

APPENDIX L

WEBSITE MATERIALS CITED



John Schroer, Commissioner

State Route 162 (Pellissippi Parkway Extension)

TDOT Continues to work on Revaluation Document

Project Description

TDOT, in cooperation with the Federal Highway Administration (FHWA), is proposing to extend and construct Pellissippi Parkway (SR 162) from its current terminus at SR 33 (Old Knoxville Highway) to SR 73 (US 321 or Lamar Alexander Highway) in Blount County. The length of the proposed extension would be approximately 4.4 miles. TDOT and FHWA are preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) to identify and evaluate the environmental effects of the proposed project and to identify measures to minimize harm.

The proposed action is intended to address the following transportation needs in the study area:

- Limited mobility options in Blount County and Maryville due to the primarily radial roadway network that now exists.
- Poor local road network with substandard cross sections.
- Lack of a northwest/east connection east of Alcoa and Maryville to help serve:
 - Expanding residential development occurring in eastern Alcoa and Maryville and northern Blount County; and
 - Increasing demand for trips between Maryville and Alcoa and the Knoxville area to the north.
- Safety issues on roadways in the area, including roads in the Maryville core that through travelers between north and western portions of the county and the eastern portions of the county must pass. Numerous rear-end crashes and angle crashes have been reported due to high volumes of traffic and lack of access management along the roadways.
- Traffic congestion and poor levels of service on the major arterial roads in the study area (US 129, SR 33, US 411 and US 321).

The core transportation objectives of the proposed action are:

- Enhance regional transportation system linkages.
- Improve circumferential mobility by providing travel options to the existing radial roadway network in Blount County, Maryville, and Alcoa.
- Improve roadway safety on the existing roadway network, including the Maryville core.
- Achieve acceptable traffic flows (level of service) on the transportation network or not adversely affect traffic flows on the existing network.

Additional objectives of the proposed action include:

- Support community and growth management goals.

- Minimize adverse impacts to neighborhoods and businesses, farmlands, and the natural and cultural environment.

The Pellissippi Parkway Extension was one of six Bicentennial Parkways included in Tennessee's 1986 Urgent Highway Needs Plan. The plan described this project as a 19.5-mile extension of Pellissippi Parkway from I-40 in western Knox County to US 321 in eastern Blount County. Pellissippi Parkway between I-40/75 and SR 33 was designed and built in four sections between 1987 and 2005. The extension of Pellissippi Parkway from SR 33 to US 321 was included in the Knoxville Urban Area Transportation Planning Organization's (TPO) 1995 Update of the Long Range Transportation Plan (LRTP), and has been included in subsequent updates of the LRTP. The 1998 Federal Transportation Equity Act for the 21 Century or TEA-21 included the extension of Pellissippi Parkway between SR 33 and US 321 in the High Priority Projects Program.

The DEIS evaluated the following alternatives: **No-Build; Build Alternatives A and C** - extend Pellissippi Parkway as a new four-lane divided roadway with interchanges at SR-33, SR-35/US411, and SR-73/US 321; and **Build Alternative D** - upgrade existing two-lane network to connect SR-33 with SR-73/US 321. Alternative A was selected as the Preferred Alternative by TDOT in May 2012. TDOT modified the alignment to avoid potential archaeological resources in July 2013.

- [Draft Environmental Impact Statement \(pdf\)](#)

Alternatives previously considered but dismissed were public transit, transportation system management (TSM) activities, improve currently deficient local roads, and a new four-lane divided roadway corridor closer to the Little River.

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For Local Government

SR 162 Project Home

Project News

Project Timeline

Public Involvement

Public Library

Project Contacts

Newsroom

Sitemap

Contact Us

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John Schroer, Commissioner

State Route 162 (Pellissippi Parkway Extension)

From SR 33 to SR 73 (US 321) in Blount County.

Project News

[Decision Made for Pellissippi Parkway Extension \(SR 162\) Project](#) West alignment shift at southern end of Preferred Alternative selected

Western Shift Chosen for Preferred Alternative

On Monday, July 29, 2013, TDOT announced that the west alignment shift at the southern end of the Preferred Alternative has been selected for the Pellissippi Parkway Extension (State Route 162) project in Blount County.

TDOT held an Informal Briefing on Thursday, May 30, 2013 in the project area. The purpose of the briefing was to inform potentially affected residents and businesses of minor shifts (east and west) in the alignment of the Preferred Alternative near the southern terminus of the proposed project (as identified in the Draft Environmental Impact Statement). A shift is necessary to avoid an identified environmentally sensitive (archaeological) area.

Click [here](#) to view the media release.

Prior to modification of the Preferred Alternative, TDOT held a Community Briefing on May 30, 2013 to offer those potentially impacted by the modification, a minor shift to either the east or west, an opportunity to see and comment on the shifts under TDOT consideration. [Click here](#) to view the briefing flyer (pdf) [and materials made available at the briefing.](#)

Modification of the Preferred Alternative

Following the selection of the Preferred Alternative in 2012, the Phase II archaeological investigations revealed one site that has been determined to be eligible for the National Register of Historic Places. Since the Preferred Alternative had already been analyzed and selected over the other Build Alternatives, TDOT focused on identifying potential avoidance options via minor alignment shifts in the vicinity of the sensitive portion of the eligible archaeology site, rather than major shifts of the alignment. TDOT identified and investigated two possible minor shifts in the route of the Preferred Alternative, between Davis Ford Road and US 321/SR 73 (the southern terminus of the project).

The two minor alignment shifts are identified below and illustrated in the figure below

- The **east alignment shift** would move the ROW about 300 feet eastward, away from the Kensington Place mobile home community and toward the developing Sweetgrass Plantation subdivision.
- The **west alignment shift** would move the ROW about 150 feet to the west into the mobile home community.

The typical section of each alignment shift would be the same as defined for the Preferred Alternative: a four-lane divided roadway with a 48-foot depressed median. The avoidance shifts would each be about 1.4 miles in length.

TDOT investigated potential archaeology, noise, ecology, farmland, relocations and environmental justice impacts for each shift.

The two potential alignment shifts and the impacts of these shifts were presented to the public at a Community Briefing held on May 30, 2013 in the project area. The meeting was attended by 136 persons, and approximately 150 comments were received by the close of the comment period (June 15, 2013).

In making the determination of the alignment shift, TDOT considered the amount and type of impacts of each shift and the potential to mitigate adverse effects. TDOT also gave consideration to public input received during the May 30th Community Briefing and the associated comment period.

TDOT has determined that the alignment of the Preferred Alternative would be best modified by the west shift for the following reasons:

- The overall length of the west shift is shorter and the amount of right-of-way required is less.
- The west shift minimizes impacts to the operations of two active farms.
- The west shift is farther away from a local church, thus minimizing potential access and noise impacts
- The difference in estimated cost between the east and west shifts is negligible (east shift: \$40.94 million, west shift: \$40.95 million).
- Currently predicted noise levels make the Kensington Place mobile home community eligible for a noise barrier that would minimize both noise and visual impacts.
- Though the west shift increases impacts to streams, wetlands and floodplains, these will be minimized during the design and permitting process of the project.
- Displaced residents in the Kensington Place mobile home community will be offered relocation assistance by TDOT. And, any residents who want to stay within their community would likely be able to relocate to one of the numerous site pads available.
- While there would be adverse impacts within Kensington Place with the west shift, TDOT and FHWA have determined through an environmental justice analysis that these impacts would not change the finding of the approved DEIS that the project would have no disproportionately high and adverse impacts to minority and low-income populations compared with the rest of the corridor pursuant to Title VI of the 1964 Civil Rights Act and Executive Order 12898.

The conceptual plans for the Preferred Alternative with the west alignment shift are available for the public view. Click [here](#) to view a PDF of the 11-sheet set of conceptual plans.

Hard copies of the plan sets are available for viewing at the following locations:

Blount County Public Library
508 N Cusick Street
Maryville, TN 37804

Blount County Chamber of Commerce
201 S Washington Street
Maryville, TN 37804

Knoxville Regional Transportation Planning Organization
400 Main Street Suite 403
Knoxville, TN 37902

TDOT Region 1
7345 Region Lane
Knoxville, TN 37914

Please keep in mind that alternative alignments are conceptual during the NEPA evaluation phase of a project, and these conceptual plans are subject to change. A preferred alternative concept in the NEPA phase is not yet a final design. After the Final Environmental Impact Statement (FEIS) is approved and the Record of Decision (ROD) is issued, TDOT's Design Division will prepare detailed engineering plans for the project. When field surveys are conducted during final design, TDOT will be able to determine right-way limits, edges of pavement, location of shoulders and, for those areas in which it is proposed, curb and gutters, and sidewalk widths. Until the final design plans are prepared, it is not possible to know specifically how a particular property and property owner will be impacted by the project.

Click [here](#) to obtain news regarding project activities.

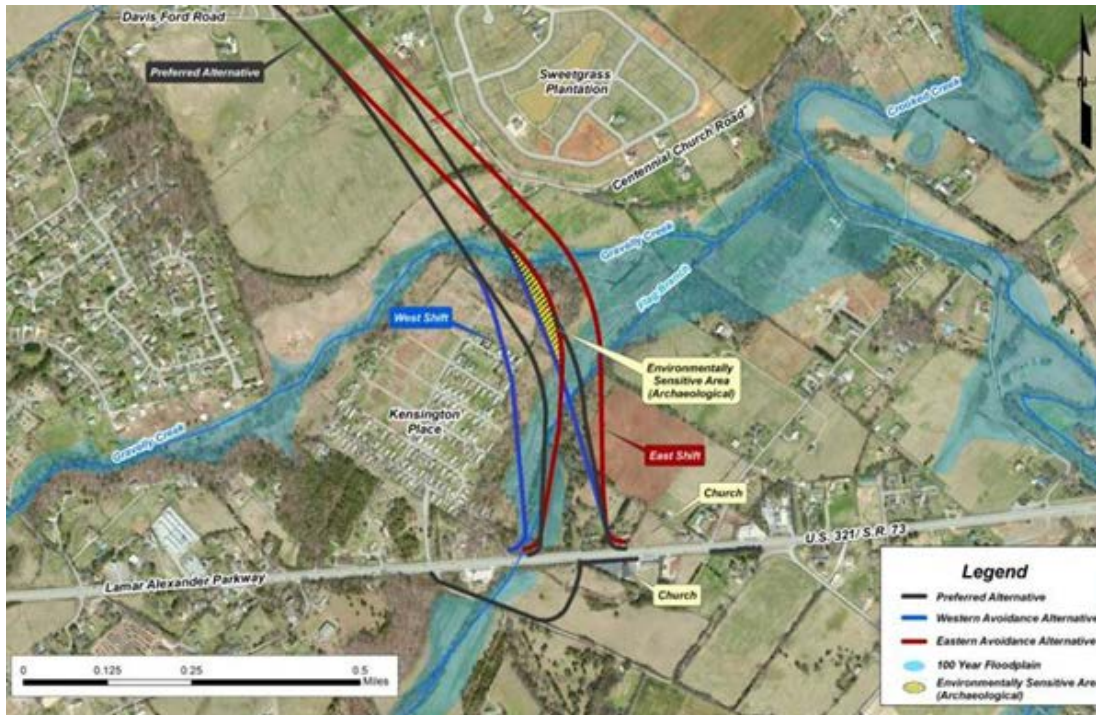
The schedule to complete the FEIS and the Record of Decision (ROD) has been adjusted to take into account additional steps that have been identified in 2013.

- Evaluation of alignment options to avoid an identified environmentally sensitive (archaeological) site
- An update of the project's traffic forecasts and operational analysis based on the June 2013 update to the Knoxville regional traffic model

- Preparation of a reevaluation of the DEIS since more than 3 years have passed since the DEIS was circulated

The expected schedule to complete the FEIS and ROD as shown below is dependent upon expeditious agency reviews.

- Complete new Traffic and Noise Analyses – Complete
- FHWA issues Final EIS – Winter 2015
- FHWA issues Record of Decision – Spring 2015



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[SR 162 Project Home](#)

[Project News](#)

[Project Timeline](#)

[Public Involvement](#)

[Public Library](#)

[Project Contacts](#)

[Newsroom](#)

[Sitemap](#)



John Schroer, Commissioner

State Route 162 (Pellissippi Parkway Extension)

From SR 33 to SR 73 (US 321) in Blount County.

Project Timeline

Activities Completed:

- Initiation of EIS and Scoping – April through July 2006
- Public Alternatives Workshop – October 2007
- Public Information Workshop – February 2008
- Development of Refined Alternatives – April through June 2008
- Identification of Alternatives to be Evaluated in the DEIS – August 2008
- Environmental Technical Studies, including field studies – September 2008 through August 2009
- Draft Environmental Impact Statement (DEIS) preparation – Spring and Summer 2009
- DEIS approved by FHWA – April 14, 2010
- Notice of Availability of DEIS in Federal Register – May 7, 2010
- Comment Period for DEIS - May through August 10, 2010
- Public Hearing – July 20, 2010
- Review and Address Public and Agency Comments – Fall 2010 / Summer 2011
- Selection of Preferred Alternative – Winter 2011-2012
- Agency Concurrence with Preferred Alternative and Preliminary Mitigation – May 2012
- Community Briefing on Alignment Modification Options to avoid environmentally sensitive (archaeological) site – May 2013
- Selection of West Alignment Shift to modify Preferred Alternative – July 2013

Upcoming Activities (Updated May 23, 2014)

- Reevaluation of DEIS – Summer 2014
- FHWA issues Final EIS – Winter 2015*
- FHWA issues Record of Decision – Spring 2015*

* *Schedule is dependent upon expeditious agency reviews.*

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[SR 162 Project Home](#)

[Project News](#)

[Project Timeline](#)

[Public Involvement](#)

[Public Library](#)

[Project Contacts](#)

[Newsroom](#)

[Sitemap](#)

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[Services Index](#)

[Transportation Map](#)

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State Route 162 (Pellissippi Parkway Extension)

From SR 33 to SR 73 (US 321) in Blount County.

Public Involvement

This Web site, <http://www.tdot.state.tn.us/pellissippi/>, will be one of the principal means of public involvement and feedback.

Public comments concerning this project can also be submitted to: TDOT.Comments@tn.gov

On Monday, July 29, 2013, TDOT announced that the west alignment shift at the southern end of the Preferred Alternative has been selected for the Pellissippi Parkway Extension (State Route 162) project in Blount County.

After careful consideration, the west alignment was selected for a variety of reasons. The overall length of the west shift is shorter than the east shift, with less right-of-way acquisition required. The west shift also minimizes impacts to the operations of two active farms, and is farther away from a local church, thus minimizing potential access and noise impacts. Displaced residents in the Kensington Place mobile home community will be offered relocation assistance by TDOT. Any displaced residents who want to stay within their community would likely be able to relocate to one of the available site pads. The mobile home community also would be potentially eligible for a noise barrier that would minimize both noise and visual impacts.

The Preferred Alternative will include this shift when presented in the FEIS that will be submitted to the Federal Highway Administration (FHWA) later this summer. A record of decision from the FHWA is expected by the end of 2013.

No meetings are currently scheduled

Project Newsletters

- [Newsletter Issue 2 June 2012](#) (pdf)
- [Newsletter Issue 1 Sept 2008](#) (pdf)

Recent Meetings

TDOT held an informal an Informal Briefing on Thursday, May 30, 2013. It was held at the Rio Revolution Church in Maryville from 5:00 to 7:00 PM (Briefing Announcement). There were 136 attendees. TDOT shared information regarding potential shifts in the previously selected Preferred Alternative (Alternative A, among others evaluated in the DEIS) near the southern portion. A shift is necessary to avoid an identified environmentally sensitive area.

Comments on the potential shifts should be postmarked by June 15, 2013 (Note: this is a change from the original date of June 10, 2013).

[Click here](#) for the announcement flyer on the Community Briefing. (English and Spanish). (pdf)

[Click here](#) for the Briefing Notice Postcard

This page contains only public involvement information and materials. For other project materials go to the [Project Library](#) page.

- [Click here to view](#) the handout from the Community Briefing (in English) (Powerpoint)
- [Click here to view](#) the handout from the Community Briefing (en Espanol) (Powerpoint)
- [Click here to view](#) the presentation from the Community Briefing (in English) (PDF)
- [Click here to view](#) the presentation from the Community Briefing (en Espanol) (PDF)
- [Click here to view](#) the comment form made at available at the Community Briefing (PDF)
- [Click here to view](#) the Frequently Asked Questions (FAQs) made available at the Community Briefing (PDF)
- [Click here to view](#) the map display from the Community Briefing (PDF)

Past Meetings

DEIS Public Hearing

July 20, 2010

Heritage High School

Maryville, TN

[View](#) the presentation from the July 20, 2010 Public Hearing. (PDF)

[View](#) the July 20, 2010 Public Hearing handout. (PDF)

[Click here](#) for a copy of the Public Hearing Transcript.

[Click here](#) (*Large PDF File, 46 MB*) for a copy of the combined public comments received on the DEIS from the public hearing and comment period, which ended August 30, 2010.

Copies of the Draft Environmental Impact Statement (DEIS) are available for public inspection at the following locations:

Blount County Public
Library
508 N. Cusick Street
Maryville, TN 37804

Blount County Chamber of
Commerce
201 S. Washington Street
Maryville, TN 37804

Mike Russell
TDOT Region 1
7345 Region Lane
Knoxville, TN 37914

Public Information Meeting

February 19, 2008

Heritage High School

Maryville, TN

[View](#) the presentation from the February 19, 2008 Public Meeting. (PDF)

[View](#) the preliminary alternative corridors map presented at February 19, 2008 Public Meeting. (PDF)

[View](#) the February 19, 2008 Public Meeting handout. (PDF)

A compilation of the comment forms, letters and emails received by TDOT and the court reporter transcripts from the October 25, 2007 Public Alternatives Workshop and comment period through November 15, 2007 is available for public inspection at the locations listed below. Copies of the public comments regarding the project that were received between July 6 and December 31, 2006 are also available at these locations:

Blount County Chamber of Commerce
201 South Washington Street
Maryville, TN 37804

Blount County Public Library
508 North Cusick Street
Maryville, TN 37804

Public Alternatives Workshop

October 25, 2007

Maryville, TN

[Click here](#) to view the formal presentation from the October 25, 2007 Public Alternatives Workshop.

[Click here](#) to view the preliminary alternative corridors map presented at October 25, 2007 Public Alternatives Workshop.

[Click here](#) to view the October 25, 2007 Public Alternatives Workshop handout.

Coordination Plan for Agency and Public Involvement

Environmental Streamlining and Stewardship requires transportation agencies to work together with natural, cultural, and historic resource agencies to establish realistic timeframes for the environmental review of transportation projects. These agencies then need to work cooperatively to adhere to those timeframes, while they are protecting and enhancing the environment. The efficient and effective coordination of multiple environmental reviews, analyses, and permitting actions is essential to meeting the Environmental Streamlining and Stewardship mandates for highway and transit projects under SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)).

SAFETEA-LU includes several provisions intended to enhance the consideration of environmental issues and impacts within the transportation planning process and encourage the use of the products from planning in the NEPA process. Developing an effective public involvement program requires a variety of techniques that can meet the needs of a given transportation plan, program, or project. Current Federal statutes and regulations derived largely from the Intermodal Surface Transportation Efficiency Act (ISTEA) and the National Environmental Policy Act (NEPA) provide general guidelines for locally developed public involvement processes and procedures.

A Coordination Plan for Agency and Public Involvement for the Pellissippi Parkway Extension is listed below:

[Coordination Plan for Agency and Public Involvement](#) (PDF)

Notice of Intent

A Notice of Intent to Prepare an Environmental Impact Statement (EIS) was published in the Federal Register on April 25, 2006.

[View Notice of Intent published in Federal Register, April 25, 2006](#) (PDF)

Public Scoping Meetings

Two public scoping meetings were held on June 13, 2006, in Blount County. The purpose of the meetings was to receive input from the public for defining the purpose and need for the project; determining the range of alternatives to be considered in the EIS; and identifying the environmental, social and economic issues and concerns to be addressed in the EIS.

The two meetings shared the same format and information. TDOT representatives were on hand to answer questions concerning the project. The meetings were held at Eagleton Elementary School and Heritage High School. The official transcripts of the meetings are below.

[Pellissippi Scoping Comments for April 25, 2006 through July 5, 2006](#) (PDF)

Please note: These comments do not represent the entirety of public comments received on this project. Comment Forms submitted between June 13, 2006 and July 5, 2006 are retained as public record at the Tennessee Department of Transportation Community Relations Office, Suite 700, James K. Polk Building, 505 Deaderick Street, Nashville, Tennessee. Hard copies of these documents are also available for viewing at the Blount County Library and the Blount County Chamber of Commerce.

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For the Public

For Contractors
and Consultants

For Local Government

SR 162 Project Home

Project News

Project Timeline



John Schroer, Commissioner

State Route 162 (Pellissippi Parkway Extension)

From SR 33 to SR 73 (US 321) in Blount County.

Project Library

DEIS Studies

Documents are in PDF format

- [2011 Addendum to the Traffic Operations Technical Report](#)
- [Traffic Forecast Report 2007](#)
- [Traffic Operations Report 2008](#)
- [Crash Analysis Report Update 2009](#)
- [Community Impacts Assessment 2009](#)
- [Economic Impacts Analysis 2009](#)
- [Air Quality Report 2010](#)
- [Noise Report 2009](#)
- [Historic Report 2009](#)
- [Ecology Report 2010](#)
- [Phase 1 Haz Mat Assessment 2008](#)
- [Indirect Cumulative Analysis 2009](#)

Post-DEIS Studies

- [2011 Addendum to the Traffic Operations Technical Report](#)
- [2013 PPE Biological Assessment](#)

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For the Public

For Contractors
and Consultants

For Local Government

SR 162 Project Home

Project News

Project Timeline



John Schroer, Commissioner

State Route 162 (Pellissippi Parkway Extension)

From SR 33 to SR 73 (US 321) in Blount County.

Project Contacts

For more information on this project, you may contact the following:

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7345 Region Lane
Knoxville, TN 37914

or

P.O. Box 58
Knoxville, TN 37901
Phone: 865.594.2400

Environmental Manager

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TDOT Environmental Division
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For the Public

For Contractors
and Consultants

For Local Government

SR 162 Project Home

Project News

Project Timeline

[Public Involvement](#)

[Public Library](#)

[Project Contacts](#)

[Newsroom](#)

[Sitemap](#)

[Contact Us](#)

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[Grant Information](#)

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Agency Services

[Services Index](#)

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New Census Figures Confirm Regional Connections

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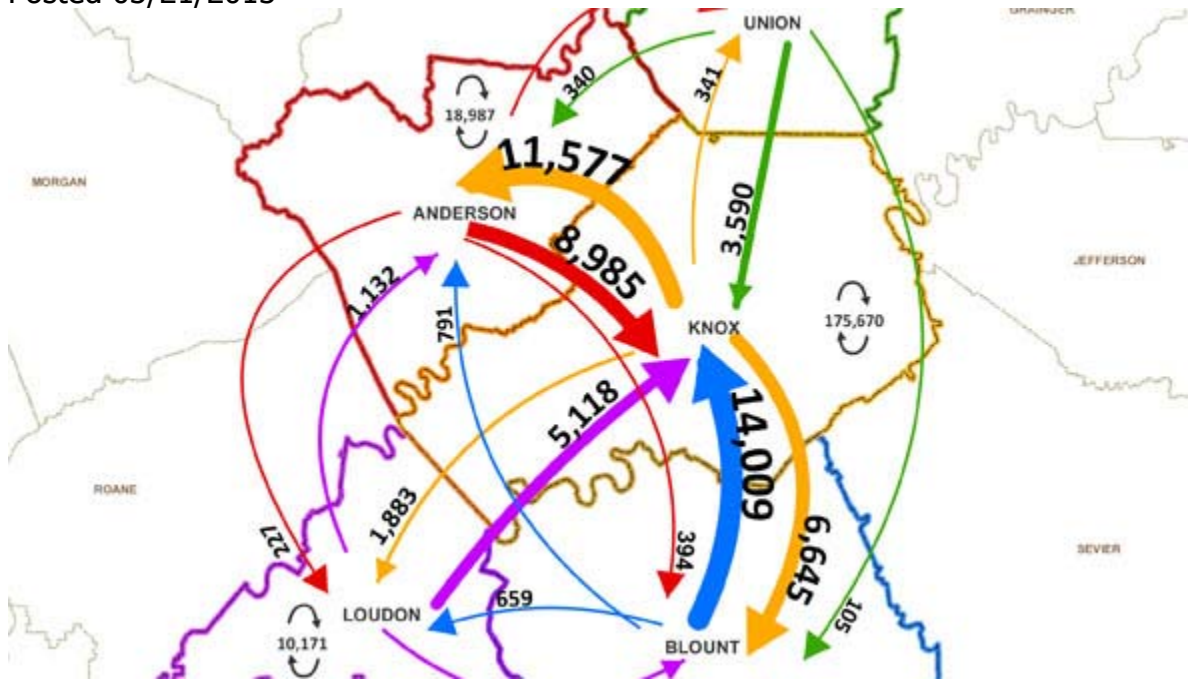
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Posted 03/21/2013



A recent data release from the U.S. Census Bureau showed that 1 in 6 area workers, or almost 60,000 people, commute to another PlanET county for work. What are the implications for this level of mobility on our region?

A recent data release from the U.S. Census Bureau has confirmed what residents of Anderson, Blount, Knox, Loudon, and Union Counties already know: the people who live and work in our region share daily connections. With one in six local workers driving to a neighboring county in the region to go to work each day, it's clear that our economic, environmental, and cultural ties don't stop at county lines.

Almost 60,000 of the PlanET region's 350,000 workers commute to another county within the region every day. In Anderson County alone, nearly 10,000 residents—one-third of its workers—go to a different county elsewhere in the five-county region for work. Similar rates of daily commuting are reported for Blount and Loudon counties. And more than half of Union County's residents travel to a neighboring county to work. ([See map.](#))

According to the American Community Survey—a product of the U.S. Census Bureau—the flow of commuters traveling to work from their home counties to some other county in the PlanET region is on the rise, continuing a decade-long trend.

A look at commuting figures leads to questions about how our region works, and how some changes might be desired for its future. For example, can more jobs be brought to Union County so 55 percent of its workers don't have to drive to another county for work? Do Union County residents face transportation cost burdens that affect their quality of life? With more than 20,000 people traveling between Knox and Anderson counties each workday, should we take a look at regional transit? Can we do a better job providing housing opportunities in areas closer to employment centers? What are the impacts on our region's air quality in light of the growing need to drive farther for work?

Our region's population is expected to reach over 1,000,000 in the next 30 years. The trend in commuter flows reaffirms a need to think regionally, not just about our transportation system, but also about the economy, environment, and overall health and well-being of our communities.

Because we are living regionally, we need to plan regionally. The decisions that residents, developers, and elected officials make now will have a huge impact on the future of our communities. We need to ask the right questions and develop a vision for that future now because how we grow matters!

Related Articles

[Why Do We Live Where We Live?](#)

LABOR FORCE ESTIMATES SUMMARY - TENNESSEE

March 27, 2013

Annual Average 2012 - BM12

	Labor Force	Employment	Unemployment	Unemp. Rate (%)
UNITED STATES	154,975,000	142,469,000	12,506,000	8.1 %
TENNESSEE	3,113,600	2,864,200	249,400	8.0
Metropolitan Statistical Areas (MSAs)				
Chattanooga, TN-GA MSA	261,570	242,060	19,510	7.5 %
Hamilton County	166,530	154,090	12,450	7.5
Marion County	12,550	11,430	1,120	8.9
Sequatchie County	6,310	5,820	490	7.8
Georgia Portion	76,180	70,730	5,450	7.2
Clarksville, TN-KY MSA	117,050	107,070	9,970	8.5
Montgomery County	77,910	71,810	6,100	7.8
Stewart County	5,940	5,340	600	10.1
Kentucky Portion	33,200	29,930	3,270	9.9
Cleveland, TN MSA	57,790	53,330	4,460	7.7
Bradley County	50,080	46,370	3,720	7.4
Polk County	7,710	6,960	740	9.6
Jackson, TN MSA	58,110	53,320	4,790	8.2
Chester County	8,380	7,670	710	8.5
Madison County	49,730	45,650	4,080	8.2
Johnson City, TN MSA	100,300	92,970	7,330	7.3
Carter County	28,010	25,760	2,250	8.0
Unicoi County	8,570	7,780	790	9.2
Washington County	63,720	59,430	4,300	6.7
Kingsport-Bristol, TN-VA MSA	146,990	136,250	10,740	7.3
Hawkins County	26,040	23,980	2,070	7.9
Sullivan County	75,060	69,840	5,220	7.0
Virginia Portion	45,880	42,430	3,450	7.5
Knoxville, TN MSA	366,380	342,210	24,170	6.6
Anderson County	36,370	33,520	2,850	7.8
Blount County	63,860	59,500	4,360	6.8
Knox County	232,490	217,910	14,570	6.3
Loudon County	24,780	23,110	1,670	6.7
Union County	8,890	8,170	720	8.1
Memphis, TN-MS-AR MSA	615,740	560,500	55,240	9.0
Fayette County	17,650	15,900	1,740	9.9
Shelby County	435,210	395,790	39,420	9.1
Tipton County	28,420	25,900	2,520	8.9
Arkansas Portion	20,870	18,540	2,330	11.2
Mississippi Portion	113,590	104,360	9,230	8.1
Morristown, TN MSA	62,930	56,880	6,050	9.6
Grainger County	9,810	8,790	1,020	10.4
Hamblen County	29,190	26,570	2,630	9.0
Jefferson County	23,930	21,520	2,410	10.1
Nashville-Murfreesboro, TN MSA	850,820	794,690	56,130	6.6
Cannon County	6,610	6,120	480	7.3
Cheatham County	20,730	19,230	1,500	7.2
Davidson County	335,020	312,760	22,260	6.6
Dickson County	25,130	23,090	2,040	8.1
Hickman County	10,530	9,570	970	9.2
Macon County	10,990	10,100	890	8.1
Robertson County	35,170	32,690	2,480	7.1
Rutherford County	145,970	136,530	9,440	6.5
Smith County	9,270	8,580	700	7.5
Sumner County	85,350	79,660	5,700	6.7
Trousdale County	3,730	3,430	300	8.1
Williamson County	99,320	94,000	5,320	5.4
Wilson County	63,000	58,950	4,050	6.4

LABOR FORCE ESTIMATES SUMMARY - TENNESSEE

Annual Average 2012 - BM12

	Labor Force	Employment	Unemployment	Unemp. Rate (%)
Micropolitan Statistical Areas				
Athens (McMinn Co.)	24,410	22,180	2,240	9.2 %
Brownsville (Haywood Co.)	8,770	7,790	980	11.2
Columbia (Maury Co.)	36,190	32,800	3,380	9.3
Cookeville	51,500	47,380	4,120	8.0
Jackson Co.	5,080	4,610	480	9.4
Overton Co.	10,280	9,390	890	8.7
Putnam Co.	36,140	33,390	2,750	7.6
Crossville (Cumberland Co.)	24,470	22,260	2,210	9.0
Dyersburg (Dyer Co.)	17,220	15,220	2,000	11.6
Greeneville (Greene Co.)	29,050	25,890	3,170	10.9
Harriman (Roane Co.)	27,490	25,390	2,100	7.6
Humboldt (Gibson Co.)	21,260	18,800	2,460	11.6
LaFollette (Campbell Co.)	16,980	15,190	1,790	10.5
Lawrenceburg (Lawrence Co.)	16,540	14,670	1,870	11.3
Lewisburg (Marshall Co.)	12,430	11,040	1,390	11.2
Martin (Weakley Co.)	16,370	14,440	1,940	11.8
McMinnville (Warren Co.)	17,390	15,790	1,600	9.2
Newport (Cocke Co.)	16,440	14,620	1,820	11.1
Paris (Henry Co.)	13,720	12,320	1,400	10.2
Sevierville (Sevier Co.)	50,710	46,280	4,430	8.7
Shelbyville (Bedford Co.)	22,680	20,660	2,020	8.9
Tullahoma	50,480	46,640	3,840	7.6
Coffee Co.	26,830	24,820	2,010	7.5
Franklin Co.	20,270	18,690	1,580	7.8
Moore Co.	3,380	3,130	250	7.4
Union City, TN-KY	16,960	14,640	2,320	13.7
Obion Co.	14,480	12,550	1,930	13.3
Kentucky portion (Fulton Co.)	2,490	2,100	390	15.7
Cities				
Bartlett	28,650	26,800	1,850	6.5 %
Brentwood	18,700	17,720	980	5.2
Bristol	13,030	12,160	870	6.6
Chattanooga	78,530	71,900	6,640	8.4
Clarksville	57,980	53,380	4,600	7.9
Cleveland	20,240	18,630	1,610	8.0
Collierville	21,760	20,380	1,380	6.4
Columbia	14,960	13,460	1,500	10.0
Cookeville	15,440	14,300	1,140	7.4
Franklin	34,940	33,060	1,880	5.4
Gallatin	14,350	13,220	1,130	7.9
Germantown	19,510	18,400	1,110	5.7
Hendersonville	28,560	26,800	1,770	6.2
Jackson	31,490	28,700	2,780	8.8
Johnson City	32,560	30,370	2,190	6.7
Kingsport	20,970	19,370	1,600	7.6
Knoxville	91,330	84,560	6,770	7.4
LaVergne	19,290	17,980	1,310	6.8
Lebanon	13,440	12,440	1,010	7.5
Maryville	13,190	12,270	920	7.0
Memphis	289,720	260,190	29,530	10.2
Morristown	12,990	11,700	1,290	9.9
Murfreesboro	59,940	55,940	4,000	6.7
Nashville	335,020	312,760	22,260	6.6
Oak Ridge	14,260	13,210	1,060	7.4
Smyrna	22,770	21,200	1,570	6.9
Spring Hill	15,580	14,600	980	6.3

