows each nation's ratings for total emissions by gigagrams of carbon dioxide equivalent, which is the unit of measurement used by the parties to the Framework Convention to allow comparisons among greenhouse gases, which differ in their effects on the atmosphere and expected lifetimes.

Table 2: Four Developed Nations' Ratings of Confidence in Their Data for Total Emissions in 2001

Gigagrams of carbon dioxide equivalent

Nation	Developed nations' ratings of confidence for total emissions							
	Amount rated high	Percentage rated high	Amount rated medium	Percentage rated medium	Amount rated low	Percentage rated low	Amount not rated	Percentage not rated
Germany	948,175	93.1	59,054	5.8	7,982	0.8	3,817	0.4
Japan	1,244,048	95.7	20,056	1.5	35,326	2.7	15	0 ^a
United Kingdom	561,274	82.9	53,907	8.0	62,036	9.2	12	0 ^a
United States	5,670,596	72.9	1,462,157	18.8	567,775	7.3	73,816	1.0

Source: GAO analysis of data from the four nations' 2003 submissions to the Framework Convention Secretariat.

Notes:

Percentages do not total to 100 because of rounding.

In compiling this table, to fully report the nations' ratings for the six gases, we added the amount of removals to the amount of gross emissions; consequently, the data in the table do not match the net emissions reported by the nations.

^aPercentage is less than .005 and rounds to 0.

Although the national inventory reports contained some information about the nations' confidence in their data, none of the nations explained the criteria they used to determine the high-, medium-, and low-confidence ratings they reported.

Developed Nations Must Use Quantitative Methods to Assess Their Confidence in Their Data in 2004

In November 2002, the parties decided to require developed nations to use the quantitative methods in the IPCC good practice guidance to develop estimates of data uncertainty beginning with the 2004 submissions. Instead of designating high, medium, or low ratings of confidence, under the new requirements, developed nations must quantify their uncertainty in their emissions estimates for each gas by each major source using 95 percent confidence levels. In addition, they must combine the source uncertainty estimates into a quantified uncertainty estimate for the inventory as a whole and estimate the uncertainty in the trend between the base year and the most recent year.

The IPCC good practice guidance provides detailed instructions for nations to follow to produce the quantitative estimates of data uncertainty. The guidance also describes two methods for combining quantitative uncertainty estimates—one consisting of relatively simple statistical calculations that result in a numerical uncertainty estimate, and the other using computer simulation to calculate the estimates. The computer simulation is a more sophisticated method and should result in more accurate estimates; however, according to the EPA official responsible for compiling the U.S. inventory, the computer simulation also is more costly than the simpler method. Because of this, the good practice guidance states that the nations must use the simpler of the two methods to produce their combined uncertainty estimates; in addition, they are encouraged to use the more sophisticated method when sufficient resources and expertise are available.

For example, in its 2003 inventory submission, the United Kingdom used both methods from the good practice guidance to quantitatively estimate its confidence in its 2001 emissions data as a whole. Using the simpler method, the United Kingdom reported an uncertainty value of 17 percent for its inventory data as a whole; that is, the United Kingdom was 95 percent confident that total emissions were between 17 percent less and 17 percent more than the total of about 660,452 gigagrams of carbon dioxide equivalent it estimated for the year. In contrast, using the more sophisticated method, the United Kingdom reported an uncertainty value of 13 percent, indicating it was 95 percent confident that total emissions were between 13 percent less and 13 percent more than the year's total estimate.

According to the EPA official responsible for compiling the 2003 U.S. inventory, the high, medium, and low categorizations reflect the early days of developing inventories, before the IPCC had developed its good practice

guidance on quantitative methods. Prior to the guidance, the parties recognized that nations would vary in their ability to perform quantitative uncertainty analysis. The parties instituted the three-part categorization in an effort to obtain information that was comparable across nations that were using different methods for assessing data uncertainty. The parties have moved to the quantitative methods because the three-part categorization approach yielded limited information about data uncertainty. For example, a nation could have uncertainty estimates of 35 percent and 60 percent but could have categorized both estimates as medium. The quantitative estimates provide information about the uncertainty of the various components of the inventory, thereby helping nations identify areas in which improvements would have the greatest effect on the accuracy of the inventory as a whole. In addition, the quantified estimates make the uncertainty analyses more consistent and understandable across nations. According to the Secretariat, the quantified uncertainty analysis also better enables expert reviewers to determine if nations are targeting their improvements in the appropriate areas.

