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LEGISLATIVE
BRANCH

Energy Audits Are Key
to Strategy for
Reducing Greenhouse
Gas Emissions





Highlights of [GAO-07-516](#), a report to congressional requesters

Why GAO Did This Study

Because of concerns about changes in Earth's climate due to greenhouse gas emissions and the potential economic and environmental consequences of these changes, GAO (1) inventoried greenhouse gas emissions generated by legislative branch operations in fiscal year 2006, as well as identified trends in emissions starting from a base year of the average annual amount emitted in fiscal years 1998 through 2001, and (2) identified a strategy for reducing emissions. To perform this work, GAO followed the Greenhouse Gas Protocol and additional guidance from the Environmental Protection Agency, using data provided by officials responsible for legislative branch operations and the General Services Administration.

What GAO Recommends

GAO recommends that the agencies that manage the operations of the legislative branch (1) establish a schedule for routinely conducting energy audits that provide sufficiently detailed information to justify investing in projects, and (2) implement selected projects as part of an overall plan to reduce emissions that considers cost-effectiveness, the extent to which the projects reduce emissions, and funding options. The affected agencies agreed with GAO's findings and recommendations and provided technical comments that GAO incorporated, as appropriate.

www.gao.gov/cgi-bin/getrpt?GAO-07-516.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Terrell G. Dorn at (202) 512-6923 or dorn@gao.gov.

LEGISLATIVE BRANCH

Energy Audits Are Key to Strategy for Reducing Greenhouse Gas Emissions

What GAO Found

Legislative branch operations generated about 316,000 metric tons of greenhouse gas emissions (expressed in carbon dioxide equivalents) in fiscal year 2006. The amount of greenhouse gas emissions generated by legislative branch operations is equal to the emissions produced by about 57,455 cars and represents an increase of about 4 percent from the average annual quantity emitted in fiscal years 1998 through 2001. The largest source of these emissions (63 percent) was the consumption of electricity purchased from an external provider that relies primarily on fossil fuel combustion to generate the electricity. The second-largest source of emissions (32 percent) was the combustion of fossil fuels in the Capitol Power Plant to produce steam for the majority of the legislative branch buildings. The remaining 5 percent of emissions came from other sources that each generated 1 percent or less of emissions, such as natural gas and chilled water purchased from outside sources and business travel in government-owned and -leased vehicles. While emissions in 2006 increased 4 percent over the base year levels, emissions in the intervening years varied depending on factors such as fluctuations in weather, the fuel mix used at the Capitol Power Plant, and the quantity of renewable energy used by legislative branch operations.

A strategy for reducing emissions includes conducting energy audits to identify and evaluate energy efficiency and renewable energy projects, as well as evaluating other emissions-reduction projects that may fall outside the scope of energy audits. Such a strategy would also involve developing an implementation plan that considers cost-effectiveness, the extent to which the projects reduce emissions, and funding options. Energy audits are a key step because the projects identified through the audits would address the largest sources of emissions—purchased electricity and fossil fuel combustion in the Capitol Power Plant—and would include information on cost-effectiveness and the potential for reducing emissions. Agencies could finance these projects through direct appropriations or contracts with utility or energy service companies. Since fiscal year 1998, the Architect of the Capitol, GAO, and the Government Printing Office have commissioned 11 energy audits of some of their facilities, but the audits have generally not been comprehensive and the agencies have varied in the extent to which they have implemented the projects identified through the audits. Another part of a strategy would involve evaluating the cost-effectiveness, emissions reduction, and funding options of projects that may fall outside the scope of energy audits—such as acquiring fuel-efficient vehicles—on a case-by-case basis. The energy audits and evaluations of other projects would provide information for legislative branch agencies to develop plans for implementing projects to reduce emissions.

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Abbreviations

AOC	Architect of the Capitol
CBO	Congressional Budget Office
CNG	compressed natural gas
CRS	Congressional Research Service
DOE	Department of Energy
EPA	Environmental Protection Agency
ESPC	energy savings performance contract
FEMP	Federal Energy Management Program
GPO	Government Printing Office
GSA	General Services Administration
LEED	Leadership in Energy and Environmental Design
LOC	Library of Congress
NREL	National Renewable Energy Laboratory
REC	renewable energy certificate
UESC	utility energy savings contract
VOC	volatile organic compounds
WRI	World Resources Institute

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United States Government Accountability Office
Washington, DC 20548

April 25, 2007

The Honorable Mary L. Landrieu
Chairman
The Honorable Wayne Allard
Ranking Minority Member
Subcommittee on Legislative Branch
Committee on Appropriations
United States Senate

The Honorable Richard J. Durbin
United States Senate

Greenhouse gas emissions—including carbon dioxide, methane, nitrous oxide, and certain synthetic chemicals—result from a variety of sources, such as the combustion of fossil fuels, industrial activities, and natural processes. According to the Intergovernmental Panel on Climate Change, greenhouse gas emissions, especially carbon dioxide, have contributed to increased global temperatures and related changes in Earth’s climate. Climatic changes resulting from greenhouse gas emissions could have significant economic and environmental consequences, including elevated sea levels, shifts in agricultural productivity, and damage to sensitive ecosystems. Because most U.S. carbon dioxide emissions result from the combustion of fossil fuels, efforts to cut emissions generally focus on increasing the efficiency of activities powered by fossil fuels or switching to renewable-energy sources. Besides decreasing emissions, these efforts often achieve financial savings through decreased energy expenditures.

The U.S. government has taken some action to inventory and reduce greenhouse gas emissions. For example, the federal government published an inventory of the country’s greenhouse gas emissions in 2006 and has developed voluntary programs that encourage participants to conduct inventories and set targets to reduce their emissions. Furthermore, certain energy-efficiency and air-quality programs for the federal government, while not specifically designed to reduce greenhouse gas emissions, have had that effect. Agencies within the executive branch of government have also responded to an executive order that directed them to inventory their emissions and set an emissions reduction target.¹ However, legislative

¹Revoked by E.O. 13423 (Jan. 24, 2007).

branch agencies have not been required to inventory their emissions or implement an overall emissions reduction strategy, and they have not undertaken any comprehensive voluntary efforts.

The legislative branch includes Congress and its supporting agencies—the Architect of the Capitol (AOC), GAO, Government Printing Office (GPO), Library of Congress (LOC), Congressional Budget Office (CBO), U.S. Botanic Garden, Medicare Payment Advisory Commission, and Stennis Center for Public Service. (See app. III for a map of legislative branch facilities in the Washington, D.C., metropolitan area.) AOC has jurisdiction over the day-to-day operations of the legislative branch facilities that are located in the Capitol complex, including the Senate Office Buildings, House Office Buildings, U.S. Capitol Building and Grounds, LOC Buildings and Grounds, Capitol Power Plant, U.S. Capitol Police Buildings, and U.S. Botanic Garden.

GAO was asked to (1) conduct an inventory (including the amount and sources) of greenhouse gas emissions generated by legislative branch operations in fiscal year 2006, as well as identify trends in emissions starting from a base year of the average annual amount emitted in fiscal years 1998 through 2001, and (2) identify a strategy for reducing emissions.

To conduct an inventory of the greenhouse gas emissions generated by legislative branch operations, we followed the Greenhouse Gas Protocol² and additional guidance from the Environmental Protection Agency’s (EPA) Climate Leaders program.³ In accordance with the Greenhouse Gas Protocol, the scope of our work included direct emissions, such as the combustion of fossil fuels at the Capitol Power Plant, and indirect emissions from the consumption of purchased electricity, natural gas, steam, and chilled water. We excluded other indirect emissions that are optional under the Greenhouse Gas Protocol, such as those generated from business travel in private vehicles or commercial airplanes, employee

²The Greenhouse Gas Protocol was developed by the World Resources Institute, a U.S. nongovernmental organization, and the World Business Council for Sustainable Development, a Geneva-based coalition of 170 international companies, as internationally accepted accounting and reporting standards. It was designed to be program/policy neutral and is compatible with most greenhouse gas inventory programs.

³Climate Leaders is an EPA-sponsored industry-government partnership that works with companies to develop long-term comprehensive climate change strategies. Partners set a corporatwide greenhouse gas reduction goal and inventory their emissions to measure progress.

commuting, or paper use. Our work covered the legislative branch's leased and owned facilities and vehicles within the Washington, D.C., metropolitan area. We excluded indirect emissions from the U.S. Capitol Police for security reasons, as well as nonlegislative branch facilities under AOC's jurisdiction, such as the U.S. Supreme Court. We also excluded emissions from the Medicare Payment Advisory Commission and the Stennis Center for Public Service because of their small size and location within buildings outside of the legislative branch. To calculate emissions and identify emissions trends, we collected and analyzed data for fiscal years 1998 through 2006 from AOC, CBO, GAO, GPO, LOC, the Senate Sergeant at Arms, the House of Representatives Chief Administrative Officer, and the General Services Administration (GSA). The House of Representatives Chief Administrative Officer was unable to provide fuel use data from the House of Representatives' 23 vehicles or volatile organic compound (VOC) emissions data from its furniture shop that performs wood refinishing, painting, and upholstery. In addition, AOC was unable to provide data on leaks from their oil, diesel, and propane tanks. Therefore, greenhouse gas emissions from these sources were not included in our calculations. We used the average annual emissions in fiscal years 1998 through 2001 as the base year for our trend analysis because this is the time period set by the Chicago Climate Exchange, a voluntary greenhouse gas reduction program. We also used data from the National Oceanic and Atmospheric Administration to compare changes in the local weather to changes in emissions to help explain emission trends.

To identify a strategy for reducing emissions, we reviewed documents from the World Resources Institute (WRI), and Congressional Research Service (CRS); and we interviewed officials and reviewed documents from AOC, GPO, and GAO to learn about energy audits and emissions reduction projects that the legislative branch has already implemented. We also interviewed officials from DOE's National Renewable Energy Laboratory (NREL) and Federal Energy Management Program (FEMP) about energy audits, and types of emissions reduction projects and their cost-effectiveness; and officials from GSA about emissions reduction projects related to government-owned and -leased vehicles. In addition, we interviewed Pepco Energy Services about its renewable-energy contracts with the legislative branch agencies. (See app. I for a more detailed description of our scope and methodology and app. II for the steps we followed to conduct an inventory of legislative branch greenhouse gas emissions.) We conducted our work from August 2006 through April 2007.

Results in Brief

Legislative branch operations generated about 316,000 metric tons of greenhouse gas emissions (expressed in carbon dioxide equivalents⁴) in fiscal year 2006.⁵ This amount is equal to the emissions produced by approximately 57,455 cars and represents an increase of about 12,400 metric tons (4 percent) from the average annual quantity emitted in fiscal years 1998 through 2001. The largest source of these emissions (63 percent) was the consumption of electricity purchased from an external provider that relies primarily on fossil fuel combustion to generate the electricity. The second-largest source of emissions (32 percent) was the combustion of fossil fuels in the Capitol Power Plant to produce steam for the majority of the legislative branch buildings.⁶ The remaining 5 percent of emissions came from a variety of other sources that each generated 1 percent or less of emissions, including the consumption of natural gas and chilled water purchased from outside sources, business travel in government-owned and -leased vehicles, leaks in refrigeration equipment, the release of VOCs, and the combustion of fossil fuels in emergency generators. While emissions in 2006 increased 4 percent over the base year levels, emissions in the intervening years varied depending on several factors, including fluctuations in weather, the fuel mix used at the Capitol Power Plant, and the quantity of renewable energy purchased by legislative branch agencies.

A strategy for reducing emissions includes conducting energy audits to identify and evaluate energy-efficiency and renewable-energy projects, as well as evaluating other emissions reduction projects that may fall outside the scope of energy audits. The strategy would also involve developing an implementation plan that considers cost-effectiveness, the extent to which the projects reduce emissions, and funding options. Focusing on energy audits to identify projects would assist the legislative branch agencies in

⁴Carbon dioxide equivalents provide a universal standard of measurement against which the impacts of releasing different greenhouse gases can be evaluated.