LABOR FORCE ESTIMATES SUMMARY - TENNESSEE

Annual Average 2012 - BM12

	Labor Force	Employment	Unemployment	Unemp. Rate (%)
Counties				
Anderson Co.	36,370	33,520	2,850	7.8 %
Bedford Co.	22,680	20,660	2,020	8.9
Benton Co.	6,950	6,240	710	10.2
Bledsoe Co.	4,880	4,390	490	9.9
Blount Co.	63,860	59,500	4,360	6.8
Bradley Co.	50,080	46,370	3,720	7.4
Campbell Co.	16,980	15,190	1,790	10.5
Cannon Co.	6,610	6,120	480	7.3
Carroll Co.	13,800	12,300	1,500	10.9
Carter Co.	28,010	25,760	2,250	8.0
Cheatham Co.	20,730	19,230	1,500	7.2
Chester Co.	8,380	7,670	710	8.5
Claiborne Co.	13,220	11,850	1,370	10.4
Clay Co.	3,460	3,120	340	9.9
Cocke Co.	16,440	14,620	1,820	11.1
Coffee Co.	26,830	24,820	2,010	7.5
Crockett Co.	6,830	6,130	700	10.2
Cumberland Co.	24,470	22,260	2,210	9.0
Davidson Co.	335,020	312,760	22,260	6.6
Decatur Co.	5,750	5,200	550	9.6
DeKalb Co.	9,930	9,160	770	7.7
Dickson Co.	25,130	23,090	2,040	8.1
Dyer Co.	17,220	15,220	2,000	11.6
Fayette Co.	17,650	15,900	1,740	9.9
Fentress Co.	8,280	7,540	750	9.0
Franklin Co.	20,270	18,690	1,580	7.8
Gibson Co.	21,260	18,800	2,460	11.6
Giles Co.	13,620	12,370	1,250	9.2
Grainger Co.	9,810	8,790	1,020	10.4
Greene Co.	29,050	25,890	3,170	10.9
Grundy Co.	6,090	5,520	570	9.4
Hamblen Co.	29,190	26,570	2,630	9.0
Hamilton Co.	166,530	154,090	12,450	7.5
Hancock Co.	2,330	2,050	270	11.7
Hardeman Co.	10,910	9,700	1,200	11.0
Hardin Co.	12,160	11,000	1,150	9.5
Hawkins Co.	26,040	23,980	2,070	7.9
Haywood Co.	8,770	7,790	980	11.2
Henderson Co.	12,510	11,190	1,320	10.6
Henry Co.	13,720	12,320	1,400	10.2
Hickman Co.	10,530	9,570	970	9.2
Houston Co.	4,130	3,730	400	9.6
Humphreys Co.	9,190	8,340	850	9.3
Jackson Co.	5,080	4,610	480	9.4
Jefferson Co.	23,930	21,520	2,410	10.1
Johnson Co.	7,370	6,650	720	9.8
Knox Co.	232,490	217,910	14,570	6.3
Lake Co.	2,800	2,510	290	10.2
Lauderdale Co.	9,920	8,680	1,230	12.4
Lawrence Co.	16,540	14,670	1,870	11.3
Lewis Co.	5,290	4,730	570	10.7
Lincoln Co.	17,590	16,630	970	5.5
Loudon Co.	24,780	23,110	1,670	6.7
McMinn Co.	24,410	22,180	2,240	9.2
McNairy Co.	10,730	9,690	1,040	9.7
Macon Co.	10,990	10,100	890	8.1

LABOR FORCE ESTIMATES SUMMARY - TENNESSEE

Annual Average 2012 - BM12

	Employment	Employment	Employment	Unemp. Rate (%)
Madison Co.	49,730	45,650	4,080	8.2
Marion Co.	12,550	11,430	1,120	8.9
Marshall Co.	12,430	11,040	1,390	11.2
Maury Co.	36,190	32,800	3,380	9.3
Meigs Co.	5,400	4,860	540	9.9
Monroe Co.	18,890	16,890	2,000	10.6
Montgomery Co.	77,910	71,810	6,100	7.8
Moore Co.	3,380	3,130	250	7.4
Morgan Co.	8,870	7,950	920	10.4
Obion Co.	14,480	12,550	1,930	13.3
Overton Co.	10,280	9,390	890	8.7
Perry Co.	2,670	2,360	320	11.8
Pickett Co.	1,950	1,710	240	12.5
Polk Co.	7,710	6,960	740	9.6
Putnam Co.	36,140	33,390	2,750	7.6
Rhea Co.	13,580	12,150	1,430	10.5
Roane Co.	27,490	25,390	2,100	7.6
Robertson Co.	35,170	32,690	2,480	7.1
Rutherford Co.	145,970	136,530	9,440	6.5
Scott Co.	8,080	6,670	1,410	17.4
Sequatchie Co.	6,310	5,820	490	7.8
Sevier Co.	50,710	46,280	4,430	8.7
Shelby Co.	435,210	395,790	39,420	9.1
Smith Co.	9,270	8,580	700	7.5
Stewart Co.	5,940	5,340	600	10.1
Sullivan Co.	75,060	69,840	5,220	7.0
Sumner Co.	85,350	79,660	5,700	6.7
Tipton Co.	28,420	25,900	2,520	8.9
Trousdale Co.	3,730	3,430	300	8.1
Unicoi Co.	8,570	7,780	790	9.2
Union Co.	8,890	8,170	720	8.1
Van Buren Co.	2,290	2,030	270	11.6
Warren Co.	17,390	15,790	1,600	9.2
Washington Co.	63,720	59,430	4,300	6.7
Wayne Co.	6,500	5,800	700	10.8
Weakley Co.	16,370	14,440	1,940	11.8
White Co.	11,120	9,870	1,260	11.3
Williamson Co.	99,320	94,000	5,320	5.4
Wilson Co.	63,000	58,950	4,050	6.4

[Home](#) > [International](#) > International Energy Statistics

International Energy Statistics

Petroleum	Natural Gas	Coal	Electricity	Renewables	Total Energy	Indicators	Country		
CO2 Emissions	Carbon Intensity	Energy Intensity	Conversions	Population	Coal Prices	Electricity Prices	Petroleum Prices	Natural Gas Prices	Heat Content

Country: Start Year: End Year:

Product: Unit:

Total Carbon Dioxide Emissions from the Consumption of Energy (Million Metric Tons) [Units Conversion](#) [Download Excel](#)

	2007	2008	2009	2010	2011
North America	7,065.083	6,877.108	6,407.535	6,617.038	6,506.960
Bermuda	0.751	0.750	0.712	0.699	0.777
Canada	593.090	578.248	549.684	546.652	552.557
Greenland	0.600	0.642	0.648	0.648	0.611
Mexico	444.270	452.794	421.124	432.210	462.293
Saint Pierre and Miquelon	0.089	0.092	0.089	0.089	0.091
United States	6,026.284	5,844.582	5,435.279	5,636.739	5,490.631
Central & South America	1,169.560	1,222.954	1,200.598	1,288.268	1,339.474
Antarctica	0.245	0.264	0.245	0.072	0.137
Antigua and Barbuda	0.631	0.659	0.666	0.666	0.732
Argentina	168.937	171.476	170.494	174.393	190.605

Footnotes:

-- = Not applicable
 (s) = Value is too small for the number of decimal places shown
 NA = Not available
 W = Data withheld to avoid disclosure
 F = Forecast

Related Information:

- [Table Notes](#)
- [Sources](#)
- [Glossary](#)
- [Contacts](#)
- [Country](#)



U.S. Energy Information
Administration

Emissions of Greenhouse Gases in the United States 2009

March 2011



Independent Statistics & Analysis

www.eia.gov

U.S. Department of Energy
Washington, DC 20585

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Disclaimer

This report was prepared by the U.S. Energy Information Administration (EIA), the statistical and analytical agency within the U.S. Department of Energy. By law, EIA's data, analyses, and forecasts are independent of approval by any other officer or employee of the United States Government. The views in this report therefore should not be construed as representing those of the Department of Energy or other Federal agencies.

Preface

Title XVI, Section 1605(a) of the Energy Policy Act of 1992 (enacted October 24, 1992) provides:

Not later than one year after the date of the enactment of this Act, the Secretary, through the Energy Information Administration, shall develop, based on data available to, and obtained by, the Energy Information Administration, an inventory of the national aggregate emissions of each greenhouse gas for each calendar year of the baseline period of 1987 through 1990. The Administrator of the Energy Information Administration shall annually update and analyze such inventory using available data. This subsection does not provide any new data collection authority.

This report—the eighteenth annual report—presents the U.S. Energy Information Administration’s latest estimates of emissions for carbon dioxide, methane, nitrous oxide, and other greenhouse gases. Documentation for these estimates is available online at www.eia.gov/oiaf/1605/ggrpt.

This report uses activity data on coal and natural gas consumption and electricity sales and losses by sector from the January 2011 *Monthly Energy Review (MER)*.

In keeping with current international practice, this report presents data on greenhouse gas emissions in million metric tons carbon dioxide equivalent. The data can be converted to carbon equivalent units by multiplying by 12/44.

Data on ozone-depleting gases with high global warming potentials (high-GWP gases) are directly from the U.S. Environmental Protection Agency (EPA). For this report, updated EPA values were available for hydrofluorocarbons (HFCs). However, no updates were available for perfluorocarbons (PFCs) or sulfur hexafluoride (SF₆), and last year’s values are used instead.

Historical data in the chapter tables are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

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Contents

1. Greenhouse gas emissions overview	
1.1. Total emissions.....	1
1.2. Energy-related carbon dioxide emissions by fuel and end use	2
1.3. Decomposition of U.S. greenhouse gas changes.....	3
1.4. Greenhouse gas emissions in the U.S. economy.....	4
1.5. U.S. emissions in a global perspective.....	8
1.6. Recent U.S. and international developments in global climate change.....	11
1.7. Special topic: Energy and carbon initiatives at the U.S. Department of Energy.....	14
1.8. Units for measuring greenhouse gases.....	16
1.9. Methodology updates for this report.....	18
1.10. Special topic: Black carbon.....	19
2. Carbon dioxide emissions	
2.1. Total carbon dioxide emissions	21
2.2. Energy-related carbon dioxide emissions	22
2.3. Residential sector carbon dioxide emissions.....	23
2.4. Commercial sector carbon dioxide emissions	24
2.5. Energy-related industrial sector carbon dioxide emissions	25
2.6. Transportation sector carbon dioxide emissions.....	26
2.7. Electric power sector carbon dioxide emissions	28
2.8. Carbon dioxide emissions and carbon sequestration from nonfuel uses of energy inputs.....	29
2.9. Adjustments to energy consumption	31
2.10. Other carbon dioxide emissions sources	33
3. Methane emissions	
3.1. Total emissions.....	35
3.2. Energy sources	36
3.3. Agricultural sources.....	38
3.4. Waste management sources.....	39
3.5. Industrial process sources	40
4. Nitrous oxide emissions	
4.1. Total emissions.....	41
4.2. Agricultural sources.....	42
4.3. Energy sources	44
4.4. Industrial sources.....	45
4.5. Waste management sources.....	46
5. High-GWP gases	
5.1. Total emissions.....	47
5.2. Hydrofluorocarbons.....	48
5.3. Perfluorocarbons	50
5.4. Sulfur hexafluoride	51
6. Land use	
6.1. Total land use, land use change, and forests	53
6.2. Forest lands and harvested wood pools.....	55
6.3. Croplands and grasslands	57
6.4. Urban trees, yard trimmings, and food scraps.....	59
6.5. Carbon dioxide emissions from bioenergy	60
A1. Notes and sources	
A1.1. Table Notes and Sources	63
A1.2. Figure Notes and Sources	65
A2. Glossary	69

Tables

1. Greenhouse gas emissions overview

1. U.S. emissions of greenhouse gases, based on global warming potential, 1990-2009.....	1
2. U.S. greenhouse gas intensity and related factors, 1990-2009	3
3. Distribution of total U.S. greenhouse gas emissions by end-use sector, 2009.....	6
4. World energy-related carbon dioxide emissions by region, 1990-2035	9
5. Greenhouse gases and 100-year net global warming potentials	17

2. Carbon dioxide emissions

6. U.S. carbon dioxide emissions from energy and industry, 1990-2009	21
7. U.S. energy-related carbon dioxide emissions by end-use sector.....	22
8. U.S. carbon dioxide emissions from residential sector energy consumption, 1990-2009	23
9. U.S. carbon dioxide emissions from commercial sector energy consumption, 1990-2009	24
10. U.S. carbon dioxide emissions from industrial sector energy consumption, 1990-2009.....	25
11. U.S. carbon dioxide emissions from transportation sector energy consumption, 1990-2009	27
12. U.S. carbon dioxide emissions from electric power sector energy consumption, 1990-2009.....	28
13. U.S. carbon dioxide emissions from nonfuel uses of energy fuels, 1990-2009.....	29
14. U.S. carbon sequestration from nonfuel uses of energy fuels, 1990-2009	30
15. U.S. carbon dioxide emissions: adjustments for U.S. Territories and international bunker fuels, 1990-2009	32
16. U.S. carbon dioxide emissions from other sources, 1990-2009.....	34

3. Methane emissions

17. U.S. methane emissions, 1990-2009	35
18. U.S. methane emissions from energy sources, 1990-2009	37
19. U.S. methane emissions from agricultural sources, 1990-2009.....	38
20. U.S. methane emissions from waste management sources, 1990-2009	39
21. U.S. methane emissions from industrial process sources, 1990-2009	40

4. Nitrous oxide emissions

22. U.S. nitrous oxide emissions, 1990-2009.....	41
23. U.S. nitrous oxide emissions from agricultural sources, 1990-2009.....	43
24. U.S. nitrous oxide emissions from energy sources, 1990-2009	44
25. U.S. nitrous oxide emissions from industrial sources, 1990-2009	45
26. U.S. nitrous oxide emissions from waste management sources, 1990-2009	46

5. High-GWP gases

27. U.S. emissions of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, 1990-2009	47
28. U.S. emissions of hydrofluorocarbons, 1990-2009.....	49
29. U.S. emissions of perfluorocarbons, 1990-2009.....	50
30. U.S. emissions of sulfur hexafluoride by source, 1990-2009.....	51

6. Land use

31. Net U.S. carbon dioxide sequestration from land use, land use change, and forestry, 1990-2008	54
32. Net carbon dioxide sequestration in U.S. forests and harvested wood pools, 1990-2008	56
33. Net carbon dioxide sequestration in U.S. croplands and grasslands, 1990-2008.....	58
34. Net carbon dioxide sequestration in U.S. urban trees, yard trimmings, and food scraps, 1990-2008.....	59
35. Emissions of carbon dioxide from biofuel/bioenergy use by sector and fuel, 1990-2009	62

Figures

1. Greenhouse gas emissions overview

1. U.S. greenhouse gas emissions by gas, 2009	1
2. U.S. energy-related carbon dioxide emissions by major fuel, 2009.....	2
3. U.S. energy-related carbon dioxide emissions by sector, 2009	2
4. Annual changes in Kaya identity terms (GDP, Energy/GDP, CO ₂ /Energy) and energy-related carbon dioxide emissions, 2005-2009	3
5. Greenhouse gas emissions in the U.S. economy.....	5
6. World carbon dioxide emissions by region, 1990, 2007, 2025, and 2035.....	8
7. Regional shares of world carbon dioxide emissions, 1990, 2007, 2025, and 2035.....	8
8. U.S. emissions of black carbon by source, 2001 and 2020	19

2. Carbon dioxide emissions

9. Annual change in U.S. carbon dioxide emissions, 1991-2009	21
10. Energy-related carbon dioxide emissions for selected sectors, 1990-2009.....	22
11. Annual changes in U.S. heating degree-days and residential sector carbon dioxide emissions from direct fuel combustion, 1990-2009	23
12. U.S. commercial sector carbon dioxide emissions and per capita income, 1990-2009.....	24
13. U.S. industrial sector carbon dioxide emissions and major industrial fuel use, 1990-2009.....	25
14. U.S. vehicle miles traveled and carbon dioxide emissions from gasoline and diesel transportation fuel use, 1990-2009	26
15. U.S. electric power sector energy sales and losses and carbon dioxide emissions from primary fuel combustion, 1990-2009.....	28
16. U.S. carbon dioxide emissions from other sources, 2009	33

3. Methane emissions

17. U.S. methane emissions by source, 1990-2009	35
18. U.S. methane emissions from energy sources, 1990-2009	36
19. U.S. methane emissions from agriculture by source, 2009.....	38
20. U.S. methane emissions from waste management by source, 1990-2009	39
21. U.S. methane emissions from industrial processes by source, 1990-2009.....	40

4. Nitrous oxide emissions

22. U.S. nitrous oxide emissions by source, 1990-2009	41
23. U.S. nitrous oxide emissions from agriculture by source, 2009	42
24. U.S. nitrous oxide emissions from energy use by source, 1990-2009	44
25. U.S. nitrous oxide emissions from industry by source, 1990-2009.....	45
26. U.S. nitrous oxide emissions from waste management by source, 1990-2009.....	46

5. High-GWP gases

27. U.S. emissions of high-GWP gases, 1990-2009.....	47
28. U.S. emissions of HFCs, 1990-2009.....	48
29. U.S. emissions of PFCs, 1990-2009	50
30. U.S. emissions of SF ₆ by source, 1990-2009.....	51

6. Land use

31. U.S. carbon sequestration from land use, land use change, and forestry, 1990-2008.....	53
32. Carbon sequestration in U.S. forest lands and harvested wood pools, 2008	55
33. Carbon sequestration in U.S. croplands and grasslands, 1990-2008.....	57
34. Carbon sequestration in U.S. urban trees, yard trimmings, and food scraps, 1990-2008.....	59

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1. Greenhouse gas emissions overview

1.1. Total emissions

Total U.S. anthropogenic (human-caused) greenhouse gas emissions in 2009 were 5.8 percent below the 2008 total (Table 1). The decline in total emissions—from 6,983 million metric tons carbon dioxide equivalent (MMT_{CO₂e}) in 2008 to 6,576 MMT_{CO₂e} in 2009—was the largest since emissions have been tracked over the 1990-2009 time frame. It was largely the result of a 419-MMT_{CO₂e} drop in carbon dioxide (CO₂) emissions (7.1 percent). There was a small increase of 7 MMT_{CO₂e} (0.9 percent) in methane (CH₄) emissions, and an increase of 8 MMT_{CO₂e} (4.9 percent), based on partial data, in emissions of man-made gases with high global warming potentials (high-GWP gases). (Draft estimates for emissions of HFC and PFC substitutes for ozone-depleting substances in 2009 are included; 2008 data are used for emissions of other high-GWP gases.) Emissions of nitrous oxide (N₂O), on the other hand, fell by 4 MMT_{CO₂e} (1.7 percent).

The decrease in U.S. CO₂ emissions in 2009 resulted primarily from three factors: an economy in recession, a particularly hard-hit energy-intensive industries sector, and a large drop in the price of natural gas that caused fuel switching away from coal to natural gas in the electric power sector.

Methane emissions totaled 731 MMT_{CO₂e} in 2009 (Figure 1), up by 7 MMT_{CO₂e} (0.9 percent) from 2008. Increases in energy-related methane emissions—largely from underground coal mining—were offset by decreases in emissions from agricultural sources. Methane emissions from waste management systems rose by 7 MMT_{CO₂e}, while industrial emissions declined by 0.4 MMT_{CO₂e}.

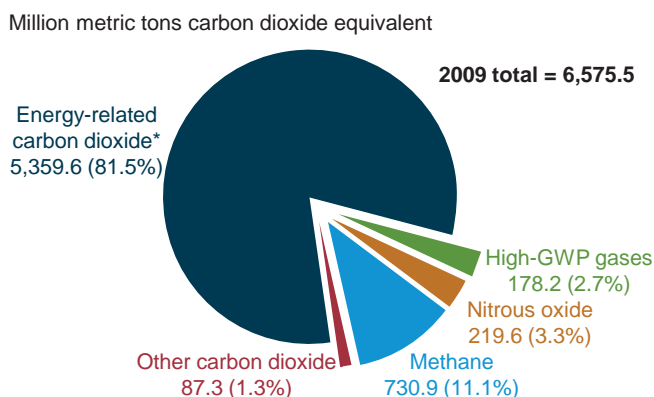
Emissions of nitrous oxide dropped by 4 MMT_{CO₂e} (1.7 percent) to 220 MMT_{CO₂e}. The decrease came mainly from a reduction in energy-related emissions, as well as declines in industrial-related and agricultural nitrous oxide emissions.

Based on a partial estimate, U.S. emissions of high-GWP gases totaled 178 MMT_{CO₂e} in 2009—8 MMT_{CO₂e} (4.9 percent) above the 2008 level. Emissions of hydrofluorocarbons (HFCs) rose by 7 MMT_{CO₂e} (5.4 percent) from 2008 to 2009.

U.S. greenhouse gas emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	6,133.2	7,109.4	6,983.1	6,575.5
Change from 1990 (million metric tons CO ₂ e)		976.1	849.8	442.3
(percent)		15.9%	13.9%	7.2%
Average annual change from 1990 (percent)		1.0%	0.7%	0.4%
Change from 2005 (million metric tons CO ₂ e)			-126.3	-533.8
(percent)			-1.8%	-7.5%
Change from 2008 (million metric tons CO ₂ e)				-407.5
(percent)				-5.8%

Figure 1. U.S. greenhouse gas emissions by gas, 2009



*Adjusted by removing emissions from bunker fuels and adding emissions from U.S. Territories.

Table 1. U.S. emissions of greenhouse gases, based on global warming potential,^a 1990-2009 (million metric tons carbon dioxide equivalent)

Gas	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Carbon dioxide	5,040.9	5,353.4	5,900.3	5,923.3	6,031.3	6,055.2	5,961.6	6,059.5	5,865.5	5,446.8
Methane	768.8	732.7	663.1	660.6	661.6	669.2	678.5	690.9	724.2	730.9
Nitrous oxide	221.4	236.2	217.8	211.8	222.0	223.6	223.7	228.6	223.5	219.6
High-GWP gases ^b	102.1	119.4	154.0	145.4	157.0	161.3	163.6	171.4	169.9	178.2
Total	6,133.2	6,441.7	6,935.3	6,941.1	7,071.9	7,109.4	7,027.4	7,150.4	6,983.1	6,575.5
Difference from 2005	—	—	—	—	—	—	-82.0	41.0	-126.3	-533.8
Percent difference from 2005	—	—	—	—	—	—	-1.2%	0.6%	-1.8%	-7.5%

^aNet, 100-year global warming potentials as presented in Intergovernmental Panel on Climate Change, *Fourth Assessment Report: Climate Change 2007: The Physical Science Basis* (Cambridge University Press, September 2007).

^bHydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆).

Note: Totals may not equal sum of components due to independent rounding.

1.2. Energy-related carbon dioxide emissions by fuel and end use

Energy-related CO₂ emissions dominate total U.S. greenhouse gas emissions (Figure 1). The figures below show the shares of energy-related CO₂ emissions accounted for by major energy fuels and by energy sectors.

Petroleum is the largest fossil fuel source for energy-related CO₂ emissions, contributing 43 percent of the total (Figure 2).

Coal is the second-largest fossil fuel contributor, at 35 percent. Although coal produces more CO₂ per unit of energy produced than petroleum does (i.e., coal has a higher carbon intensity than petroleum), petroleum consumption—in terms of British thermal units (Btu)—made up 45.0 percent of total fossil fuel energy consumption in 2009, as compared with coal's 25 percent.

Natural gas, with a carbon intensity that is about 55 percent of the carbon intensity of coal and 75 percent of the carbon intensity of petroleum, accounted for 30 percent of U.S. fossil energy use in 2009 but only 22 percent of total energy-related CO₂ emissions.

In Figure 3, emissions are divided into three categories: emissions from the direct use of fossil fuels in homes (for example, natural gas for heating), commercial buildings, and industry; emissions from fuel use for transportation (principally, petroleum); and emissions from the conversion of primary energy to electricity in the electric power sector.

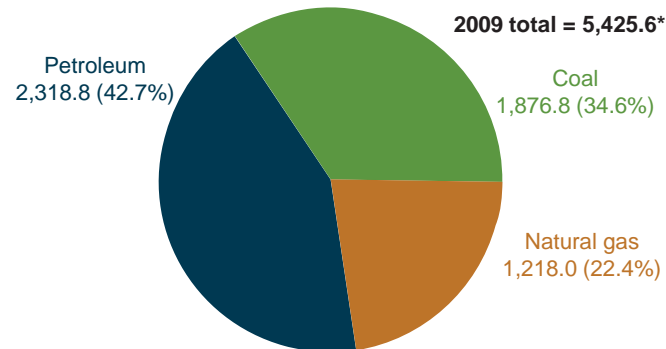
The electric power sector is the largest source, accounting for 40 percent of all energy-related CO₂ emissions. The electric power sector consists of those entities whose primary business is the production of electricity.

The transportation sector is the second-largest source, at 34 percent of the total. Those emissions are principally from the combustion of motor gasoline, diesel fuel, and jet fuel.

Direct fuel use in the residential and commercial sectors (mainly for heating) and the use of fuels to produce process heat in the industrial sector together accounted for 26 percent of total CO₂ emissions in 2009.

Figure 2. U.S. energy-related carbon dioxide emissions by major fuel, 2009

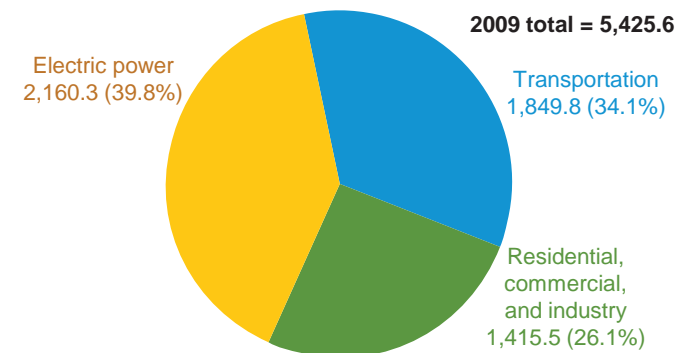
Million metric tons carbon dioxide



*Includes small amounts of CO₂ from non-biogenic municipal solid waste and geothermal energy (0.2 percent of total).

Figure 3. U.S. energy-related carbon dioxide emissions by sector, 2009

Million metric tons carbon dioxide



Note: Elsewhere in this report, electric power sector emissions are allocated to the end-use sectors by sales. These values are unadjusted for bunker fuels and U.S. Territories.

1.3. Decomposition of U.S. greenhouse gas changes

While the U.S. economy declined by 2.6 percent in 2009, a 5.8-percent decrease in total greenhouse gas emissions meant that U.S. greenhouse gas intensity decreased by 3.3 percent from 2008 to 2009.

Because energy-related CO₂ is such a large component of greenhouse gas emissions, it is helpful to analyze energy-related CO₂ emissions by using an equation known as the Kaya identity. The Kaya identity relates percent changes in energy-related CO₂ emissions to changes in the economy through the following approximation:

$$\% \Delta \text{CO}_2 \approx \% \Delta \text{GDP} + \% \Delta (\text{Energy}/\text{GDP}) + \% \Delta (\text{CO}_2/\text{Energy})$$

where % Δ represents percentage change.

As indicated in Figure 4, energy-related CO₂ emissions have declined in every year since 2005, with the exception of 2007. Although this is not a long period of time, it is instructive to examine the reasons for the change in trend as compared with the period from 1990 to 2005. A lower rate of economic growth from 2005 to 2009 (averaging 0.5 percent per year, as compared with the average of 3.1 percent per year from 1990 to 2005) is a key driver of the changing trend in emissions.

Over both periods, the energy intensity of the economy declined by an average of 1.9 percent per year, as the trend toward a service-oriented, post-industrial U.S. economy continued. In contrast, a drop in the carbon intensity of the U.S. energy supply may represent a new trend: from 1990 to 2005, carbon intensity increased on average by 1.0 percent per year, but from 2005 to 2009 it fell by an average of 1.9 percent per year, as natural gas was increasingly substituted for coal, and renewable electricity generation continued to grow. In combination, these factors resulted in a 7.1-percent decline in energy-related CO₂ emissions from 2008 to 2009 (Table 2).

Figure 4. Annual changes in Kaya identity terms (GDP, Energy/GDP, CO₂/Energy) and energy-related carbon dioxide emissions, 2005-2009

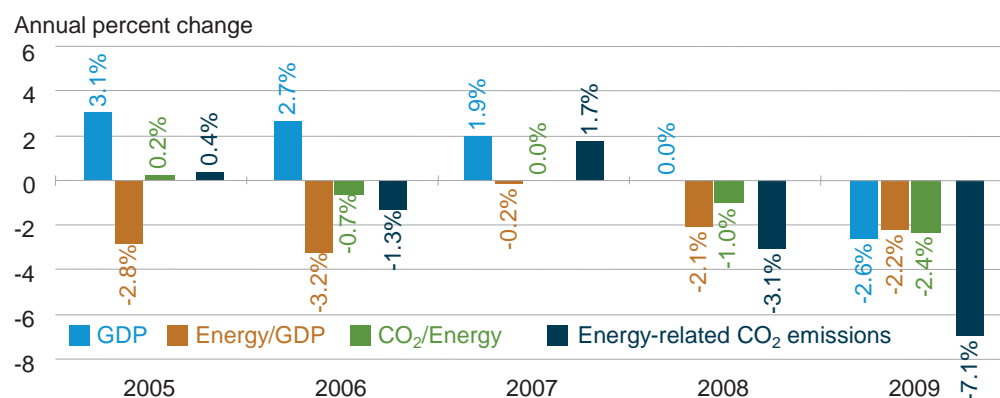


Table 2. U.S. greenhouse gas intensity and related factors, 1990-2009

	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Gross domestic product (billion 2005 dollars)	8,033.9	9,093.7	11,226.0	11,840.7	12,263.8	12,638.4	12,976.2	13,228.9	13,228.8	12,880.6
Greenhouse gas emissions (MMTCO ₂ e)	6,133.2	6,441.7	6,935.3	6,941.1	7,071.9	7,109.4	7,027.4	7,150.4	6,983.1	6,575.5
Greenhouse gas intensity (MTCO ₂ e per million 2005 dollars)	763.4	708.4	617.8	586.2	576.6	562.5	541.6	540.5	527.9	510.5
Change from previous year (percent)										
Energy-related CO ₂ emissions		1.1	3.3	0.8	2.0	0.4	-1.3	1.7	-3.1	-7.1
Gross domestic product (GDP)		2.5	4.1	2.5	3.6	3.1	2.7	1.9	0.0	-2.6
Energy/GDP		-0.4	-1.8	-2.1	-1.3	-2.8	-3.2	-0.2	-2.1	-2.2
CO ₂ /Energy		-1.1	1.0	0.5	-0.2	0.2	-0.7	0.0	-1.0	-2.4
Greenhouse gas intensity		-1.6	-1.3	-1.6	-1.6	-2.4	-3.7	-0.2	-2.3	-3.3

1.4. Greenhouse gas emissions in the U.S. economy

Figure 5 illustrates the flow of U.S. greenhouse gas emissions in 2009, from their sources to their end uses. The left side shows CO₂ quantities by fuel sources and quantities for other gases; the right side shows their distribution by sector. The center of the diagram indicates the split between CO₂ emissions from direct fuel combustion and those from electricity conversion. Adjustments indicated at the top of the diagram for U.S. territories and international bunker fuels correspond to greenhouse gas reporting requirements developed by the United Nations Framework Convention on Climate Change (UNFCCC).

CO₂. CO₂ emission sources include energy-related emissions (primarily from fossil fuel consumption) and emissions from industrial processes. The energy subtotal (5,426 MMTCO₂e) includes petroleum, coal, and natural gas consumption and smaller amounts from nonbiogenic municipal solid waste and some forms of geothermal power generation. The energy subtotal also includes emissions from nonfuel uses of fossil fuels, mainly as inputs to other products. Industrial process emissions (87 MMTCO₂e) include CO₂ stripped from natural gas and flared natural gas, cement manufacture, limestone and dolomite calcination, soda ash manufacture and consumption, CO₂ manufacture, and aluminum production. The sum of the energy subtotal and industrial processes equals unadjusted CO₂ emissions (5,513 MMTCO₂e). The energy component of unadjusted emissions can be divided into direct fuel use (3,265 MMTCO₂e) and fuel converted to electricity (2,160 MMTCO₂e).

Non-CO₂ gases. Methane (731 MMTCO₂e) and nitrous oxide (220 MMTCO₂e) sources include emissions related to energy, agriculture, waste management, and industrial processes. High-GWP gases (178 MMTCO₂e) include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). These gases have a variety of uses in the U.S. economy, including as refrigerants, insulators, solvents, and aerosols; as etching, cleaning, and firefighting agents; and as cover gases in various manufacturing processes.

Adjustments. In keeping with the UNFCCC, CO₂ emissions from U.S. Territories (47 MMTCO₂e) are added to the U.S. total, and CO₂ emissions from fuels used for international transport (both oceangoing vessels and airplanes) (113 MMTCO₂e) are subtracted to derive total U.S. greenhouse gas emissions (6,576 MMTCO₂e).