The Parties Are Taking Steps to Improve the Quality of Emissions Data

To improve the quality of data on greenhouse gas emissions, the parties to the Framework Convention are refining their requirements for both Annex I and non-Annex I nations. In addition, they are bolstering the review processes for Annex I nations. The changes are to begin to take effect over the next few years. The parties currently have no plans to change the way that non-Annex I nations' inventories are assessed.

Changes in Requirements for Annex I and Non-Annex I Nations Take Effect over the Next Few Years

The parties have revised their requirements for both Annex I and non-Annex I nations, with the changes taking effect over the next few years. The revisions fall mainly into two areas: procedures for estimating emissions and procedures for reporting those estimates.

The parties have revised both the estimating and reporting requirements for Annex I nations. Regarding estimating, for example, beginning with the 2004 submissions, Annex I nations will be required to use both the 1996 IPCC estimating guidelines and the 2000 IPCC good practice guidance. Previously, Annex I nations were required to use only the 1996 estimating guidance and were encouraged, but not required, to use the good practice guidance. Regarding reporting, the parties have specified in greater detail than before the information that should be included in Annex I nations' national inventory reports and in the data tables in the common reporting

format. For example, nations should include explanations of how they recalculated their previous years' data and, as previously discussed, the methods they used to quantify their confidence in the data in their national inventory reports. In their reports, nations should document that they prepared their estimates in accordance with the IPCC good practice guidance or explain why they did not; for example, an explanation is required if they used a more sophisticated methodology than that specified in the guidance. The nations should also cross-reference the information in the national inventory report to explain the estimates reported in the data tables. Furthermore, Annex I nations must submit their national inventory reports following a specified format designed to facilitate review of the inventories.

The parties also revised the reporting requirements for non-Annex I nations that submit inventories in 2003 or later. Non-Annex I nations that had not submitted an inventory prior to 2003 must include data in their initial inventories for either 1990 or 1994 to establish an inventory baseline. Those submitting their second inventories should provide data for 2000 as well. This is in contrast to the requirement that Annex I nations submit data for all years, from 1990 to the present. Similarly, the parties specified that non-Annex I nations should report data for carbon dioxide, methane, and nitrous oxide and encouraged reporting of the other three gases—hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. In contrast, Annex I nations are required to report data for all six gases. According to the manager of the 2003 U.S. inventory, the estimating and reporting requirements for non-Annex I nations are less demanding to encourage those nations to report because those nations generally have fewer resources available for reporting.

In addition, the parties have requested that the IPCC continue to improve its guidance on estimating. Currently, the good practice guidance does not address estimating emissions and removals for the land-use change and forestry sector. According to the EPA official who managed the 2003 U.S. inventory, the IPCC deferred guidance on estimating emissions and removals because it was developing a special report on them, which was subsequently published in 2000. On the basis of that report, the IPCC began drafting new good practice guidance for estimating emissions and removals for the land-use change and forestry sector, which is due to be completed in late 2003. As part of this effort, the IPCC is also refining the data tables for the land-use change and forestry sector. In addition, according to the same EPA official, the IPCC is merging the 1996 guidelines with its good practice guidance and expects to complete the effort by 2007.

The Parties Are Bolstering the Review Process for Annex I Nations, but Not for Other Nations

The parties are strengthening the expert review process for Annex I nations' submissions by conducting more reviews and standardizing the review processes. Beginning with the 2003 submissions, each of the 39 Annex I nations will undergo one of the three types of expert reviews each year: an in-country review once every 5 years and either a desk review or a centralized review in each of the intervening years. This requirement contrasts with the practices of the past 3 years, when the experts performed from 8 to 21 expert reviews in a year. Furthermore, to standardize the reviews, the parties have spelled out, in greater detail than before, the elements that are to be examined during reviews and have developed a standardized format for reporting the results of the reviews. In addition, according to EPA inventory managers, in another effort to make the expert reviews more uniform, the Secretariat is developing a handbook and a training program for the expert reviewers and has specified the composition and responsibilities of the teams of expert reviewers.