⁵The House of Representatives Chief Administrative Officer was unable to provide fuel use data from the House of Representatives' 23 vehicles or VOC emissions data from its furniture shop that does wood refinishing, painting, and upholstery. In addition, AOC was unable to provide data on leaks from its oil, diesel, and propane tanks. Therefore, greenhouse gas emissions from these sources were not included in our calculations.

⁶The Capitol Power Plant also provides steam for Union Station, Folger Shakespeare Library, and Postal Square, which are not legislative branch facilities, with the exception of AOC's leased space in Postal Square. Emissions from the combustion of fossil fuels in the Capitol Power Plant to produce steam for these buildings was included in our calculations, as required by the Greenhouse Gas Protocol.

addressing the largest sources of emissions—the consumption of purchased electricity and fossil fuel combustion in the Capitol Power Plant. In addition to identifying specific projects, energy audits also include information on cost-effectiveness and the potential for reducing emissions. The agencies could finance these projects through direct appropriations or contracts with utility or energy service companies, under which the company initially pays for the work and the agency later repays the company with the resulting energy savings. Since fiscal year 1998, AOC, GAO, and GPO have commissioned 11 energy audits of their facilities, but the audits have generally not been comprehensive and the agencies have varied in the extent to which they have implemented the projects identified through the audits. Another part of this strategy to reduce emissions would involve evaluating projects that may fall outside the scope of energy audits, such as (1) projects to reduce electricity emissions by curtailing energy use, purchasing high-efficiency appliances, using renewable electricity, and considering the energy efficiency of facilities when constructing new facilities and before entering into leases; (2) projects to reduce emissions from the combustion of fossil fuels in the Capitol Power Plant by adjusting the fuel mix; (3) projects to reduce vehicle emissions by acquiring fuel-efficient vehicles and vehicles that run on renewable fuel; and (4) projects to reduce overall emissions by purchasing credits for emissions reductions that take place outside an entity’s sphere of operations. The cost-effectiveness, emissions reduction, and funding options for each of these projects would have to be evaluated on a case-by-case basis. The energy audits and project evaluations would provide information for the legislative branch to develop plans for implementing projects to reduce emissions.

Since energy audits are a key step in identifying projects to reduce the largest sources of emissions and agencies that manage the operations of the legislative branch have varied in the extent to which they have used such audits, we are recommending that these agencies establish a schedule for routinely conducting energy audits that provide sufficiently detailed information—such as targeted or comprehensive audits—to justify investing in projects. Furthermore, the agencies should implement selected projects as part of an overall plan to reduce emissions that considers cost-effectiveness, the extent to which the projects reduce emissions, and funding options. In commenting on a draft of this report, the agencies that manage the operations of the legislative branch agreed with the report’s overall findings and recommendations, and offered technical suggestions which we have incorporated, as appropriate. The Architect of the Capitol noted that, while AOC operates the facilities within the Capitol complex and would be responsible for energy audits of

the building systems and implementing the projects that result from the energy audits, the agency has little influence over the energy use activities of the occupants of the facilities.

Background

Carbon dioxide is by far the most prevalent of the greenhouse gases—gases that trap heat in the atmosphere—emitted in the United States, accounting for about 85 percent of emissions. The other principal greenhouse gases are methane, nitrous oxide, and three types of synthetic gases—hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Like carbon dioxide, methane and nitrous oxide are released during the combustion of fossil fuels by stationary and mobile sources. Hydrofluorocarbons are emitted from refrigerants that leak from chillers and air-handling units. Perfluorocarbons and sulfur hexafluoride⁷ are generally not emitted by legislative branch operations.

Each greenhouse gas has a global warming potential—a measure of its heat-trapping ability relative to that of carbon dioxide. For example, methane is 21 times more potent than carbon dioxide, so its global warming potential is 21. Global warming potentials are used to convert emissions of non-carbon-dioxide gases into their carbon dioxide equivalents to allow comparisons of the total cumulative warming effects of different greenhouse gases. Carbon dioxide equivalents are calculated by multiplying the emissions of the non-carbon-dioxide gas by its corresponding global warming potential (see app. I for a list of the global warming potentials of the principal greenhouse gases). The common unit of measure for reporting greenhouse gas emissions is metric tons of carbon dioxide equivalents.⁸

Legislative branch operations generate greenhouse gas emissions from the combustion of fossil fuels in the Capitol Power Plant; business travel in government-owned and -leased vehicles; the use of heavy machinery; the release of VOCs in furniture and print shops; fugitive emissions, such as leaks in refrigeration equipment and fuel tanks; the combustion of fossil fuels in emergency generators; and the consumption of purchased

⁷Perfluorocarbons are emitted as byproducts of aluminum productions and semiconductor manufacturing, and sulfur hexafluoride is emitted from certain semiconductor manufacturing processes.

⁸A metric ton equals 2,205 pounds, while a short ton, a measurement used in the United States, equals 2,000 pounds.

electricity, natural gas, steam, and chilled water. AOC, GAO, and GPO have jurisdiction over the majority of these sources through their management of legislative branch property. While AOC operates the facilities within the Capitol complex, LOC, CBO, the Senate, and the House of Representatives are responsible for their own energy consumption. These entities also procure their own office equipment, and own and lease vehicles independent of AOC. In addition, the Senate and House of Representatives run the operations of their own furniture shops that perform wood refinishing, painting, and upholstery, and the Senate operates its own print shops. LOC also leases facilities independent of those managed by AOC. Table 1 shows the number of facilities, vehicles, and other property managed by each entity.

Table 1: Number of Facilities, Vehicles, and Other Property Managed by the Legislative Branch in the Washington, D.C., Area in Fiscal Year 2006

	AOC	GAO	GPO	Senate	House of Representatives	CBO	LOC
Government-owned facilities	31 ^a	1	4 ^b	0	0	0	0
Leased facilities	5 ^c	0	1	0	0	0	2
Vehicles ^d	152	10	61	55	23	1	21
Streetlights	1,169	0	0	0	0	0	0
Parking lots	5	0	0	0	0	0	0

Source: GAO analysis of AOC, GAO, GPO, Senate Sergeant at Arms, House Chief Administrative Officer, CBO, LOC, and GSA data.

^aThe furniture shops managed by the Senate and House of Representatives are located within government-owned facilities under AOC's jurisdiction.

^bGPO headquarters consists of three contiguous buildings and one building directly across the street.

^cThe print shop managed by the Senate is located within a leased facility under AOC's jurisdiction.

^dGovernment-owned and -leased vehicles and heavy machinery.

The Capitol Power Plant produces steam and chilled water for the majority of the Capitol complex, as well as steam for GPO.⁹ Steam is used for heating buildings and hot water, as well as for cooking and humidification. Chilled water is used for cooling buildings and equipment, as well as for dehumidification. Two of the Capitol Power Plant's seven

⁹The Capitol Power Plant also produces steam and chilled water for Union Station, Folger Shakespeare Library, and Postal Square, which are not legislative branch facilities, with the exception of AOC's leased space in Postal Square.

boilers are coal-fired units with auxiliary gas burners, and the other five run on natural gas or oil. AOC uses a mix of fossil fuels—coal, oil, and natural gas—in the Capitol Power Plant to help ensure continuity of operations in case of a supply shortage or an increase in the price of one of the fuels. Ten chillers in the Capitol Power Plant’s refrigeration plants run on electricity to generate chilled water.¹⁰ In addition to the steam and chilled water produced by the Capitol Power Plant, AOC purchases steam and chilled water from GSA for one building under its jurisdiction (the Ford House Office Building), and GAO also purchases its steam from GSA. GAO has six electric-powered chillers and GPO has three electric-powered chillers that produce chilled water for these agencies. The legislative branch agencies purchase their electricity primarily from Pepco Energy Services and natural gas from Washington Gas.

Options to reduce emissions include projects that can be divided into five categories—energy efficiency, renewable energy, adjustment of power plant fuel mix to include less carbon-intensive fuel, energy curtailment, and offsets. Energy efficiency means using less energy to produce a given level of service or an increase in output for the same amount of energy. Energy-efficiency projects include enhancing the energy efficiency of equipment, installing a cogeneration (combined heat and power) system, and upgrading vehicles to more fuel-efficient models. Renewable energy is derived from resources that are generally not depleted by human use, such as the sun, wind, and water movement. In most cases, renewable energy releases less carbon dioxide than fossil fuels.¹¹ Renewable-energy projects include purchasing renewable energy, generating renewable energy on site, procuring alternative-fuel vehicles, and adjusting power plant fuel mix to include renewable fuels. In addition to adjusting the fuel mix to include renewable fuels, adjustments could be made to the fuel mix to use less carbon-intensive fuel, such as natural gas. Energy curtailment means a decrease in activity to reduce energy consumption, such as turning off

¹⁰Our analysis did not include the new chillers being installed under AOC’s project to expand the Capitol Power Plant’s West Refrigeration Plant because it is outside the time period covered by our study.

¹¹As reported by CRS, wind and solar energy have zero carbon dioxide emissions in operation but may need an energy storage backup system (such as batteries or fuel cells) that does require fossil fuel use. When biomass is developed as an energy crop, the carbon dioxide emissions are near zero because each new crop absorbs the same amount of emissions as are released by combusting the previous crop. However, while the burning of biomass results in near zero emissions, there are emissions when the full life cycle is taken into account, such as harvesting and transporting the biomass.

lights when not in use. Finally, offsets refer to projects that would reduce or remove emissions outside an entity's sphere of operations and are generally used to supplement other projects that directly reduce emissions.

Legislative Branch Operations Generated 316,000 Metric Tons of Greenhouse Gas Emissions in 2006, a 4 Percent Increase from Base Year Levels

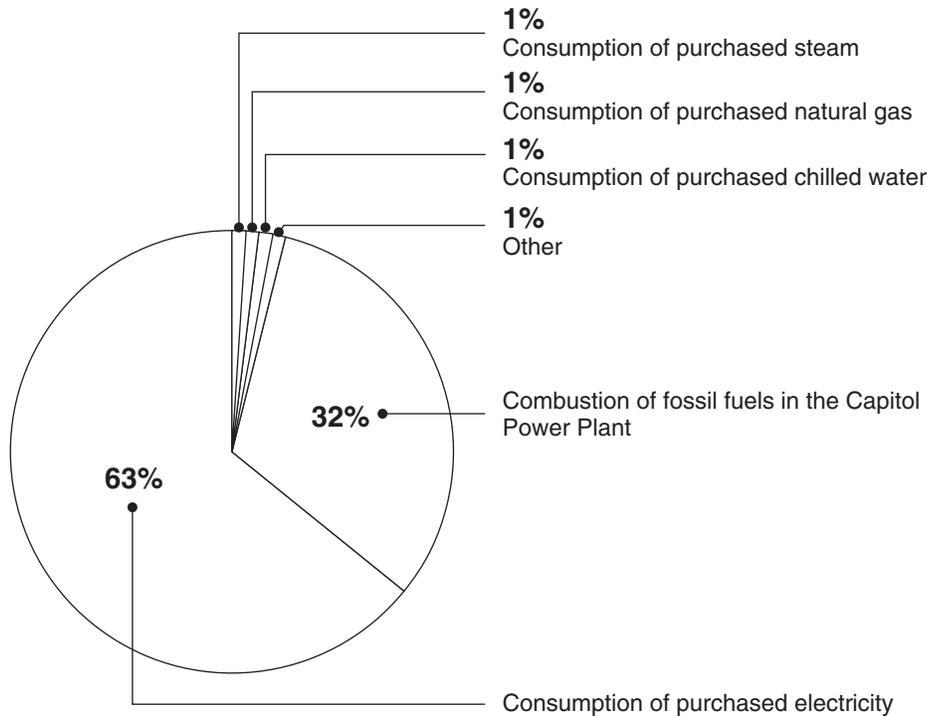
Legislative branch operations generated about 316,000 metric tons of greenhouse gas emissions (expressed in carbon dioxide equivalents) in fiscal year 2006.¹² Electricity use was the largest source of emissions, accounting for 198,989 metric tons, or approximately two-thirds (63 percent) of total emissions (see fig. 1). Electricity purchased by legislative branch agencies is generated primarily from the combustion of fossil fuels, such as coal, oil, and natural gas. The second-largest source of emissions was the combustion of fossil fuels—primarily coal and natural gas—in the Capitol Power Plant to produce steam for the majority of the legislative branch buildings.¹³ The Capitol Power Plant produced 102,659 metric tons of greenhouse gas emissions in fiscal year 2006, or approximately one-third (32 percent) of total emissions.¹⁴ In addition, the consumption of purchased natural gas, steam, and chilled water each accounted for approximately 1 percent of the greenhouse gas emissions from legislative branch operations. The natural gas was used to heat buildings within the Capitol complex that do not receive steam from the Capitol Power Plant, to operate appliances in GAO's cafeteria, and as part of the printing process at GPO. Finally, business travel in government-owned and -leased vehicles and the use of heavy machinery, the release of VOCs in furniture and print shops, the combustion of fossil fuels in emergency generators, and leaks in refrigeration equipment at the Capitol Power Plant each accounted for less than 1 percent of emissions.