Emissions by end-use sector. CO₂ emissions by end-use sector are based on EIA's estimates of energy consumption (direct fuel use and purchased electricity) by sector and on the attribution of industrial process emissions by sector. CO₂ emissions from purchased electricity are allocated to the end-use sectors, based on their shares of total electricity sales. Non-CO₂ gases are allocated by direct emissions in those sectors plus emissions in the electric power sector that can be attributed to the end-use sectors on the basis of electricity sales.

Residential emissions (1,186 MMTCO₂e) include energy-related CO₂ emissions (1,172 MMT) and non-CO₂ emissions (14 MMTCO₂e). The non-CO₂ sources include methane and nitrous oxide emissions from direct fuel use. Non-CO₂ indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF₆ emissions related to electricity transmission and distribution, are also included.

Commercial emissions (1,288 MMTCO₂e) include both energy-related CO₂ emissions (1,012 MMT) and non-CO₂ emissions (276 MMTCO₂e). The non-CO₂ emissions include direct emissions from landfills, wastewater treatment plants, and commercial refrigerants, and emissions of methane and nitrous oxide from stationary combustion. Non-CO₂ indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF₆ emissions related to electricity transmission and distribution, are also included.

Industrial emissions (2,240 MMTCO₂e) include CO₂ emissions (1,505 MMT)—which can be broken down between combustion (1,418 MMT) and process emissions (87 MMT)—and non-CO₂ emissions (735 MMTCO₂e). The non-CO₂ direct emissions include emissions from agriculture (methane and nitrous oxide), coal mines (methane), petroleum and natural gas pipelines (methane), industrial process emissions (methane, nitrous oxide, HFCs, PFCs, and SF₆), and direct stationary combustion emissions of methane and nitrous oxide. Non-CO₂ indirect emissions attributable to purchased electricity, including methane and nitrous oxide emissions from electric power generation and SF₆ emissions related to electricity transmission and distribution, are also included.

Transportation emissions (1,861 MMTCO₂e) include energy-related CO₂ emissions from mobile source combustion (1,757 MMT) and non-CO₂ emissions (104 MMTCO₂e). The non-CO₂ emissions include methane and nitrous oxide emissions from mobile source combustion and HFC emissions from the use of refrigerants for mobile source air-conditioning units.

Figure 5. Greenhouse gas emissions in the U.S. economy

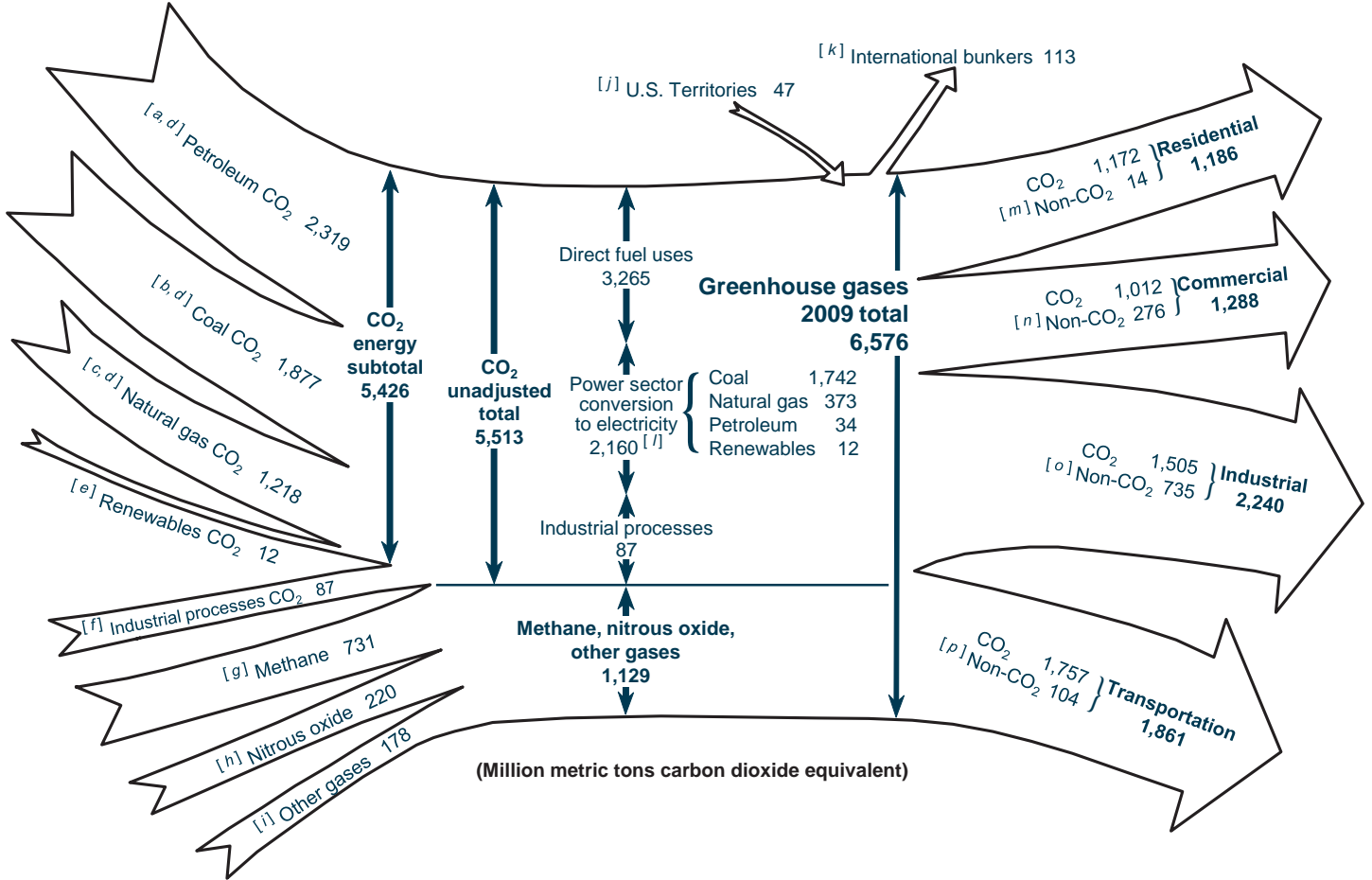


Diagram notes

- [a] CO₂ emissions related to petroleum consumption (includes 64 MMTCO₂ of nonfuel-related emissions).
- [b] CO₂ emissions related to coal consumption (includes 0.3 MMTCO₂ of nonfuel-related emissions).
- [c] CO₂ emissions related to natural gas consumption (includes 13 MMTCO₂ of nonfuel-related emissions).
- [d] Excludes carbon sequestered in nonfuel fossil products.
- [e] CO₂ emissions from the plastics portion of municipal solid waste (11 MMTCO₂) combusted for electricity generation and very small amounts (0.4 MMTCO₂) of geothermal-related emissions.
- [f] Includes mainly direct process emissions. Some combustion emissions are included from waste combustion outside the electric power sector and flaring of non-marketed natural gas.
- [g] Includes methane emissions related to energy, agriculture, waste management, and industrial processes.
- [h] Includes nitrous oxide emissions related to agriculture, energy, industrial processes, and waste management.
- [i] Includes hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.
- [j] Includes only energy-related CO₂ emissions from fossil fuels. Emissions are allocated to end-use sectors in proportion to U.S. ratios. Therefore, the sector CO₂ values shown here do not match the values in the carbon dioxide chapter.
- [k] Includes vessel bunkers and jet fuel consumed for international travel. Under the UNFCCC, these emissions are not included in country emission inventories. Emissions are subtracted from the transportation sector total.

- [j] CO₂ emissions from electricity generation in the commercial and industrial sectors are included in those sectors.
 - [m] Non-CO₂: Direct stationary combustion emissions of methane and nitrous oxide plus indirect power sector emissions of methane, nitrous oxide, and other greenhouse gases.
 - [n] Non-CO₂: Direct stationary combustion emissions of methane and nitrous oxide plus indirect power sector emissions of methane, nitrous oxide, and other greenhouse gases. Additional direct emissions include emissions from landfills, wastewater treatment, and commercial refrigerants.
 - [o] Non-CO₂: Direct stationary combustion emissions of methane and nitrous oxide plus indirect power sector emissions of methane, nitrous oxide, and other greenhouse gases. In addition, all agricultural emissions are included in the industrial sector as well as direct process emissions of methane, nitrous oxide, and the other gases.
 - [p] Non-CO₂: Direct mobile combustion emissions of methane and nitrous oxide. Also, emissions related to transportation refrigerants are included.
- Source:** Estimates presented in this report. CO₂ emissions by end-use sector are based on EIA's estimates of energy consumption by sector and on industrial process emissions. CO₂ emissions from the electric power sector are allocated to the end-use sectors based on electricity sales to the sector. Non-CO₂ emissions by end-use sector are allocated by direct emissions in those sectors plus indirect emissions from the electric power sector allocated by electricity sales. Data are preliminary. Totals may not equal sum of components due to independent rounding.

**Table 3. Distribution of total U.S. greenhouse gas emissions by end-use sector, 2009
(million metric tons carbon dioxide equivalent)**

Greenhouse gas and source	Sector				Total
	Residential	Commercial	Industrial	Transportation	
Carbon dioxide					
Energy-related (adjusted)	1,172.3	1,012.3	1,417.7	1,757.3	5,359.6
Industrial processes	—	—	87.3	—	87.3
<i>Carbon dioxide subtotal</i>	<i>1,172.3</i>	<i>1,012.3</i>	<i>1,505.0</i>	<i>1,757.3</i>	<i>5,446.8</i>
Methane					
Energy					
Coal mining	—	—	86.0	—	86.0
Natural gas systems	—	—	183.0	—	183.0
Petroleum systems	—	—	23.5	—	23.5
Stationary combustion	4.4	1.0	1.6	—	7.1
Stationary combustion: electricity	0.3	0.3	0.2	—	0.8
Mobile sources	—	—	—	2.7	2.7
Waste management					
Landfills	—	179.7	—	—	179.7
Domestic wastewater treatment	—	17.8	—	—	17.8
Industrial wastewater treatment	—	—	10.4	—	10.4
Industrial processes	—	—	4.2	—	4.2
Agriculture					
Enteric fermentation	—	—	144.9	—	144.9
Animal waste	—	—	58.3	—	58.3
Rice cultivation	—	—	11.2	—	11.2
Crop residue burning	—	—	1.4	—	1.4
<i>Methane subtotal</i>	<i>4.7</i>	<i>198.8</i>	<i>524.7</i>	<i>2.7</i>	<i>730.9</i>
Nitrous oxide					
Agriculture					
Nitrogen fertilization of soils	—	—	139.6	—	139.6
Solid waste of animals	—	—	20.8	—	20.8
Crop residue burning	—	—	0.6	—	0.6
Energy					
Mobile combustion	—	—	—	28.8	28.8
Stationary combustion	0.9	0.3	3.7	—	5.0
Stationary combustion: electricity	3.3	3.2	2.2	—	8.7
Industrial processes	—	—	10.8	—	10.8
Waste management					
Human sewage in wastewater	—	4.8	—	—	4.8
Waste combustion	—	—	—	—	0.0
Waste combustion: electricity	0.2	0.2	0.1	—	0.4
<i>Nitrous oxide subtotal</i>	<i>4.4</i>	<i>8.4</i>	<i>177.9</i>	<i>28.9</i>	<i>219.6</i>

(continued on page 7)

Table 3. Distribution of total U.S. greenhouse gas emissions by end-use sector, 2009 (continued)
(million metric tons carbon dioxide equivalent)

Greenhouse gas and source	Sector				Total
	Residential	Commercial	Industrial	Transportation	
Hydrofluorocarbons (HFCs)					
HFC-23	—	—	17.6	—	17.6
HFC-32	—	1.7	—	—	1.7
HFC-125	—	27.2	—	—	27.2
HFC-134a	—	—	—	72.4	72.4
HFC-143a	—	25.9	—	—	25.9
HFC-236fa	—	1.4	—	—	1.4
<i>HFCs subtotal</i>	<i>0.0</i>	<i>56.3</i>	<i>17.6</i>	<i>72.4</i>	<i>146.3</i>
Perfluorocarbons (PFCs)					
CF ₄	—	—	4.0	—	4.0
C ₂ F ₆	—	—	4.1	—	4.1
NF ₃ , C ₃ F ₈ , and C ₄ F ₈	—	—	0.5	—	0.5
<i>PFCs subtotal</i>	<i>0.0</i>	<i>0.0</i>	<i>8.6</i>	<i>0.0</i>	<i>8.6</i>
Other HFCs, PFCs/PFPEs	—	7.9	—	—	7.9
Sulfur hexafluoride (SF ₆)					
Electric applications	4.8	4.5	3.2	—	12.4
Other sources	—	—	2.9	—	2.9
<i>SF₆ subtotal</i>	<i>4.8</i>	<i>4.9</i>	<i>6.1</i>	<i>0.0</i>	<i>15.4</i>
Total greenhouse gas emissions	1,186.2	1,288.3	2,239.9	1,861.2	6,575.5

1.5. U.S. emissions in a global perspective

Total U.S. energy-related CO₂ emissions in 2007 (including nonfuel uses of fossil fuels) are estimated at 6,022 MMT—about 20 percent of the 2007 world total for energy-related CO₂ emissions, estimated at 29,728 MMT (Table 4).

CO₂ emissions related to energy use in the mature economies of countries that are members of the Organization for Economic Cooperation and Development (OECD)—including OECD North America, OECD Europe, Japan, South Korea, and Australia/New Zealand—were estimated at 13,711 MMT in 2007, or 46 percent of the world total, with the remaining 54 percent of worldwide energy-related CO₂ emissions (16,017 MMT) estimated to have come from non-OECD countries (Figure 6).

In EIA's *International Energy Outlook 2010 (IEO2010)* Reference case, projections of energy use and emissions are sensitive to economic growth rates and energy prices. Projections for a range of alternative growth and price scenarios are presented in *IEO2010*.

U.S. energy-related CO₂ emissions are projected to increase by an average of 0.2 percent per year from 2007 to 2035 in the *Annual Energy Outlook 2011 (AEO2011)* Reference case, while emissions from the non-OECD economies (*IEO2010* Reference case) grow by 1.7 percent per year. Both rates are lower than previous projections as a result of the 2008-2009 global recession and newly enacted energy policies. Consequently, the U.S. share of world CO₂ emissions is projected to fall to 15.8 percent (6,320 MMT out of a global total of 39,975 MMT) in 2035 (Figure 7).

China's share of global energy-related CO₂ emissions is projected to grow from 21 percent in 2007 to 31 percent in 2035, and China accounts for 56 percent of the projected increase in world emissions over the period. India accounts for the second-largest share of the projected increase, 7 percent.

World energy-related carbon dioxide emissions, 1990, 2005, 2007, and 2035

	1990	2005	2007	2035
Estimated emissions (million metric tons)	21,537	28,329	29,728	42,386
Change from 1990 (million metric tons)		6,793	8,191	20,849
(percent)		31.5%	38.0%	96.8%
Average annual change from 1990 (percent)		1.8%	1.9%	1.7%
Change from 2005 to 2035 (million metric tons)				14,057
(percent)				49.6%
Annual average change from 2005 to 2035 (percent)				1.4%

Figure 6. World carbon dioxide emissions by region, 1990, 2007, 2025, and 2035

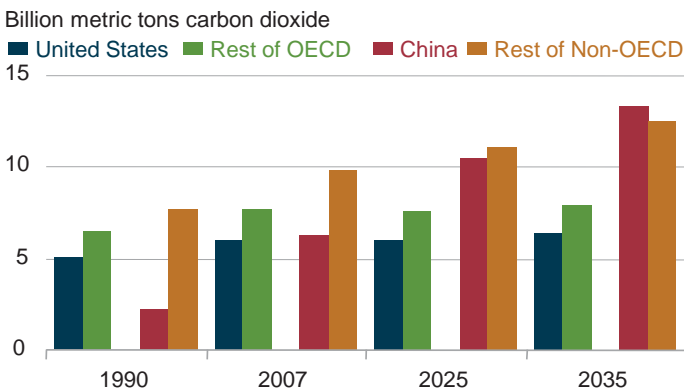


Figure 7. Regional shares of world carbon dioxide emissions, 1990, 2007, 2025, and 2035

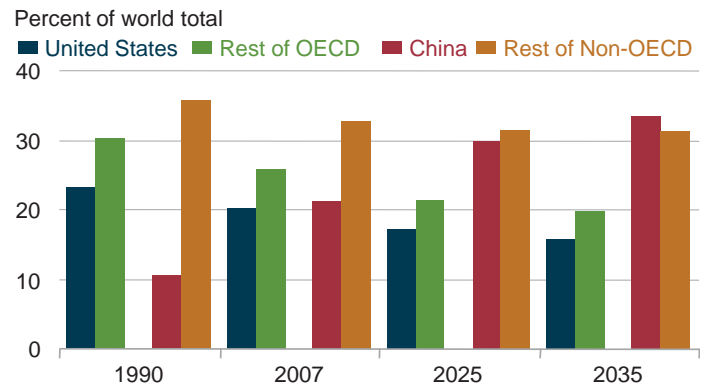


Table 4. World energy-related carbon dioxide emissions by region, 1990-2035
(million metric tons carbon dioxide, percent share of world emissions)

Region/Country	History				Projections					Average annual percent change, 2007-2035 ^a
	1990	2005	2006	2007	2015	2020	2025	2030	2035	
OECD										
OECD North America	5,812	7,034	6,940	7,052	6,683	6,827	7,078	7,360	7,699	0.3
	(27.0%)	(24.8%)	(24.1%)	(23.7%)	(21.2%)	(20.2%)	(19.5%)	(18.8%)	(18.2%)	(5.1%)
United States ^b	5,039	5,996	5,918	6,022	5,679	5,774	5,931	6,110	6,315	0.2
	(23.4%)	(21.2%)	(20.5%)	(20.3%)	(18.1%)	(17.1%)	(16.3%)	(15.6%)	(14.9%)	(2.3%)
Canada	471	628	596	586	553	554	579	609	643	0.3
	(2.2%)	(2.2%)	(2.1%)	(2.0%)	(1.8%)	(1.6%)	(1.6%)	(1.6%)	(1.5%)	(0.5%)
Mexico	302	410	426	444	451	499	568	641	741	1.8
	(1.4%)	(1.4%)	(1.5%)	(1.5%)	(1.4%)	(1.5%)	(1.6%)	(1.6%)	(1.7%)	(2.3%)
OECD Europe	4,149	4,398	4,426	4,386	4,110	4,042	4,037	4,052	4,107	-0.2
	(19.3%)	(15.5%)	(15.3%)	(14.8%)	(13.1%)	(12.0%)	(11.1%)	(10.3%)	(9.7%)	-(2.2%)
OECD Asia	1,595	2,203	2,196	2,273	2,149	2,201	2,263	2,318	2,388	0.2
	(7.4%)	(7.8%)	(7.6%)	(7.6%)	(6.8%)	(6.5%)	(6.2%)	(5.9%)	(5.6%)	(0.9%)
Japan	1,054	1,254	1,253	1,262	1,102	1,114	1,106	1,085	1,064	-0.6
	(4.9%)	(4.4%)	(4.3%)	(4.2%)	(3.5%)	(3.3%)	(3.0%)	(2.8%)	(2.5%)	-(1.6%)
South Korea	243	496	486	516	535	570	627	687	757	1.4
	(1.1%)	(1.8%)	(1.7%)	(1.7%)	(1.7%)	(1.7%)	(1.7%)	(1.8%)	(1.8%)	(1.9%)
Australia/ New Zealand	298	453	457	495	512	517	530	546	567	0.5
	(1.4%)	(1.6%)	(1.6%)	(1.7%)	(1.6%)	(1.5%)	(1.5%)	(1.4%)	(1.3%)	(0.6%)
Total OECD	11,556	13,635	13,562	13,711	12,942	13,070	13,378	13,730	14,194	0.1
	(53.7%)	(48.1%)	(47.0%)	(46.1%)	(41.1%)	(38.7%)	(36.8%)	(35.0%)	(33.5%)	(3.8%)

(continued on page 10)

^aValues in parentheses indicate percentage share of total world absolute change from 2007 to 2035.

^bIncludes the 50 States and the District of Columbia.

Note: The U.S. numbers include carbon dioxide emissions attributable to geothermal energy and nonbiogenic materials in municipal solid waste.

Table 4. World energy-related carbon dioxide emissions by region, 1990-2035 (continued)
(million metric tons carbon dioxide, percent share of world emissions)

Region/Country	History				Projections					Average annual percent change, 2007-2035 ^a
	1990	2005	2006	2007	2015	2020	2025	2030	2035	
Non-OECD										
Non-OECD Europe and Eurasia	4,246	2,843	2,876	2,896	2,882	2,914	2,965	3,042	3,172	0.3
	(19.7%)	(10.0%)	(10.0%)	(9.7%)	(9.2%)	(8.6%)	(8.2%)	(7.8%)	(7.5%)	(2.2%)
Russia	2,393	1,650	1,672	1,663	1,642	1,648	1,666	1,715	1,811	0.3
	(11.1%)	(5.8%)	(5.8%)	(5.6%)	(5.2%)	(4.9%)	(4.6%)	(4.4%)	(4.3%)	(1.2%)
Other	1,853	1,193	1,204	1,233	1,240	1,266	1,299	1,327	1,361	0.4
	(8.6%)	(4.2%)	(4.2%)	(4.1%)	(3.9%)	(3.8%)	(3.6%)	(3.4%)	(3.2%)	(1.0%)
Non-OECD Asia	3,677	8,382	8,830	9,426	11,228	12,971	14,897	16,906	18,984	2.5
	(17.1%)	(29.6%)	(30.6%)	(31.7%)	(35.7%)	(38.5%)	(41.0%)	(43.1%)	(44.8%)	(75.5%)
China	2,293	5,558	5,862	6,284	7,716	9,057	10,514	11,945	13,326	2.7
	(10.6%)	(19.6%)	(20.3%)	(21.1%)	(24.5%)	(26.8%)	(28.9%)	(30.5%)	(31.4%)	(55.6%)
India	573	1,187	1,287	1,399	1,566	1,751	1,905	2,079	2,296	1.8
	(2.7%)	(4.2%)	(4.5%)	(4.7%)	(5.0%)	(5.2%)	(5.2%)	(5.3%)	(5.4%)	(7.1%)
Other Non-OECD Asia	811	1,637	1,681	1,743	1,946	2,163	2,478	2,882	3,362	2.4
	(3.8%)	(5.8%)	(5.8%)	(5.9%)	(6.2%)	(6.4%)	(6.8%)	(7.4%)	(7.9%)	(12.8%)
Middle East	704	1,395	1,446	1,515	1,939	2,134	2,287	2,450	2,692	2.1
	(3.3%)	(4.9%)	(5.0%)	(5.1%)	(6.2%)	(6.3%)	(6.3%)	(6.2%)	(6.4%)	(9.3%)
Africa	659	982	988	1,011	1,157	1,237	1,347	1,461	1,610	1.7
	(3.1%)	(3.5%)	(3.4%)	(3.4%)	(3.7%)	(3.7%)	(3.7%)	(3.7%)	(3.8%)	(4.7%)
Central and South America	695	1,092	1,133	1,169	1,311	1,407	1,502	1,613	1,734	1.4
	(3.2%)	(3.9%)	(3.9%)	(3.9%)	(4.2%)	(4.2%)	(4.1%)	(4.1%)	(4.1%)	(4.5%)
Brazil	235	366	380	394	478	534	601	682	761	2.4
	(1.1%)	(1.3%)	(1.3%)	(1.3%)	(1.5%)	(1.6%)	(1.7%)	(1.7%)	(1.8%)	(2.9%)
Other Central/South America	460	726	753	775	833	873	901	931	973	0.8
	(2.1%)	(2.6%)	(2.6%)	(2.6%)	(2.6%)	(2.6%)	(2.5%)	(2.4%)	(2.3%)	(1.6%)
Total Non-OECD	9,981	14,694	15,273	16,017	18,517	20,663	22,998	25,472	28,192	2.0
	(46.3%)	(51.9%)	(53.0%)	(53.9%)	(58.9%)	(61.3%)	(63.2%)	(65.0%)	(66.5%)	(96.2%)
Total World	21,537	28,329	28,835	29,728	31,459	33,733	36,376	39,202	42,386	1.3

^aValues in parentheses indicate percentage share of total world absolute change from 2007 to 2035.

1.6. Recent U.S. and international developments in global climate change

United States: Federal actions

U.S. Environmental Protection Agency

Rules for Mandatory Reporting of Greenhouse Gases by 31 industries and emissions sources were finalized by the U.S. Environmental Protection Agency (EPA) in October 2009.¹ Final rules and methods were proposed in April 2010 for a second group of industries: oil and natural gas systems; five industries that emit fluorinated greenhouse gases (GHGs); and facilities that inject and store CO₂ underground for the purposes of geologic sequestration or enhanced oil and gas recovery. The rules were finalized in November and December 2010, with data collection for this second group beginning in January 2011. Reporting rules for the remaining sources from the original proposed rule that were not finalized in October 2009 were finalized in June 2010. This batch of final rules included magnesium production, underground coal mines, industrial wastewater treatment, and industrial landfills. However, the EPA has not acted to finalize the proposed rules for ethanol production, food processing, and coal suppliers.

In December 2009, the EPA issued its final endangerment and cause or contribute findings for greenhouse gas emissions from light-duty vehicles, classifying them as a danger to public health and welfare. As a result, the EPA and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA), in April 2010, jointly published Corporate Average Fuel Economy (CAFE) and GHG emissions standards to regulate emissions from light-duty vehicles of model years 2012-2016.

In May 2010, a Presidential memo declared that the rulemaking to set standards for light-duty vehicles of model years 2017-2025 would begin, and also directed the EPA and NHTSA for the first time to draft efficiency rules for medium- and heavy-duty engines and vehicles.² A Notice of Intent to conduct a joint rulemaking on light-duty vehicles for model years 2017-2025, which includes the Agencies' initial assessment of a potential future standard, was released in September 2010.³ Proposed rules covering model years 2014-2018 were announced in October 2010. Also in May 2010, the EPA published its Tailoring Rule, which details the Agency's plans to begin regulating GHG emissions from large industrial GHG sources, including power generation facilities, industrial boilers, and oil refineries.⁴ The EPA began requiring Clean Air Act (CAA) permits for stationary GHG sources under the Prevention of Significant Deterioration (PSD) requirements of the CAA in January 2011.⁵ In August 2010, the EPA announced plans to amend or take over State permitting operations in cases where the State Implementation Plan (SIP) for PSD permitting did not adequately address GHG emissions, as would be required by the CAA.⁶

Other Federal agencies and offices

Implementation of Executive Order 13514 (EO 13514). The White House Council on Environmental Quality (CEQ) and DOE's Federal Energy Management Program (FEMP) developed guidance and calculation methodologies for Federal agencies to conduct and report their GHG inventories under the requirements of EO 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* (October 5, 2009). The final guidelines for FY 2008 and FY 2010 inventory submissions were published in October 2010. CEQ and FEMP will continue to update the guidelines and methodologies to cover additional emissions sources and provide improved calculation methods for future inventory years.

Individual agencies submitted their Strategic Sustainability Performance Plans in June 2010, detailing their strategies to help reach the overall Federal Government-wide goal to reduce Scope 1 and 2 emissions by 28 percent and Scope 3 emissions by 13 percent.⁷

New home appliance efficiency standards agreement. In August, a coalition of energy and water efficiency and consumer advocacy groups, along with major home appliance manufacturers and their industry association, announced an agreement to increase the efficiency of Energy Star home appliances and to seek tax credits for the production of super-efficient appliances.

American Recovery and Reinvestment Act. As of September 30, 2010, the close of the government's fiscal year 2010, DOE had used \$35.2 billion in Recovery Act appropriations and \$7.5 billion in Treasury tax incentive programs to support more than \$100 billion

¹U.S. Environmental Protection Agency, "Climate Change—Regulatory Initiatives: Greenhouse Gas Reporting Program," website www.epa.gov/climatechange/emissions/ghgrulemaking.html.

²National Highway Traffic Safety Administration, "NHTSA and EPA To Propose Greenhouse Gas and Fuel Efficiency Standards for Medium- and Heavy-Duty Trucks; Begin Process for Further Light-Duty Standards: Fact Sheet" (May 2010), website www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/LD_HD_FE_FactSheet.pdf.

³U.S. Environmental Protection Agency and U.S. Department of Transportation, "Notice of Upcoming Joint Rulemaking To Establish 2017 and Later Model Year Light Duty Vehicle GHG Emissions and CAFE Standards" (September 30, 2010), website www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/2017+CAFE_and_GHG_Notice_of_Intent.pdf.

⁴U.S. Environmental Protection Agency, "Regulations & Standards," website www.epa.gov/NSR/actions.html; and Pew Center on Global Climate Change, "EPA's 'Tailoring' Rule," website www.pewclimate.org/federal/executive/epa-tailoring-rule.

⁵U.S. Environmental Protection Agency, "Proposed Rules on Clean Air Act Permits for Sources of Greenhouse Gas Emissions Under the Prevention of Significant Deterioration Program," website www.epa.gov/NSR/documents/20100810SIPFIPFactSheet.pdf.

⁶"Action To Ensure Authority To Issue Permits Under the Prevention of Significant Deterioration Program to Sources of Greenhouse Gas Emissions: Federal Implementation Plan," *Federal Register* (September 2, 2010), website www.federalregister.gov/articles/2010/09/02/2010-21706/action-to-ensure-authority-to-issue-permits-under-the-prevention-of-significant-deterioration; and "Proposed Rules," *Federal Register* (September 2, 2010), website www.gpo.gov/fdsys/pkg/FR-2010-09-02/pdf/2010-21706.pdf.

⁷Scope 1 emissions include direct GHG emissions from sources that are owned or controlled by a Federal agency. Scope 2 emissions include direct GHG emissions that result from the generation of electricity, heat, or steam purchased by a Federal agency. Scope 3 emissions include GHG emissions from sources not owned or directly controlled by a Federal agency, such as vendor supply chains, delivery services, and employee travel and commuting.

in clean energy projects. This funding went to support more than 8,000 projects across the country, selected from among more than 30,000 applications.⁸

United States: Regional and State initiatives

Regional GHG initiatives

The Western Climate Initiative (WCI) consists of seven western U.S. member States, four Canadian member provinces, and an additional 14 observing States and provinces in the United States, Canada, and Mexico. The U.S. member States hold 19 percent of the total U.S. population and produce 20 percent of U.S. GDP.⁹ In July 2010, WCI released its comprehensive design strategy, which outlines its plan to reduce regional GHG emissions to 15 percent below 2005 levels by 2020.

State energy and GHG legislation

A number of new energy efficiency, renewable energy, and climate change laws were enacted in States across the country in 2010,¹⁰ including: RPS amendments (Maryland increased its solar carve-out, and Colorado increased its solar energy target to 30 percent of total energy production by 2020); an ocean energy development goal (Maine); electric vehicle incentives (Maryland); a carbon tax (Montgomery County, Maryland); a low carbon fuel standard for vehicle fuels (California); energy efficiency standards for utilities (Massachusetts) and for new commercial buildings (California); smart grid policy development (Maine); and planning for reductions in GHG emissions from the transportation sector (Oregon).

In July 2010, the Governors of Rhode Island and Massachusetts signed a Memorandum of Understanding (MOU) on the development of offshore wind energy facilities in the Federal waters off of their coasts. The MOU requires that the States coordinate and collaborate on wind energy efforts in an "area of mutual interest" in their overlapping shared waters.¹¹

International actions

UNFCCC and the Kyoto Protocol

The 15th Conference of the Parties (COP-15) and 5th Meeting of the Parties to the Kyoto Protocol (CMP-5) were held in Copenhagen, Denmark, in December 2009. The main product of the meetings was the Copenhagen Accord, which had been agreed to by 140 of the 192 UNFCCC nations as of November 2010.¹² The Accord is a non-binding statement pledging action on:

- A goal to limit global warming to 2 degrees Celsius
- Submission of mitigation goals by individual nations
- Funding \$30 billion in "new and additional" financing for mitigation, adaptation, technology development, and capacity building in developing nations over the 2010-2012 period, increasing to \$100 billion per year by 2020
- Reporting and verification of national inventories and mitigation actions
- Establishment of a mechanism to use developed country financing in support of efforts to reduce emissions from deforestation and forest degradation and to enhance carbon sinks.

COP-16 and CMP-6 convened from November 29 through December 10, 2010, in Cancun, Mexico. The Parties adopted a package of agreements that reaffirms and builds upon the Copenhagen Accord of 2009. The Cancun Agreements¹³ include the following actions:

- Reaffirm the Accord's goal to limit global average temperature rise to 2 degrees Celsius above pre-industrial levels
- Formally recognize the reduction pledges made in the Copenhagen Accord for the first time by "taking note" of the pledges made by both developed and developing nations
- Indicate that the Clean Development Mechanism (CDM) and Joint Implementation, by which Annex I nations may use non-Annex I mitigation projects to offset their emissions, will continue beyond 2012
- Create a new "standardized baseline" process for some types of CDM projects

⁸U.S. Department of Energy, Secretary Stephen Chu, "Progress" (email to DOE employees) (October 6, 2010).

⁹Western Climate Initiative, *Design for the WCI Regional Program*, "Design Summary and Documentation" (July 27, 2010), p. 3, website <http://westernclimateinitiative.org/component/remository/func-startdown/281>; and Pew Center on Global Climate Change, "Western Climate Initiative (WCI) Partners Release Comprehensive Strategy to Address Climate Change," website www.pewclimate.org/news/WCI_design/WCI_07_10.