According to the Secretariat, the parties have no plans to change the assessment process for non-Annex I nations' inventories, but the new reporting guidance for non-Annex I nations would facilitate changes to the assessment process, should the parties decide to institute them.

Scope and Methodology

To examine the results of the most recent expert reviews of the greenhouse gas inventories submitted by the four economically developed nations included in our study—Germany, Japan, the United Kingdom, and the United States—we reviewed and analyzed the Secretariat's status reports showing the results of its initial reviews (called stage 1 reviews by the Secretariat) of the most recently submitted inventories (2003). We also reviewed the reports on the parties' most recent expert reviews (called in-depth reviews by the Secretariat) of the four nations' inventories (2000 for Japan, 2000 and 2002 for the United Kingdom, 2000 for the United States, and 2001 for Germany) and related documentation on reporting requirements and review processes issued by the Secretariat. We interviewed officials at EPA who manage the U.S. greenhouse gas inventory and serve as inventory experts for the parties, as well as officials from the State Department's Bureau of Oceans and International Environmental and Scientific Affairs who are responsible for policy issues related to the Framework Convention. In addition, we reviewed and analyzed the limited information provided to us by the Secretariat in response to questions we posed.

To describe the results of any assessments of inventories of the three developing nations included in our study—China, India, and Mexico—we reviewed and analyzed the Secretariat’s reports on its assessments of inventories submitted by non-Annex I nations, including the latest inventory submitted by Mexico (2001); related documentation on non-Annex I nation reporting requirements and assessment processes; and other Secretariat information documenting which non-Annex I nations have submitted inventories. We also interviewed the officials at EPA and the Department of Energy who are most familiar with the three nations’ efforts to compile and report their inventories, as well as the cognizant officials from the State Department.

To determine the extent to which the developed nations have confidence in their data, we analyzed the confidence information each nation provided in its 2003 submission. To describe any changes in assessing confidence in the data that are to take effect in the future, we examined documentation from the Secretariat and the relevant sections of the four developed nations’ 2003 submissions.

To describe the steps the parties are taking to improve the quality of future inventory data and determine when those improvements might be in place, we reviewed and analyzed documentation of the parties’ new estimating, reporting, and review requirements; interviewed cognizant EPA officials; and reviewed and analyzed the limited information on this issue submitted to us by the Secretariat in response to questions we posed.

We performed our work between November 2002 and November 2003 in accordance with generally accepted government auditing standards.

Agency Comments

We provided a draft of this report to the Secretary of State, the Administrator of EPA, and the Framework Convention Secretariat for review and comment. EPA provided clarifying comments, which we incorporated where appropriate. We did not receive comments from the State Department or the Framework Convention Secretariat.

As arranged with your offices, we plan no further distribution of this report until 30 days after the date of this letter, unless you publicly announce its contents earlier. At that time, we will send copies of this report to interested congressional committees; the Chairmen and Ranking Minority

Members, Senate Committee on Appropriations, House Committee on Appropriations, Senate Committee on Governmental Affairs, and House Committee on Government Reform; the EPA Administrator; and the Secretary of State. We will make copies available upon request to other interested parties. This report will also be available at no cost on GAO's Web site at <http://www.gao.gov>.

If you or your staffs have any questions about this report, please call me at (202) 512-3841. I can also be reached at stephensonj@gao.gov. Key contributors to this report are listed in appendix II.

A handwritten signature in black ink, reading "John B. Stephenson". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

John B. Stephenson
Director, Natural Resources
and Environment

Results of Expert Reviews of the Four Developed Nations' Inventories

The six expert review reports we examined did not follow identical formats; however, they generally highlighted the experts' findings and suggestions for improvement in a summary section at the beginning of each report. The experts noted instances of noncompliance with the reporting requirements. In addition, the experts noted some instances in which the nations did not comply with the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, even though following the good practice guidance was not a requirement at the time that the inventories were submitted. The summary-level findings and suggestions for each of the six expert reviews we examined are listed in table 3.