¹²The House of Representatives Chief Administrative Officer was unable to provide fuel use data from the House of Representatives' 23 vehicles or VOC emissions data from its furniture shop that performs wood refinishing, painting, and upholstery. In addition, AOC was unable to provide data on leaks from their oil, diesel and propane tanks. Therefore, greenhouse gas emissions from these sources were not included in our calculations.

¹³The Capitol Power Plant also provides steam for Union Station, Folger Shakespeare Library, and Postal Square, which are not legislative branch facilities, with the exception of AOC's leased space in Postal Square. Emissions from the combustion of fossil fuels in the Capitol Power Plant to produce steam for these buildings was included in our calculations, as required by the Greenhouse Gas Protocol.

¹⁴Coal used to fuel boilers generated 57 percent of the Capitol Power Plant's emissions from the combustion of fossil fuels, while natural gas generated 38 percent, and oil 5 percent of the plant's emissions from the combustion of fossil fuels.

Figure 1: Source of Legislative Branch Greenhouse Gas Emissions, Fiscal Year 2006



Source: GAO analysis of AOC, GAO, GPO, Senate Sergeant at Arms, House of Representatives Chief Administrative Officer, CBO, LOC, and GSA data.

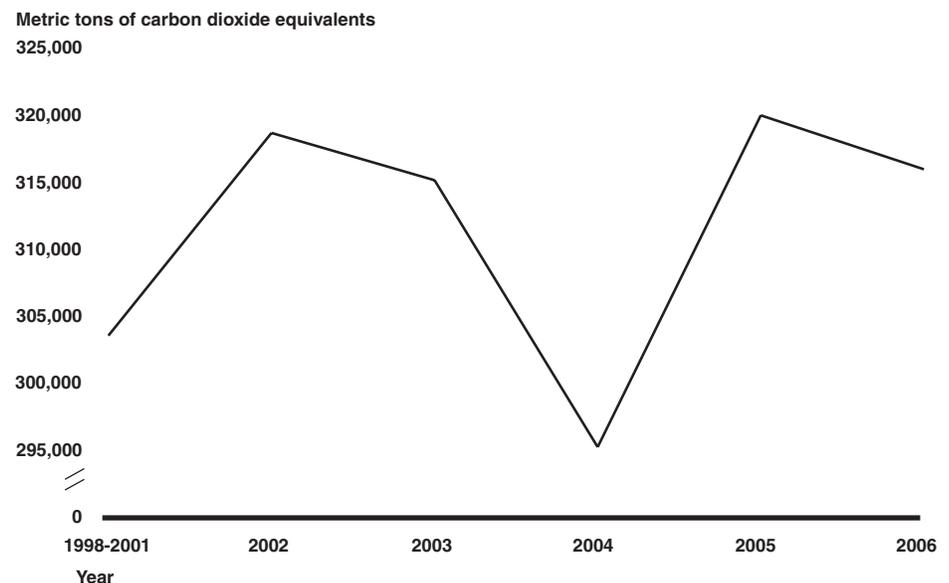
Note: Sources do not equal 100 percent due to rounding.

Our analysis of emissions by type of greenhouse gas showed that carbon dioxide represented 99 percent of total emissions from legislative branch operations in fiscal year 2006. Hydrofluorocarbons, nitrous oxide, and methane made up the remaining 1 percent of emissions. Although nitrous oxide and methane emissions were generated from multiple sources and hydrofluorocarbons were generated from a sole source—R-134a refrigerant that escaped from two chillers at the Capitol Power Plant through a gasket leak between June and August 2006—hydrofluorocarbons represented the majority of the non-carbon-dioxide emissions, in part because of R-134a’s high global warming potential.

Overall, greenhouse gas emissions generated by legislative branch operations in fiscal year 2006 increased 4 percent from the annual average quantity emitted in fiscal years 1998 through 2001 (see fig. 2). Factors that could have influenced emissions trends—and may continue to influence trends in the future—include emissions reduction projects and changes in

square footage of buildings, weather, numbers of employees, operating hours, security measures, sources of production, energy prices, and numbers of vehicles. Despite the overall increase in emissions, there was one notable decrease in emissions during this time period—a 6 percent decrease from fiscal year 2003 to fiscal year 2004. The 6 percent decrease can likely be attributed to AOC’s purchase of renewable energy from Pepco Energy Services during an 8-month period beginning in September 2003. The most recent decrease in emissions (1 percent), from fiscal year 2005 to fiscal year 2006, was likely influenced by two factors: a change in the fuel mix at the Capitol Power Plant that was due to a malfunction in the coal-fired boilers, which required AOC to replace some coal with more expensive—but less emissions-intensive—natural gas; and lower fuel consumption that was due to more moderate temperatures. Emissions trends varied by agency (see app. IV for emissions trends by agency). For example, GPO emissions decreased 28 percent primarily due to a reduction in staff levels.

Figure 2: Legislative Branch Greenhouse Gas Emissions, Fiscal Years 1998-2001 through 2006



Source: GAO analysis of AOC, GAO, GPO, Senate Sergeant at Arms, House of Representatives Chief Administrative Officer, CBO, LOC, and GSA data.

A Strategy for Reducing Emissions Generated by Legislative Branch Operations Includes Conducting Energy Audits and Evaluating Other Projects

A strategy for reducing emissions includes conducting energy audits to identify and evaluate energy-efficiency and renewable-energy projects, as well as evaluating other emissions reduction projects that may fall outside the scope of energy audits. The strategy would also involve developing an implementation plan that considers cost-effectiveness, the extent to which the projects reduce emissions, and funding options.¹⁵

Energy Audits Are Key to Addressing Largest Sources of Emissions

Conducting energy audits would assist the legislative branch in addressing the largest sources of emissions—the consumption of purchased electricity and fossil fuel combustion in the Capitol Power Plant—because these audits identify cost-effective systemwide energy-efficiency and renewable-energy projects.¹⁶ Energy audits typically include information on projects that could address these emissions sources, as well as projects that could reduce emissions from other sources, such as the consumption of purchased natural gas and leaks in refrigeration equipment. Energy audits also include information on the cost-effectiveness of projects and on the extent to which the projects could reduce emissions, which assist agencies in evaluating and selecting projects. In general, projects identified by energy audits as generating savings sufficient to pay for the capital costs of the projects are deemed cost-effective. Other projects identified through the energy audits may partially pay for themselves and could be considered cost-effective relative to other projects. Energy-efficiency projects are generally more cost-effective than renewable-energy projects because many renewable-energy projects are not cost competitive when compared with more traditional sources of power.

There are three main types of energy audits—preliminary, targeted, and comprehensive. Each type is distinguished by the level of detail and analysis required to complete the audit. Less detailed audits include less accurate estimates of project costs and energy savings. Preliminary energy

¹⁵An implementation plan would also consider continuity of operations, security, and neighborhood concerns.

¹⁶Generally, on-site renewable generation projects are included in an energy audit upon request.

audits are the least detailed and provide quick evaluations to determine a project's potential. These energy audits do not provide sufficiently detailed information to justify investing in the identified projects. Instead, preliminary audits are primarily used to decide if a more detailed evaluation is necessary. Targeted audits are detailed analyses of specific systems, such as lighting or boiler replacement. Comprehensive audits are detailed evaluations of all major energy-using systems. Targeted and comprehensive audits provide sufficiently detailed information to justify investing in projects. AOC, GAO, and GPO commissioned six preliminary, four targeted, and one comprehensive energy audit of some of their facilities from fiscal years 1998 through 2006.¹⁷

AOC commissioned preliminary audits of the Capitol in June 2000, the Rayburn House Office Building in April 2003 and December 2003, the Hart Senate Office Building in December 2003, and the LOC Madison Building in May 2005. These audits identified cost-effective projects, meeting the definition of cost-effectiveness found at 10 CFR §§ 436.18-436.22. For example, the energy audit of the LOC Madison Building identified 12 cost-effective projects with savings-to-investment ratios¹⁸ ranging from 1.02 to 3.87. It was estimated that these projects would reduce emissions from electricity by approximately 4,760 metric tons per year. However, according to agency officials, AOC has not followed up with energy audits that provide sufficiently detailed information to justify investing in projects at these facilities because of fiscal constraints.¹⁹ There are also approximately 27 buildings under AOC's jurisdiction that have not had any type of energy audit. In the fiscal year 2008 budget, AOC requested \$1.1 million to fund the first two years of a five-year plan to perform energy surveys of all its facilities.

In addition to the energy audits, AOC has conducted Facility Condition Assessments and other studies of facilities in need of upgrades and

¹⁷According to a FEMP official, several of AOC's audits (the SAVEnergy audits) were more detailed than a preliminary audit, but did not provide sufficiently detailed information to justify investing in projects. Therefore, we are including these audits within the preliminary energy audit category.

¹⁸One criterion for determining the cost-effectiveness of projects is the savings-to-investment ratio—that is, the ratio of the present value savings to the present value costs of an energy conservation measure. A ratio of 1.0 or greater is considered cost-effective.

¹⁹AOC had a comprehensive energy audit prior to 1998 that identified a project to replace 160,000 lights with energy saving lights throughout the Capitol Complex. AOC implemented this project in 1998.

repairs, which identified projects that would yield potential energy efficiency improvements. However, most of these projects have not been implemented. Since 2004, AOC has evaluated the viability of changing the Capitol Power Plant to cogeneration, which could provide steam, supplementary electricity, and backup power to the Capitol complex and reduce emissions by more efficiently capturing the energy output. AOC also began a project in 2001 to evaluate the clean coal technology alternatives to supplement or replace the existing Capitol Power Plant steam generating facilities to reduce emissions from burning coal. In addition, AOC took initial steps in response to legislation that required the agency to develop and implement a cost-effective energy conservation strategy.²⁰ For example, AOC purchased a building automation system that will be used to operate mechanical and electrical systems more efficiently throughout the Capitol complex, purchased energy-efficient chillers to supplement production of chilled water at the Capitol Power Plant, and is evaluating proposals from contractors for installing energy conservation measures, including on-site renewable energy, on the rooftop of the Dirksen Senate Office Building.

In 1999, GPO had a preliminary energy audit and chose to implement two of the projects identified as cost-effective—the replacement of its chillers and 15,000 light fixtures—after a targeted energy audit of the chillers in 2000. According to officials, GPO pursued only those projects with the shortest payback periods because of its limited budget and plans to relocate. GPO does not have a regular schedule for conducting energy audits.

GAO had a comprehensive energy audit in 2002 and plans to have another comprehensive energy audit by fiscal year 2009. GAO also conducts a targeted energy audit of its facility every 2 years as part of its building

²⁰In the Energy Policy Act of 1992, Congress included language requiring that AOC (1) implement a lighting retrofit program to replace incandescent lighting and, subject to available funding, to upgrade florescent lighting in the Capitol, House and Senate Office buildings, and the Capitol grounds, and (2) to evaluate and report on other potential energy conservation measures. Pub. L. 102-486, § 168. In a provision attached to the Legislative Branch Appropriations Act, 1999, Pub. L. 105-275, § 310 (1998), AOC was tasked with developing and implementing a cost-effective energy conservation strategy for all facilities administered by Congress. This language was repealed by the Energy Policy Act of 2005, Pub. L. 109-58, § 101, amending Part 3 of title V of the National Energy Conservation Policy Act, 42 U.S.C. 8251 *et seq.*, which additionally expanded energy and water conservation planning by AOC in order to achieve a cost-effective energy conservation and management plan.

assessment report. GAO has implemented the majority of the projects identified through its audits, such as installing optimization controls for the air-handling system and installing specialized software to decrease electricity use during periods of peak demand.²¹ In addition, GAO routinely considers other opportunities taking into account technology, price, and available funding.