¹⁰Pew Center on Global Climate Change, "States News," website www.pewclimate.org/states-regions/news; and Environment Northeast, "2010.01.29- New York Times-Massachusetts Sets Ambitious Energy Standards" (January 1, 2010), website www.env-ne.org/resources/open/p/id/1048.

¹¹Rhode Island Government, "Rhode Island and Massachusetts Sign Agreement To Collaborate on the Development of Offshore Wind in Federal Waters" (July 26, 2010), website www.ri.gov/press/view/11879.

¹²United Nations Framework Convention on Climate Change, "Copenhagen Accord," website <http://unfccc.int/home/items/5262.php>.

¹³Pew Center on Global Climate Change, "Sixteenth Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change and Sixth Session of the Meeting of the Parties to the Kyoto Protocol" (December, 2010), website www.pewclimate.org/docUploads/cancun-climate-conference-cop16-summary.pdf; and United Nations Framework Convention on Climate Change, "UN Climate Change Conference in Cancun Delivers Balanced Package of Decisions, Restores Faith in Multilateral Process" (December 11, 2010), website http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/pr_20101211_cop16_closing.pdf.

- Set out a reporting framework that continues annual submission of inventories by developed nations and creates a new registry for developing nations to report on mitigation actions that receive international financing and includes general guidelines for reporting autonomous actions
- Provide a framework to develop financing and other policies to Reduce Emissions from Deforestation and Degradation (REDD+) and call upon developing nations to develop national strategies and reference levels for future efforts to reduce deforestation
- Establish the World Bank as interim trustee of The Green Climate Fund, which seeks to raise \$100 billion per year from public and private sources by 2020 to support greenhouse gas mitigation efforts in developing countries
- Set up the Cancun Adaptation Framework to formalize and outline efforts to enhance adaptation activities by all UNFCCC members
- Establish the Technology Mechanism to assist developing countries with identification, transfer, and application of appropriate low-carbon technologies.

Montreal Protocol

The United States, Canada, and Mexico continued to move forward with their proposal, first announced in 2009, to amend the Montreal Protocol to include a binding schedule for phasing down production and consumption of 20 hydrofluorocarbons (HFCs). The proposal calls for developed countries to reduce their production and consumption of the 20 HFCs to 15 percent of a 2004-2006 average baseline by 2033, and for developing nations to meet the same level by 2043. The proposal was considered at the 22nd Meeting of the Parties to the Montreal Protocol in Bangkok in November. The United States, Canada, and Mexico also offered a proposal to increase project-based efforts to control emissions from HFC-23 and HCFC-22 production.¹⁴ (For more information on domestic efforts to reduce emissions of high-GWP gases, see Chapter 5.)

Major Economies Forum

The 6th, 7th, and 8th Meetings of the Leaders' Representatives to the Major Economies Forum on Energy and Climate Change convened during 2010.¹⁵ Representatives of the 17 major economies, the United Nations, and guest smaller nations discussed the path forward after COP-15 in Copenhagen and toward COP-16 in Cancun. Discussions centered around further development of the Copenhagen Accord and goals for progress in Cancun, including an emphasis on monitoring, reporting, verification, and transparency; quick implementation of the Accord's Fast Start Financing provisions; the future of the Kyoto Protocol; and different notions of equity. Separately, a Clean Energy Ministerial meeting track was launched to advance initiatives related to energy supply, energy efficiency, and energy access. The Ministerial met in July to develop steps toward accelerated deployment of clean energy technologies and will meet again in April 2011 in Abu Dhabi.¹⁶

Bilateral and multilateral agreements

The U.S. State Department signed two memoranda of understanding (MOU) in 2010 related to cooperation on greenhouse gas emissions. In March, the United States signed an MOU with Brazil establishing a "Climate Change Policy Dialogue," which aims to increase cooperation between the two nations on energy efficiency, capacity building, and combating deforestation.¹⁷ In July, the United States and China signed an MOU to cooperate in the development of clean energy and energy efficiency technologies and engage in a policy dialog.¹⁸

¹⁴United Nations Environment Programme, "Issues for Discussion by and Information for the Attention of the Twenty-Second Meeting of the Parties" (July 9th, 2010), website http://ozone.unep.org/Meeting_Documents/mop/22mop/MOP-22-2E.pdf.

¹⁵Major Economies Forum on Energy and Climate, "Past Meetings," website www.majoreconomiesforum.org/past-meetings/.

¹⁶Clean Energy Ministerial, "2010 Clean Energy Ministerial," website <http://cleanenergyministerial.org/>.

¹⁷U.S. Department of State, "Secretary Clinton and Brazilian Foreign Minister Amorim Announce Increased Cooperation on Climate Change" (March 3, 2010), website www.state.gov/r/pa/prs/ps/2010/03/137723.htm.

¹⁸U.S. Department of State, "U.S.-China Memorandum of Understanding to Enhance Cooperation on Climate Change, Energy and the Environment" (July 28, 2010), website www.state.gov/r/pa/prs/ps/2009/july/126592.htm.

1.7. Special topic: Energy and carbon initiatives at the U.S. Department of Energy

Under EO 13514, all Federal Government agencies are required to develop integrated sustainability plans that include greenhouse gas emission reductions; efficient water use; waste reduction and pollution prevention; and increased efficiency in buildings, products, and vehicle fleets.¹⁹ At the U.S. Department of Energy (DOE), the mission of the Federal Energy Management Program (FEMP) is to facilitate the Federal Government's implementation of sound, cost-effective energy management and investment practices in order to enhance the Nation's energy security and environmental stewardship. Serving its mission, FEMP assists DOE and other agencies in planning and implementing strategies to achieve conservation, efficiency, and renewable energy goals under EO 13514 and other mandates.

DOE has more than 15,000 Federal employees in offices and laboratories around the country. Under the EO 13514 requirement to quantify Agency GHG emissions, DOE calculated a fiscal year (FY) 2008 baseline of 5 MMTCO₂e and established a goal of a 28-percent absolute reduction in its emissions by 2020.²⁰

In October 2010, FEMP released its *Annual GHG and Sustainability Data Report, Version 1.0* to coincide with the release of the *Federal Greenhouse Gas Accounting and Reporting Guidance* and *Technical Support Document* by the White House Council on Environmental Quality. The documents and reporting tool aid Federal agencies in gauging their progress toward goals set under EO 13514 by providing guidance and the means for the necessary data collection.²¹ The *Data Report* includes reporting requirements for facility and operational energy and water use, as well as calculation of Federal fleet fuel use, fulfilling previous FEMP requirements. FEMP will continue to release updated versions of the *Data Report* to aid agencies in realizing their EO 13514 goals. Notable initiatives contributing to DOE's efforts to achieve EO 13514 goals are described below.

DOE Headquarters facilities

DOE Headquarters (HQ) is located in the James Forrestal building in downtown Washington, DC, and in Germantown, MD. The HQ facilities house more than 5,800 of the Agency's Federal and contract employees. Initiatives to increase energy savings and efficiency at DOE HQ buildings include the following.

Solar array

Installed on the roof of the Forrestal building in September 2008, the solar array generates about 235,000 kilowatthours of electricity per year. The array is also important for technology demonstration and testing purposes. In addition to the main configuration, the array contains several examples of solar panel technologies, along with monitoring stations to measure power generation in relation to weather conditions.

Energy savings

In December 2009, DOE entered into an Energy Savings Performance Contract (ESPC) involving a large-scale HQ retrofit project. An ESPC allows DOE to finance the project with minimal initial cost, because the installation costs will be offset by monetary savings associated with reduced resource consumption.²² The project focuses on reducing energy consumption in the Forrestal building and water consumption at the Germantown facilities. Construction is scheduled to be completed by December 2011. The efforts are expected to result in reductions of energy consumption by 22 percent at the Forrestal building and water consumption by 11 percent in Germantown.

In spring 2010, the Forrestal corridor lighting system was rewired to allow for all lights, with the exception of emergency lighting, to be turned off during night and weekend hours. This upgrade should reduce energy consumption by about 280,000 kilowatthours per year.

Forrestal west and south buildings cool roofs

DOE has completed a "cool roof" on the cafeteria and plans to complete one for the south building at the Forrestal complex over the summer of 2011. The project includes roof engineering designs that will reflect sunlight and emit heat more efficiently than existing roofs, reducing energy consumption and costs associated with summertime cooling. It also includes solar hot water heating for the cafeteria, energy savings and life-cycle cost evaluation, and other technical and economic analyses.

(continued on page 15)

¹⁹U.S. Department of Energy, Energy Efficiency & Renewable Energy, "Energy Management at DOE" (May 2010), website www1.eere.energy.gov/femp/about/energymanage.html.

²⁰A. Lawrence, "Implementing Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance at the Department of Energy" (March 2010), website www.hss.energy.gov/nuclearsafety/env/training/eo13514_overview_presentation.pdf, slide 30, "DOE Scope 1 and 2 GHGs."

²¹Federal Facilities Environmental Stewardship & Compliance Assistance Center, "FEMP Releases Greenhouse Gas Inventory Reporting Tool for Federal Agencies" (October 2010), website www.fedcenter.gov/Announcements/index.cfm?id=16388&page_id=1854.

²²U.S. Department of Energy, Energy Efficiency & Renewable Energy, "Energy Savings Performance Contracts" (September 2010), website www1.eere.energy.gov/femp/financing/espcs.html.

1.7. Special topic: Energy and carbon initiatives at the U.S. Department of Energy (continued)

Other notable DOE projects

During December 2009, DOE awarded 16 new Energy Savings Performance Contracts (ESPCs), including the following.

Savannah River Biomass Steam Plant, Aiken, South Carolina

DOE's Savannah River Biomass Steam Plant is one of the largest of its kind. Originally powered by coal-burning boilers, the project, financed by an ESPC, has replaced the original boilers with two steam boilers powered by the combustion of woody biomass. These upgrades are estimated to save \$34 million a year in fuel, operations, and maintenance costs.

Existing Building Assessment Tool

In 2009, DOE continued to use the Existing Building Assessment Tool (EBAT), part of the High Performance Sustainable Building Assessment Tool. EBAT aids in identifying and prioritizing sustainability projects for retrofitting DOE's building stock with energy-efficient technologies.²³ DOE's building portfolio currently includes 20 Leadership in Energy and Environmental Design (LEED) certified buildings. LEED is an internationally recognized green building certification system, which verifies that a building was designed and constructed to improve energy savings, CO₂ emission reductions, and other environmental factors.²⁴ The assessment tool is being used to identify candidate projects that would enable additional buildings to gain certification.

National Renewable Energy Laboratory, Golden, Colorado

DOE's National Renewable Energy Laboratory (NREL) facility in Golden, Colorado, has begun efforts to achieve net-zero energy consumption. Part of the initiative includes "greening" its data center by consolidating servers from 250 to 50, arranging servers to enable more efficient air flow, and using more energy-efficient methods to cool the air around servers. The efforts will reduce power consumption at the data center by 65 percent.²⁵

Future DOE projects

Data center acceleration campaign

DOE is planning a \$2.5 million strategic energy efficiency plan for its information technology infrastructure. The plan emphasizes 41 data centers. FEMP projects a 30-percent energy savings through the implementation of existing technologies under the initiative.²⁶

Biomass generation plant at Oak Ridge, Tennessee

DOE's research facilities in Oak Ridge, Tennessee, will house a biomass steam generation plant, scheduled to be operational in 2011. The project replaces four natural-gas-fired boilers and will eliminate more than 55,000 metric tons of carbon dioxide emissions each year, in addition to reductions in nitrogen oxide and sulfur dioxide emissions.²⁷

²³U.S. Department of Energy, Energy Efficiency & Renewable Energy, FEMP Year in Review 2009 (December 2009), website www1.eere.energy.gov/femp/pdfs/yrinreview_2009.pdf, p. 8.

²⁴U.S. Green Building Council, "Intro—What LEED Is" (2010), website www.usgbc.org/DisplayPage.aspx?CMSPageID=1988.

²⁵White House Council on Environmental Quality, "Leading by Example—Making the Federal Government More Sustainable, E.O. 13514: Agencies Leading by Example" (February 2010), website www.whitehouse.gov/sites/default/files/microsites/20100128-ceq-agency-stories.pdf; and National Renewable Energy Laboratory, "NREL Targets Data Centers for Energy Savings" (June 2008), website www.nrel.gov/features/20080601_green_it.html.

²⁶Future DOE projects described in this section are detailed in U.S. Department of Energy, Energy Efficiency & Renewable Energy, FEMP Year in Review 2009 (December 2009), p. 15, website www1.eere.energy.gov/femp/pdfs/yrinreview_2009.pdf.

²⁷White House Council on Environmental Quality, "Leading by Example—Making the Federal Government More Sustainable, E.O. 13514: Agencies Leading by Example" (February 2010), website www.whitehouse.gov/sites/default/files/microsites/20100128-ceq-agency-stories.pdf.

1.8. Units for measuring greenhouse gases

Emissions data are reported here in metric units. Metric tons are relatively intuitive for users of U.S. measurement units, because 1 metric ton is only about 10 percent heavier than a short ton.

Throughout this report, emissions of carbon dioxide and other greenhouse gases are given in carbon dioxide equivalents. In the case of carbon dioxide, emissions denominated in the molecular weight of the gas or in carbon dioxide equivalents are the same. Carbon dioxide equivalent data can be converted to carbon equivalents by multiplying by 12/44.

Emissions of other greenhouse gases (such as methane) can also be measured in carbon dioxide equivalent units by multiplying their emissions (in metric tons) by their global warming potentials (GWPs). Carbon dioxide equivalents are the amount of carbon dioxide by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another radiatively active gas.

Carbon dioxide equivalents are computed by multiplying the weight of the gas being measured (for example, methane) by its estimated GWP (which is 25 for methane). As indicated in Table 5, the GWP for methane was estimated at 21 in the second scientific assessment and 23 in the third. These changes reflect enhanced knowledge, through climate research, of methane's radiative efficiency. Also, as the level of carbon dioxide in the atmosphere increases, it becomes marginally less potent as a greenhouse gas. Consequently, other gases with lower atmospheric concentrations are relatively more potent. In 2008, the IPCC Working Group I released Errata to its Fourth Assessment Report, *Climate Change 2007: The Physical Science Basis*.²⁸ The Errata revise the reported GWPs for a small number of high-GWP gases. The GWPs published in the Errata to the Fourth Assessment Report (AR4) were used in the calculation of carbon dioxide equivalent emissions for this report. Table 5 summarizes the GWP values from the Second, Third, and Fourth Assessment Reports.

²⁸Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis: Errata* (Cambridge, UK: Cambridge University Press, 2008), website www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf.

Table 5. Greenhouse gases and 100-year net global warming potentials

Greenhouse gas	Chemical formula	Global warming potential		
		SAR ^a	TAR ^b	AR4 ^c
Carbon dioxide	CO ₂	1	1	1
Methane	CH ₄	21	23	25
Nitrous oxide	N ₂ O	310	296	298
Hydrofluorocarbons				
HFC-23 (trifluoromethane)	CHF ₃	11,700	12,000	14,800
HFC-32 (difluoromethane)	CH ₂ F ₂	650	550	675
HFC-41 (monofluoromethane)	CH ₃ F	150	97	92
HFC-125 (pentafluoroethane)	CHF ₂ CF ₃	2,800	3,400	3,500
HFC-134 (1,1,2,2-tetrafluoroethane)	CHF ₂ CHF ₂	1,000	1,100	1,100
HFC-134a (1,1,1,2-tetrafluoroethane)	CH ₂ FCF ₃	1,300	1,300	1,430
HFC-143 (1,1,2-trifluoroethane)	CHF ₂ CH ₂ F	300	330	353
HFC-143a (1,1,1-trifluoroethane)	CF ₃ CH ₃	3,800	4,300	4,470
HFC-152 (1,2-difluoroethane)	CH ₂ FCH ₂ F	—	43	53
HFC-152a (1,1-difluoroethane)	CH ₃ CHF ₂	140	120	124
HFC-161 (ethyl fluoride)	CH ₃ CH ₂ F	—	12	12
HFC-227ea (heptafluoropropane)	CF ₃ CHFCF ₃	2,900	3,500	3,220
HFC-236cb (1,1,1,2,2,3-hexafluoropropane)	CH ₂ FCF ₂ CF ₃	—	1,300	1,340
HFC-236ea (1,1,1,2,3,3-hexafluoropropane)	CHF ₂ CHFCF ₃	—	1,200	1,370
HFC-236fa (1,1,1,3,3,3-hexafluoropropane)	CF ₃ CH ₂ CF ₃	6,300	9,400	9,810
HFC-245ca (1,1,2,2,3-pentafluoropropane)	CH ₂ FCF ₂ CHF ₂	560	640	693
HFC-245fa (1,1,1,3,3-pentafluoropropane)	CHF ₂ CH ₂ CF ₃	—	950	1,030
HFC-365mfc (pentafluorobutane)	CF ₃ CH ₂ CF ₂ CH ₃	—	890	794
HFC-43-10mee (decafluoropentane)	CF ₃ CHFCHFCF ₂ CF ₃	1,300	1,500	1,640
Perfluorocarbons				
Perfluoromethane	CF ₄	6,500	5,700	7,390
Perfluoroethane	C ₂ F ₆	9,200	11,900	12,200
Perfluoropropane	C ₃ F ₈	7,000	8,600	8,830
Perfluorobutane (FC 3-1-10)	C ₄ F ₁₀	7,000	8,600	8,860
Perfluorocyclobutane	c-C ₄ F ₈	8,700	10,000	10,300
Perfluoropentane	C ₅ F ₁₂	7,500	8,900	9,160
Perfluorohexane (FC 5-1-14)	C ₆ F ₁₄	7,400	9,000	9,300
Sulfur hexafluoride	SF ₆	23,900	22,200	22,800
Nitrogen trifluoride	NF ₃	—	10,800	17,200

^aIPCC's second scientific assessment report.

^bIPCC's third scientific assessment report.

^cIPCC's fourth scientific assessment report.

1.9. Methodology updates for this report

Carbon dioxide

Revised coal and motor gasoline carbon factors have been adopted, based on work done by the U.S. EPA.²⁹

For the first time, EIA is providing estimates of biogenic CO₂ emissions from biofuels and bioenergy, based on energy consumption data from EIA's *Monthly Energy Review (MER)*. The estimates are provided in [Chapter 6](#) for informational purposes and are not included in the total emissions estimate, because they are considered to be part of the natural carbon cycle and so are excluded under UNFCCC guidelines.

Methane

Styrene has been dropped as a source of CH₄ emissions from the chemicals industry, based on guidance from the 2006 IPCC guidelines. Those emissions have been removed from all years of this inventory.

CH₄ emission factors for passenger cars and light-duty vehicles have been revised to the values published in the 2006 IPCC guidelines, resulting in a significant decline in calculated emissions from this source category from 1990 to 2008.

Updates have been made to the specificity of the calculations used to estimate emissions from the production and management of manure, including conducting a State-level analysis of swine manure emissions for the first time. In addition, sheep populations have been separated into those on feedlots and those not on feedlots; and populations of pullets, other chickens, and turkeys have been included in the poultry account for the first time. These updates also affect the estimation of N₂O emissions from manure management.

Changes in livestock population data that are used to derive the emissions factors for calculating CH₄ emissions from enteric fermentation resulted in an average increase in emissions of 3 percent over the series.

Additional emissions factors, conversion factors, and constants applied to the calculation of emissions related to agriculture and livestock have been updated on the basis of the most recent values published by the EPA or IPCC, as applicable.

For the first time in this report, CH₄ emissions from composting and from the combustion of waste are included in the inventory.

Nitrous oxide

Emissions calculations methodologies for direct and indirect emissions of N₂O from nitrogen fertilization of agricultural soils and from runoff of fertilizer and manure applied to soils have been revised to align more completely with methods in the 2006 IPCC guidelines. Most notably, the revised IPCC methodology, which accounts for nitrogen in below-ground crop residues but omits biological fixation of nitrogen, has been implemented for the 2009 inventory.

Emissions resulting from manure that is directly deposited on lands by grazing or pasture-raised animals have been transferred from the manure management category to the agricultural soils category, and new sources of indirect emissions from soil leaching and volatilization have been included in nitrogen fertilization of soils.

The specificity of direct and indirect emissions from manure management has been improved by implementing State-level calculation of swine emissions and updating the waste management system distributions for dairy cattle and swine to annually variable State-level values.

N₂O emission factors for passenger cars and light-duty vehicles have been revised to the values published in the 2006 IPCC guidelines, resulting in a significant decline in calculated emissions from this source category from 1990 to 2008.

Emissions estimates for 2007 and 2008 have been corrected to account for the 2006 closing of the smallest adipic acid plant in the United States, which was the only remaining plant that did not use abatement technology. Also, the N₂O emission factor for adipic acid production has been revised to the value published in the 2006 IPCC guidelines.

For the first time in this report, N₂O emissions from composting are included in the inventory.

High-GWP gases

Data for 2009 covering the use or production of HFCs, PFCs, and SF₆ in industrial applications are not yet available for inclusion in the 2009 GHG inventory. To obtain a total, the 2008 values for those emissions were used. Draft estimates for emissions of HFC and PFC substitutes for ozone-depleting substances are included in Chapter 5. Complete final estimates of those emissions will be available in the EPA's 2009 inventory of greenhouse gas emissions and sinks, to be published in April 2011.³⁰

²⁹U.S. Environmental Protection Agency, 40 CFR: Protection of the Environment, Part 98—Mandatory Greenhouse Gas Reporting, "Table C-1 to Subpart C of Part 98—Default CO₂ Emission Factors and High Heat Values for Various Types of Fuel," *Federal Register*, Vol. 74, No. 209 (October 30, 2009), p. 56410, website www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-FinalRule.pdf.

³⁰For details on the changes described above, see U.S. Energy Information Administration, *Documentation For Emissions of Greenhouse Gases in the United States 2009* (to be published).

1.10. Special topic: Black carbon

What is black carbon?

Black carbon is an aerosol component of particulate matter formed through the incomplete combustion of fossil fuels, biofuels, and biomass. It is found in both anthropogenic (human-caused) and naturally occurring soot. The science and understanding of black carbon have evolved rapidly over the past decade. This has drawn attention to black carbon's contribution to climate change. Globally, the primary sources of black carbon include emissions from diesel engines, cook stoves, wood fires, and forest fires. In contrast with CO₂, which has an atmospheric lifetime of more than 100 years, black carbon remains in the atmosphere for only a few weeks. Therefore, reducing black carbon emissions may be an effective way to slow climate change in the short term. The 20-year GWP of black carbon is estimated at 2,200, with a 100-year GWP of 680.³¹ Because of its relatively short atmospheric lifetime, the 20-year GWP is considered a more accurate estimate of the climate impact of black carbon emissions.

Black carbon contributes to changes in the atmosphere in two ways. First, when it is suspended in the air it absorbs sunlight and generates heat and can affect regional cloud formation and precipitation patterns, which may have a cooling effect. Second, when deposited on snow and ice, it absorbs sunlight, generating heat and counteracting the usual reflective (cooling) effects of pure snow, thus warming both the air above and the snow and ice below, accelerating melting, and further reducing the reflective power of snow and ice cover. Its warming effects in the polar regions are of particular concern.

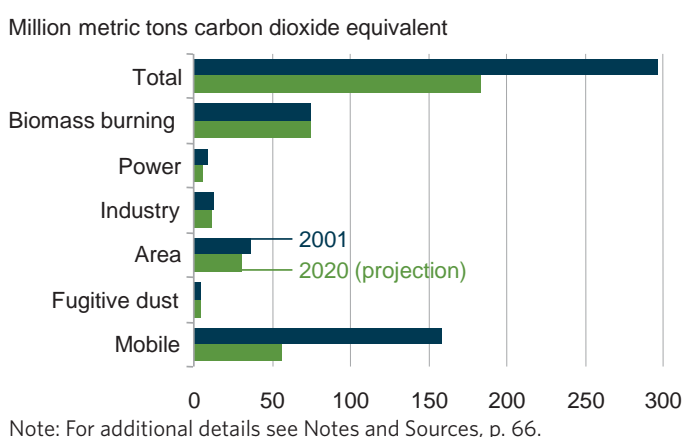
In 2010, in the Department of the Interior, Environment and Related Agencies Appropriations Act, the U.S. Congress allocated money for the EPA to conduct a study of black carbon emissions and their possible effects on climate change. The study is due to be published in April 2011.³²

Regional sources of black carbon emissions

Since 1950, the United States, Europe, and the former Soviet Union have significantly reduced black carbon emissions from fossil fuel sources.³³ U.S. emissions of black carbon—measured as elemental carbon—are estimated to have fallen by 30 percent from 1990 to 2005, when they made up about 6 percent of total world black carbon emissions.³⁴ The primary source of black carbon emissions in the United States is mobile combustion (vehicle fuels), and 90 percent of emissions in this category are from diesel fuel use. Figure 8 shows a breakdown of U.S. black carbon emissions sources in 2001 and projections for 2020. After mobile emissions, biomass combustion is the second-largest source of black carbon emissions in the United States, and its share of the total is expected to grow as diesel emissions continue to be reduced.

Technology has played a major role in reducing black carbon emissions. Important technologies include filters placed in diesel vehicle engines to capture the emissions, fuel switching (e.g., from diesel to natural gas in buses), and cleaner-burning, more

Figure 8. U.S. emissions of black carbon by source, 2001 and 2020



(continued on page 20)

³¹T. Bond and H. Sun, "Can Reducing Black Carbon Emissions Counteract Global Warming?" *Environmental Science & Technology*, Vol. 39, No. 16 (2005), p. 5922, website <http://pubs.acs.org/doi/pdfplus/10.1021/es0480421>.

³²Office of Management and Budget, Appendix, Budget of the United States Government, Fiscal Year 2011 (Washington, DC, 2010), "U.S. Environmental Protection Agency," p. 1142, website www.whitehouse.gov/sites/default/files/omb/budget/fy2011/assets/appendix.pdf.

³³T. Novakov, V. Ramanathan, J.E. Hansen, T.W. Kirchstetter, M. Sato, J. E. Sinton, and J.A. Sathaye, *Large Historical Changes of Fossil-Fuel Black Carbon Aerosols*, LBNL-50881 (Berkeley, CA: Lawrence Berkeley National Laboratory, September 2002), website <http://ies.lbl.gov/drupal/files/ies.lbl.gov.sandbox/50881.pdf>.

³⁴V. Rao and J.H. Somers, "Black Carbon as a Short-Lived Climate Forcer: A Profile of Emission Sources and Co-Emitted Pollutants," presented at the 19th Annual International Emission Inventory Conference: Emissions Inventories—Informing Emerging Issues (San Antonio, TX: September 27-30, 2010), website www.epa.gov/ttn/chieff/conference/ei19/session5/rao.pdf.

1.10. Special topic: Black carbon (continued)

efficient cook stoves in developing nations. Today, the majority of black carbon emissions come from developing countries.³⁵ The leading emitters are Asia, Latin America, and Africa.³⁶ China and India, in particular, are responsible for more than one-fourth of global black carbon pollution.³⁷ Significant sources of biomass-related emissions in the developing world include deforestation by burning, wildfires, and savannah burning.³⁸

Reducing emissions of black carbon

The United States does not have any regulations in force that are directly aimed at reducing black carbon emissions. However, some States have included black carbon emissions and corresponding reduction strategies in their Climate Action Plans.³⁹ Also, Federal rules developed to address particulate matter, a class of criteria pollutant under the Clean Air Act, and smog-forming nitrogen oxide from engines and stationary sources have the added effect of reducing black carbon emissions. Key regulations in effect include National Ambient Air Quality Standards (NAAQS) for airborne particulates, the Clean Air Highway Diesel Rule (2001), the Diesel Emissions Reduction Act (2005), and the Clean Air Visibility Rule (2005).⁴⁰ These regulations typically require the use of emission control technologies, such as particulate filters, to reduce emissions. The EPA estimates that the rules already finalized will lead to reductions in U.S. emissions of black carbon by 38 percent in 2020 from their 2001 baseline (Figure 8), primarily by achieving additional reductions in the mobile emissions sector.⁴¹ The 2020 projection assumes continued implementation of the Clean Air Nonroad Diesel Rule, the Clean Air Highway Diesel Rule, and the Clean Air Interstate Rule, among others. If all areas meet their NAAQS requirements for small-diameter particulate matter (PM_{2.5}), the reduction is projected to reach 42 percent, with total U.S. emissions of black carbon falling to 255,000 metric tons in 2020. The State of Maine estimates that the cost of reducing black carbon emissions through use of ultra-low-sulfur diesel (ULSD) and clean diesel technologies would be \$14 per ton CO₂e.⁴²

In December 2009, the United States pledged \$5 million in funding for the development and implementation of black carbon mitigation strategies for the Arctic.⁴³ The pledge came in the wake of the April 2009 Tromsø Declaration, in which the Arctic Council recognized the impacts of black carbon, methane, and other short-lived climate-forcing emissions on climate change in the Arctic.⁴⁴

International strategies to reduce emissions from deforestation, such as the Reducing Emissions from Deforestation and Forest Degradation (REDD) policies being discussed under the UNFCCC process, could also contribute to black carbon emissions reductions, particularly in the developing world.

³⁵T.C. Bond, E. Bhardwaj, R. Dong, R. Jogani, S. Jung, C. Roden, D. G. Streets, and N. M. Trautmann, "Historical Emissions of Black and Organic Carbon Aerosol from Energy-Related Combustion, 1850–2000," *Global Biogeochemical Cycles*, Vol. 21, GB2018 (May 30, 2007), Figure 6, website www.cee.mtu.edu/~nurban/classes/ce5508/2008/Readings/Bond07.pdf.

³⁶T.C. Bond, E. Bhardwaj, R. Dong, R. Jogani, S. Jung, C. Roden, D. G. Streets, and N. M. Trautmann, "Historical Emissions of Black and Organic Carbon Aerosol from Energy-Related Combustion, 1850–2000," *Global Biogeochemical Cycles*, Vol. 21, GB2018 (May 30, 2007), Figure 6, website www.cee.mtu.edu/~nurban/classes/ce5508/2008/Readings/Bond07.pdf.

³⁷T.C. Bond, E. Bhardwaj, R. Dong, R. Jogani, S. Jung, C. Roden, D. G. Streets, and N. M. Trautmann, "Historical Emissions of Black and Organic Carbon Aerosol from Energy-Related Combustion, 1850–2000," *Global Biogeochemical Cycles*, Vol. 21, GB2018 (May 30, 2007), Figure 6, website www.cee.mtu.edu/~nurban/classes/ce5508/2008/Readings/Bond07.pdf.

³⁸T.C. Bond, "Confidence and Key Uncertainties in Black Carbon Emissions & Radiative Impacts," presentation at U.S. Environmental Protection Agency, SLCF Workshop (March 3, 2010), website www.epa.gov/air/oaqps/eog/video/pdfs/bond_epa_slcf_march_3_2010.pdf.

³⁹See, for example, Maine Department of Environmental Protection, A Climate Action Plan for Maine 2004 (December 2004), website <http://mainegh.raabassociates.org/Articles/MaineClimateActionPlan2004Volume%201.pdf>.

⁴⁰M.A. Bahner, K.A. Weitz, A. Zapata, and B. DeAngelo, "Use of Black Carbon and Organic Carbon Inventories for Projections and Mitigation Analysis," presentation at 16th Annual International Emission Inventory Conference (Raleigh, NC, May 14-17, 2007), website www.epa.gov/ttn/chief/conference/ei16/session3/k.weitz.pdf; and U.S. Environmental Protection Agency, "Reducing Particle Pollution," website www.epa.gov/oar/particlepollution/reducing.html.

⁴¹M.A. Bahner, K.A. Weitz, A. Zapata, and B. DeAngelo, website www.epa.gov/ttn/chief/conference/ei16/session3/k.weitz.pdf.

⁴²Maine Department of Environmental Protection, website <http://mainegh.raabassociates.org/Articles/MaineClimateActionPlan2004Volume%201.pdf>.

⁴³U.S. Department of State, "Strategy to Reduce Black Carbon Emissions Affecting the Arctic" (December 17, 2009), website <http://cop15.state.gov/pressroom/133771.htm>.

⁴⁴The Arctic Council, "Tromsø Declaration" (April 29, 2009), website <http://arctic-council.org/filearchive/Tromsøe%20Declaration-1..pdf>.

2. Carbon dioxide emissions

2.1. Total carbon dioxide emissions

Annual U.S. carbon dioxide emissions fell by 419 million metric tons in 2009 (7.1 percent), to 5,447 million metric tons (Figure 9 and Table 6). The annual decrease—the largest over the 19-year period beginning with the 1990 baseline—puts 2009 emissions 608 million metric tons below the 2005 level, which is the Obama Administration’s benchmark year for its goal of reducing U.S. emissions by 17 percent by 2020.

The key factors contributing to the decrease in carbon dioxide emissions in 2009 included an economy in recession with a decrease in gross domestic product of 2.6 percent, a decrease in the energy intensity of the economy of 2.2 percent, and a decrease in the carbon intensity of energy supply of 2.4 percent.

Energy-related carbon dioxide emissions accounted for 98 percent of U.S. carbon dioxide emissions in 2009 (Table 6) when adjusted for bunker fuels and U.S. Territories. The predominant share of carbon dioxide emissions comes from fossil fuel combustion, with smaller amounts from the nonfuel use of energy and emissions from U.S. Territories and international bunker fuels. Other relatively small sources include emissions from industrial processes, such as cement and limestone production.