Appendix I
Results of Expert Reviews of the Four
Developed Nations' Inventories

Table 3: Results of the Most Recent Expert Reviews of the Four Developed Nations' Inventories

Expert review	Findings	Suggestions for improvement
Centralized review of Germany's inventory submitted in 2001	<p>Inventory did not conform to Secretariat's guidelines; specifically, it did not include the following:</p> <ul style="list-style-type: none"> • sector-specific data, • a national inventory report, • required information on major sources of emissions, • recalculated data for previous years or explanation of recalculations, • quantitative uncertainty estimates nor a qualitative discussion of reasons for uncertainty, • procedures on quality assurance, • inventory in specified software format, • information on how the nation develops and manages its inventory, and • information on ongoing efforts to improve the quality of its inventory. <p>Inventory was submitted after the deadline.</p> <p>Inventory did not include information on any improvements made in response to problems identified with previous inventories.</p>	<p>Submit national inventory report with a brief explanation of methodologies and underlying assumptions that were used to compile the inventory.</p> <p>Compile a complete emissions inventory for all of the required years and sectors.</p>
Centralized review of Japan's inventory submitted in 2000	<p>Inventory did not conform to Secretariat's guidelines; specifically, it did not include the following:</p> <ul style="list-style-type: none"> • a national inventory report and • recalculated data for previous years. <p>Inventory did not contain information needed to determine completeness of sources of emissions for the industrial processes sector.</p>	<p>Improve documentation.</p> <p>Submit a national inventory report to explain methods used to estimate emissions.</p> <p>Improve the consistency of the data and information provided.</p>
In-country review of the United Kingdom's inventory submitted in 2000	<p>Inventory did not completely conform to Secretariat's guidelines; specifically, the United Kingdom did not</p> <ul style="list-style-type: none"> • provide the national inventory report on time; • apply the Secretariat's good practice guidance; • provide required details for the waste and the land-use change and forestry sectors; • include required calculations and disaggregated activity data for the sectors; • explain rationale for assumptions used for emission estimates; • use consistent assumptions and methods to report time-series information for sources of emissions in the industrial processes sector; • include information on quality assurance procedures; and • include required information on sources of and methods for estimating hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. 	<p>Archive documentation supporting the national inventory report in one location or on the Web.</p> <p>Publish findings from research on improving estimates.</p> <p>Perform quality assurance procedures for emissions data from industry.</p> <p>Report emissions and removals separately.</p>

**Appendix I
Results of Expert Reviews of the Four
Developed Nations' Inventories**

(Continued From Previous Page)

Expert review	Findings	Suggestions for improvement
Desk review of the United Kingdom's inventory submitted in 2002	No findings were noted.	Attempt to include estimates for data categories not yet included. Provide more specific information in the national inventory report on how the consistency of emissions data over time was achieved.
Desk review of the United States's inventory submitted in 2000	<p>The information included in the data tables was somewhat inconsistent with the information included in the national inventory report.</p> <p>The data tables did not include recalculations; however, the national inventory report included information on revised methodologies and updated data that were used for recalculations.</p> <p>The inventory did not include information on the quality assurance procedures that were used.</p> <p>The inventory did not include information on the quality of estimates in the data tables.</p>	<p>For more complete and transparent reporting in the land-use change and forestry sector,</p> <ul style="list-style-type: none"> • include a description of methods used for estimating carbon dioxide removals in forest soils and landfills; • provide more explanation on factors used to estimate carbon dioxide removals in the forest floor, understory vegetation, and harvested wood products; and • include data on emissions and removals from abandonment of managed lands and nonforest organic mineral soils.
In-country review of the United States's inventory submitted in 2000	<p>The information included in the data tables was somewhat inconsistent with the information included in the national inventory report.</p> <p>The data were estimated using complex methods and models that required data at a more detailed level than was provided.</p> <p>Although the national inventory report contained some information on quantitative and qualitative indications of uncertainties for emissions sources, the estimates were not complete.</p> <p>The national inventory report provided no specific information on verification and quality assurance procedures.</p>	Apply quality assurance procedures to all sectors.

Source: GAO analysis of expert reviews.

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In addition to the individuals named above, Simin Ho and Karla Springer made key contributions to this report. Nancy Crothers, Sandra Edwards, Barbara Johnson, Karen Keegan, Andria Key, Charlotte Moore, Chris Moriarity, Katherine Raheb, and Anne Rhodes-Kline also made important contributions.

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