Legislative branch agencies have three methods for financing energy audits and implementing projects: energy savings performance contracts (ESPC), utility energy savings contracts (UESC), or direct appropriations. Congress authorized agencies to use ESPCs to privately finance energy-efficiency and renewable-energy projects in 1986. Under an ESPC, agencies enter into a long-term contract (up to 25 years) with a private energy services company under which the company conducts a comprehensive energy audit of the agency, then finances and implements projects approved by the agency. The agency then repays the company with the resulting energy savings. The energy audits of the Rayburn and Hart buildings were done through an initial proposal for an ESPC. UESCs are similar to ESPCs, but are offered by electric and gas utilities and can cover smaller projects. The third financing mechanism is direct appropriations. While GPO's preliminary audit was conducted by Pepco Energy Services under an initial proposal for an UESC, GPO opted to fund the projects with direct appropriations. According to GPO officials, the projects cost \$6 million and reduced the agency's energy bills by \$1 million a year. GAO funds its energy audits through direct appropriations and seeks funding for implementing projects in its annual budget requests.

In 1995, DOE's FEMP initiated the SAVEnergy Program, which provided funding for energy audits of federal facilities but not for project implementation. FEMP funding for SAVEnergy audits was eliminated in fiscal year 2006. Three energy audits—for the Capitol and the Rayburn and Madison buildings—were conducted under the SAVEnergy Program.

²¹GAO implemented numerous additional energy-efficiency projects identified through energy audits during the height of GAO's building modernization program in the early to mid-1990s—a time period that is outside the scope of our study. The projects included: high-efficiency chillers, variable-speed pumping, variable air volume air handlers, high-efficiency motors, building temperature controls, heating hot water improvements, domestic hot water improvements, roof insulation, and window film.

Evaluating Other Projects Could Identify Additional Ways to Reduce Emissions

In addition to projects identified through energy audits, a strategy would include evaluating other projects to reduce emissions that may fall outside the scope of energy audits, such as (1) projects to reduce electricity emissions by curtailing energy use, purchasing high-efficiency appliances, using renewable electricity, and considering the energy efficiency of facilities when constructing new facilities and before entering into leases; (2) projects to reduce emissions from the combustion of fossil fuels in the Capitol Power Plant by adjusting the fuel mix; (3) projects to reduce vehicle emissions by acquiring fuel-efficient vehicles and vehicles that run on renewable fuel; and (4) projects to reduce overall emissions by purchasing offsets. The cost-effectiveness, emissions reductions, and funding options for each of these projects would have to be evaluated on a case-by-case basis. Compared with projects identified through energy audits, several of these projects cost more to implement but could reduce emissions faster.

Projects to Further Reduce Electricity Emissions

- *Curtailing energy use:* These projects would include enhancing outreach and education efforts to encourage building occupants to curtail their energy use. Examples of energy curtailment outreach efforts include a June 2006 memo from GAO management requesting all employees to help conserve electricity, AOC's "how-to guides" distributed to Members of Congress and their staff detailing cost-effective methods to save energy in the workplace, and GPO's goal-sharing program, which is an incentive award program that encourages employees to reduce energy consumption and splits the cost savings realized from these efforts equally between the agency and its employees. According to GPO, fiscal year 2006 energy savings totaled \$558,604, for an estimated award of \$126.27 per employee. Energy curtailment activities generally involve a trade-off between convenience and productivity, and energy use.
- *Purchasing energy-efficient computer equipment and appliances:* Energy-efficient products have been identified through two federal programs—the Energy Star Program and FEMP. Energy Star-qualified and FEMP-designated products meet energy-efficiency guidelines set by EPA and DOE and, in general, represent the top 30 percent most energy efficient-products in their class of products. These products cover a wide range of categories, including appliances and office equipment. According to the Energy Star program, office products that have earned the Energy Star rating use about half as much electricity as standard equipment and generally cost the same as equipment that is not Energy Star-qualified. Under section 104 of the Energy Policy Act of 2005, agencies are required to purchase Energy Star-qualified and FEMP-designated products. Some of the agencies have reported adopting such practices to further reduce emissions. For example, officials from AOC and GAO reported that they

currently have all Energy Star-qualified information technology equipment.

- *Purchasing renewable electricity:* Renewable-energy certificates (REC) represent the environmental, social, and other positive attributes of electricity generated by renewable resources. RECs can be purchased independent of the associated electricity from a wholesale supplier or bundled with the electricity from a utility company. It is usually less expensive to buy RECs from a wholesale supplier because a supplier generally has access to a wider array of resources than a utility company. In both cases, purchasing RECs helps the electricity generator invest more money in renewable energy, increasing the amount of renewable electricity and decreasing the amount of fossil fuel electricity entering the country's power supply. For 8 months beginning in September 2003, AOC purchased RECs from its utility, Pepco Energy Services—equal to 51,296,000 kilowatt hours, or approximately 15 percent of its annual electricity use. In November 2006, AOC, GPO, and GAO participated in a GSA areawide electricity contract with Pepco Energy Services to purchase RECs equal to 3 percent of their energy consumption in order to meet the Energy Policy Act of 2005 federal purchase requirement.²² Other federal agencies, such as the Environmental Protection Agency, have chosen to purchase RECs equal to 100 percent of their energy use.
- *Leasing and constructing energy-efficient facilities:* Another way to reduce emissions is to consider the efficiency of potential building space when renewing or entering into a new lease as well as applying energy-efficiency measures in the design and construction of new federal facilities. Under the Energy Policy Act of 1992, executive branch agencies are required to fully consider energy efficiency when leasing and constructing facilities. AOC was also required to apply federal building energy standards adopted under the act to new buildings within its jurisdiction. AOC adopted a standard equivalent to a Silver rating of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System in 2006 as a minimum standard for all new construction.²³ The LEED Rating System, created and maintained by the U.S. Green Building Council, provides a benchmark for the design, construction, and operation of high-performance green buildings.

²²Section 203 of the Energy Policy Act of 2005 establishes a goal of ensuring that the federal government consumes not less than 3 percent renewable energy in fiscal years 2007 through 2009, not less than 5 percent in fiscal years 2010 through 2012, and not less than 7.5 percent in fiscal year 2013 and in each fiscal year thereafter.

²³The construction of the Capitol Visitor Center predates this requirement.

Projects to Further Reduce Emissions from the Combustion of Fossil Fuels in the Capitol Power Plant

- *Adjusting the fuel mix:* The fuel mixture at the Capitol Power Plant could be adjusted to include renewable fuels, such as biomass. However, using renewable fuels would require extensive boiler retrofits and changes to emissions control technology. The agency could also adjust the fuel mixture to increase the use of natural gas since natural gas produces less carbon dioxide than any other fossil fuel. As discussed earlier, when AOC substituted natural gas for some coal in 2006 because of problems with its coal boilers, emissions from the power plant decreased. However, in 2006, the price of natural gas was more than five times higher than coal.

Projects to Further Reduce Vehicle Emissions

- *Acquiring fuel-efficient vehicles:* Approximately 296—92 percent—of legislative branch vehicles in fiscal year 2006 were trucks (approximately 73 percent of which are light duty trucks). Heavy duty trucks have an actual average fuel economy of 8.8 miles per gallon, light duty trucks have an actual average fuel economy of 16.2 miles per gallon, and cars have an actual average fuel economy of 22.4 miles per gallon. Hybrid-electric vehicles have even higher fuel economies because they combine an electric motor and battery pack with an internal combustion engine to improve efficiency. For example, the hybrid Toyota Camry is rated at 39 miles per gallon, while the rating for the gasoline-fueled standard model is 27 miles per gallon. There are currently no hybrid-electric vehicles in the legislative branch vehicle fleets. Hybrid electric vehicles are, on average, about \$8,200 more expensive than the lowest-priced gasoline vehicle in fiscal year 2007.
- *Acquiring alternative-fuel vehicles:* Alternative-fuel vehicles include dedicated, flexible-fuel, or dual-fuel vehicles designed to operate on at least one alternative fuel, such as ethanol or biodiesel. The legislative branch vehicle fleets include 35 alternative-fuel vehicles and, in September 2006, AOC adopted a policy specifying that all newly acquired vehicles, with a few exceptions, are to be alternative-fuel vehicles. Although legislative branch entities are purchasing these vehicles, they generally fuel them with gasoline because the infrastructure for supplying alternative fuel in the Washington, D.C., metropolitan area is not conveniently located for legislative branch employees.²⁴ LOC was the only entity that reported using ethanol to fuel its alternative-fuel vehicles to date, using 18 gallons in fiscal year 2006. LOC also reported using 8 cubic feet of compressed natural gas in fiscal years 2005 through 2006 to fuel its two gasoline/compressed natural gas light-duty vehicles. Alternative-fuel

²⁴The closest ethanol fuel pumps are located at a service station that is approximately 2 miles from the legislative branch buildings, and the service station only fuels legislative branch vehicles that are leased by GSA.

vehicles that run on ethanol or gasoline are, on average, \$1,500 more expensive than the lowest-priced gasoline vehicle in fiscal year 2007 and get 20 percent to 30 percent fewer miles per gallon, but Congress is encouraging the use of these vehicles because burning ethanol in vehicles instead of gasoline reduces emissions by 18 percent to 29 percent per gallon. In response, AOC's alternative fuel-vehicle policy states that the initial cost shall not be considered as a factor unless it exceeds the initial cost of a comparable conventionally fueled vehicle by at least 5 percent. However, despite the emissions reductions associated with burning ethanol in vehicles instead of gasoline, the net energy benefit of using ethanol is less clear cut when full life-cycle emissions are taken into account. If the emissions from the production of ethanol are included, ethanol can have higher emissions per gallon. It can also have higher emissions of VOCs per mile traveled, compared with gasoline.

Projects to Reduce Overall Emissions

- *Purchasing offsets:* Offsets are credits for emissions reductions outside an entity's sphere of operations and can be purchased in the retail marketplace. Offset projects range from buying credits for carbon sequestration resulting from planting trees to funding energy-efficiency upgrades at a power plant in another city. The price of offsets ranges from \$5 to \$25 per ton, averaging about \$10 per ton. While not specifically considered offsets, RECs also reduce emissions outside an entity's sphere of operations. The renewable electricity associated with nationally-sourced RECs—those generated by sources in another part of the country—do not enter the customer's electricity supply. In general, these RECs are less expensive than RECs generated from local sources. However, RECs generated from local sources support local projects, and the renewable energy enters the local electricity supply which increases the amount of renewable electricity received by the customer. The legislative branch agencies' RECs contract did not exclude national RECs, but Pepco Energy Services won the contract with a proposal that included only RECs generated from local sources.

Conclusions

Although the legislative branch is not required to inventory greenhouse gas emissions or develop an overall strategy to reduce emissions, individual legislative branch agencies have been taking some steps to minimize or reduce emissions. However, the legislative branch as a whole has not focused on reducing emissions. The base year, inventory, and trends presented in this report could serve as a starting point for a legislative branch initiative to follow the efforts of other U.S. government and private-sector entities to reduce emissions.

Energy audits are a key step in identifying projects to reduce the largest sources of emissions from legislative branch operations. While all legislative branch agencies recognize the benefits of energy audits to reduce emissions, the agencies have varied in the extent to which they have used such audits. Consequently, each agency would benefit from a schedule to conduct audits regularly and a plan for implementing and financing the most cost-effective projects identified through the audits. The legislative branch could also evaluate other projects to reduce emissions, including curtailing energy use, acquiring fuel-efficient and alternative-fuel vehicles, and purchasing offsets, and combine these evaluations with information acquired from energy audits to develop an implementation plan for reducing emissions.