U.S. carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	5,040.9	6,055.2	5,865.5	5,446.8
Change from 1990 (million metric tons)		1,014.3	824.6	405.9
(percent)		20.1%	16.4%	8.1%
Average annual change from 1990 (percent)		1.2%	0.8%	0.4%
Change from 2005 (million metric tons)			-189.7	-608.4
(percent)			-3.1%	-10.0%
Change from 2008 (million metric tons)				-418.7
(percent)				-7.1%

Figure 9. Annual change in U.S. carbon dioxide emissions, 1991-2009

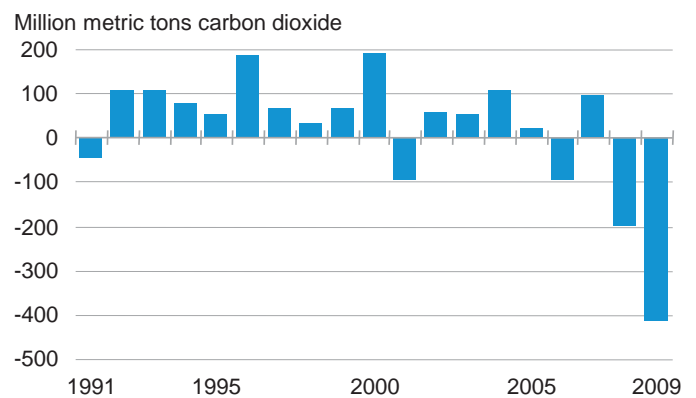


Table 6. U.S. carbon dioxide emissions from energy and industry, 1990-2009 (million metric tons carbon dioxide)

Fuel type or process	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Energy consumption										
Petroleum	2,186.6	2,207.1	2,460.6	2,518.4	2,608.6	2,627.6	2,602.5	2,603.2	2,443.5	2,318.8
Coal	1,821.4	1,913.1	2,155.5	2,135.7	2,160.2	2,181.9	2,146.9	2,172.2	2,139.4	1,876.8
Natural gas	1,024.6	1,183.7	1,240.6	1,191.1	1,194.4	1,175.2	1,157.0	1,234.7	1,243.0	1,218.0
Renewables ^a	6.2	10.3	10.5	11.8	11.5	11.6	11.9	11.7	12.0	12.0
<i>Energy subtotal</i>	<i>5,038.7</i>	<i>5,314.3</i>	<i>5,867.2</i>	<i>5,856.9</i>	<i>5,974.7</i>	<i>5,996.4</i>	<i>5,918.3</i>	<i>6,021.8</i>	<i>5,838.0</i>	<i>5,425.6</i>
Nonfuel use emissions ^b	94.1	101.9	105.5	97.3	105.0	100.7	103.5	101.7	97.7	82.8
Nonfuel use sequestration ^c	250.0	283.6	306.0	290.0	313.4	303.5	299.8	292.1	264.4	245.7
Adjustments to energy ^d	-82.9	-63.2	-64.7	-32.6	-45.3	-44.6	-62.7	-67.5	-76.1	-66.0
<i>Adjusted energy subtotal</i>	<i>4,955.9</i>	<i>5,251.1</i>	<i>5,802.6</i>	<i>5,824.3</i>	<i>5,929.3</i>	<i>5,951.8</i>	<i>5,855.7</i>	<i>5,954.2</i>	<i>5,761.9</i>	<i>5,359.6</i>
Other sources	85.1	102.3	97.8	98.9	102.0	103.5	105.9	105.3	103.6	87.3
Total	5,040.9	5,353.4	5,900.3	5,923.3	6,031.3	6,055.2	5,961.6	6,059.5	5,865.5	5,446.8

^aIncludes emissions from electricity generation using nonbiogenic municipal solid waste and geothermal energy.

^bEmissions from nonfuel uses are included in the energy subtotal above.

^cThe energy content of nonfuel uses in which carbon is sequestered is subtracted from energy consumption before emissions are calculated.

^dAdjustments include adding emissions from U.S. Territories and subtracting emissions from international bunker fuels, in keeping with international practices.

Note: Totals may not equal sum of components due to independent rounding.

2.2. Energy-related carbon dioxide emissions

Energy-related carbon dioxide emissions account for more than 80 percent of U.S. greenhouse gas emissions. These emissions were down by 7.1 percent from 5,838 million metric tons in 2008 to 5,426 million metric tons in 2009. EIA breaks energy use into four end-use sectors (Table 7), and emissions from the electric power sector are attributed to the end-use sectors based on electricity sales to each sector. Growth in energy-related carbon dioxide emissions since 1990 has resulted largely from increases associated with electric power generation and transportation fuel use. All other energy-related carbon dioxide emissions (from direct fuel use in the residential, commercial, and industrial sectors) have been either flat or declining in recent years (Figure 10). In 2009, however, emissions from both electric power and transportation fuel use were down—by 9.0 percent and 4.3 percent, respectively—continuing a trend from 2008.

Reasons for the long-term growth in electric power and transportation sector emissions include: population growth; increased demand for electricity for computers and electronics in homes and offices; strong growth in demand for commercial lighting and cooling; substitution of new electricity-intensive technologies, such as electric arc furnaces for steelmaking in the industrial sector; and increased travel as a result of relatively low fuel prices and robust economic growth in the 1990s and early 2000s. Likewise, the recent declines in emissions from both the transportation and electric power sectors are tied to the economy, with people driving less and consuming less electricity over the years 2008 and 2009.

Other sources of U.S. energy-related carbon dioxide emissions have remained constant or declined, for reasons that include increased efficiencies in heating technologies, declining activity in older “smokestack” industries (such as steel, paper, and chemicals), and the growth of less energy-intensive industries, such as computers and electronics.

U.S. energy-related carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	5,038.7	5,996.4	5,838.0	5,425.6
Change from 1990 (million metric tons)		957.7	799.2	386.9
(percent)		19.0%	15.9%	7.7%
Average annual change from 1990 (percent)		1.2%	0.8%	0.4%
Change from 2005 (million metric tons)			-158.4	-570.8
(percent)			-2.6%	-9.5%
Change from 2008 (million metric tons)				-412.4
(percent)				-7.1%

Figure 10. Energy-related carbon dioxide emissions for selected sectors, 1990-2009

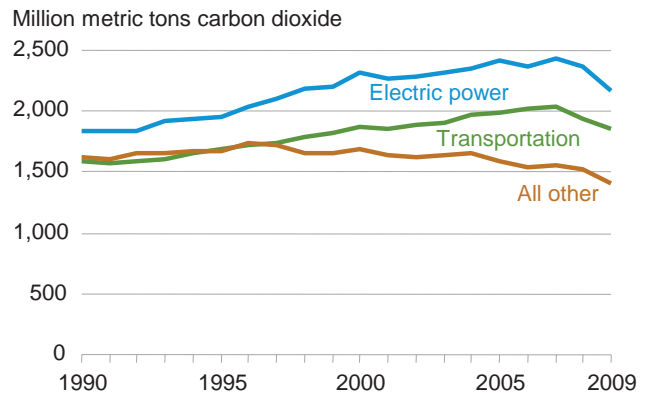


Table 7. U.S. energy-related carbon dioxide emissions by end-use sector, 1990-2009 (million metric tons carbon dioxide)

Sector	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Residential	963.4	1,039.1	1,185.1	1,230.1	1,227.8	1,261.5	1,192.0	1,242.0	1,229.0	1,162.2
Commercial	792.6	851.4	1,022.0	1,036.0	1,053.5	1,069.0	1,043.4	1,078.6	1,073.5	1,003.6
Industrial	1,695.1	1,742.8	1,788.1	1,691.9	1,731.1	1,675.2	1,661.1	1,661.6	1,597.6	1,405.4
Transportation	1,587.7	1,681.0	1,872.0	1,898.9	1,962.3	1,990.7	2,021.9	2,039.6	1,937.9	1,854.5
Total	5,038.7	5,314.3	5,867.2	5,856.9	5,974.7	5,996.4	5,918.3	6,021.8	5,838.0	5,425.6
Electricity generation ^a	1,831.0	1,960.1	2,310.2	2,319.2	2,351.5	2,416.9	2,359.5	2,425.9	2,373.7	2,160.3

^aElectric power sector emissions are distributed across the end-use sectors. Emissions allocated to sectors are unadjusted for U.S. Territories and international bunker fuels. Adjustments are made to total emissions only.

Note: Totals may not equal sum of components due to independent rounding.

2.3. Residential sector carbon dioxide emissions

Residential sector carbon dioxide emissions originate primarily from:

- Direct fuel consumption (principally, natural gas) for heating and cooking
- Electricity for cooling (and heating), appliances, lighting, and increasingly for televisions, computers, and other household electronic devices (Table 8).

Energy consumed for heating and cooling in homes and businesses has a large influence on annual fluctuations in energy-related carbon dioxide emissions because of variability in the weather as measured by heating and cooling degree-days. In 2009, heating degree-days were down slightly from 2008 (Figure 11). Although annual changes in cooling degree-days have a smaller impact on energy demand, the 4-percent decrease in 2009 helped to reduce emissions further.

In the longer run, residential emissions are affected by population growth, income, and other factors. From 1990 to 2009:

- Residential sector carbon dioxide emissions grew by an average of 1.0 percent per year.
- U.S. population is estimated to have grown by an average of about 1.1 percent per year.
- Income per capita (measured in constant dollars) grew by an average of 1.4 percent per year.
- Energy efficiency improvements for homes and appliances offset much of the growth in the number and size of housing units. As a result, direct emissions of carbon dioxide from the consumption of petroleum, coal, and natural gas in the residential sector in 2009 were up by only 0.9 percent from the 1990 level.

Residential sector carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	963.4	1,261.5	1,229.0	1,162.2
Change from 1990 (million metric tons)		298.1	265.6	198.8
(percent)		30.9%	27.6%	20.6%
Average annual change from 1990 (percent)		1.8%	1.4%	1.0%
Change from 2005 (million metric tons)			-32.5	-99.3
(percent)			-2.6%	-7.9%
Change from 2008 (million metric tons)				-66.8
(percent)				-5.4%

Figure 11. Annual changes in U.S. heating degree-days and residential sector carbon dioxide emissions from direct fuel combustion, 1990-2009

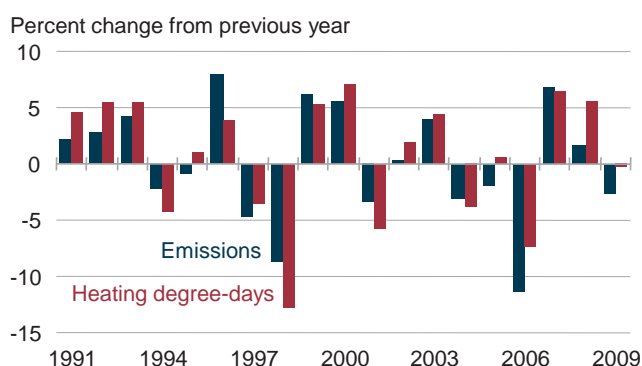


Table 8. U.S. carbon dioxide emissions from residential sector energy consumption, 1990-2009 (million metric tons carbon dioxide)

Fuel	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Petroleum										
Liquefied petroleum gas	22.2	24.9	35.0	34.3	32.3	32.3	28.1	30.5	34.9	36.5
Distillate fuel	71.6	66.2	66.2	66.2	67.6	62.5	52.1	53.1	48.5	44.5
Kerosene	4.6	5.4	6.8	5.1	6.1	6.1	4.8	3.2	1.5	1.9
<i>Petroleum subtotal</i>	<i>98.4</i>	<i>96.5</i>	<i>108.0</i>	<i>105.6</i>	<i>106.0</i>	<i>100.9</i>	<i>85.0</i>	<i>86.8</i>	<i>84.9</i>	<i>82.9</i>
Coal	3.0	1.7	1.1	1.2	1.1	0.8	0.6	0.7	0.7	0.6
Natural gas	238.3	262.9	270.8	276.4	264.3	262.4	237.5	257.3	265.8	259.1
Electricity ^a	623.7	678.1	805.2	846.9	856.4	897.3	868.9	897.2	877.5	819.5
Total	963.4	1,039.1	1,185.1	1,230.1	1,227.8	1,261.5	1,192.0	1,242.0	1,229.0	1,162.2

^aShare of total electric power sector carbon dioxide emissions weighted by sales to the residential sector.

Note: Totals may not equal sum of components due to independent rounding.

2.4. Commercial sector carbon dioxide emissions

In the commercial sector, carbon dioxide emissions result largely from energy use for lighting, heating, and cooling in commercial structures, such as office buildings, shopping malls, schools, hospitals, and restaurants.

Commercial sector emissions declined by 6.5 percent in 2009.

Lighting accounts for a larger component of energy demand in the commercial sector (approximately 18 percent of total demand in 2008) than in the residential sector (approximately 11 percent of total demand).

Commercial sector emissions are affected less by weather than are residential sector emissions: heating and cooling accounted for approximately 37 percent of energy demand in the residential sector in 2008 but only about 21 percent in the commercial sector.

In the longer run, trends in commercial sector emissions parallel trends in population growth and the economy. Commercial sector emissions grew at an average annual rate of 1.2 percent from 1990 to 2009—slightly less than the average growth of 1.4 percent per year in real income per capita (Figure 12).

Emissions from direct fuel consumption in the commercial sector declined from 1990 to 2009 (Table 9), while the sector's electricity-related emissions increased by an average of 1.7 percent per year.

Commercial sector carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	792.6	1,069.0	1,073.5	1,003.6
Change from 1990 (million metric tons)		276.4	280.8	210.9
(percent)		34.9%	35.4%	26.6%
Average annual change from 1990 (percent)		2.0%	1.7%	1.2%
Change from 2005 (million metric tons)			4.4	-65.5
(percent)			0.4%	-6.1%
Change from 2008 (million metric tons)				-69.9
(percent)				-6.5%

Figure 12. U.S. commercial sector carbon dioxide emissions and per capita income, 1990-2009

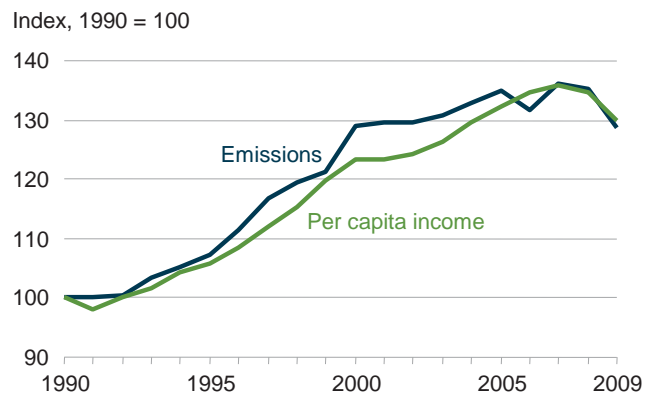


Table 9. U.S. carbon dioxide emissions from commercial sector energy consumption, 1990-2009 (million metric tons carbon dioxide)

Fuel	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Petroleum										
Motor gasoline	7.9	1.3	3.1	4.2	3.1	3.2	3.4	4.2	3.1	3.1
Liquefied petroleum gas	6.5	6.9	9.5	9.9	9.6	8.3	7.8	7.7	10.0	10.4
Distillate fuel	39.2	35.0	35.9	35.2	34.4	32.7	29.4	28.1	27.0	24.7
Residual fuel	18.1	11.1	7.2	8.8	9.7	9.1	5.9	5.9	5.8	4.9
Kerosene	0.9	1.6	2.1	1.3	1.5	1.6	1.1	0.7	0.3	0.4
<i>Petroleum subtotal^a</i>	72.5	55.9	57.9	59.4	58.3	54.9	47.6	46.6	46.1	43.6
Coal	12.0	11.2	8.8	7.8	9.8	9.3	6.2	6.7	6.5	5.8
Natural gas	142.3	164.3	172.5	173.0	169.8	163.1	154.0	164.2	171.3	169.1
Electricity ^b	565.9	620.0	782.8	795.8	815.6	841.8	835.6	861.1	849.5	785.1
Total	792.6	851.4	1,022.0	1,036.0	1,053.5	1,069.0	1,043.4	1,078.6	1,073.5	1,003.6

^aIncludes small amounts of petroleum coke.

^bShare of total electric power sector carbon dioxide emissions weighted by sales to the commercial sector.

Note: Totals may not equal sum of components due to independent rounding.

2.5. Energy-related industrial sector carbon dioxide emissions

Trends in U.S. industrial sector emissions are closely tied to economic output in energy-intensive manufacturing. In 2009, industrial carbon dioxide emissions fell by 12.0 percent from their 2008 level and were 17.1 percent (290 million metric tons) below their 1990 level (Table 10). Decreases in industrial sector carbon dioxide emissions have resulted largely from a structural shift away from energy-intensive manufacturing in the U.S. economy. The share of manufacturing activity represented by less energy-intensive industries, such as computer chip and electronic component manufacturing, has increased, while the share represented by the more energy-intensive industries has fallen.

Coke plants consumed 15 million short tons of coal in 2009, down from 39 million short tons in 1990. Other industrial coal consumption declined from 76 million short tons in 1990 to 45 million short tons in 2009, as reflected by a drop in emissions from coal use (Figure 13). From 1990 to 2009, coal use in the industrial sector declined by 47 percent.

Emissions from coal, natural gas, and total petroleum use in 2009 all were below their 1990 levels, although emissions from the combustion of some petroleum products were above their 1990 levels.

Industrial sector carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	1,695.1	1,675.2	1,597.6	1,405.4
Change from 1990 (million metric tons)		-19.9	-97.4	-289.6
(percent)		-1.2%	-5.7%	-17.1%
Average annual change from 1990 (percent)		-0.1%	-0.3%	-1.0%
Change from 2005 (million metric tons)			-77.5	-269.7
(percent)			-4.6%	-16.1%
Change from 2008 (million metric tons)				-192.2
(percent)				-12.0%

Figure 13. U.S. industrial sector carbon dioxide emissions and major industrial fuel use, 1990-2009

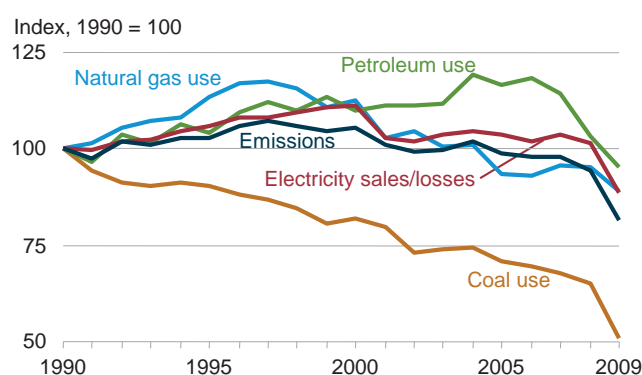


Table 10. U.S. carbon dioxide emissions from industrial sector energy consumption, 1990-2009 (million metric tons carbon dioxide)

Fuel	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Petroleum										
Motor gasoline	13.2	14.1	10.6	22.7	26.0	24.8	26.1	21.2	17.0	16.9
Liquefied petroleum gas	38.9	45.4	56.4	50.0	55.2	51.3	55.7	54.4	41.8	41.1
Distillate fuel	83.9	82.4	87.4	82.6	88.3	91.8	91.7	91.9	92.0	84.4
Residual fuel	30.6	24.5	17.0	15.5	17.5	19.9	16.4	13.2	13.6	11.6
Lubricants	6.9	6.6	7.0	5.9	6.0	5.9	5.8	6.0	5.6	5.0
Kerosene	0.9	1.1	1.1	1.7	2.0	2.8	2.1	1.0	0.3	0.4
Petroleum coke	63.8	66.9	74.1	76.0	82.1	79.7	82.2	80.0	76.2	73.0
Other	127.3	113.6	116.8	139.7	141.6	140.6	150.2	147.6	129.7	110.7
Petroleum subtotal	365.5	354.7	370.4	394.1	418.6	416.8	430.4	415.4	376.2	343.1
Coal	258.4	232.5	210.8	189.9	190.5	182.9	179.4	174.6	168.2	130.9
Coal coke net imports	0.5	7.0	7.5	5.8	15.7	5.0	6.9	2.9	4.7	-2.7
Natural gas	432.4	490.0	480.8	430.0	431.5	397.5	394.2	406.3	406.9	383.1
Electricity ^a	638.3	658.7	718.6	672.0	674.7	672.8	650.2	662.3	641.8	551.0
Total^b	1,695.1	1,742.8	1,788.1	1,691.9	1,731.1	1,675.2	1,661.1	1,661.6	1,597.6	1,405.4

^aShare of total electric power sector carbon dioxide emissions weighted by sales to the industrial sector.

^bIncludes emissions from nonfuel uses of fossil fuels. See Table 14 for details by fuel category.

Note: Totals may not equal sum of components due to independent rounding.

2.6. Transportation sector carbon dioxide emissions

Carbon dioxide emissions from the U.S. transportation sector in 2009 were 81 million metric tons lower than in 2008 but still 267 million metric tons higher than in 1990 (Table 11).

The transportation sector has led all U.S. end-use sectors in emissions of carbon dioxide since 1999; however, with a decline in economic growth in 2009, emissions from the transportation sector fell by 4.3 percent from their 2008 level, which in turn were down from 2007.

Petroleum combustion is by far the largest source of carbon dioxide emissions in the transportation sector.

Increases in the consumption of ethanol fuel in recent years have mitigated the growth in transportation sector emissions. (Reported emissions from energy inputs to ethanol production plants are counted in the industrial sector.)

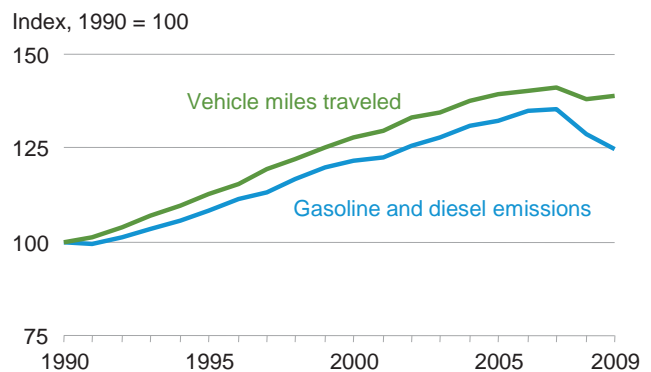
Emissions from gasoline and diesel fuel combustion in the transportation sector generally have paralleled total vehicle miles traveled since 1990 (Figure 14). In 2009, however, vehicles miles traveled rose slightly while combined emissions from gasoline and diesel fuel declined—likely as a result of more efficient vehicles and increased consumption of biofuels.

The transportation sector has dominated the growth in U.S. carbon dioxide emissions since 1990, accounting for 69 percent of the total increase in U.S. energy-related carbon dioxide emissions.

Transportation sector carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	1,587.7	1,990.7	1,937.9	1,854.5
Change from 1990 (million metric tons)		403.1	350.2	266.8
(percent)		25.4%	22.1%	16.8%
Average annual change from 1990 (percent)		1.5%	1.1%	0.8%
Change from 2005 (million metric tons)			-52.9	-136.3
(percent)			-2.7%	-6.8%
Change from 2008 (million metric tons)				-83.4
(percent)				-4.3%

Figure 14. U.S. vehicle miles traveled and carbon dioxide emissions from gasoline and diesel transportation fuel use, 1990-2009



**Table 11. U.S. carbon dioxide emissions from transportation sector energy consumption, 1990-2009
(million metric tons carbon dioxide)**

Fuel	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Petroleum										
Motor gasoline	966.8	1,028.6	1,121.3	1,161.5	1,184.6	1,186.1	1,194.4	1,201.2	1,146.0	1,137.5
Liquefied petroleum gas	1.4	1.1	0.8	1.0	1.2	1.8	1.7	1.4	2.5	2.6
Jet fuel	222.6	222.1	253.8	231.5	239.8	246.3	239.5	238.0	226.3	204.4
Distillate fuel	267.8	306.9	377.8	414.5	433.9	444.4	469.2	472.3	441.8	404.7
Residual fuel	80.1	71.7	69.9	45.0	58.3	66.0	71.4	78.3	72.5	59.9
Lubricants ^a	6.5	6.2	6.7	5.6	5.6	5.6	5.5	5.6	5.2	4.7
Aviation gasoline	3.1	2.7	2.5	2.1	2.2	2.4	2.3	2.2	2.0	1.8
<i>Petroleum subtotal</i>	<i>1,548.4</i>	<i>1,639.3</i>	<i>1,832.8</i>	<i>1,861.1</i>	<i>1,925.6</i>	<i>1,952.7</i>	<i>1,984.0</i>	<i>1,999.0</i>	<i>1,896.3</i>	<i>1,815.7</i>
Coal ^b	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas	36.1	38.4	35.7	33.3	31.9	33.1	33.2	35.3	36.7	34.1
Electricity ^c	3.2	3.2	3.6	4.5	4.8	5.0	4.7	5.3	4.9	4.7
Total	1,587.7	1,681.0	1,872.0	1,898.9	1,962.3	1,990.7	2,021.9	2,039.6	1,937.9	1,854.5

^aIncludes emissions from nonfuel uses of fossil fuels. See Table 14 for details by fuel category.

^bSmall amounts of coal consumed for transportation are reported as industrial sector consumption.

^cShare of total electric power sector carbon dioxide emissions weighted by sales to the transportation sector.

Note: Totals may not equal sum of components due to independent rounding.

2.7. Electric power sector carbon dioxide emissions

The electric power sector consists of companies whose primary business is the generation of electricity. Since about 2000, as a result of changes in the fuel mix and efficiency improvements, electricity sales growth has outpaced the growth in emissions from the power sector (Figure 15).

Carbon dioxide emissions from U.S. electric power generation declined by 9.0 percent in 2009 (Table 12). The drop resulted from a 4.1-percent decrease in the sector's total electricity generation and a 5.1-percent reduction in the carbon intensity of the electricity supply. The lower overall carbon intensity of power generation in 2009 was, in part, the result of a 33.5-percent increase (19 billion kilowatthours) in generation from wind resources. Although there was a slight drop in generation from nuclear power plants, hydroelectric generation increased by 7.3 percent, and total generation from all the energy sources that produce no direct carbon dioxide emissions increased by 2.7 percent from 2008.

Although electric power sector generation from all fossil fuels in 2009 was 196 billion kilowatthours lower than in 2008 (7.0 percent), generation from natural gas, the least carbon-intensive fossil fuel, increased by 4.8 percent.

Electric power sector carbon dioxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	1,831.0	2,416.9	2,373.7	2,160.3
Change from 1990 (million metric tons)		585.8	542.7	329.3
(percent)		32.0%	29.6%	18.0%
Average annual change from 1990 (percent)		1.9%	1.5%	0.9%
Change from 2005 (million metric tons)			-43.1	-256.5
(percent)			-1.8%	-10.6%
Change from 2008 (million metric tons)				-213.4
(percent)				-9.0%

Figure 15. U.S. electric power sector energy sales and losses and carbon dioxide emissions from primary fuel combustion, 1990-2009

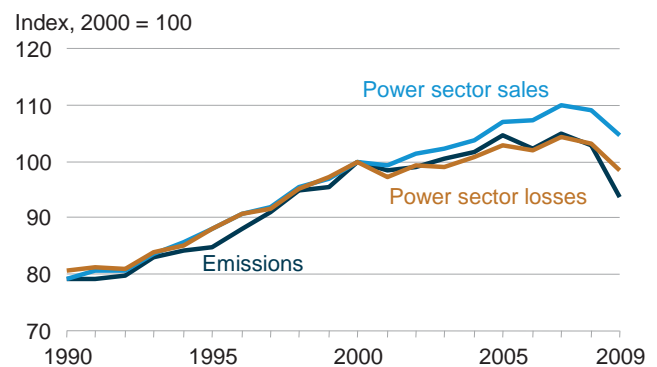


Table 12. U.S. carbon dioxide emissions from electric power sector energy consumption, 1990-2009 (million metric tons carbon dioxide)

Fuel	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Petroleum										
Residual fuel oil	91.6	44.6	68.6	68.5	69.3	69.1	28.4	31.3	18.9	14.3
Distillate fuel oil	7.1	7.9	12.8	11.8	8.1	8.4	5.4	6.5	5.3	5.1
Petroleum coke	3.1	8.2	10.1	17.8	22.7	24.9	21.8	17.5	15.7	14.2
<i>Petroleum subtotal</i>	<i>101.8</i>	<i>60.7</i>	<i>91.5</i>	<i>98.1</i>	<i>100.1</i>	<i>102.3</i>	<i>55.6</i>	<i>55.3</i>	<i>40.0</i>	<i>33.6</i>
Coal	1,547.6	1,660.7	1,927.4	1,931.0	1,943.1	1,983.8	1,953.7	1,987.3	1,959.4	1,742.2
Natural gas	175.5	228.2	280.9	278.3	296.8	319.1	338.2	371.7	362.3	372.6
Municipal solid waste ^a	5.8	10.0	10.1	11.4	11.2	11.2	11.5	11.3	11.6	11.6
Geothermal	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	1,831.0	1,960.1	2,310.2	2,319.2	2,351.5	2,416.9	2,359.5	2,425.9	2,373.7	2,160.3

^aEmissions from nonbiogenic sources, including fuels derived from recycled tires.

Notes: Emissions for total fuel consumption are allocated to end-use sectors in proportion to electricity sales. Totals may not equal sum of components due to independent rounding.

2.8. Carbon dioxide emissions and carbon sequestration from nonfuel uses of energy inputs

Nonfuel uses of fossil fuels (for purposes other than their energy value) create carbon dioxide emissions and also sequester carbon in nonfuel products, such as plastics.

In 2009, carbon dioxide emissions from nonfuel uses of energy inputs totaled 83 million metric tons—15.3 percent below the 2008 total (Table 13). Carbon sequestration from nonfuel uses of energy inputs in 2009 included 246 million metric tons carbon dioxide equivalent (CO₂e) that was sequestered in nonfuel products rather than emitted to the atmosphere (Table 14). The 2009 sequestration total was 7.0 percent below the 2008 total.

Carbon dioxide emissions from nonfuel uses of energy inputs, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	97.1	102.2	97.7	82.8
Change from 1990 (million metric tons)		5.1	0.5	-14.4
(percent)		5.3%	0.6%	-14.8%
Average annual change from 1990 (percent)		0.3%	0.0%	-0.8%
Change from 2005 (million metric tons)			-4.6	-19.5
(percent)			-4.5%	-19.1%
Change from 2008 (million metric tons)				-14.9
(percent)				-15.3%

Carbon sequestration from nonfuel uses of energy inputs, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated sequestration (million metric tons)	252.8	305.1	264.4	245.7
Change from 1990 (million metric tons)		52.2	11.5	-7.1
(percent)		20.7%	4.6%	-2.8%
Average annual change from 1990 (percent)		1.3%	0.2%	-0.1%
Change from 2005 (million metric tons)			-40.7	-59.3
(percent)			-13.3%	-19.4%
Change from 2008 (million metric tons)				-18.6
(percent)				-7.0%

Table 13. U.S. carbon dioxide emissions from nonfuel uses of energy fuels, 1990-2009 (million metric tons carbon dioxide)

End use and type	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Industrial										
Petroleum										
Liquefied petroleum gas	14.8	19.5	20.4	19.0	19.4	18.3	18.7	18.9	17.7	18.6
Distillate fuel oil	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6
Residual fuel oil	1.9	2.1	2.0	1.9	2.1	2.3	2.5	2.0	2.1	1.7
Lubricants	6.9	6.6	7.0	5.9	6.0	5.9	5.8	6.0	5.6	5.0
Pentanes plus	1.1	4.1	3.2	2.3	2.3	2.0	1.4	1.8	1.6	1.3
Petrochemical feed	33.6	36.0	36.8	36.5	41.8	38.4	40.1	37.1	32.2	25.1
Petroleum coke	9.1	6.8	7.2	8.2	13.3	11.1	13.1	12.5	12.4	8.5
Special naphtha	7.8	5.2	7.1	5.9	3.7	4.6	5.1	5.7	6.2	3.4
<i>Petroleum subtotal</i>	<i>75.5</i>	<i>80.5</i>	<i>84.1</i>	<i>80.2</i>	<i>89.0</i>	<i>83.2</i>	<i>87.3</i>	<i>84.7</i>	<i>78.4</i>	<i>64.2</i>
Coal	0.5	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.3
Natural gas	14.7	17.5	16.3	13.0	11.9	12.9	12.4	12.7	13.6	13.5
<i>Industrial subtotal</i>	<i>90.6</i>	<i>98.7</i>	<i>101.0</i>	<i>93.7</i>	<i>101.4</i>	<i>96.6</i>	<i>100.2</i>	<i>97.8</i>	<i>92.4</i>	<i>78.1</i>
Transportation										
Lubricants	6.5	6.2	6.7	5.6	5.6	5.6	5.5	5.6	5.2	4.7
Total	97.1	104.9	107.6	99.3	107.1	102.2	105.7	103.5	97.7	82.8

Notes: Emissions from nonfuel use of energy fuels are included in the energy consumption tables in this chapter. Totals may not equal sum of components due to independent rounding.

**Table 14. U.S. carbon sequestration from nonfuel uses of energy fuels, 1990-2009
(million metric tons carbon dioxide equivalent)**

End use and type	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Industrial										
Petroleum										
Liquefied petroleum gas	59.2	78.2	81.7	76.0	77.6	73.2	74.6	75.8	70.9	74.4
Distillate fuel oil	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6
Residual fuel oil	1.9	2.1	2.0	1.9	2.1	2.3	2.5	2.0	2.1	1.7
Asphalt and road oil	88.5	89.1	96.4	92.2	98.6	100.0	95.4	90.5	76.5	66.0
Lubricants	6.9	6.6	7.0	5.9	6.0	5.9	5.8	6.0	5.6	5.0
Pentanes plus	4.4	16.2	12.7	9.0	9.1	8.0	5.7	7.4	6.3	5.2
Petrochemical feed	46.0	50.0	57.7	59.2	69.1	64.2	63.2	57.5	49.9	46.0
Petroleum coke	9.1	6.8	7.2	8.2	13.3	11.1	13.1	12.5	12.4	8.5
Waxes and miscellaneous	12.6	10.2	11.2	11.6	10.7	10.7	12.0	11.5	12.0	12.2
<i>Petroleum subtotal</i>	<i>228.9</i>	<i>259.3</i>	<i>276.4</i>	<i>264.6</i>	<i>287.0</i>	<i>276.2</i>	<i>273.0</i>	<i>263.8</i>	<i>236.2</i>	<i>219.7</i>
Coal	1.4	2.1	1.8	1.5	1.5	1.5	1.4	1.4	1.4	1.0
Natural gas	16.0	19.0	23.3	20.3	21.4	21.8	22.1	23.0	21.5	20.4
<i>Industrial subtotal</i>	<i>246.3</i>	<i>280.4</i>	<i>301.5</i>	<i>286.4</i>	<i>309.9</i>	<i>299.5</i>	<i>296.6</i>	<i>288.2</i>	<i>259.1</i>	<i>241.0</i>
Transportation										
Lubricants	6.5	6.2	6.7	5.6	5.6	5.6	5.5	5.6	5.2	4.7
Total	252.8	286.6	308.2	292.0	315.5	305.1	302.0	293.8	264.4	245.7

Notes: Emissions from nonfuel use of energy fuels are included in the energy consumption tables in this chapter. Totals may not equal sum of components due to independent rounding.

2.9. Adjustments to energy consumption

EIA's greenhouse gas emissions inventory includes two adjustments to energy-related carbon dioxide emissions (Table 15). First, the unadjusted energy consumption and carbon dioxide emissions data in this report correspond to EIA's coverage of energy consumption, which includes the 50 States and the District of Columbia; but under the UNFCCC, the United States is also responsible for emissions emanating from its Territories. Therefore, emissions from the Territories are added as an adjustment to the U.S. total. Second, because the UNFCCC definition of energy consumption excludes international bunker fuels, emissions from international bunker fuels are subtracted from the U.S. total. Similarly, emissions from military bunker fuels are also subtracted from the U.S. total.

The net adjustment in emissions has been negative in every year from 1990 to 2009, because emissions from international and military bunker fuels have exceeded emissions from U.S. Territories in each of the years. The net negative adjustment for 2009 was 66 million metric tons.

Carbon dioxide emissions from U.S. territories,* 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	31.6	58.4	49.5	47.4
Change from 1990 (million metric tons)		26.8	17.9	15.7
(percent)		84.7%	56.6%	49.8%
Average annual change from 1990 (percent)		4.2%	2.5%	2.1%
Change from 2005 (million metric tons)			-8.9	-11.1
(percent)			-15.2%	-18.9%
Change from 2008 (million metric tons)				-2.2
(percent)				-4.4%

*Added to total U.S. emissions.

Carbon dioxide emissions from international bunker fuels,* 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	114.5	103.0	125.6	113.4
Change from 1990 (million metric tons)		-11.5	11.1	-1.1
(percent)		-10.0%	9.7%	-1.0%
Average annual change from 1990 (percent)		-0.7%	0.5%	-0.1%
Change from 2005 (million metric tons)			22.6	10.4
(percent)			21.9%	10.1%
Change from 2008 (million metric tons)				-12.2
(percent)				-9.7%

*Subtracted from total U.S. emissions.

Table 15. U.S. carbon dioxide emissions: adjustments for U.S. Territories and international bunker fuels, 1990-2009
(million metric tons carbon dioxide)

Adjusted category	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Emissions from U.S. Territories										
Puerto Rico	20.2	24.3	27.7	37.5	38.2	37.8	37.9	36.6	31.7	30.8
U.S. Virgin Islands	7.5	8.6	9.8	15.3	18.4	16.3	17.3	16.5	13.9	12.7
American Samoa	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Guam	1.8	3.6	2.9	2.4	2.0	2.1	2.3	2.1	1.7	1.7
U.S. Pacific Islands	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Wake Island	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2
<i>U.S. Territories subtotal^a</i>	<i>31.6</i>	<i>38.6</i>	<i>42.6</i>	<i>57.4</i>	<i>60.7</i>	<i>58.4</i>	<i>59.6</i>	<i>57.3</i>	<i>49.5</i>	<i>47.4</i>
Emissions from bunker fuels										
Marine bunkers (<i>subtotal</i>)	<i>62.7</i>	<i>47.0</i>	<i>37.9</i>	<i>20.0</i>	<i>29.6</i>	<i>29.8</i>	<i>50.3</i>	<i>51.5</i>	<i>56.1</i>	<i>52.0</i>
Distillate fuel	6.3	5.8	2.9	1.5	1.7	2.4	3.1	3.6	4.5	4.3
Residual fuel	56.4	41.2	35.0	18.5	27.9	27.4	47.2	47.9	51.6	47.7
Aviation bunkers (<i>subtotal</i>)	<i>38.4</i>	<i>45.8</i>	<i>61.3</i>	<i>60.7</i>	<i>66.2</i>	<i>63.9</i>	<i>63.9</i>	<i>64.8</i>	<i>61.3</i>	<i>53.2</i>
U.S. carriers	18.7	21.3	26.2	23.4	26.7	28.6	28.8	29.7	29.6	27.3
Foreign carriers	19.7	24.5	35.1	37.3	39.5	35.3	35.1	35.2	31.7	25.9
Military bunkers (<i>subtotal</i>)	<i>13.4</i>	<i>9.0</i>	<i>8.0</i>	<i>9.3</i>	<i>10.3</i>	<i>9.3</i>	<i>8.1</i>	<i>8.5</i>	<i>8.2</i>	<i>8.2</i>
<i>Bunker fuels subtotal^b</i>	<i>114.5</i>	<i>101.8</i>	<i>107.3</i>	<i>90.0</i>	<i>106.1</i>	<i>103.0</i>	<i>122.3</i>	<i>124.8</i>	<i>125.6</i>	<i>113.4</i>
Total	-82.9	-63.2	-64.7	-32.6	-45.3	-44.6	-62.7	-67.5	-76.1	-66.0

^aAdded to total U.S. emissions.

^bSubtracted from total U.S. emissions.

Note: Totals may not equal sum of components due to independent rounding.

2.10. Other carbon dioxide emissions sources

“Other emissions sources” in total accounted for 87 million metric tons of carbon dioxide in 2009, or less than 2 percent of the U.S. total.

In 2009, the second-largest source of U.S. carbon dioxide emissions (after fossil fuel consumption) was natural gas production (Figure 16 and Table 16), which includes flaring of natural gas at the wellhead and “scrubbing” of carbon dioxide from natural gas after it has been produced.

Cement manufacture, where most emissions result from the production of clinker (consisting of calcium carbonate sintered with silica in a cement kiln to produce calcium silicate), was the fourth-largest source of U.S. carbon dioxide emissions in 2009, after energy, nonfuel use of fossil fuels, and natural gas production.

Limestone consumption, especially for lime manufacture, is the source of 14 to 20 million metric tons of carbon dioxide emissions per year.

In addition, “other sources” of U.S. carbon dioxide emissions include soda ash manufacture and consumption; carbon dioxide manufacture; aluminum manufacture; and waste combustion in the commercial and industrial sectors.

U.S. carbon dioxide emissions from other sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons)	85.1	103.5	103.6	87.3
Change from 1990 (million metric tons)		18.4	18.5	2.2
(percent)		21.6%	21.8%	2.6%
Average annual change from 1990 (percent)		1.3%	1.1%	0.1%
Change from 2005 (million metric tons)			0.2	-16.2
(percent)			0.2%	-15.6%
Change from 2008 (million metric tons)				-16.3
(percent)				-15.8%

Figure 16. U.S. carbon dioxide emissions from other sources, 2009

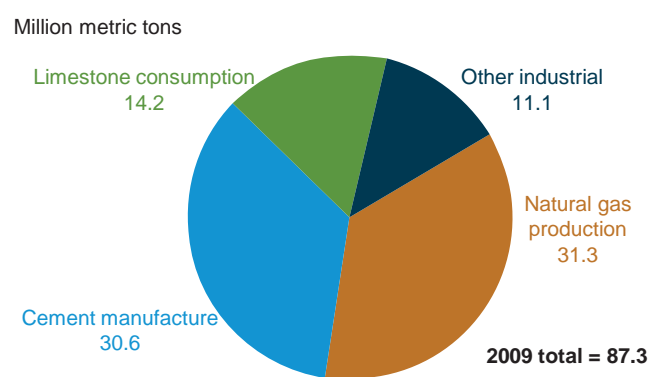


Table 16. U.S. carbon dioxide emissions from other sources, 1990-2009
(million metric tons carbon dioxide)

Fuel	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Cement manufacture										
Clinker production	32.6	36.1	40.4	42.2	44.7	45.1	45.7	44.4	40.4	30.0
Masonry cement	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	*
Cement kiln dust	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.8	0.6
<i>Cement manufacture subtotal</i>	33.3	36.9	41.3	43.2	45.7	46.1	46.7	45.4	41.3	30.6
Limestone consumption										
Lime manufacture	12.4	14.5	15.4	15.1	15.7	15.7	16.5	15.9	15.6	11.8
Iron smelting	1.7	1.2	1.1	0.9	1.0	0.8	0.9	0.8	0.8	0.4
Steelmaking	0.3	0.5	0.5	0.4	0.4	0.3	0.4	0.3	0.3	0.2
Copper refining	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Glass manufacture	0.1	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Flue gas desulfurization	0.7	0.9	1.2	1.3	1.4	1.5	1.5	1.5	1.5	1.5
Dolomite manufacture	0.5	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
<i>Limestone consumption subtotal</i>	15.9	17.8	18.6	18.0	18.9	18.8	19.6	18.9	18.6	14.2
Natural gas production										
Carbon dioxide in natural gas	14.0	16.7	18.3	18.6	18.4	18.1	18.7	19.5	20.5	21.2
Natural gas flaring	9.1	17.2	5.5	5.9	5.8	7.2	7.8	8.7	10.1	10.1
<i>Natural gas production subtotal</i>	23.1	33.9	23.8	24.5	24.3	25.3	26.6	28.2	30.6	31.3
Other										
Soda ash manufacture	3.4	3.8	3.6	3.6	3.8	3.9	3.9	4.0	4.1	3.5
Soda ash consumption	0.5	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5
Carbon dioxide manufacture	0.9	1.0	1.3	1.5	1.5	1.6	1.6	1.7	1.8	1.9
Aluminum manufacture	5.9	4.9	5.4	4.0	3.7	3.6	3.3	3.7	3.9	2.5
Shale oil production	0.2	*	*	*	*	*	*	*	*	*
Waste combustion	1.9	3.2	3.2	3.6	3.5	3.6	3.6	2.8	2.8	2.8
<i>Other subtotal</i>	12.7	13.8	14.1	13.2	13.1	13.2	13.0	12.9	13.1	11.1
Total	85.1	102.3	97.8	98.9	102.0	103.5	105.9	105.3	103.6	87.3

*Less than 0.05 million metric tons.

Note: Totals may not equal sum of components due to independent rounding.

3. Methane emissions

3.1. Total emissions

The major sources of U.S. methane emissions are energy production, distribution, and use; agriculture; and waste management (Figure 17). U.S. methane emissions in 2009 totaled 731 MMTCO₂e, 0.9 percent higher than the 2008 total of 724 MMTCO₂e (Table 17).

Methane emissions declined steadily from 1990 to 2001, as emissions from coal mining and landfills fell, then rose from 2002 to 2009 as a result of moderate increases in emissions related to energy, agriculture, and waste management that more than offset a decline in industrial emissions of methane over the same period.

The energy sector—including coal mining, natural gas systems, petroleum systems, and stationary and mobile combustion—is the largest source of U.S. methane emissions, accounting for 303 MMTCO₂e in 2009. Agricultural emissions (primarily from livestock management) and emissions from waste management (primarily landfills) also are large sources of U.S. methane emissions, contributing 216 and 208 MMTCO₂e, respectively, in 2009.

Total U.S. methane emissions, 1990, 2005, 2008, and 2009

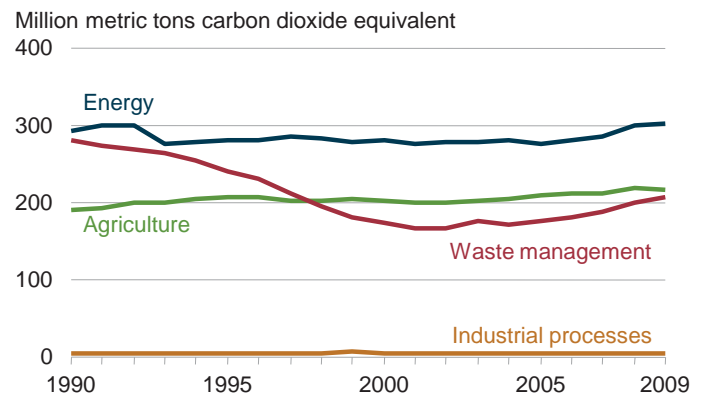
	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	768.8	669.2	724.2	730.9
Change from 1990 (million metric tons CO ₂ e)		-99.6	-44.7	-37.9
(percent)		-13.0%	-5.8%	-4.9%
Average annual change from 1990 (percent)		-0.9%	-0.3%	-0.3%
Change from 2005 (million metric tons CO ₂ e)			54.9	61.7
(percent)			8.2%	9.2%
Change from 2008 (million metric tons CO ₂ e)				6.8
(percent)				0.9%

Table 17. U.S. methane emissions, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Energy	293.1	279.9	281.7	277.7	280.0	277.0	279.8	285.8	299.3	303.0
Agriculture	190.6	207.1	201.2	202.0	204.0	209.9	211.8	212.3	219.7	215.9
Waste management	280.6	240.3	174.6	175.8	172.0	177.3	181.9	187.6	200.6	207.9
Industrial processes	4.5	5.5	5.6	5.1	5.6	5.0	5.1	5.1	4.6	4.2
Total methane	768.8	732.7	663.1	660.6	661.6	669.2	678.5	690.9	724.2	730.9

Note: Totals may not equal sum of components due to independent rounding.

Figure 17. U.S. methane emissions by source, 1990-2009



3.2. Energy sources

Natural gas systems and coal mines are the major sources of methane emissions in the energy sector (Figure 18 and Table 18). U.S. methane emissions from natural gas systems grew from 1990 to 2009 by 27 percent (39 MMTCO₂e), largely because of increases in natural gas consumption. Emissions from coal mines declined from 1990 to 2002 and remained nearly steady through 2007. In 2009, emissions from ventilation and degasification systems at underground mines increased by 9.2 percent, leading to a 4.8-percent increase in total net emissions from coal mining over the 2008 level, despite declines in emissions from both surface mining and post-mining activities.

With domestic oil production dropping by 28 percent from 1990 to 2009, methane emissions from petroleum exploration and production have declined by the same percentage.

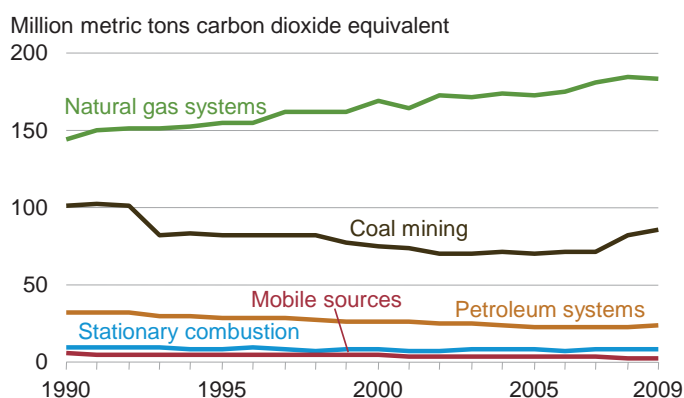
Residential wood consumption accounted for just over 45 percent of U.S. methane emissions from stationary combustion in 2009.

Methane emissions from passenger cars fell by 77 percent from 1990 to 2009, as the use of catalytic converters increased. An 11-percent drop from 2001 to 2009 in annual miles traveled by passenger cars also contributed to the decrease in emissions.

Methane emissions from energy sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	293.1	277.0	299.3	303.0
Change from 1990 (million metric tons CO ₂ e)		-16.1	6.2	9.9
(percent)		-5.5%	2.1%	3.4%
Average annual change from 1990 (percent)		-0.4%	0.1%	0.2%
Change from 2005 (million metric tons CO ₂ e)			22.3	26.0
(percent)			8.0%	9.4%
Change from 2008 (million metric tons CO ₂ e)				3.7
(percent)				1.2%

Figure 18. U.S. methane emissions from energy sources, 1990-2009



**Table 18. U.S. methane emissions from energy sources, 1990-2009
(million metric tons carbon dioxide equivalent)**

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Natural gas systems										
Production	39.9	42.7	46.9	50.2	50.9	51.6	52.6	54.6	57.3	57.8
Processing	16.2	18.0	17.9	15.7	16.2	15.9	15.7	16.6	16.3	16.5
Transmission and storage	52.6	53.7	60.4	59.6	58.5	58.3	56.2	60.1	60.2	58.3
Distribution	35.8	40.0	44.0	46.0	47.7	46.9	50.7	50.2	50.4	50.4
<i>Natural gas systems subtotal</i>	144.4	154.3	169.1	171.5	173.2	172.7	175.1	181.4	184.2	183.0
Coal mining										
Surface	11.6	12.3	13.5	13.8	14.3	14.7	15.5	15.3	15.7	14.3
Underground	90.1	70.5	60.9	56.0	57.1	55.5	55.9	55.7	66.4	71.7
<i>Coal mining subtotal</i>	101.7	82.7	74.4	69.8	71.4	70.2	71.4	71.0	82.1	86.0
Petroleum systems										
Refineries	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6
Exploration and production	31.6	28.2	25.0	24.4	23.3	22.3	21.9	21.8	21.3	22.8
Crude oil transportation	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
<i>Petroleum systems subtotal</i>	32.4	29.0	25.8	25.2	24.1	23.0	22.8	22.6	22.1	23.5
Stationary combustion	9.1	8.8	8.1	7.7	7.9	7.9	7.4	7.8	8.1	7.8
Mobile sources	5.5	5.1	4.2	3.4	3.4	3.2	3.1	3.0	2.8	2.7
Total energy sources	293.1	279.9	281.7	277.7	280.0	277.0	279.8	285.8	299.3	303.0

Note: Totals may not equal sum of components due to independent rounding.

3.3. Agricultural sources

Livestock management—including emissions from enteric fermentation (67 percent) and management of animal waste (27 percent)—accounts for the largest share of U.S. methane emissions from agricultural activities (Figure 19 and Table 19). Since 1990, there has been a shift in livestock management to larger facilities that manage waste in liquid systems, increasing the amount of methane generated from livestock waste. Increases in the U.S. swine population since 1990 have also contributed to the rise in methane emissions. Emissions of methane from animal waste fell by 1.7 percent from 2008 to 2009. Swine accounted for 42 percent (25 MMTCO₂e), and dairy cattle accounted for 49 percent (28 MMTCO₂e), of total methane emissions from livestock manure in 2009.

Enteric fermentation (food digestion) in ruminant animals also produces methane emissions, and digestion by cattle accounts for 96 percent of U.S. methane emissions from this source. With little change in the cattle population since 1990, the level of emissions from enteric fermentation has been relatively stable, with a small decrease of 3 MMTCO₂e (2.2 percent) in 2009 from the 2008 level.

Methane emissions from rice cultivation in the United States increased by almost 4 percent (0.4 MMTCO₂e) from 2008 to 2009. Emissions from crop residue burning increased by 4 percent from 2008 to 2009. Residue burning remains the smallest contributor to methane emissions from agriculture, representing less than 1 percent of total U.S. methane emissions from agriculture.

Methane emissions from agricultural sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	190.6	209.9	219.7	215.9
Change from 1990 (million metric tons CO ₂ e)		19.3	29.1	25.3
(percent)		10.1%	15.3%	13.3%
Average annual change from 1990 (percent)		0.6%	0.8%	0.7%
Change from 2005 (million metric tons CO ₂ e)			9.8	6.0
(percent)			4.7%	2.9%
Change from 2008 (million metric tons CO ₂ e)				-3.8
(percent)				-1.7%

Figure 19. U.S. methane emissions from agriculture by source, 2009

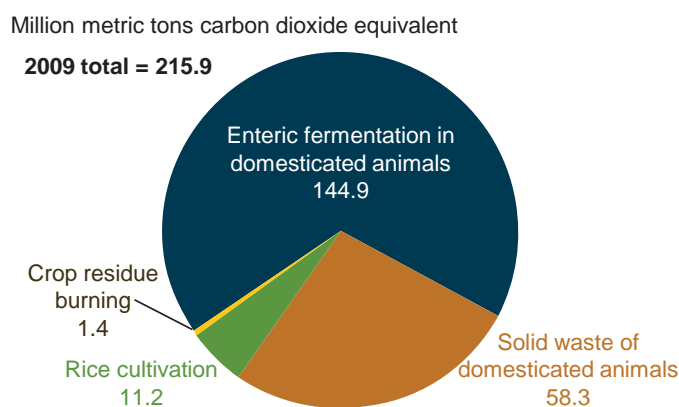


Table 19. U.S. methane emissions from agricultural sources, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Enteric fermentation in domesticated animals	139.6	149.0	139.9	140.2	140.4	142.7	144.4	145.0	148.2	144.9
Solid waste of domesticated animals	39.8	45.9	49.0	49.9	50.4	54.4	56.3	56.1	59.3	58.3
Rice cultivation	10.1	11.1	11.1	10.7	11.8	11.5	9.9	9.8	10.8	11.2
Crop residue burning	1.1	1.1	1.3	1.3	1.4	1.3	1.3	1.3	1.4	1.4
Total agricultural sources	190.6	207.1	201.2	202.0	204.0	209.9	211.8	212.3	219.7	215.9

Note: Totals may not equal sum of components due to independent rounding.

3.4. Waste management sources

Methane emissions from waste management are dominated by the decomposition of solid waste in municipal and industrial landfills (Figure 20 and Table 20). Emissions from landfills declined substantially from 1990 to 2001 as a result of increases in recycling and in the recovery of landfill methane for energy; since 2001, increases in the total amount of waste deposited in landfills have resulted in annual increases in methane emissions. The rapid growth in methane recovery from landfills during the 1990s can be traced in part to the Federal Section 29 tax credit for alternative energy sources, which provided a subsidy of approximately 1 cent per kilowatthour for electricity generated from landfill gas before June 1998. The U.S. EPA's New Source Performance Standards and Emission Guidelines, which require large landfills to collect and burn landfill gas, have also played an important role in the growth of methane recovery. In addition, the American Recovery and Reinvestment Act of 2009 included a 2-year extension (through December 31, 2012) of the production tax credit for renewable energy, including waste-to-energy and landfill gas combustion.

Wastewater treatment, including both domestic wastewater (about two-thirds) and industrial wastewater (about one-third), is responsible for 14 percent (28 MMTCO₂e) of methane emissions from waste management. In 2009, emissions from wastewater treatment at pulp and paper manufacturing facilities accounted for 47 percent (5 MMTCO₂e) of total emissions from industrial wastewater, and emissions from meat and poultry packing facilities accounted for another 41 percent (4 MMTCO₂e).

Methane emissions from waste management sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	280.6	177.3	200.6	207.9
Change from 1990 (million metric tons CO ₂ e)		-103.3	-80.0	-72.8
(percent)		-36.8%	-28.5%	-25.9%
Average annual change from 1990 (percent)		-3.0%	-1.8%	-1.6%
Change from 2005 (million metric tons CO ₂ e)			23.3	30.6
(percent)			13.1%	17.2%
Change from 2008 (million metric tons CO ₂ e)				7.3
(percent)				3.6%

Figure 20. U.S. methane emissions from waste management by source, 1990-2009

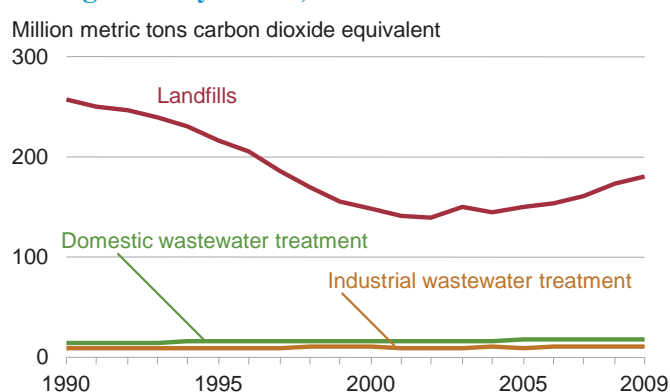


Table 20. U.S. methane emissions from waste management sources, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Landfills	257.8	215.4	148.3	149.3	145.1	150.4	154.4	160.0	172.6	179.7
Domestic wastewater treatment	14.4	15.4	16.3	16.8	16.9	17.1	17.3	17.4	17.6	17.8
Industrial wastewater treatment	8.4	9.5	10.0	9.7	9.9	9.8	10.1	10.2	10.4	10.4
Total waste management sources	280.6	240.3	174.6	175.8	172.0	177.3	181.9	187.6	200.6	207.9

Note: Totals may not equal sum of components due to independent rounding.

3.5. Industrial process sources

Methane emissions are generated by industrial processes in the production of iron and steel and chemicals (Figure 21 and Table 21). Total methane emissions from industrial processes declined by a net 0.4 MMTCO₂e (9 percent) from 2008 to 2009, as a result of declines in both chemical production and iron and steel production. Similarly, large decreases during 2009 in production of pig iron, coke, and sinter associated with iron and steel production caused methane emissions from this industrial source to drop by 43.6 percent (0.3 MMTCO₂e) from the 2008 level.

In 2009, methane emissions from industrial processes dropped below 1990 levels for the first time, resulting in a net decline of 0.3 MMTCO₂e (7.2 percent) over the past two decades; however, the 2009 decline is associated with the impact of the recession on industrial production in 2009, and emissions from industrial processes can be expected to rebound as the U.S. economy recovers.

Methane emissions from industrial process sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	4.5	5.0	4.6	4.2
Change from 1990 (million metric tons CO ₂ e)		0.5	0.1	-0.3
(percent)		11.7%	1.8%	-7.2%
Average annual change from 1990 (percent)		0.7%	0.1%	-0.4%
Change from 2005 (million metric tons CO ₂ e)			-0.4	-0.8
(percent)			-8.8%	-16.8%
Change from 2008 (million metric tons CO ₂ e)				-0.4
(percent)				-8.8%

Figure 21. U.S. methane emissions from industrial processes by source, 1990-2009

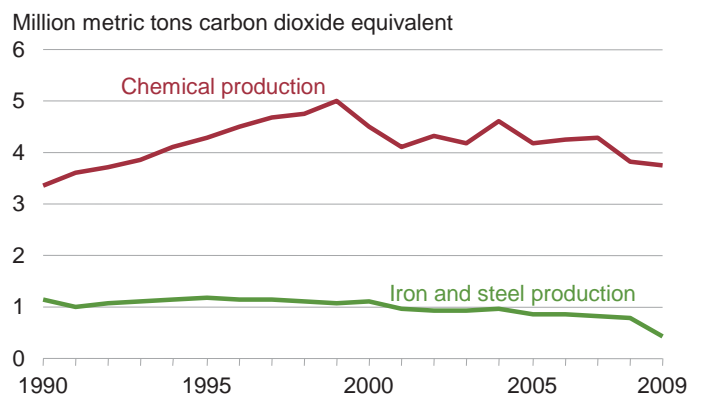


Table 21. U.S. methane emissions from industrial process sources, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Chemical production										
Ethylene	2.7	3.5	3.7	3.4	3.8	3.6	3.7	3.8	3.4	3.4
Ethylene dichloride	*	*	*	*	*	*	*	*	*	*
Styrene	*	*	*	*	*	*	*	*	*	*
Methanol	0.2	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1
Carbon black	0.4	0.5	0.5	0.4	0.5	0.5	0.4	0.4	0.4	0.3
Chemical production subtotal	3.4	4.3	4.5	4.2	4.6	4.2	4.2	4.3	3.8	3.8
Iron and steel production										
Coke ^a	*	*	*	*	*	*	*	*	*	*
Sinter	*	*	*	*	*	*	*	*	*	*
Pig iron	1.1	1.1	1.1	0.9	1.0	0.8	0.9	0.8	0.8	0.4
Iron and steel subtotal	1.1	1.2	1.1	0.9	1.0	0.9	0.9	0.8	0.8	0.4
Total industrial processes	4.5	5.5	5.6	5.1	5.6	5.0	5.1	5.1	4.6	4.2

^aBased on total U.S. production of metallurgical coke, including for uses other than iron and steel manufacture.

*Less than 0.05 million metric tons.

Note: Totals may not equal sum of components due to independent rounding.

4. Nitrous oxide emissions

4.1. Total emissions

U.S. nitrous oxide emissions in 2009 were 4 MMTCO₂e (1.7 percent) below their 2008 total (Table 22). Sources of U.S. nitrous oxide emissions include agriculture, energy use, industrial processes, and waste management (Figure 22). The largest source is agriculture (73 percent), and the majority of agricultural emissions result from nitrogen fertilization of agricultural soils (87 percent of the agriculture total) and management of animal waste (13 percent). U.S. nitrous oxide emissions rose from 1990 to 1994, fell from 1994 to 2002, and returned to an upward trajectory from 2003 to 2007, largely as a result of increased use of synthetic fertilizers. Fertilizers are the primary contributor of emissions from nitrogen fertilization of soils, which grew by more than 30 percent from 2005 to 2008.

Total nitrous oxide emissions, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	221.4	223.6	223.5	219.6
Change from 1990 (million metric tons CO ₂ e)		2.3	2.1	-1.8
(percent)		1.0%	1.0%	-0.8%
Average annual change from 1990 (percent)		0.1%	0.1%	0.0%
Change from 2005 (million metric tons CO ₂ e)			-0.2	-4.0
(percent)			-0.1%	-1.8%
Change from 2008 (million metric tons CO ₂ e)				-3.9
(percent)				-1.7%

Figure 22. U.S. nitrous oxide emissions by source, 1990-2009

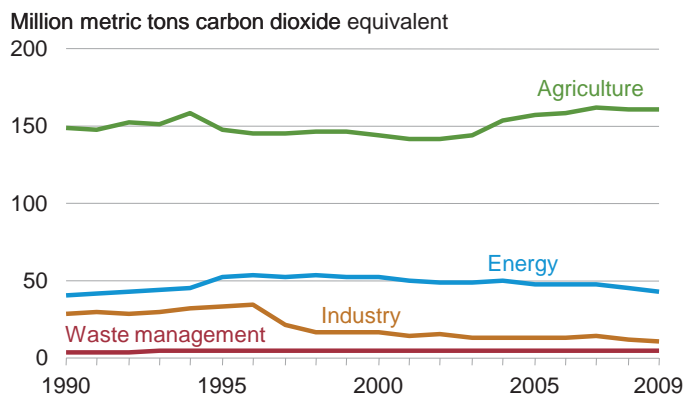


Table 22. U.S. nitrous oxide emissions, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Agriculture										
Nitrogen fertilization of soils	128.6	126.2	122.9	123.5	132.9	135.5	136.1	140.2	139.4	139.6
Solid waste of animals	19.6	20.6	20.8	20.5	20.6	20.8	21.2	21.3	21.2	20.8
Crop residue burning	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.6
<i>Agriculture subtotal</i>	<i>148.7</i>	<i>147.2</i>	<i>144.3</i>	<i>144.5</i>	<i>154.1</i>	<i>156.9</i>	<i>157.8</i>	<i>162.1</i>	<i>161.1</i>	<i>161.0</i>
Energy										
Mobile combustion	26.3	37.3	36.4	33.9	34.1	32.4	31.8	31.7	30.0	28.8
Stationary combustion	13.9	14.5	15.7	15.3	15.6	15.7	15.4	15.6	15.1	13.6
<i>Energy subtotal</i>	<i>40.2</i>	<i>51.8</i>	<i>52.1</i>	<i>49.2</i>	<i>49.7</i>	<i>48.2</i>	<i>47.2</i>	<i>47.3</i>	<i>45.1</i>	<i>42.5</i>
Industry	28.5	32.8	16.7	13.3	13.3	13.6	13.6	14.1	12.1	10.8
Waste management										
Human sewage in wastewater	3.6	4.0	4.4	4.4	4.5	4.6	4.7	4.7	4.8	4.8
Waste combustion	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
<i>Waste management subtotal</i>	<i>4.0</i>	<i>4.3</i>	<i>4.7</i>	<i>4.8</i>	<i>4.9</i>	<i>5.0</i>	<i>5.1</i>	<i>5.2</i>	<i>5.2</i>	<i>5.3</i>
Total nitrous oxide	221.4	236.2	217.8	211.8	222.0	223.6	223.7	228.6	223.5	219.6

Note: Totals may not equal sum of components due to independent rounding.

4.2. Agricultural sources

Agricultural sources, at 161 MMTCO₂e, accounted for 73 percent of U.S. nitrous oxide emissions in 2009. Nitrous oxide emissions from agricultural sources decreased by less than 1 percent (less than 0.1 MMTCO₂e) from 2008 to 2009 (Table 23). More than 85 percent (140 MMTCO₂e) of U.S. agricultural emissions of nitrous oxide in 2009 is attributable to nitrogen fertilization of soils (Figure 23), including 118 MMTCO₂e from direct emissions and 21 MMTCO₂e from indirect emissions.