Recommendations for Executive Action

Agencies that manage the operations of the legislative branch should establish a schedule for routinely conducting energy audits that provide sufficiently detailed information—such as targeted or comprehensive audits—to justify investing in projects. Furthermore, the agencies should implement selected projects as part of an overall plan to reduce emissions that considers cost-effectiveness, the extent to which the projects reduce emissions, and funding options.

Agency Comments and Our Evaluation

We provided a draft of this report to the Architect of the Capitol, the Government Printing Office, and GAO for review and comment. We received comments orally and via e-mail from officials designated to speak for their agencies. All of the agencies agreed with the report's overall findings and recommendations and offered technical suggestions that we have incorporated, as appropriate. The Architect of the Capitol noted that, while AOC operates the facilities within the Capitol complex and would be responsible for energy audits of the building systems and implementing the projects that result from the energy audits, the agency has little influence over the energy use activities of the occupants of the facilities.

We are sending copies of this report to the appropriate congressional committees, the Acting Architect of the Capitol, and the Acting Public Printer. We will also make copies available to others upon request. In addition, this report will 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 contact me at (202) 512-6923 or dornt@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Major contributors to this report are listed in appendix V.



Terrell G. Dorn
Director, Physical Infrastructure Issues

Appendix I: Objectives, Scope, and Methodology

To conduct an inventory of the greenhouse gas emissions generated by legislative branch operations, we followed the Greenhouse Gas Protocol¹ and additional guidance from the Environmental Protection Agency's (EPA) Climate Leaders program.² In accordance with the Greenhouse Gas Protocol, the scope of our work included direct emissions, such as the combustion of fossil fuels at the Capitol Power Plant, and indirect emissions from the consumption of purchased electricity, natural gas, steam, and chilled water. We excluded other indirect emissions that are optional under the Greenhouse Gas Protocol, such as those generated from business travel in private vehicles or commercial airplanes, employee commuting, or paper use. Our work covered the legislative branch's leased and owned facilities and vehicles within the Washington, D.C., metropolitan area. We excluded indirect emissions from the U.S. Capitol Police for security reasons, as well as non-legislative branch facilities under AOC's jurisdiction, such as the U.S. Supreme Court. We also excluded emissions from the Medicare Payment Advisory Commission and the Stennis Center for Public Service because of their small size and location within buildings outside of the legislative branch.

To calculate emissions for the inventory of greenhouse gas emissions and identify emissions trends, we selected a base year, which is a reference year against which changes in emissions are measured over time. We selected the average annual emissions in fiscal years 1998 through 2001 as the base year because this is the time period set by the Chicago Climate Exchange, a voluntary greenhouse gas reduction program. We collected activity data from the Architect of the Capitol (AOC), GAO, Government Printing Office (GPO), Library of Congress, Congressional Budget Office, Senate Sergeant at Arms, House of Representatives Chief Administrative Officer, and General Services Administration (GSA) for each source of emissions, such as kilowatt hours of electricity, from fiscal years 1998 through 2006. In general, we multiplied the data by a corresponding emissions factor to determine emissions for each year. An emissions

¹The Greenhouse Gas Protocol was developed by the World Resources Institute, a U.S. nongovernmental organization, and the World Business Council for Sustainable Development, a Geneva-based coalition of 170 international companies, as internationally accepted accounting and reporting standards. It was designed to be program/policy neutral and is compatible with most greenhouse gas inventory programs.

²Climate Leaders is an EPA-sponsored industry-government partnership that works with companies to develop long-term comprehensive climate change strategies. Partners set a corporatewide greenhouse gas reduction goal and inventory their emissions to measure progress.

factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. See table 2 for a list of emissions factors. We converted all greenhouse gas emissions to carbon dioxide equivalents by multiplying emissions for each greenhouse gas by its corresponding global warming potential. See table 3 for a list of the global warming potential of each greenhouse gas. The House of Representatives Chief Administrative Officer was unable to provide fuel use data from the House of Representatives' 23 vehicles or volatile organic compounds (VOC) emissions data from its furniture shop that performs wood refinishing, painting, and upholstery. In addition, AOC was unable to provide data on leaks from their oil, diesel and propane tanks. Therefore, greenhouse gas emissions from these sources were not included in our calculations. In analyzing emissions trends from the base year to fiscal year 2006, we used data from the National Oceanic and Atmospheric Administration to compare changes in the local weather to changes in emissions to help explain emission trends.

Table 2: Emissions Factors

Fuel type	Carbon dioxide emissions factor	Nitrous oxide emissions factor	Methane emissions factor
Bituminous coal from West Virginia	207.1 lbs/mmBTU	1.4 g/mmBTU	10 g/mmBTU
Oil	161.386 lbs/mmBTU	0.601 g/mmBTU	10 g/mmBTU
Natural gas	117.08 lbs/mmBTU	0.095 g/mmBTU	4.75 g/mmBTU
Electricity (Mid-Atlantic Area Council power pool)	1.098 lbs/kwh (2000+) 1.153 lbs/kwh (1999) 1.199 lbs/kwh (1998)	0.0000162 lbs/kwh	0.0000241 lbs/ kwh
Gasoline	8.87 kg/gallon	^a	^a
Diesel	9.95 kg/gallon	^a	^a
Ethanol	5.5 kg/gallon	0.076 g/mile	0.043 g/mile
Compressed natural gas	0.054 kg/cubic feet	0.113 g/mile	0.914 g/mile
Propane	139.178 lbs/mmBTU	0.22 g/gallon	0.50 g/gallon

Sources: Energy Information Administration, Environmental Protection Agency, and World Resources Institute.

^aThe emissions factor varies by vehicles type and model year. For specific values see U.S. EPA Climate Leaders GHG Inventory Protocol, Mobile Combustion Sources-Guidance, Table 3.

Table 3: Global Warming Potentials of Greenhouse Gases

Greenhouse gas	Global warming potential
Carbon dioxide	1
Methane	21
Nitrous oxide	310
Hydrofluorocarbons	
• R-23	11,700
• R-125	2,800
• R-134a	1,300
• R-143a	3,800
• R-152a	140
• R-227ea	2,900
• R-236fa	6,300
Perfluorocarbons	
• Perfluoromethane	6,500
• Perfluoroethane	9,200
Sulfur hexafluoride	23,900

Source: Intergovernmental Panel on Climate Change, 1996.

Note: While the Intergovernmental Panel on Climate Change has published updated figures since its 1996 report, nations use the 1996 figures to maintain consistency for reporting purposes.

Some legislative branch entities verified the accuracy of their activity data and made corrections as they deemed appropriate. Some entities also made assumptions about their data. For example, AOC's data were incomplete because there were periods of time for which AOC was not billed for energy use. AOC officials made the assumption that these facilities were under the control of a contractor/vendor during this period and bills were being paid for by these outside entities. We did not independently verify the accuracy of the data. In calculating the greenhouse gas emissions, we also had to make several assumptions in the absence of data. (See app. II for additional details on the calculations and assumptions.) Unless otherwise noted, we determined the data were sufficiently reliable for the purposes of this report.

To identify a strategy for reducing emissions, we reviewed documents from the World Resources Institute, and Congressional Research Service; and we interviewed officials and reviewed documents from AOC, GPO, and GAO to learn about energy audits and emissions reduction projects that the legislative branch has already implemented. We also interviewed officials from the National Renewable Energy Laboratory and DOE's

Federal Energy Management Program about energy audits, and types of emissions reduction projects and their cost-effectiveness; and officials from GSA about emissions reduction projects related to vehicles. In addition, we also interviewed Pepco Energy Services about its renewable energy contracts with the legislative branch agencies. We conducted our work from August 2006 through April 2007.

Appendix II: Technical Information on Methodology, Calculations, and Assumptions Used in Conducting an Inventory of Greenhouse Gas Emissions

Methodology

To develop a greenhouse gas inventory in accordance with the Greenhouse Gas Protocol, we set an organizational boundary, operational boundary, and base year.

Organizational boundary

This boundary defines the legislative branch and the criteria for reporting emissions.

- For the purpose of this report, the legislative branch includes the Architect of the Capitol (AOC), GAO, Government Printing Office (GPO), Library of Congress (LOC), Congressional Budget Office (CBO), and U.S. Botanic Garden. AOC has jurisdiction over the day-to-day operations of the Senate Office Buildings, House Office Buildings, U.S. Capitol and Grounds, LOC Buildings and Grounds, Capitol Power Plant, and U.S. Botanic Garden.
- We applied the Greenhouse Gas Protocol's control approach based on the operational control criterion. Under this criteria, the legislative branch accounts for 100 percent of emissions from operations over which it has operational control—the full authority to introduce and implement operating policies.
- While the Greenhouse Gas Protocol states that geographic location is not relevant to establishing an organizational boundary, the scope of this study was limited to the Washington, D.C., metropolitan area because the majority of the legislative branch activity is located in this geographic area and data for activities outside this area were not readily available.

Operational boundary

This boundary identifies and categorizes the sources of emissions from legislative branch operations.

- The inventory includes emissions from the combustion of fossil fuels in the Capitol Power Plant and emergency generators, business travel in government-owned and leased vehicles, and heavy machinery; leaks in refrigeration equipment; the release of volatile organic compounds (VOC) in furniture and print shops; leaks from oil, diesel and propane tanks;¹ and the consumption of purchased electricity, natural gas, steam, and chilled water.

¹No data were available from this source.

**Appendix II: Technical Information on
Methodology, Calculations, and Assumptions
Used in Conducting an Inventory of
Greenhouse Gas Emissions**

- These emissions are placed in categories, or “scopes,” defined by the Greenhouse Gas Protocol:

Scope 1 (direct emissions from sources that are controlled by the legislative branch):

- combustion of fossil fuel at the Capitol Power Plant;
- combustion of fossil fuels in emergency generators;
- business travel in government-owned and leased vehicles, as well as heavy machinery;
- leaks in refrigeration equipment;
- leaks from oil, diesel and propane tanks;² and
- release of VOCs in furniture and print shops.

Total Scope 1 emissions in fiscal year 2006: 106,045 metric tons of carbon dioxide equivalents.

Scope 2 (indirect emissions from the consumption of purchased electricity, natural gas, steam, and chilled water by the legislative branch):

- use of electricity,
- use of natural gas,
- use of steam, and
- use of chilled water.

Total Scope 2 emissions in fiscal year 2006: 209,946 metric tons of carbon dioxide equivalents.

Scope 3—optional (all other indirect emissions such as paper use, contracted work, shipping/courier services, Member or employee travel and commuting, resource extraction, production and waste disposal, and transmission and distribution losses associated with the consumption of purchased electricity):

- none of these optional sources were included in the inventory.

²No data were available from this source.

Base year

A base year is a reference year against which changes in emissions are measured over time. We selected the average annual amount emitted in fiscal years 1998 through 2001 for the base year because this is the time period set by the Chicago Climate Exchange, a voluntary greenhouse gas reduction program.

Calculations and
Assumptions

The following section explains calculations and assumptions needed to prepare the data for the standard emissions equation (activity data x emissions factor = emissions) as well as additional information on specific sources. It is organized by relevant emissions sources and greenhouse gases. The first part includes those calculations and assumptions that apply to all legislative branch operations; the second part includes those that are specific to individual entities. The second part also contains tables that show the results of the emissions calculations by entity, source, and scope.

General

- *Methane and nitrous oxide emissions from business travel in government-owned and -leased vehicles:* We substituted the appropriate carbon dioxide emission factors for the methane and nitrous oxide emission factors. However, unlike carbon dioxide emission factors for vehicles, which are expressed in kilograms per gallon, these emission factors are expressed in grams per mile. Therefore, we used the formula: mileage = fuel use x fuel economy when the mileage was not provided. Except where noted, we obtained the average fuel economy figures from the Federal Highway Administration's 2004 Highway Statistics.³ For vehicles fueled with ethanol, we reduced the fuel economy by 30 percent because ethanol has approximately 30 percent less energy per gallon than gasoline. For vehicles fueled with compressed natural gas (CNG), we used an average fuel economy of 13 miles per gallon of gasoline equivalent as found at www.fueleconomy.gov. Since methane and nitrous oxide vehicle emission factors vary by model year and vehicle type, we categorized each entity's vehicles by type (car, light truck, or heavy truck) and model year to the best of our ability. Since emission factors are available only through fiscal year 2002, we used the fiscal year 2002 figure for all vehicles from fiscal years 2002 through 2007. Similarly, if vehicles were older than the earliest available emissions factors, we used the earliest available factors. To estimate the mileage for each

³See <http://www.fhwa.dot.gov/policy/ohim/hs04/htm/vm1.htm>.

type of vehicle, we calculated the percentage of the vehicle type out of the total number of vehicles and then used that percentage of the total mileage. By equating the percentage of vehicle type with the percentage of mileage, we are assuming that all vehicles are driven equally.