Microbial denitrification of solid waste from domestic animals in the United States, primarily cattle, emitted 21 MMTCO₂e of nitrous oxide in 2009. The amount released is a function of animal size and manure production, the amount of nitrogen in the waste, and the method of managing the waste. This category no longer includes emissions related to manure deposited by grazing animals.

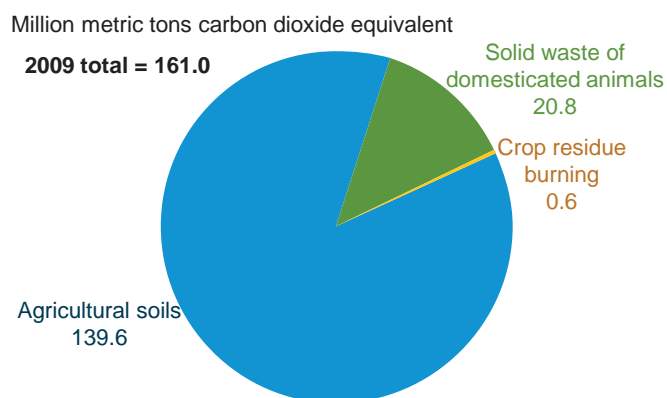
Methods for estimating agricultural emissions from nitrogen fertilization of soils have been updated for the 2009 inventory to correct for the disaggregation of organic and synthetic fertilizers, allow for indirect emissions from leaching of nitrogen only in regions with sufficient rainfall or irrigation, include below-ground crop residues while omitting biological fixation of nitrogen, and transfer emissions from manure deposited by grazing animals to the soil nitrogen amendments total (as opposed to the manure management total).

Emissions from the mineralization of mineral soils are also considered for the first time in this report, although they are zero across the whole time series since 1990 because there has been a net gain in soil carbon in mineral soils over the period at the national level. Mineralization of organic soils (histosols) continues to be a very small source of emissions.

Nitrous oxide emissions from agricultural sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	148.7	156.9	161.1	161.0
Change from 1990 (million metric tons CO ₂ e)		8.2	12.4	12.4
(percent)		5.5%	8.4%	8.3%
Average annual change from 1990 (percent)		0.4%	0.4%	0.4%
Change from 2005 (million metric tons CO ₂ e)			4.2	4.2
(percent)			2.7%	2.6%
Change from 2008 (million metric tons CO ₂ e)				0.0
(percent)				0.0%

Figure 23. U.S. nitrous oxide emissions from agriculture by source, 2009



**Table 23. U.S. nitrous oxide emissions from agricultural sources, 1990-2009
(million metric tons carbon dioxide equivalent)**

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Direct emissions (agricultural soils)										
Synthetic nitrogen fertilizers	47.5	45.8	40.7	42.9	48.5	51.7	53.5	54.6	53.3	53.3
Animal manure	27.8	29.3	26.4	25.6	25.3	25.7	25.7	25.6	25.6	24.9
Sewage sludge and other non-manure organics	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Above- and below-ground crop residues	31.2	29.6	33.8	34.0	36.3	34.8	33.3	35.7	36.3	37.2
Soil mineralization	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
<i>Direct emissions subtotal</i>	<i>109.2</i>	<i>107.6</i>	<i>103.8</i>	<i>105.3</i>	<i>113.0</i>	<i>115.0</i>	<i>115.3</i>	<i>118.8</i>	<i>118.0</i>	<i>118.2</i>
Indirect emissions (agricultural soils)										
Soil leaching and runoff	11.5	10.8	12.1	11.1	12.3	12.5	12.6	13.2	13.2	13.3
Atmospheric deposition	7.8	7.8	7.0	7.1	7.6	8.0	8.1	8.2	8.1	8.0
<i>Indirect emissions subtotal</i>	<i>19.4</i>	<i>18.6</i>	<i>19.1</i>	<i>18.2</i>	<i>19.9</i>	<i>20.5</i>	<i>20.7</i>	<i>21.5</i>	<i>21.3</i>	<i>21.4</i>
Solid waste of domesticated animals										
Cattle	15.9	16.8	16.9	16.5	16.6	16.8	17.1	17.1	16.9	16.7
Swine	1.5	1.7	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0
Poultry	1.9	1.7	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.8
Horses	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Sheep	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Goats	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
<i>Solid waste subtotal</i>	<i>19.6</i>	<i>20.6</i>	<i>20.8</i>	<i>20.5</i>	<i>20.6</i>	<i>20.8</i>	<i>21.2</i>	<i>21.3</i>	<i>21.2</i>	<i>20.8</i>
Crop residue burning	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.6
Total agricultural sources	148.7	147.2	144.3	144.5	154.1	156.9	157.8	162.1	161.1	161.0

Note: Totals may not equal sum of components due to independent rounding.

4.3. Energy sources

Emissions from energy sources made up about 19 percent of total U.S. nitrous oxide emissions in 2009. Nitrous oxide is a byproduct of fuel combustion in mobile and stationary sources (Figure 24). About two-thirds of U.S. nitrous oxide emissions from energy use can be traced to mobile sources—primarily, passenger cars and light trucks as well as other motor vehicles (Table 24). Emissions from mobile sources dropped by 3.9 percent (1 MMTCO₂e) from 2008 to 2009, primarily because of a 7.7-percent decrease in emissions from passenger cars and light trucks. Vehicle miles traveled by passenger vehicles were 2.4 percent lower in 2009 than in 2008, in part as the result of the economic recession. Nitrous oxide emissions factors for passenger cars and light-duty vehicles have been revised to the values published in the 2006 IPCC guidelines, resulting in a significant decline in calculated emissions from this source category, as described in previous reports.

Nitrous oxide emissions from stationary combustion sources result predominantly from the burning of coal at electric power plants (8 MMTCO₂e, or 60 percent of all nitrous oxide emissions from stationary combustion).

U.S. nitrous oxide emissions from energy sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	40.2	48.2	45.1	42.5
Change from 1990 (million metric tons CO ₂ e)		8.0	4.9	2.3
(percent)		19.8%	12.1%	5.6%
Average annual change from 1990 (percent)		1.2%	0.6%	0.3%
Change from 2005 (million metric tons CO ₂ e)			-3.1	-5.7
(percent)			-6.4%	-11.8%
Change from 2008 (million metric tons CO ₂ e)				-2.6
(percent)				-5.8%

Figure 24. U.S. nitrous oxide emissions from energy use by source, 1990-2009

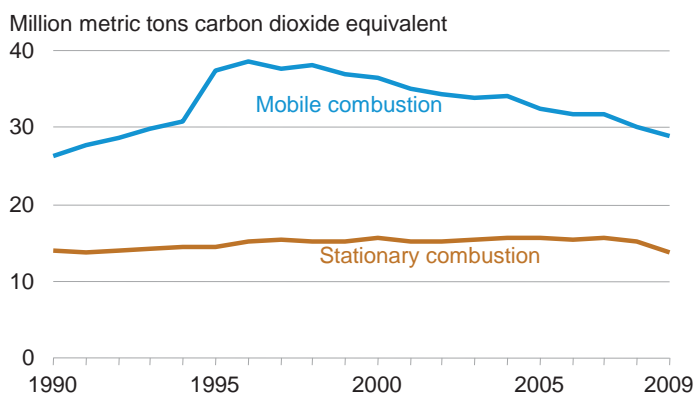


Table 24. U.S. nitrous oxide emissions from energy sources, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Mobile combustion										
Motor vehicles	22.7	33.7	32.5	30.5	30.3	28.5	27.8	27.8	26.4	25.7
Passenger cars	13.9	17.9	15.3	12.7	12.1	10.7	10.0	9.6	8.7	8.2
Light-duty trucks	7.0	13.6	14.6	15.0	15.4	15.0	15.1	15.4	14.9	14.6
Other motor vehicles	1.8	2.2	2.6	2.7	2.8	2.8	2.8	2.8	2.8	2.8
Other mobile sources	3.6	3.6	3.9	3.4	3.8	3.9	4.0	4.0	3.6	3.2
<i>Mobile combustion subtotal</i>	<i>26.3</i>	<i>37.3</i>	<i>36.4</i>	<i>33.9</i>	<i>34.1</i>	<i>32.4</i>	<i>31.8</i>	<i>31.7</i>	<i>30.0</i>	<i>28.8</i>
Stationary combustion										
Residential and commercial	1.5	1.4	1.3	1.3	1.3	1.3	1.1	1.2	1.3	1.2
Industrial	4.7	4.9	4.8	4.4	4.7	4.5	4.6	4.5	4.1	3.7
Electric power	7.8	8.3	9.6	9.6	9.7	9.9	9.7	9.9	9.7	8.7
<i>Stationary combustion subtotal</i>	<i>13.9</i>	<i>14.5</i>	<i>15.7</i>	<i>15.3</i>	<i>15.6</i>	<i>15.7</i>	<i>15.4</i>	<i>15.6</i>	<i>15.1</i>	<i>13.6</i>
Total from energy sources	40.2	51.8	52.1	49.2	49.7	48.2	47.2	47.3	45.1	42.5

Note: Totals may not equal sum of components due to independent rounding.

4.4. Industrial sources

U.S. industrial sources emitted 11 MMTCO₂e of nitrous oxide in 2009, a decrease of 10.8 percent from 2008 (Table 25). The two industrial sources of nitrous oxide emissions are production of adipic acid and production of nitric acid. Nitric acid, a primary ingredient in fertilizers, is manufactured by oxidizing ammonia with a platinum catalyst. The oxidation process releases nitrous oxide emissions. Adipic acid is a fine white powder used primarily in the manufacture of nylon fibers and plastics. There are three companies operating U.S. plants that manufacture adipic acid by oxidizing a ketone-alcohol mixture with nitric acid. The chemical reaction results in nitrous oxide emissions.

The large decline in nitrous oxide emissions from industrial processes since 1996 (Figure 25) is a result of the installation of emissions control technology at three of the four adipic acid plants operating in the United States before 2006 and the closing in 2006 of the only U.S. adipic acid plant without emission control technology. Emission estimates for 2007 and 2008 published in this year's report have been corrected to account for the plant's closing, as indicated by the zero values for uncontrolled sources in 2007, 2008, and 2009. In addition, the nitrous oxide emission factor for adipic acid production has been revised to the value published in the 2006 IPCC guidelines.

U.S. nitrous oxide emissions from industrial sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	28.5	13.6	12.1	10.8
Change from 1990 (million metric tons CO ₂ e)		-14.9	-16.4	-17.7
(percent)		-52.4%	-57.5%	-62.1%
Average annual change from 1990 (percent)		-4.8%	-4.6%	-5.0%
Change from 2005 (million metric tons CO ₂ e)			-1.4	-2.8
(percent)			-10.6%	-20.3%
Change from 2008 (million metric tons CO ₂ e)				-1.3
(percent)				-10.8%

Figure 25. U.S. nitrous oxide emissions from industry by source, 1990-2009

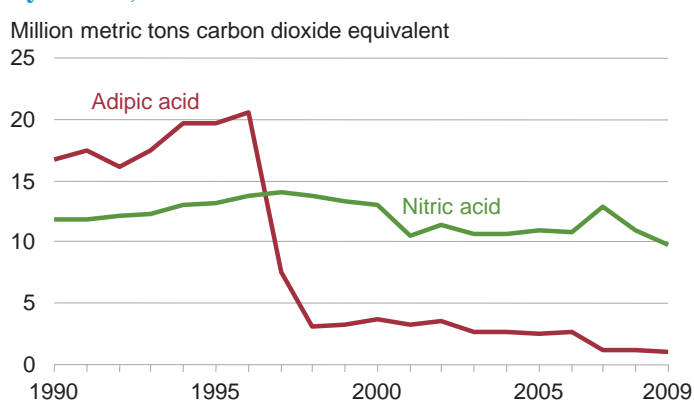


Table 25. U.S. nitrous oxide emissions from industrial sources, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Adipic acid										
Controlled sources	0.7	0.8	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.1
Uncontrolled sources	16.0	18.9	2.6	1.4	1.4	1.4	1.5	0.0	0.0	0.0
<i>Adipic acid subtotal</i>	16.7	19.7	3.7	2.6	2.7	2.6	2.7	1.2	1.2	1.1
Nitric acid	11.8	13.1	12.9	10.7	10.6	11.0	10.8	12.8	11.0	9.7
Total industrial sources	28.5	32.8	16.7	13.3	13.3	13.6	13.6	14.1	12.1	10.8

Note: Totals may not equal sum of components due to independent rounding.

4.5. Waste management sources

In 2009, treatment of residential and commercial wastewater produced 92 percent (5 MMTCO₂e) of all nitrous oxide emissions from waste management. An additional 0.4 MMTCO₂e was emitted from the combustion of municipal solid waste (Figure 26 and Table 26). Estimates of nitrous oxide emissions from domestic wastewater treatment are directly related to population size and per-capita intake of protein.

Nitrous oxide is emitted from wastewater that contains nitrogen-based organic materials, such as those found in human or animal waste. Factors that influence the amount of nitrous oxide generated from wastewater include temperature, acidity, biochemical oxygen demand, and nitrogen concentration.

U.S. nitrous oxide emissions from waste management sources, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	4.0	5.0	5.2	5.3
Change from 1990 (million metric tons CO ₂ e)		1.0	1.2	1.3
(percent)		25.9%	30.6%	31.8%
Average annual change from 1990 (percent)		1.5%	1.5%	1.5%
Change from 2005 (million metric tons CO ₂ e)			0.2	0.2
(percent)			3.7%	4.7%
Change from 2008 (million metric tons CO ₂ e)				0.0
(percent)				0.9%

Figure 26. U.S. nitrous oxide emissions from waste management by source, 1990-2009

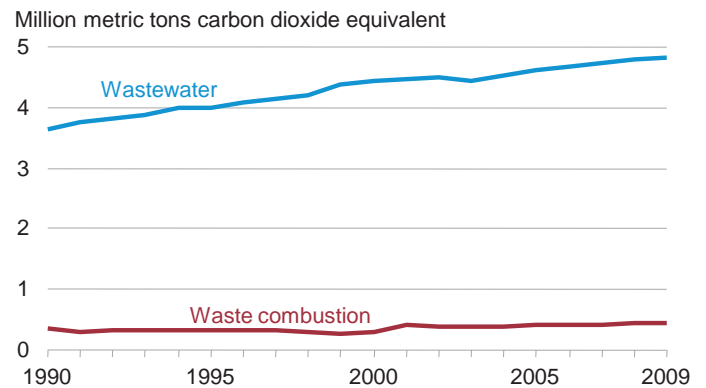


Table 26. U.S. nitrous oxide emissions from waste management sources, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Domestic and commercial wastewater	3.6	4.0	4.4	4.4	4.5	4.6	4.7	4.7	4.8	4.8
Waste combustion	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	4.0	4.3	4.7	4.8	4.9	5.0	5.1	5.2	5.2	5.3

Note: Totals may not equal sum of components due to independent rounding.

5. High-GWP gases

5.1. Total emissions

Greenhouse gases with high global warming potential (high-GWP gases) are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆), which together represented 3 percent of U.S. greenhouse gas emissions in 2009.

Emissions estimates for the high-GWP gases are provided to EIA by the EPA's Office of Air and Radiation. The estimates for emissions of HFCs not related to industrial processes or electric transmission are derived from the EPA Vintaging Model. Emissions from manufacturing and utilities are derived by the EPA from a mix of public and proprietary data, including from the EPA's voluntary emission reduction partnership programs.

For this year's EIA inventory, 2008 values for HFC-23 from HCFC-22 production and for all industrial emissions of PFCs and SF₆ are used as placeholders for 2009. The updated values will be available when the U.S. inventory is submitted by the EPA to the UNFCCC in April 2011. Emissions of HFCs used as substitutes for ozone-depleting substances and "other" HFCs and PFCs/PFPEs, which are aggregated to protect confidential data, have been updated for 2009, showing a 5.7-percent increase from 2008.

Emissions of high-GWP gases have increased steadily since 1990 (Figure 27 and Table 27), largely because HFCs are being used to replace chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and other ozone-depleting substances that are being phased out under the terms of the Montreal Protocol, which entered into force on January 1, 1989.

As part of the global phasedown of HCFCs, according to the U.S. schedule mandated in the Clean Air Act, 2010 was a target year to end production and imports of HCFC-142b and HCFC-22, with the exception of use in equipment manufactured before January 1, 2010. Under the Clean Air Act, U.S. HCFC production and imports will be completely phased out by January 1, 2030, as agreed upon in the Montreal Protocol.

PFC emissions have declined since 1990 as a result of production declines in the U.S. aluminum industry, as well as industry efforts to lower emissions per unit of output.

U.S. emissions of high-GWP gases, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	102.1	161.3	169.9	178.2
Change from 1990 (million metric tons CO ₂ e)		59.2	67.8	76.1
(percent)		57.9%	66.4%	74.5%
Average annual change from 1990 (percent)		3.1%	2.9%	3.0%
Change from 2005 (million metric tons CO ₂ e)			8.6	16.9
(percent)			5.4%	10.5%
Change from 2008 (million metric tons CO ₂ e)				8.3
(percent)				4.9%

Figure 27. U.S. emissions of high-GWP gases, 1990-2009

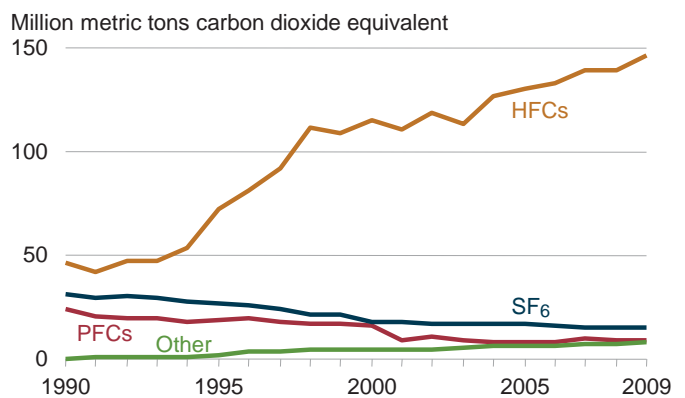


Table 27. U.S. emissions of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, 1990-2009 (million metric tons carbon dioxide equivalent)

Gas	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Hydrofluorocarbons	46.3	72.5	115.2	113.6	126.4	130.1	132.8	139.7	138.9	146.3
Perfluorocarbons	24.4	18.6	16.2	9.1	8.0	8.0	8.0	9.6	8.6	8.6
Other HFCs, PFCs/PFPEs	0.3	1.8	4.4	5.4	5.8	6.2	6.5	6.8	7.1	7.9
Sulfur hexafluoride	31.1	26.6	18.2	17.4	16.8	17.0	16.3	15.4	15.4	15.4
Total high-GWP gases	102.1	119.4	154.0	145.4	157.0	161.3	163.6	171.4	169.9	178.2

Notes: Other HFCs, PFCs/PFPEs include HFC-152a, HFC-227ea, HFC-245fa, HFC-4310mee, and a variety of PFCs and perfluoropolyethers (PFPEs). They are grouped together to protect confidential data. Totals may not equal sum of components due to independent rounding.

5.2. Hydrofluorocarbons

HFCs are compounds that contain carbon, hydrogen, and fluorine. They are used as solvents, residential and commercial refrigerants, firefighting agents, and propellants for aerosols. Although they do not destroy stratospheric ozone, they are powerful greenhouse gases. For example, HFC-134a, the most prominent substitute for ozone-depleting substances, has a global warming potential of 1,430 according to the IPCC’s Fourth Assessment Report (see Table 5 on page 17 for GWP comparison).

Emissions of substitutes for ozone-depleting substances, including HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, and HFC-236fa, have grown from trace amounts in 1990 to 129 MMTCO₂e in 2009 (Table 28).

All the growth in HFC emissions since 1990 can be attributed to the use of HFCs as replacements for ozone-depleting substances. HFC emissions from industrial and other applications have declined by 45.3 percent over this period. The market for chemicals to replace ozone-depleting substances is still expanding, with HFCs increasingly used in fire protection applications to replace Halon 1301 and Halon 1211.

Since 1997, HFC-134a—used as a replacement for CFCs in air conditioners for passenger vehicles, trains, and buses—has accounted for the largest share of total HFC emissions (Figure 28). In 2009, HFC-134a emissions represented 47 percent of total HFC emissions, including the group of other HFCs/PFCs/PFPEs.

To encourage vehicle manufacturers to reduce emissions of HFC-134a from mobile air conditioners, the EPA has included HFC crediting in the new fuel economy and emission standards for light-duty vehicles that were published in April 2010. The rule includes flexibility provisions by which manufacturers can receive credits toward the CO₂e emission standard by using air conditioners with low leak rates or alternative refrigerants.⁴⁵

Emissions of HFC-32, HFC-125, and HFC-143a each have more than tripled over the past 8 years. HFC-32 and HFC-125 are components of the refrigerant blend R-410, which is used in many air-conditioning applications. As the prevalence of air-conditioning equipment has grown, the use of R-410 has increased substantially. HFC-143a and HFC-125 are the major constituents of refrigerant blends R-404A and R-507A, which are used in commercial refrigeration applications. As the number of grocery and other stores using refrigeration has grown, so has the demand for refrigeration equipment and, thus, for HFC-143a and HFC-125.

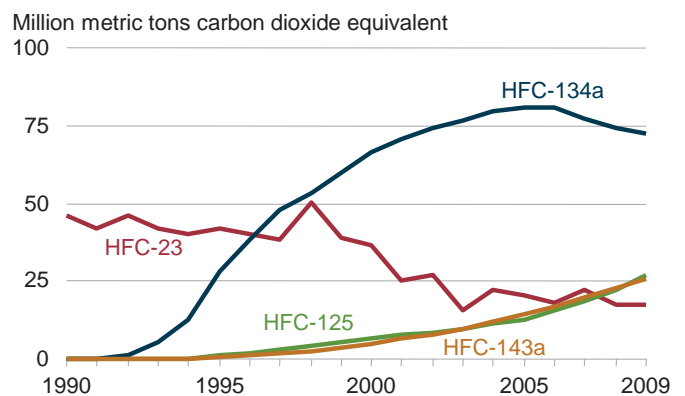
Under the Clean Air Act, manufacture and import of HCFC-22, except for use as a feedstock and in equipment manufactured before 2010, was scheduled to be phased out by January 1, 2010. Manufacturers of HCFC-22 are using cost-effective methods to make voluntary reductions in the amount of HFC-23 created as a byproduct of HCFC-22 manufacture; however, HCFC-22 production remains a steady source of U.S. emissions of HFC-23.

Because the use of HFCs to replace ozone-depleting CFCs and HCFCs increases GHG emissions, multilateral discussions have been ongoing since 2009 to consider adding HFCs to the Montreal Protocol. Negotiations have centered on similar proposals from the Federated States of Micronesia and jointly from the United States, Canada, and Mexico that seek to amend the Montreal Protocol to create a schedule for phasing down consumption of HFCs.

U.S. emissions of HFCs, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	46.3	130.1	138.9	146.3
Change from 1990 (million metric tons CO ₂ e)		83.8	92.6	100.0
(percent)		181.1%	200.0%	216.1%
Average annual change from 1990 (percent)		7.1%	6.3%	6.2%
Change from 2005 (million metric tons CO ₂ e)			8.7	16.2
(percent)			6.7%	12.4%
Change from 2008 (million metric tons CO ₂ e)				7.5
(percent)				5.4%

Figure 28. U.S. emissions of HFCs, 1990-2009



⁴⁵U.S. Environmental Protection Agency, *EPA and NHTSA Finalize Historic National Program To Reduce Greenhouse Gases and Improve Fuel Economy for Cars and Trucks*, EPA-420-F-10-014 (Washington, DC, April 2010), website www.epa.gov/otaq/climate/regulations/420f10014.htm.

**Table 28. U.S. emissions of hydrofluorocarbons, 1990-2009
(million metric tons carbon dioxide equivalent)**

Gas	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
HFC-23	46.3	42.1	36.5	15.8	22.1	20.3	17.9	21.9	17.6	17.6
HFC-32	*	*	*	0.2	0.3	0.4	0.6	0.9	1.2	1.7
HFC-125	*	1.0	6.6	9.8	11.3	12.9	15.4	18.4	22.1	27.2
HFC-134a	*	28.4	66.3	76.9	79.8	81.0	80.8	77.5	74.0	72.4
HFC-143a	*	0.6	4.9	9.8	11.9	14.3	16.9	19.7	22.5	25.9
HFC-236fa	*	0.4	0.8	1.1	1.2	1.2	1.3	1.3	1.4	1.4
Total HFCs	46.3	72.5	115.2	113.6	126.4	130.1	132.8	139.7	138.9	146.3

*Less than 0.05 million metric tons carbon dioxide equivalent.

Note: Totals may not equal sum of components due to independent rounding.

5.3. Perfluorocarbons

The two principal sources of U.S. PFC emissions are domestic aluminum production and semiconductor manufacture, which yield perfluoromethane (CF₄) and perfluoroethane (C₂F₆).

Total emissions of PFCs have fallen by two-thirds since 1990 (Figure 29 and Table 29). PFC emissions from aluminum production have declined markedly since 1990 (although the decline has been offset in part by increased emissions from semiconductor manufacturing). Emissions from process inefficiencies during aluminum production, known as “anode effects,” have been greatly reduced, and in addition, high costs for alumina and energy have led to production cutbacks.

Perfluoroethane is used as an etchant and cleaning agent in semiconductor manufacturing. The portion of the gas that does not react with the materials is emitted to the atmosphere. Established in 1996, the PFC Reduction/Climate Partnership for the Semiconductor Industry aims to reduce, via process efficiency upgrades, emissions of several high-GWP gases that result from the manufacture of semiconductors, including perfluoroethane.⁴⁶ From 1995 to 2008, total emissions of high-GWP gases (in terms of carbon dioxide equivalents) from the U.S. semiconductor industry fell by 12.6 percent, including a 6.4-percent drop in PFC emissions.

U.S. emissions of PFCs, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	24.4	8.0	8.6	8.6
Change from 1990 (million metric tons CO ₂ e)		-16.5	-15.9	NA
(percent)		-67.5%	-64.9%	NA
Average annual change from 1990 (percent)		-7.2%	-5.7%	NA
Change from 2005 (million metric tons CO ₂ e)			0.6	0.6
(percent)			7.9%	7.9%
Change from 2008 (million metric tons CO ₂ e)				NA
(percent)				NA

Figure 29. U.S. emissions of PFCs, 1990-2009

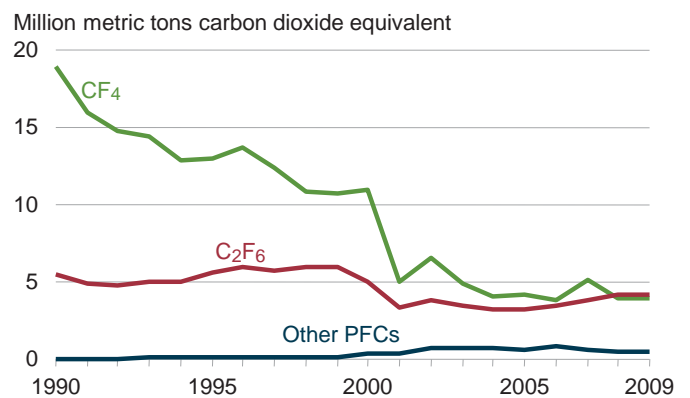


Table 29. U.S. emissions of perfluorocarbons, 1990-2009
(million metric tons carbon dioxide equivalent)

Gas	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
CF ₄	18.9	13.0	10.9	4.9	4.0	4.1	3.8	5.1	4.0	4.0
C ₂ F ₆	5.5	5.5	5.0	3.4	3.3	3.2	3.4	3.8	4.1	4.1
C ₃ F ₈	*	*	0.2	0.1	0.1	*	*	0.1	*	*
C ₄ F ₈	*	*	*	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NF ₃ ^a	*	0.1	0.2	0.5	0.5	0.4	0.7	0.5	0.4	0.4
Total PFCs	24.4	18.6	16.2	9.1	8.0	8.0	8.0	9.6	8.6	8.6

*Less than 0.05 million metric tons carbon dioxide equivalent.

^aNF₃ is not a perfluorocarbon, but it is a perfluorinated compound.

Note: Totals may not equal sum of components due to independent rounding.

⁴⁶U.S. Environmental Protection Agency, “PFC Reduction / Climate Partnership for the Semiconductor Industry,” website www.epa.gov/highgwp/semiconductor-pfc/index.html.

5.4. Sulfur hexafluoride

SF₆, an excellent dielectric gas or insulating gas for high-voltage applications, is used primarily in electrical applications—as an insulator and arc interrupter for circuit breakers, switch gear, and other equipment in electricity transmission and distribution systems. Other, minor applications of SF₆ include leak detection and the manufacture of loudspeakers and lasers and as an atmospheric tracer for experimental purposes.

Total U.S. emissions of SF₆ have declined by more than 50 percent since 1990 (Figure 30 and Table 30), and industry efforts to reduce emissions of SF₆ from electrical power systems have led to a decline of more than 50 percent in emissions of SF₆ from utility systems since 1990. Seventy-seven members of the electric power industry (about 45 percent of the industry) participate in the SF₆ Emission Reduction Partnership for Electric Power Systems by reporting and reducing SF₆ emissions. Since the establishment of the Partnership, the SF₆ emission leakage rate of participants had dropped from 17 percent to 7 percent annually as of 2006.⁴⁷

SF₆ is also used in the manufacture of semiconductors, where fluorinated gases are used in plasma etching, plasma-enhanced chemical vapor deposition, magnesium metal casting, and in magnesium production as a cover gas. Emissions of SF₆ from the semiconductor industry have more than doubled since 1990. In contrast, emissions from the magnesium industry have fallen over time. Established in 1999, the SF₆ Emission Reduction Partnership for the Magnesium Industry aims to eliminate SF₆ emissions from magnesium production and casting processes by the end of 2010 by optimizing equipment design and operation and improving SF₆ gas management practices.⁴⁸ Emissions of SF₆ from the magnesium smelting industry fell by 65 percent from 1995 to 2008 (Table 30).

U.S. emissions of SF₆, 1990, 2005, 2008, and 2009

	1990	2005	2008	2009
Estimated emissions (million metric tons CO ₂ e)	31.1	17.0	15.4	15.4
Change from 1990 (million metric tons CO ₂ e)		-14.1	-15.7	NA
(percent)		-45.3%	-50.5%	NA
Average annual change from 1990 (percent)		-3.9%	-3.8%	NA
Change from 2005 (million metric tons CO ₂ e)			-1.6	-1.6
(percent)			-9.5%	-9.5%
Change from 2008 (million metric tons CO ₂ e)				NA
(percent)				NA

Figure 30. U.S. emissions of SF₆ by source, 1990-2009

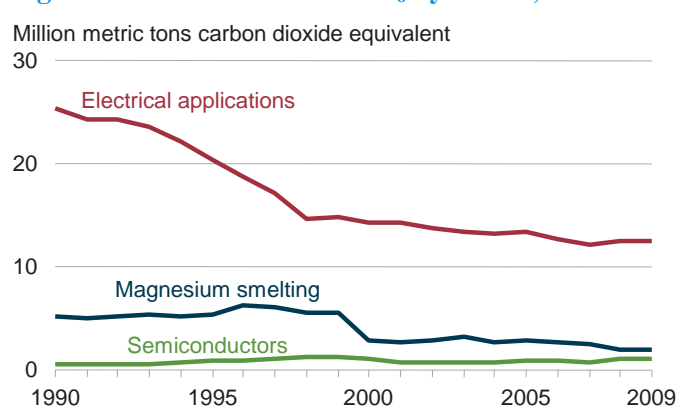


Table 30. U.S. emissions of sulfur hexafluoride by source, 1990-2009 (million metric tons carbon dioxide equivalent)

Source	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
Electrical applications	25.4	20.4	14.3	13.3	13.3	13.3	12.6	12.1	12.5	12.5
Magnesium smelting	5.2	5.4	2.9	3.3	2.8	2.8	2.7	2.5	1.9	1.9
Semiconductors	0.5	0.9	1.0	0.8	0.8	0.9	0.9	0.8	1.0	1.0
Total SF₆	31.1	26.6	18.2	17.4	16.9	17.0	16.3	15.4	15.4	15.4

Note: Totals may not equal sum of components due to independent rounding.

⁴⁷U.S. Environmental Protection Agency, "SF₆ Emission Reduction Partnership for Electric Power Systems," website www.epa.gov/highgwp/electricpower-sf6/index.html.

⁴⁸U.S. Environmental Protection Agency, "SF₆ Emission Reduction Partnership for the Magnesium Industry," website www.epa.gov/highgwp/magnesium-sf6/index.html.

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6. Land use

6.1. Total land use, land use change, and forests

This chapter presents estimates of carbon sequestration (removal from the atmosphere) and emissions (release into the atmosphere) from forests, croplands, grasslands, and residential areas (urban trees, grass clippings, and food scraps) in the United States. In 2008, land use, land use change, and forests were responsible for estimated net carbon sequestration of 940 MMTCO₂e (Table 31), representing 16 percent of total U.S. CO₂ emissions.