- *Emissions from the release of VOCs:* We first calculated the carbon emissions using the formula: carbon emissions = VOC release x carbon content. We used the standard carbon content of VOCs, which is 56 percent of the VOC release, according to the U.S. Environmental Protection Agency (EPA). To convert carbon emissions to carbon dioxide emissions, we used the conversion factor 44/12 as laid out in EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004.
- *Emissions from the consumption of purchased steam:* To convert steam consumption at the Ford House Office Building and GAO from pounds to BTUs, we used the heat content 1,003.342 BTUs/pound.⁴ To determine emissions, we calculated the activity data—that is, the fuel used by the General Services Administration (GSA) to generate every mmBTU of steam consumed. We used the formula: activity data [fuel input] = steam produced/boiler efficiency. We took boiler efficiency into account because some fuel input is lost in flue gases when fuel enters the boiler. Since we were unable to obtain the boiler efficiency for GSA's boilers, we used the default efficiency value of 80 percent recommended by the EPA Climate Leaders program. Next, we divided the activity data into fuel type because the fuel input included both natural gas and oil. We calculated the emissions for each type of fuel and then added them to determine total emissions.
- *Emissions from the consumption of purchased electricity and natural gas at leased facilities:* Under the operational control approach set forth by the Greenhouse Gas Protocol, we defined operational control based on the agency occupying the space and, therefore, included the emissions from legislative branch capital leases and operating leases as Scope 2 emissions, even if this required estimating energy use based on an entity's occupied square footage.

⁴See http://www.energystar.gov/ia/business/tools_resources/target_finder/help/Energy_Units_Conversion_Table.htm.

**Appendix II: Technical Information on
Methodology, Calculations, and Assumptions
Used in Conducting an Inventory of
Greenhouse Gas Emissions**

- *Emissions from leased vehicles:* Under operational controls set forth by the Greenhouse Gas Protocol, all leased vehicles are Scope 1 emissions. Therefore, there was no need to differentiate between government-owned and -leased vehicles.
- *Adjustment for purchased renewable energy certificates (REC):* We used the following formula to calculate emissions from renewable electricity: emissions = activity data for green electricity x emissions factor for power pool where renewable power is generated. We determined the power pool where the renewable power was generated using data provided to us by Pepco Energy Services. These emissions were subtracted from Scope 2 emissions to determine total net emissions.

Entity specific

AOC

Table 4: Capitol Complex Greenhouse Gas Emissions from Operations under AOC’s Jurisdiction by Scope and Source for Base Year and Fiscal Year 2006

Metric tons of carbon dioxide equivalents

Scope and source of emissions	Fiscal years 1998-2001	Fiscal year 2006
Scope 1		
Combustion of coal in Capitol Power Plant	34,733.26	58,297.95
Combustion of oil in Capitol Power Plant	17,316.47	5,367.95
Combustion of natural gas in Capitol Power Plant	43,770.56	38,993.21
Refrigeration equipment leakage		2,322.31
Business travel in government-owned and -leased vehicles; heavy machinery	402.70	377.78
Release of VOCs in paint shop	7.45	7.45
Scope 1 total	96,230.44	105,366.66
Scope 2		
Consumption of purchased electricity	153,691.41	165,660.45
Consumption of purchased natural gas	1,169.57	1,738.49
Consumption of purchased chilled water	5,754.24	4,153.32
Consumption of purchased steam	1,075.92	1,627.71
Scope 2 total	161,691.14	173,179.97
Total	257,921.59	278,546.63

Source: GAO analysis of AOC and GSA data.

- *Emissions from the combustion of fossil fuels in the Capitol Power Plant:* AOC officials provided us with test certifications of the coal's heat content from fiscal years 2003 through 2006. To convert pounds of coal to BTUs for each of these fiscal years, we used an average of that year's test certifications. For fiscal years 1998 through 2002, we took an average of the BTU/pound ratings we used for fiscal years 2003 through 2006. To convert gallons of oil to BTUs, AOC officials reported using the heat content of 140,000 BTUs/gallon provided by DOE. It is also important to note that the Capitol Power Plant's emissions include emissions from the steam that is sold to Union Station, Folger Shakespeare Library, and Postal Square, which are not legislative branch facilities, with the exception of AOC's leased space in Postal Square.
- *Emissions from the consumption of purchased electricity:* Electricity service to the Capitol Power Plant coal yard stopped in 2004 because of construction. When Pepco Energy Services restarted the service, it did so without reinstalling a meter (an internal account coordination oversight at the utility). Upon discovery of the problem, Pepco Energy Services installed a new meter at the beginning of fiscal year 2007 and negotiated an estimated usage/cost with AOC for the months the account was not metered. However, according to AOC officials, the settlement does not accurately reflect usage. Therefore, we assumed that the coal-yard electricity usage remained constant for fiscal years 2003 through 2006.
- *Emissions from business travel in government-owned and -leased vehicles:* Gasoline fuel use data were available for fiscal years 2003 through 2006, and diesel fuel use data were available for fiscal years 2004 through 2006. Therefore, we assumed the vehicle activity data remained constant for the earlier years. In addition, if employees fueled vehicles using a GSA-issued fleet services card, AOC officials said this fuel would not be accounted for in the data they provided to us. AOC also reported a shuttle bus in its inventory, but it is fueled and maintained by a contractor; therefore, its fuel use was not included in the inventory. AOC has seven alternative-fuel vehicles. However, from our discussions with AOC officials, we assumed that these vehicles were fueled with gasoline.
- *Methane and nitrous oxide emissions from business travel in government-owned and -leased vehicles:* According to AOC, the number of vehicles remained relatively constant during fiscal years 1998 through 2006. Vehicle type and model year data were available for fiscal year 2006. Therefore, we assumed that the vehicle type data

remained constant from fiscal years 1998 through 2006. We also assumed that the model year was 1 year earlier than the year we were calculating, unless the model year provided in the fiscal year 2006 data was earlier. In such cases, we kept the earlier year. In addition, AOC provided diesel-fuel use data that were aggregated for vehicles and heavy machinery. Therefore, we used the diesel vehicle fuel emission factor to calculate aggregate emissions from the diesel fuel used by vehicles and heavy machinery.

- *Emissions from propane powered heavy machinery:* AOC provided activity data for 1 month. We used the monthly activity data to calculate annual fuel use and then assumed that fuel use remained constant during fiscal years 1998 through 2006. To convert pounds of propane to BTUs, we used the heat content 20,293 BTUs/pound and to convert pounds of propane to gallons, we used the density 4.53 pounds/gallon as laid out in the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004.
- *Emissions from leaks in refrigeration equipment:* Two of AOC's chillers leaked R-134a in fiscal year 2006 and have since been repaired.
- *Emissions from the combustion of fossil fuels in emergency generators:* AOC's emergency generators run on oil from the Capitol Power Plant. Therefore, emissions from the generators are included in the Capitol Power Plant calculations.
- *Emissions from the consumption of purchased steam:* AOC's data on the Ford House Office Building's steam consumption differed from GSA's data. We used GSA's data because GSA supplies the steam to the Ford House Office Building.
- *Emissions from the consumption of purchased chilled water:* GSA supplies chilled water to the Ford House Office Building from chillers in the nearby building formerly occupied by the Food and Drug Administration. GSA officials estimated the percentage of the chillers' electricity use that was used to produce chilled water for the Ford House Office Building because there is no meter. In addition, since data was not available for years prior to fiscal year 2002, we assumed that the annual consumption remained constant.
- *Emissions from the consumption of purchased electricity and natural gas at leased facilities:* AOC has one capital lease—Senate Warehouse—and four operating leases—P Street Warehouse, Plaza 500, Postal Square, and GPO—within the scope of our study. AOC

provided activity data for its capital lease and its operating lease at P Street Warehouse, but not for its other operating leases because these leased facilities are not billed separately for energy use. However, GPO's activity data includes AOC's leased space in its facility. We estimated the energy use of the other two leased facilities by allocating the facilities' total energy use, provided by GSA, on a per-square-foot basis. We used the gross square footage of the entire facility that was found in the GSA energy usage building summary report. GSA also provided the square footage of AOC's leased spaces.

- *Emissions from the release of VOCs:* AOC provided activity data on its spray paint booths using aggregate estimates based on Washington, D.C., air permit applications. According to AOC officials, data remained constant for each year.
- *Emissions from leaks in fuel tanks:* According to AOC officials, the agency does not track data on leaks from oil or diesel tanks because their vapor pressures are low at ambient temperatures. It also does not track data on leaks from propane tanks.
- *Adjustment for purchased renewable energy certificates (REC):* We determined the power pool where the renewable power was generated using data provided to us by Pepco Energy Services and made assumptions about the amount of renewable energy generated from each location. After calculating the emissions, we then allocated one-eighth of these emissions to fiscal year 2003 and seven-eighths to fiscal year 2004 since AOC purchased renewable energy for 8 months beginning in September 2003. These emissions are subtracted from AOC's Scope 2 emissions to determine net emissions.

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GPO

Table 5: GPO's Greenhouse Gas Emissions by Scope and Source for Base Year and Fiscal Year 2006

Metric tons of carbon dioxide equivalents

Scope and source of emissions	Fiscal years 1998-2001	Fiscal year 2006
Scope 1		
Business travel in government-owned and -leased vehicles	210.11	166.51
Release of VOCs in print shop	28.48	28.48
Combustion of diesel in emergency generator	2.04	2.04
Scope 1 total	240.63	197.03
Scope 2		
Consumption of purchased electricity	28,130.68	20,030.13
Consumption of purchased natural gas	1,618.66	1,449.51
Scope 2 total	29,749.34	21,479.64
Total	29,989.97	21,676.67

Source: GAO analysis of GPO data.

- *Emissions from business travel in government-owned and -leased vehicles:* GPO provided gasoline activity data for fiscal years 2003 through 2006. For fiscal years 1998 through 2002, we used calendar year data. The average diesel vehicle activity data were available for fiscal year 2006, and the data are an extrapolation based on a 2-month survey of credit card receipts. Therefore, we assumed diesel-fuel use remained constant for fiscal years 1998 through 2006.
- *Methane and nitrous oxide emissions from business travel in government-owned and -leased vehicles:* We obtained fiscal year 2005 model year and type data from GPO's Office of Comptroller, Property Management Program, and fiscal year 2006 data from the Customer Services department and the Office of the Inspector General, which operate their own vehicles. Agency officials reported that the number of vehicles remained relatively constant for fiscal years 1998 through 2006. We assumed the vehicle type data remained constant for fiscal years 1998 through 2006 and, therefore, added the 2005 and 2006 data from the three divisions for total vehicle data. We also assumed that the model year was 1 year earlier than the year for which we were calculating emissions, unless the model year provided in the fiscal year 2005/2006 data was earlier. In such cases, we kept the earlier year.

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- *Emissions from the consumption of purchased natural gas:* To convert cubic feet of natural gas to BTUs, we used the heat content 1,011.5691 BTUs/cubic feet.⁵
- *Emissions from leaks in refrigeration equipment:* GPO reported that it used R-134a in a closed system and has not purchased any additional refrigerant. Therefore, we assumed there were no leaks.
- *Emissions from combustion of fossil fuels in emergency generator:* To convert gallons of diesel to BTUs, we used the heat content 138,691 BTUs/gallon.
- *Emissions from the release of VOCs:* Activity data were available for fiscal year 2005 from GPO's print shop. Therefore, we assumed the activity data remained constant for fiscal years 1998 through 2006.
- *Emissions from the consumption of purchased electricity and natural gas at leased facilities:* Emissions generated by AOC's leased space within GPO's facility was not separated from GPO's emissions. GPO also had operating leases for two warehouses in Laurel, Maryland (Laurel 1 and Laurel 2) for fiscal years 1998 through 2004 and retained Laurel 2 through fiscal year 2006. GPO provided electricity and natural gas use data for Laurel 1 and Laurel 2 for fiscal years 2002 through 2006 using the adjusted annual usage figures from Baltimore Gas and Electricity bills for the period from mid-September to mid-October of each year, with three exceptions. The fiscal year 2004 natural gas and electricity use data for Laurel 1 was taken from the BGE bills for the period of March 16 to April 17, 2004, and July 16 to August 17, 2004, respectively, because bills were not available for the later months. In addition, the fiscal year 2006 natural gas use data for Laurel 2 are the sum of usage indicated on a duplicate bill provided by Baltimore Gas and Electricity showing monthly usage from October 2005 to October 2006. Since no data were available for fiscal years 1998 through 2001, we had to make several assumptions. For fiscal years 1998 to 1999 for Laurel 1 electricity use, we assumed the electricity use was 113 percent of the known electricity use in fiscal year 2002 because the square footage occupied by GPO in those 2 years was 113 percent of the square footage in fiscal year 2002. Similarly, we assumed that the electricity use in fiscal years 2000 to 2001 was the same as in fiscal year 2002 because the square footage occupied by GPO was the same. For

⁵See http://www.energyshop.com/es/toolbox/gj_to_m3.cfm.

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natural gas use at Laurel 1 for fiscal years 1998 through 2001, we used the average natural gas use for fiscal years 2002 through 2004 because there was significant variation in the years that data were available. In addition, for fiscal years 1998 through 1999, we assumed that natural gas usage was 113 percent of this average as we did with electricity usage. For Laurel 2 electricity use for fiscal years 1998 through 2001, we assumed the same electricity use as fiscal year 2002 since square footage remained constant; and for natural gas for fiscal years 1998 through 2002, we used the average natural gas use for fiscal years 2003 through 2006 because there was significant variation in the years that data were available. It is important to note that while data were available for fiscal year 2002, GPO officials were unable to explain the low usage figure.

GAO

Table 6: GAO's Greenhouse Gas Emissions by Scope and Source for Base Year and Fiscal Year 2006

Metric tons of carbon dioxide equivalents

Scope and source of emissions	Fiscal years 1998-2001	Fiscal year 2006
Scope 1		
Business travel in government-owned and -leased vehicles	16.16	23.64
Combustion of oil in emergency generators	10.21	10.21
Scope 1 total	26.37	33.85
Scope 2		
Consumption of purchased electricity	10,713.40	11,659.28
Consumption of purchased natural gas	26.50	26.50
Consumption of purchased steam	2,418.82	1,498.25
Scope 2 total	13,158.71	13,184.03
Total	13,185.08	13,217.88

Source: GAO.

- *Emissions from business travel in government-owned and -leased vehicles:* We needed to calculate activity data because GAO does not maintain fuel use data. The formula we used was: activity data [estimated fuel use] = mileage/fuel economy. We used the fuel economy figures provided at www.fueleconomy.gov for those vehicles whose make and model we knew. Otherwise, we used the average fuel economy figures provided by the Federal Highway Administration's

2004 Highway Statistics.⁶ Vehicle mileage data were available for fiscal years 2001 through 2006. Therefore, we assumed the data remained constant for fiscal years 1998 through 2001.

- *Methane and nitrous oxide emissions from business travel in government-owned and -leased vehicles:* If vehicle type data were provided, we used the fuel economy figures from www.fueleconomy.gov. We did not have model year data, so we assumed that the model year was 1 year earlier than the year for which we were calculating emissions.
- *Emissions from the consumption of purchased natural gas:* To convert hundreds of cubic feet of natural gas to BTUs, we used the heat content 101,156.9138 BTUs/hundreds of cubic feet.⁷
- *Emissions from combustion of fossil fuels in emergency generators:* To convert gallons of fuel oil to BTUs, we used the heat content 138,691 BTUs/gallon.
- *Emissions from the consumption of purchased electricity and natural gas at leased facilities:* GAO leases space to the Army Corps of Engineers, which is in the executive branch. We estimated the Army Corps of Engineers energy use by allocating the facilities' energy use on a per-square-foot basis. We then subtracted the Army Corps' energy use from the building's total energy use to calculate GAO's emissions. The Corps began leasing 200,000 square feet of the GAO building in fiscal year 2000 and then added 20,000 square feet in fiscal year 2001.

⁶See <http://www.fhwa.dot.gov/policy/ohim/hs04/hm/vm1.htm>.

⁷See http://www.energyshop.com/es/toolbox/gj_to_m3.cfm.

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Senate Sergeant at Arms

Table 7: Senate Sergeant at Arms' Greenhouse Gas Emissions by Scope and Source for Base Year and Fiscal Year 2006

Metric tons of carbon dioxide equivalents

Scope and source of emissions	Fiscal years 1998-2001	Fiscal year 2006
Scope 1		
Business travel in government-owned and -leased vehicles	168.91	337.06
Release of VOCs in furniture shop	2.87	2.93
Total	171.77	339.99

Source: GAO analysis of Senate Sergeant at Arms data.

- Emissions from business travel in government-owned and -leased vehicles:* The Senate Sergeant at Arms did not maintain activity data for its vehicles. Therefore, to calculate the activity data, it used the formula: activity data [fuel use] = amount expended / average price per gallon. The average price per gallon was obtained from the Energy Information Administration, Motor Gasoline Retail Prices, U.S. City Average table. The Senate Sergeant at Arms provided us with gasoline-fuel use data and was unable to provide diesel-fuel use data. Therefore, we performed our calculations as if all vehicles used gasoline, although the Senate Sergeant at Arms has five diesel vehicles. Consequently, actual emissions are likely to be higher than our calculations. The Senate has 19 alternative-fuel vehicles. However, on the basis of our discussions with a Senate Sergeant at Arms official, we assumed that these vehicles were fueled with gasoline. The Senate Sergeant at Arms provided vehicle activity data for fiscal years 1999 through 2006. Therefore, we assumed that the vehicle activity data were constant for fiscal years 1998 through 1999.
- Methane and nitrous oxide emissions from business travel in government-owned and -leased vehicles:* The Senate Sergeant at Arms provided us with the number of vehicles for each year for fiscal years 1998 through 2006. Since the vehicle type data were available only for fiscal year 2006, we assumed that the vehicle type data remained constant for fiscal years 1998 through 2006. We also assumed that the model year was 1 year earlier than the year for which we were calculating emissions, unless the model year provided in the fiscal year 2006 data was earlier. In such cases, we kept the earlier year.

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- *Emissions from the release of VOCs:* The Senate Sergeant at Arms provided activity data from its furniture and print shops. For the furniture shop, VOC emissions were not available for some chemicals. Therefore, we used the average VOC emissions from the chemicals that were available. For the print shop, activity data were available for fiscal years 2000 through 2006. Therefore, we assumed the activity data remained constant for fiscal years 1998 and 1999. However, in 2000, the print shop transitioned to soy-based ink. We also assumed equal use of each ink type; therefore, we used the average VOC content. In addition, the VOC content of one ink type was provided to us in pounds per gallon. To convert pounds of ink to gallons, we assumed the density is equal to water—8.33 pounds per gallon, according to EPA.

CBO

Table 8: CBO’s Greenhouse Gas Emissions by Scope and Source for Base Year and Fiscal Year 2006

Metric tons of carbon dioxide equivalents

Scope and source of emissions	Fiscal years 1998-2001	Fiscal year 2006
Scope 1		
Business travel in government-owned and -leased vehicles	-	0.43
Total	-	0.43

Source: GAO analysis of CBO data.

- *Emissions from business travel in government-owned and -leased vehicles:* We needed to calculate activity data because CBO does not maintain fuel use data. The formula we used was: activity data [estimated fuel use] = mileage/fuel economy. We used the average fuel economy figures provided by the Federal Highway Administration’s 2004 Highway Statistics.⁸ CBO first obtained a vehicle in the last 2 months of fiscal year 2004. Therefore, the activity data for that year are prorated.

⁸See <http://www.fhwa.dot.gov/policy/ohim/hs04/htm/vm1.htm>.

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LOC

Table 9: LOC’s Greenhouse Gas Emissions by Scope and Source for Base Year and Fiscal Year 2006

Metric tons of carbon dioxide equivalents

Scope and source of emissions	Fiscal years 1998-2001	Fiscal year 2006
Scope 1		
Business travel in government-owned and -leased vehicles	89.61	107.15
Scope 1 total	89.61	107.15
Scope 2		
Consumption of purchased electricity	1,664.85	1,638.68
Consumption of purchased natural gas	564.70	464.05
Scope 2 total	2,229.55	2,102.73
Total	2,319.16	2,209.88

Source: GAO analysis of LOC and GSA data.

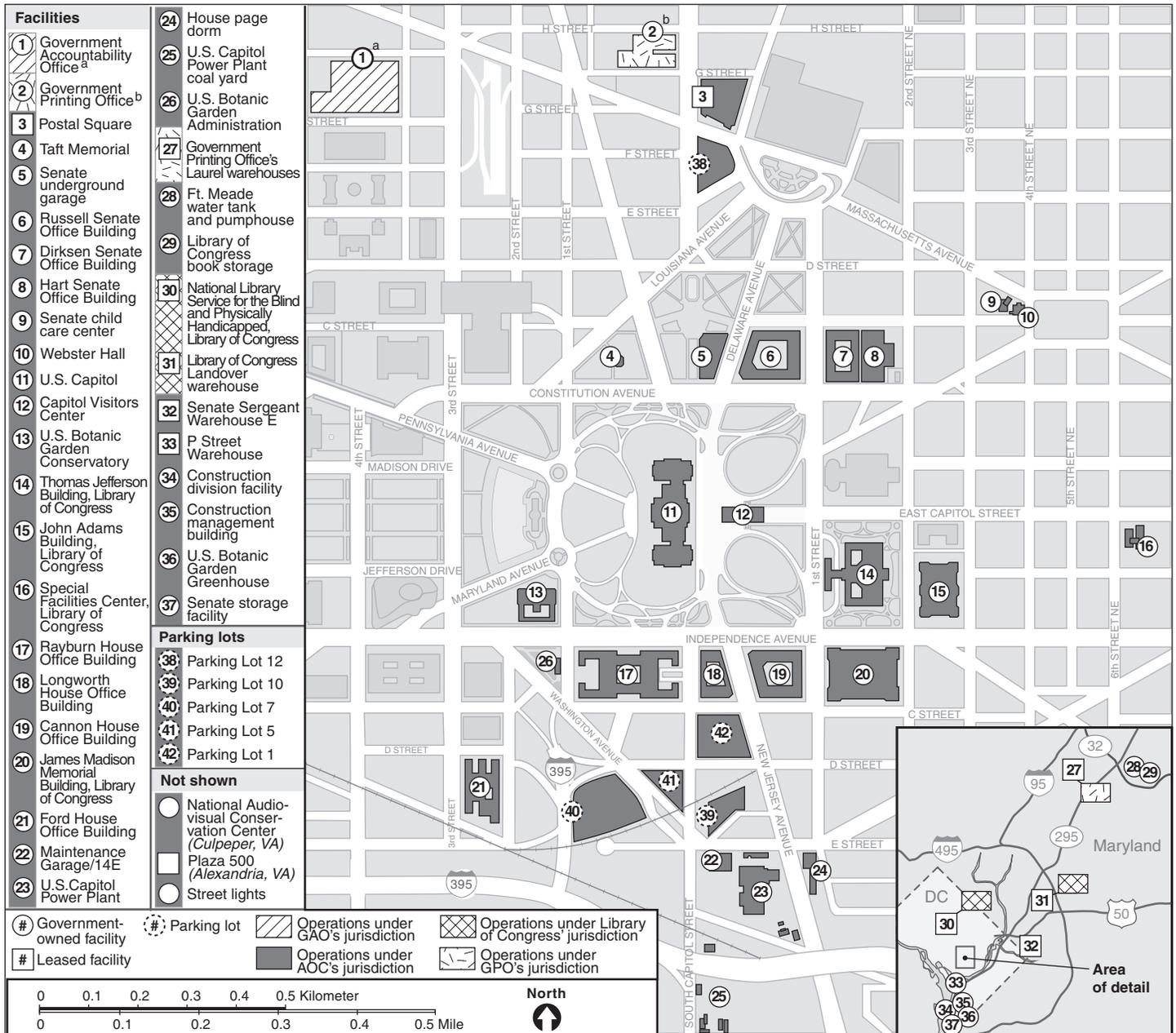
- *Emissions from business travel in government-owned and -leased vehicles:* The vehicle activity data were available for fiscal years 2004 through 2006. Therefore, we assumed fuel use remained constant for fiscal years 1998 through 2004.
- *Methane and nitrous oxide emissions from business travel in government-owned and -leased vehicles:* We obtained 2006 model year and type data. We assumed the vehicle type data remained constant from fiscal years 1998 through 2006. We also assumed that the model year was 1 year earlier than the year for which we were calculating emissions, unless the model year provided in the fiscal year 2006 data was earlier. In such cases, we kept the earlier year. To convert cubic feet of compressed natural gas to gallons of gasoline equivalent, we used the conversion factor 121.5 cubic feet/gallon of gasoline equivalent found at www.fueleconomy.gov.
- *Emissions from the consumption of purchased electricity and natural gas at leased facilities:* LOC has operating leases for two facilities—Landover warehouse and National Library for the Blind and

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Physically Handicapped. GSA provided us with activity data for both leases. To convert cubic feet of natural gas to BTUs, we used the heat content 1,011.5691 BTUs/cubic feet.⁹

⁹See http://www.energyshop.com/es/toolbox/gj_to_m3.cfm.

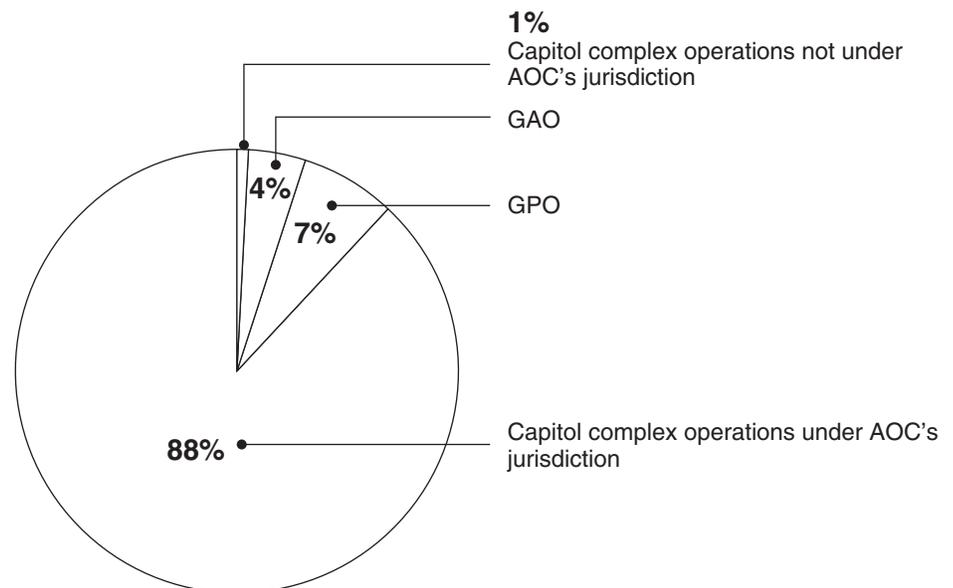
Appendix III: Map of Legislative Branch Facilities



Appendix IV: Emissions Trends, by Agency

Capitol complex operations under the Architect of the Capitol's (AOC) jurisdiction accounted for 88 percent of legislative branch greenhouse gas emissions in fiscal year 2006 (see fig. 3). The Government Printing Office (GPO) and GAO accounted for 7 percent and 4 percent of emissions, respectively. Capitol complex operations not under AOC's jurisdiction, such as Senate Sergeant at Arms' vehicles and release of volatile organic compounds and the Library of Congress' two leased facilities, made up the remaining 1 percent of emissions.

Figure 3: Greenhouse Gas Emissions by Agency, Fiscal Year 2006

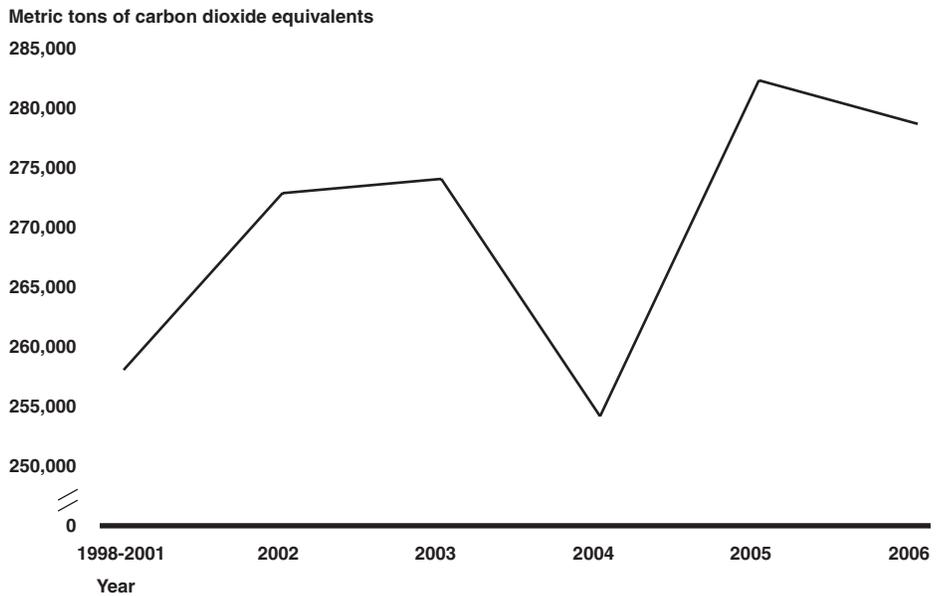


Source: GAO analysis of data from AOC, GPO, GAO, LOC, CBO, the Senate Sergeant at Arms, the House of Representatives Chief Administrative Officer, and the General Services Administration.

AOC

Overall, emissions from Capitol complex operations under AOC’s jurisdiction increased by 8 percent from the base year to fiscal year 2006. There were two decreases in emissions during this time period—a 7 percent decrease from fiscal year 2003 to fiscal year 2004 and a 1 percent decrease from fiscal year 2005 to fiscal year 2006 (see fig. 4).

Figure 4: Capitol Complex Greenhouse Gas Emissions from Operations under AOC’s Jurisdiction, Fiscal Years 1998-2001 to 2006



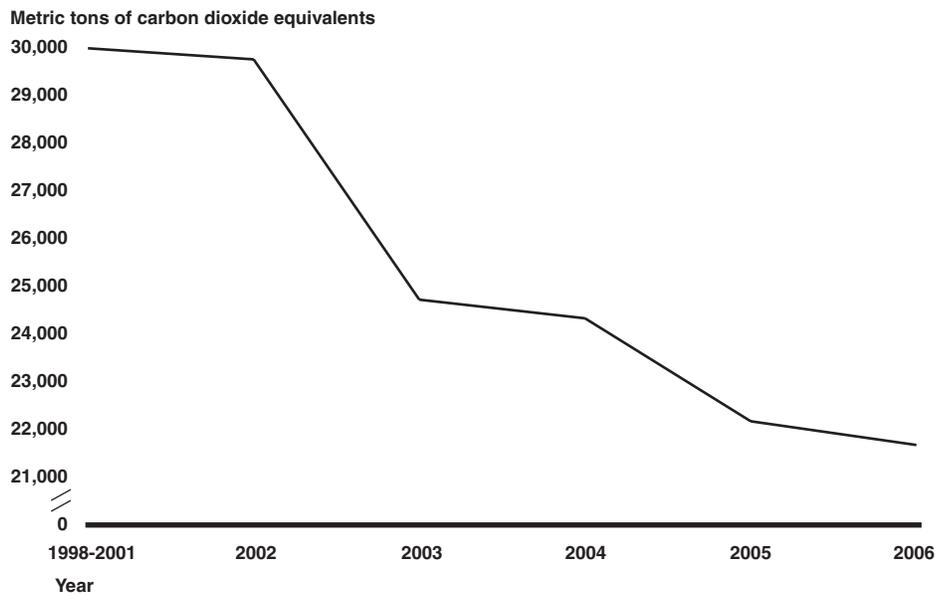
Source: GAO analysis of AOC and GSA data.

Note: AOC officials attribute the fiscal year 2004 decrease in emissions primarily to the purchase of renewable energy and the fiscal year 2006 decrease in emissions primarily to burning less coal, due to a malfunction in the coal-fired boilers, and lower fuel consumption.

GPO

The emissions generated by GPO decreased by 18 percent from the base year (the average of fiscal years 1998 through 2001) through fiscal year 2003 and then continued to decrease through fiscal year 2006, for an overall decrease of 28 percent (see fig. 5).¹

Figure 5: GPO's Greenhouse Gas Emissions, Fiscal Years 1998-2001 to 2006



Source: GAO analysis of GPO data.

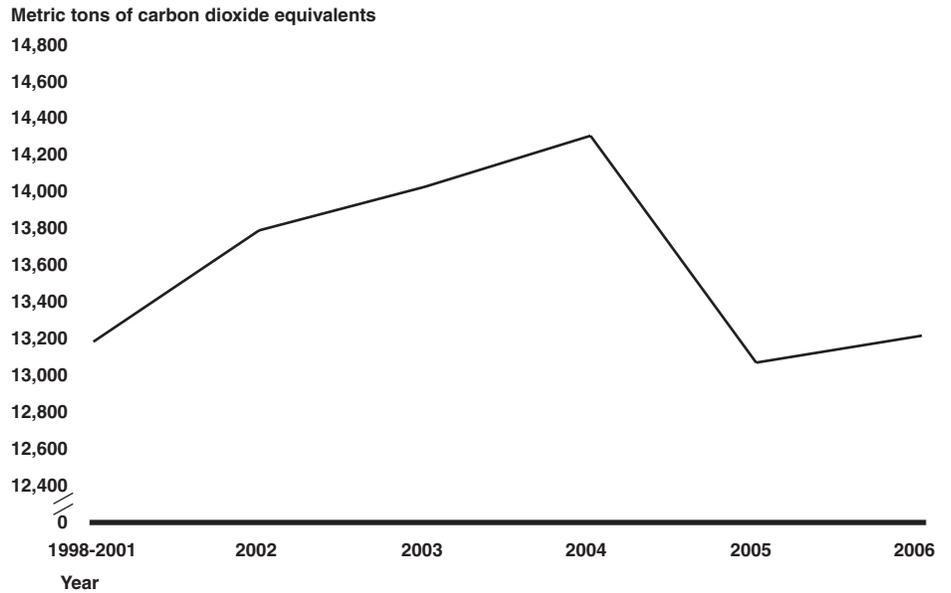
Note: GPO officials attribute the decrease in emissions primarily to a reduction in staff levels.

¹Includes emissions from AOC's leased space within the GPO building.

GAO

The emissions generated by GAO increased 9 percent through 2004 and then decreased 8 percent through fiscal year 2006, for an overall increase of 0.2 percent (see fig. 6).

Figure 6: GAO's Greenhouse Gas Emissions, Fiscal Years 1998-2001 to 2006



Source: GAO analysis of GSA and GAO data.

Note: GAO officials attribute the decrease in emissions from fiscal years 2004 through 2006 to energy efficiency measures identified through targeted energy audits, primarily the installation of optimization controls for air handlers and specialized software to decrease electricity use during periods of peak demand.

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the contact named above, key contributors to this report were Sara Vermillion (Assistant Director), Elizabeth R. Eisenstadt, Michael Hix, Bert Japikse, Heather Krause, Sara Ann Moessbauer, Joshua Ormond, Frank Rusco, and Stephanie Sand.

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