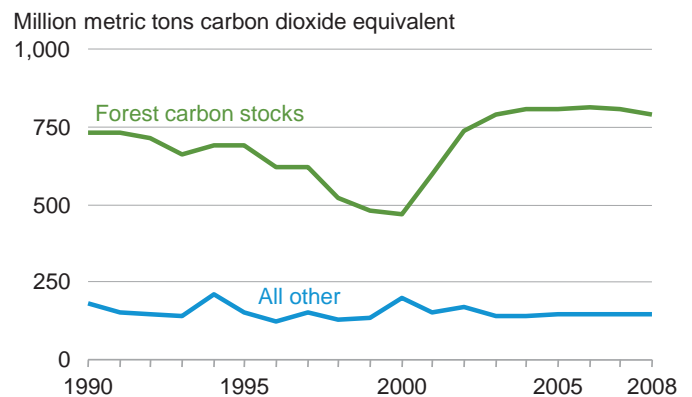
The largest sequestration category in 2008 was forest lands and harvested wood pools,⁴⁹ with estimated sequestration increasing from 730 MMTCO₂e in 1990 to 792 MMTCO₂e in 2008. The second-largest carbon sequestration category was urban trees,⁵⁰ responsible for 57 MMTCO₂e in 1990 and 94 MMTCO₂e in 2008. Landfilled yard trimmings and food scraps, both of which also contain carbon, sequestered 10 MMTCO₂e in 2008. Croplands and grasslands were estimated to have sequestered 18 MMTCO₂e and 9 MMTCO₂e, respectively, in 2008.⁵¹ Land converted to grassland sequestered 24 MMTCO₂e in 2008.

Preparing soils for cultivation involves drainage and tilling, both of which lead to the release of carbon from soil to the atmosphere. In 2008, land that became cropland emitted 6 MMTCO₂e.

U.S. carbon sequestration from land use, land use change and forestry, 1990, 2005, 2007, and 2008

	1990	2005	2007	2008
Estimated sequestration (million metric tons CO ₂ e)	909.4	950.4	955.4	940.3
Change from 1990 (million metric tons CO ₂ e)		30.9	46.0	30.9
(percent)		3.4%	5.1%	3.4%
Average annual change from 1990 (percent)		0.3%	0.3%	0.2%
Change from 2005 (million metric tons CO ₂ e)			5.0	-10.1
(percent)			0.5%	-1.1%
Change from 2007 (million metric tons CO ₂ e)				-15.1
(percent)				-1.6%

Figure 31. U.S. carbon sequestration from land use, land use change, and forestry, 1990-2008



⁴⁹The IPCC (United Nations Intergovernmental Panel on Climate Change) category is Forest Land Remaining Forest Land (referred to in this chapter as “forest lands and harvested wood pools”), which includes carbon sequestered in forest ecosystems as well as carbon “exported” from forest ecosystems in hardwood products and solid waste disposal sites. Carbon in the latter categories originates in the forest ecosystem and is emitted slowly over decades or even centuries.

⁵⁰Urban trees are included in the IPCC categories “Settlements Remaining Settlements” and “Land Converted to Settlements,” which are essentially forest-like ecosystems but in urbanized areas (such as parks).

⁵¹These estimates are from the IPCC categories “Croplands Remaining Croplands” and “Grasslands Remaining Grasslands.”

Table 31. Net U.S. carbon dioxide sequestration from land use, land use change, and forestry, 1990-2008 (million metric tons carbon dioxide equivalent)

Component	1990	1995	2000	2003	2004	2005	2006	2007	2008
Forest land and harvested wood pools ^a	729.8	692.6	467.7	790.7	805.5	806.6	812.5	806.9	791.9
Croplands and grasslands									
Cropland remaining cropland ^b	29.4	22.9	30.2	17.7	18.1	18.3	19.1	19.7	18.1
Land converted to cropland	-2.2	-2.9	-2.4	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9
Grassland remaining grassland	52	26.7	52.6	9.2	9.1	9	8.9	8.8	8.7
Land converted to grassland	19.8	22.3	27.3	24.9	24.7	24.6	24.5	24.3	24.2
<i>Croplands and grasslands subtotal</i>	<i>99.1</i>	<i>69.0</i>	<i>107.7</i>	<i>45.8</i>	<i>46.0</i>	<i>46.0</i>	<i>46.6</i>	<i>46.9</i>	<i>45.1</i>
Urban trees, yard trimmings, and food scraps									
Urban trees	57.1	67.3	77.5	83.7	85.7	87.8	89.8	91.9	93.9
Yard trimmings	21.2	12.5	8.2	7.1	6.4	6.6	6.8	6.3	6.3
Food scraps	2.2	1.4	3.1	3.1	3.5	3.5	3.6	3.5	3.3
<i>Urban trees, yard trimmings, and food scraps subtotal</i>	<i>80.5</i>	<i>81.2</i>	<i>88.8</i>	<i>93.9</i>	<i>95.6</i>	<i>97.9</i>	<i>100.2</i>	<i>101.7</i>	<i>103.5</i>
Total	909.4	842.9	664.2	930.3	947.1	950.4	959.2	955.4	940.3

^aEstimates include carbon stock changes in both forest land remaining forest land and land converted to forest land.

^bEstimates include carbon stock changes in mineral soils and organic soils on cropland remaining cropland and liming emissions from all cropland, grassland, and settlement categories.

Note: Totals may not equal sum of components due to independent rounding.

6.2. Forest lands and harvested wood pools

Forest ecosystems constitute the largest source of carbon sequestration in the United States, with the sequestered carbon contained in above-ground or below-ground components of trees and other forest vegetation, as well as dead wood and litter.⁵² In 2008, forests and harvested wood products sequestered 792 MMTCO₂e (Table 32). More than one-half of the forest total (397 out of 704 MMTCO₂e) was above-ground biomass in the form of tree trunks and branches. Soil organic carbon was the second-largest category of sequestered carbon in 2008, estimated at 146 MMTCO₂e. Another large category in 2008 was below-ground biomass—i.e., the root systems of trees and other plants—at an estimated total of 79 MMTCO₂e. Litter and dead wood, which are rich in plant matter that continues to be mainly carbon, accounted for 56 MMTCO₂e and 26 MMTCO₂e, respectively, of the carbon sequestered in forests in 2008. Although some of the carbon in litter and dead wood is released through decomposition, the continuing fall of trunks, branches, leaves, and other plant materials adds to the mass of litter and dead wood, leading to an overall increase in carbon stored.

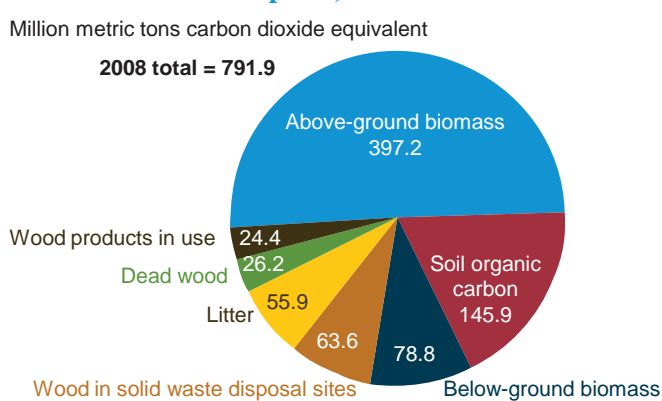
Harvested wood in the form of durable wood products, either in use or in landfills, accounted for 132 MMTCO₂e of carbon sequestration in 1990. That total dropped to 88 MMTCO₂e in 2008, primarily as a result of greater use of imported wood, imported wood products, and wood substitutes.⁵³

Carbon sequestration in U.S. forest lands and harvested wood pools, 1990, 2005, 2007, and 2008

	1990	2005	2007	2008
Estimated sequestration (million metric tons CO ₂ e)	729.8	806.6	806.9	791.9
Change from 1990 (million metric tons CO ₂ e)		76.7	77.1	62.1
(percent)		10.5%	10.6%	8.5%
Average annual change from 1990 (percent)		0.7%	0.6%	0.5%
Change from 2005 (million metric tons CO ₂ e)			0.3	-14.7
(percent)			*	-1.8%
Change from 2007 (million metric tons CO ₂ e)				-15.0
(percent)				-1.9%

*Less than 0.5 percent.

Figure 32. Carbon sequestration in U.S. forest lands and harvested wood pools, 2008



⁵²The term “dead wood” refers to large, non-living woody biomass either standing, lying on the ground (excluding litter), or in the soil. “Litter” (mainly, fallen leaves) refers to smaller fallen and partially decomposed matter on the forest floor.

⁵³Wood products originating from forests outside the United States are not included in the U.S. greenhouse gas inventory.

**Table 32. Net carbon dioxide sequestration in U.S. forests and harvested wood pools, 1990-2008
(million metric tons carbon dioxide equivalent)**

Carbon pool	1990	1995	2000	2003	2004	2005	2006	2007	2008
Forests									
Above-ground biomass	377.7	398.3	309.3	396.8	397.2	397.2	397.2	397.2	397.2
Below-ground biomass	74.5	79.3	61.7	78.7	78.8	78.8	78.8	78.8	78.8
Dead wood	29.4	31.0	15.8	22.4	22.4	23.4	26.2	26.2	26.2
Litter	46.5	28.3	-3.4	54.0	55.9	55.9	55.9	55.9	55.9
Soil organic carbon	70.0	37.2	-28.7	143.9	145.9	145.9	145.9	145.9	145.9
<i>Forests subtotal</i>	<i>598.1</i>	<i>574.2</i>	<i>354.8</i>	<i>695.9</i>	<i>700.2</i>	<i>701.2</i>	<i>703.9</i>	<i>703.9</i>	<i>703.9</i>
Harvested wood									
Wood products	64.8	55.2	47.0	35.5	45.6	45.4	45.1	39.1	24.4
Wood in solid waste disposal sites	67.0	63.2	65.9	59.3	59.8	59.9	63.4	63.8	63.6
<i>Harvested wood subtotal</i>	<i>131.8</i>	<i>118.4</i>	<i>112.9</i>	<i>94.8</i>	<i>105.3</i>	<i>105.4</i>	<i>108.6</i>	<i>103.0</i>	<i>88.0</i>
Total	729.8	692.6	467.7	790.7	805.5	806.6	812.5	806.9	791.9

Notes: The sums of the annual net stock changes in this table (shown in the "Total" row) represent estimates of the actual net flux between the total forest carbon pool and the atmosphere. The Forest estimates are based on periodic measurements; harvested wood estimates are based on annual surveys and models. Totals may not equal sum of components due to independent rounding.

6.3. Croplands and grasslands

Croplands and grasslands fall into four categories: cropland remaining cropland; land converted to cropland; grassland remaining grassland; and land converted to grassland.

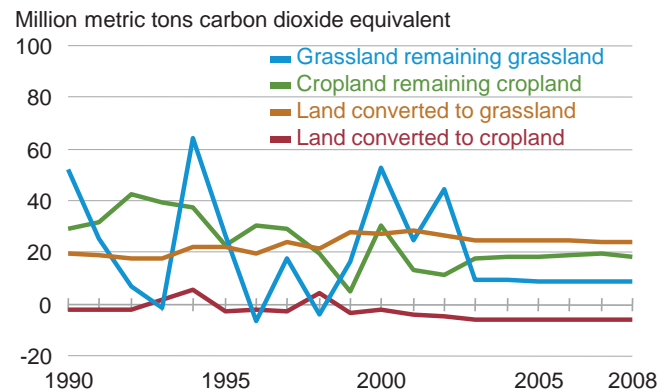
Organic soils contain 12 to 20 percent carbon; mineral soils contain 1 to 6 percent carbon. Soils gain carbon through the decomposition of dead plant matter by soil microorganisms and lose carbon through drainage and agricultural activities, such as tilling. Over time, unless the soil is disturbed repeatedly, its carbon content reaches a balance between sequestration and emissions. Carbon sequestration and emissions from the mineral and organic soils in croplands and grasslands vary, depending on how the lands are maintained or converted. Mineral and organic soils can gain (sequester) or lose (emit) carbon, depending on climate, land use, and soil properties.

As a whole, the estimated aggregate flux of CO₂ for the four categories of croplands and grasslands resulted in the sequestration of 45 MMTCO₂e in 2008 (Table 33). Land Converted to Grassland, Cropland Remaining Cropland, and Grassland Remaining Grassland sequestered 24, 18, and 9 MMTCO₂e, respectively, and Land Converted to Cropland emitted 6 MMTCO₂e. Areas were classified as Cropland Remaining Cropland in a given year between 1990 and 2008 if the land use had been cropland for the previous 20 years. For organic soils, annual fluxes were estimated from the U.S. Department of Agriculture's National Resources Inventory (NRI); the 1990 NRI estimate was applied for 1990-1993, and the 1997 NRI estimate was applied for 1993-2008.

Carbon sequestration in U.S. croplands and grasslands, 1990, 2005, 2007, and 2008

	1990	2005	2007	2008
Estimated sequestration (million metric tons CO ₂ e)	99.0	46.0	46.9	45.1
Change from 1990 (million metric tons CO ₂ e)		-53.0	-52.1	-53.9
(percent)		-53.5%	-52.6%	-54.4%
Average annual change from 1990 (percent)		-5.0%	-4.3%	-4.3%
Change from 2005 (million metric tons CO ₂ e)			0.9	-0.9
(percent)			2.0%	-2.0%
Change from 2007 (million metric tons CO ₂ e)				-1.8
(percent)				-3.8%

Figure 33. Carbon sequestration in U.S. croplands and grasslands, 1990-2008



**Table 33. Net carbon dioxide sequestration in U.S. croplands and grasslands, 1990-2008
(million metric tons carbon dioxide equivalent)**

Carbon pool	1990	1995	2000	2003	2004	2005	2006	2007	2008
Cropland remaining cropland									
Mineral soils	56.8	50.6	57.9	45.3	45.8	45.9	46.8	47.3	45.7
Organic soils	-27.4	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7
<i>Cropland remaining cropland subtotal</i>	<i>29.4</i>	<i>22.9</i>	<i>30.2</i>	<i>17.7</i>	<i>18.1</i>	<i>18.3</i>	<i>19.1</i>	<i>19.7</i>	<i>18.1</i>
Land converted to cropland									
Mineral soils	0.3	-0.3	0.3	-3.3	-3.3	-3.3	-3.3	-3.3	-3.3
Organic soils	-2.4	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6	-2.6
<i>Land converted to cropland subtotal</i>	<i>-2.2</i>	<i>-2.9</i>	<i>-2.4</i>	<i>-5.9</i>	<i>-5.9</i>	<i>-5.9</i>	<i>-5.9</i>	<i>-5.9</i>	<i>-5.9</i>
Grassland remaining grassland									
Mineral soils	55.9	30.4	56.3	12.9	12.8	12.7	12.6	12.5	12.4
Organic soils	-3.9	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7	-3.7
<i>Grassland remaining grassland subtotal</i>	<i>52.0</i>	<i>26.7</i>	<i>52.6</i>	<i>9.2</i>	<i>9.1</i>	<i>9.0</i>	<i>8.9</i>	<i>8.8</i>	<i>8.7</i>
Land converted to grassland									
Mineral soils	20.3	23.2	28.1	25.7	25.6	25.5	25.4	25.2	25.1
Organic soils	-0.5	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
<i>Land converted to grassland subtotal</i>	<i>19.8</i>	<i>22.3</i>	<i>27.3</i>	<i>24.9</i>	<i>24.7</i>	<i>24.6</i>	<i>24.5</i>	<i>24.3</i>	<i>24.2</i>
Total	99.0	69.0	107.7	45.8	46.0	45.9	46.6	46.9	45.1
Liming of soils ^a	-4.7	-4.4	-4.3	-4.6	-3.9	-4.3	-4.2	-4.5	-3.8

^aIncludes emissions from liming on land converted to cropland, grassland remaining grassland, land converted to grassland, and settlements remaining settlements. This value is counted as a carbon dioxide emission under limestone consumption shown in Table 16.

Note: Negative values indicate emissions.

6.4. Urban trees, yard trimmings, and food scraps

In 2008, urban trees, yard trimmings, and food scraps sequestered 104 MMTCO₂e (Table 34).

Urban trees sequester carbon through photosynthesis, just as forest trees do. Because urban trees often have more space in urban settings such as streets and parks than do trees in forests, they tend to grow bigger and sequester more carbon per tree.

The estimate of carbon sequestration in yard trimmings is for the portion of grass clippings, leaves, and other garden wastes deposited in landfills. Yard trimmings that are composted at individual residences or in municipal composting programs or are used in waste-to-energy activities are not accounted for in this category. From 1990 to 2008, the estimate for carbon sequestration in yard trimmings has changed more than the estimates for the two other categories combined, with a decrease of 70 percent attributed to an increase in municipal composting programs.

From 1990 to 2008, a slight increase in landfill disposal of food scraps was far outweighed by the decrease in disposal of yard trimmings, leading to a net decrease in annual carbon sequestration at landfills from 24 MMTCO₂e in 1990 to 10 MMTCO₂e in 2008.

Carbon sequestration in U.S. urban trees, yard trimmings, and food scraps, 1990, 2005, 2007, and 2008

	1990	2005	2007	2008
Estimated sequestration (million metric tons CO ₂ e)	80.5	97.9	101.7	103.5
Change from 1990 (million metric tons CO ₂ e)		17.4	21.2	23.0
(percent)		21.6%	26.3%	28.6%
Average annual change from 1990 (percent)		1.3%	1.5%	1.6%
Change from 2005 (million metric tons CO ₂ e)			3.8	5.6
(percent)			3.9%	5.7%
Change from 2007 (million metric tons CO ₂ e)				1.8
(percent)				1.8%

Figure 34. Carbon sequestration in U.S. urban trees, yard trimmings, and food scraps, 1990-2008

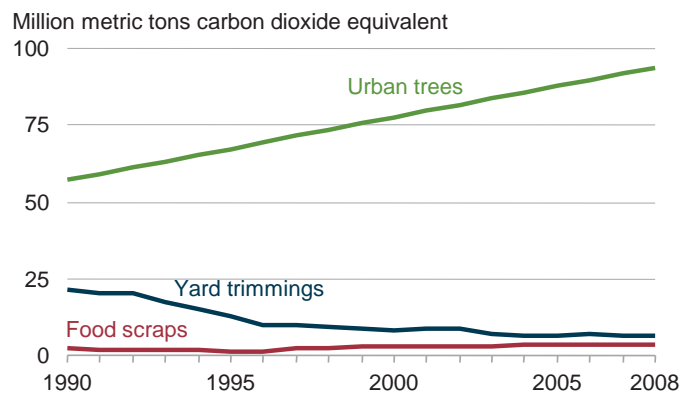


Table 34. Net carbon dioxide sequestration in U.S. urban trees, yard trimmings, and food scraps, 1990-2008 (million metric tons carbon dioxide equivalent)

Carbon pool	1990	1995	2000	2003	2004	2005	2006	2007	2008
Urban trees	57.1	67.3	77.5	83.7	85.7	87.8	89.8	91.9	93.9
Yard trimmings									
Grass	1.9	0.8	0.4	0.4	0.3	0.4	0.5	0.4	0.4
Leaves	9.7	6.0	4.0	3.5	3.2	3.3	3.3	3.1	3.1
Branches	9.7	5.8	3.7	3.2	2.9	2.9	3.0	2.8	2.7
<i>Yard trimmings subtotal</i>	21.2	12.5	8.2	7.1	6.4	6.6	6.8	6.3	6.3
Food scraps	2.2	1.4	3.1	3.1	3.5	3.5	3.6	3.5	3.3
Total	80.5	81.2	88.8	93.9	95.6	97.9	100.2	101.7	103.5

Note: Totals may not equal sum of components due to independent rounding.

6.5. Carbon dioxide emissions from bioenergy

According to current international convention, CO₂ released through the combustion of energy or fuel derived from plants (bioenergy or biofuels) is excluded from reported energy-related emissions. The related fossil fuel emissions from the transportation and processing of the biological feedstocks are captured within overall energy sector emissions, but currently they are not allocated to the biofuels. Additionally, the CO₂ released from biofuel or bioenergy combustion is assumed to be fully accounted for by the uptake of carbon during the growth of the feedstock used to produce the biofuels or bioenergy. However, analysts have debated whether the increased use of biomass energy may result in a loss of terrestrial carbon stocks and foregone future sequestration by natural vegetation. The initial loss of carbon stocks in natural vegetation cleared to grow biomass feedstocks and the foregone future removal of CO₂ are not captured in energy sector emissions. To capture the potential net emissions, the international convention for GHG inventories is to report the net carbon flux from land use change (such as when forests are converted to cropland to grow feedstocks) in the Land Use category. Although accounting for land use emissions is more challenging than for most of the other emissions sources, emissions and sequestration associated with domestic U.S. land use change should in principle be accounted for in this chapter of the inventory report. However, from a global greenhouse gas emissions perspective, the key uncertainty regarding aggregate net biogenic emissions is indirect land use change that occurs abroad. As discussed below, there are many factors that ultimately determine the net effect of biogenic energy sources on CO₂ emissions.

For the first time, this report is providing estimates of direct biogenic CO₂ emissions from combustion of biofuels and bioenergy (see Table 35).⁵⁴ Other greenhouse gases, such as methane released from wood that is burned in home fireplaces and woodstoves, are counted in EIA's emissions inventory, because they are not considered part of the natural carbon cycle.

Direct biogenic combustion emissions by sector

Emissions estimates are provided here for direct emissions from bioenergy consumption in the four end-use sectors (residential, commercial, industrial, and transportation) and for the electric power sector.

Residential emissions result from the use of wood and wood-derived fuels, principally for heating and often for aesthetic reasons. As indicated in Table 35, these emissions have fluctuated over time but have decreased overall since 1990.

Commercial bioenergy emissions result from the use of wood and wood-derived fuels for heat and electricity generation, including emissions from combined heat and power generation plants that cannot be assigned to either the electric power sector or the industrial sectors according to North American Industry Classification System (NAICS) codes.⁵⁵ Energy consumed at municipal landfills in the form of solid biogenic waste and landfill gas also is included in the commercial sector. Finally, small amounts of ethanol and wood consumed directly for their heating value are included. There has been gradual growth of biofuel consumption in the commercial sector.

Industrial bioenergy emissions result from the combustion of wood and wood-derived fuels by plants generating process heat and electricity that are assigned to the industrial sector by NAICS codes, including emissions from combined heat and power plants. Most of the biogenic fuel consumption in the industrial sector is in the pulp and paper industry. The industrial sector dominates biogenic emissions, but its share is declining.

Transportation bioenergy emissions are principally from ethanol fuel use. Biodiesel emissions include the use of any liquid biofuel suitable as a diesel substitute, additive, or extender. Because of the increase in fuel ethanol consumption (primarily, blended into gasoline), the transportation sector has seen the largest growth in biogenic CO₂ emissions, from 4 million metric tons in 1990 to 64 million metric tons in 2009.

Electric power emissions from bioenergy result from the use of wood and wood-derived fuels by plants generating electricity and by combined heat and power plants. In addition, emissions from power generation using solid biogenic waste and landfill gas are included in this category. Biogenic emissions in the electric power sector grew by an average of 2.8 percent per year from 1990 to 2009.

Emissions by fuel

Wood has historically been the largest source of biogenic carbon dioxide emissions. However, emissions from wood burning have dropped from 208 million metric tons in 1990 to 177 million metric tons in 2009, or by nearly 1 percent per year.

Waste was the second-largest source of biogenic emissions in 1990, at 24 million metric tons, and emissions from waste combustion have increased by about 3 percent per year since 1990.

Fuel ethanol, which was a negligible source of biogenic emissions in 1990, was second only to wood in 2009. Emissions from fuel ethanol combustion have grown by more than 15 percent per year, to a total of 62 million metric tons in 2009.

Biodiesel is a relatively new energy source of biogenic emissions, increasing from a negligible level in 2000 to 3.0 million metric tons CO₂ in 2009.

⁵⁴Source: U.S. Energy Information Administration, *Monthly Energy Review* (Washington, DC: October 2010), website www.eia.gov/FTPROOT/multifuel/mer/00351010.pdf. MER data are available through 2009. EPA data for other tables in this chapter are available only through 2008.

⁵⁵NAICS is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. economy.

Life cycle analysis of carbon emissions from bioenergy

The growth of plant material (or feedstock) and its eventual conversion into usable bioenergy involve emissions related to both land use and energy use. However, when a feedstock is grown in an area that doesn't usually support agriculture or natural vegetation, it can lead to additional sequestration of carbon. When sequestration equals or exceeds emissions, the bioenergy source can be considered carbon neutral or better. Analyses of the life-cycle carbon emissions of biofuels or bioenergy have focused on different aspects of their production, transportation, and consumption. As for any other product, their carbon neutrality usually is assessed by considering all the upstream and downstream emissions of greenhouse gases. In addition, indirect changes in land use can be evaluated as a component of biofuel production.

Greenhouse gas emissions from the biofuels or bioenergy life cycle include: (1) emissions associated with the growth of feedstocks (emissions from farm machinery, soils, and the use of fertilizers derived from fossil fuels); (2) emissions from the processing of feedstocks into fuel or energy (including transportation to the processing facility and emissions from processing); (3) emissions from transportation of fuels to end users; and (4) emissions from end uses (combustion in vehicles or in the generation of electricity or heat). On the other hand, however, the growth of biofuel feedstocks (corn, soybeans, tree crops, grasses, etc.) removes CO₂ from the atmosphere as discussed above. Emissions associated with sources (1), (2), and (3) are accounted for elsewhere in this inventory. This section focused on source (4).

The life-cycle emissions associated with bioenergy depends in part on the vegetation displaced by the establishment of feedstock crops. Although the concept that land use change has an impact on carbon stocks is universal, it is a concern primarily in tropical ecosystems. When land is diverted from food production to the production of biofuel feedstock in a given area, and overall food production falls as a result, land in other areas is sometimes converted to cropland to meet market demand. Such indirect land use change can be local, national, or even global and can involve the conversion of forests to cropland. The effects of indirect land use changes on CO₂ emissions are difficult to quantify, because they can occur anywhere in the world, and because estimates depend on assumptions about the supply response to demand for bioenergy feedstocks. Assumptions about supply response in the United States and bilateral trade responses in the rest of the world are critical to evaluating the greenhouse gas emissions impacts of indirect land use change.⁵⁶ Whether or not indirect land use change occurs depends on factors such as yield, acreage, and bilateral trade.

⁵⁶R. Keeney and T.W. Hertel, *The Indirect Land Use Impacts of U.S. Biofuel Policies: The Importance of Acreage, Yield, and Bilateral Trade Responses*, GTAP Working Paper No. 52 (2008), website www.gtap.agecon.purdue.edu/resources/download/4104.pdf; and J.A. Mathews and H. Tan, "Biofuels and Indirect Land Use Change Effects: The Debate Continues," *Wiley InterScience* (2009), website www.ncfap.org/documents/biofuels_aviation/iLUC%20Searchingercritique%20BioFPR.pdf.

Table 35. Emissions of carbon dioxide from biofuel/bioenergy use by sector and fuel, 1990-2009
(million metric tons carbon dioxide)

Sector	1990	1995	2000	2005	2006	2007	2008	2009	Average annual growth, 1990-2009
Residential									
Wood	54.4	48.8	39.4	40.3	36.6	40.3	42.2	40.3	-1.6%
<i>Subtotal</i>	<i>54.4</i>	<i>48.8</i>	<i>39.4</i>	<i>40.3</i>	<i>36.6</i>	<i>40.3</i>	<i>42.2</i>	<i>40.3</i>	<i>-1.6%</i>
Commercial									
Wood	6.2	6.8	6.7	6.5	6.1	6.5	6.8	6.7	0.5%
Waste (biogenic)	1.7	2.3	2.4	3.1	3.3	2.8	3.1	3.3	3.7%
Fuel ethanol	*	*	*	0.1	0.1	0.1	0.1	0.2	8.7%
<i>Subtotal</i>	<i>7.9</i>	<i>9.1</i>	<i>9.1</i>	<i>9.7</i>	<i>9.5</i>	<i>9.5</i>	<i>10.1</i>	<i>10.2</i>	<i>1.4%</i>
Industrial									
Wood	135.3	155.0	153.4	136.2	138.1	132.5	126.1	114.8	-0.9%
Waste (biogenic)	11.5	11.0	7.4	13.4	11.8	13.1	13.0	14.6	1.3%
Fuel ethanol	0.1	0.1	0.1	0.5	0.7	0.7	0.8	0.9	15.7%
<i>Subtotal</i>	<i>146.8</i>	<i>166.0</i>	<i>160.9</i>	<i>150.1</i>	<i>150.5</i>	<i>146.3</i>	<i>139.9</i>	<i>130.4</i>	<i>-0.6%</i>
Transportation									
Fuel ethanol	4.1	7.7	9.2	22.4	30.2	38.1	53.8	61.2	15.2%
Biodiesel	—	—	—	0.9	2.5	3.4	3.0	3.0	—
<i>Subtotal</i>	<i>4.1</i>	<i>7.7</i>	<i>9.2</i>	<i>23.3</i>	<i>32.7</i>	<i>41.5</i>	<i>56.8</i>	<i>64.2</i>	<i>15.5%</i>
Electric power									
Wood	12.1	11.8	12.6	17.4	17.1	17.4	16.6	16.9	1.8%
Waste (biogenic)	11.3	16.7	16.2	20.0	20.9	21.5	23.4	23.7	4.0%
<i>Subtotal</i>	<i>23.3</i>	<i>28.4</i>	<i>28.8</i>	<i>37.4</i>	<i>38.0</i>	<i>39.0</i>	<i>40.0</i>	<i>40.6</i>	<i>3.0%</i>
Total by sector	236.5	260.0	247.4	260.8	267.2	276.6	289.0	285.6	1.0%
Fuel									
Wood	207.9	222.3	212.1	200.4	197.8	196.8	191.7	178.8	-0.8%
Waste	24.4	29.9	25.9	36.6	36.0	37.4	39.5	41.6	2.8%
Fuel ethanol	4.2	7.8	9.3	22.9	31.0	38.9	54.8	62.3	15.2%
Biodiesel	—	—	—	0.9	2.5	3.4	3.0	3.0	—
Total by fuel	236.5	260.0	247.4	260.8	267.2	276.6	289.0	285.6	1.0%

*Less than 0.05 million metric tons carbon dioxide equivalent.

Note: Data are from EIA's *Monthly Energy Review*, including 2009 values. EPA data for other tables in this chapter are available only through 2008.

A1. Notes and sources

A1.1. Table Notes and Sources

Chapter 1: Greenhouse gas emissions overview

Table 1. U.S. emissions of greenhouse gases, based on global warming potential, 1990-2009: Sources: Emissions: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009). Global warming potentials: Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis: Errata* (Cambridge, UK: Cambridge University Press, 2008), website www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf.

Table 2. U.S. greenhouse gas intensity and related factors, 1990-2009: Sources: Emissions: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009). GDP: U.S. Department of Commerce, Bureau of Economic Analysis, website www.bea.gov (November 2010).

Table 3. Distribution of total U.S. greenhouse gas emissions by end-use sector, 2009: Source: Estimates presented in this report. Notes: CO₂ emissions by end-use sector are based on EIA's estimates of energy consumption by sector and on industrial process emissions. CO₂ emissions from the electric power sector are allocated to the end-use sectors based on electricity sales to the sector. Non-CO₂ emissions by end-use sector are allocated by direct emissions in those sectors plus indirect emissions from the electric power sector allocated by electricity sales. Totals may not equal sum of components due to independent rounding.

Table 4. World energy-related carbon dioxide emissions by region, 1990-2035: Sources: History: EIA, International Energy Statistics, website www.eia.gov/emeu/international; and U.S. estimates presented in this report. Projections: EIA, *Annual Energy Outlook 2011 Early Release Overview*, DOE/EIA-0383ER(2011) (Washington, DC, December 2010), website www.eia.gov/aeo (U.S. projections); and *International Energy Outlook 2010*, DOE/EIA-0484(2010) (Washington, DC, July 2010), Table A10, website www.eia.gov/oiaf/ieo (world projections). Note: Because newer U.S. values are used, the totals for North America, OECD, and the world in this report do not match the corresponding values in *International Energy Outlook 2010*.

Table 5. Greenhouse gases and 100-year net global warming potentials: Sources: SAR: Intergovernmental Panel on Climate Change, *Climate Change 1995: The Science of Climate Change* (Cambridge, UK: Cambridge University Press, 1996). This document was part of the Second Assessment Report (SAR) by the Intergovernmental Panel on Climate Change. TAR: Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), website www.grida.no/publications/other/ipcc_tar/. This document was part of the Third Assessment Report (TAR) by the Intergovernmental Panel on Climate Change. AR4: Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis: Errata* (Cambridge, UK: Cambridge University Press, 2008), website www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf. This document describes errata in parts of the Fourth Assessment Report (AR4) by the Intergovernmental Panel on Climate Change.

Chapter 2: Carbon dioxide emissions

Table 6. U.S. carbon dioxide emissions from energy and industry, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 7. U.S. energy-related carbon dioxide emissions by end-use sector, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 8. U.S. carbon dioxide emissions from residential sector energy consumption, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 9. U.S. carbon dioxide emissions from commercial sector energy consumption, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 10. U.S. carbon dioxide emissions from industrial sector energy consumption, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 11. U.S. carbon dioxide emissions from transportation sector energy consumption, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 12. U.S. carbon dioxide emissions from electric power sector energy consumption, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 13. U.S. carbon dioxide emissions from nonfuel uses of energy fuels, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 14. U.S. carbon sequestration from nonfuel uses of energy fuels, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 15. U.S. carbon dioxide emissions: adjustments for U.S. Territories and international bunker fuels, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 16. U.S. carbon dioxide emissions from other sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Chapter 3: Methane emissions

Table 17. U.S. methane emissions, 1990-2009: Sources: EIA, published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2009*, DOE/EIA-0573(2009) (Washington, DC, March 2011). Data in this table are revised from the data contained in *Emissions of Greenhouse Gases in the United States 2008*. Emissions calculations based on Intergovernmental Panel on Climate Change, *IPCC Guidelines for National Greenhouse Gas Inventories* (2006 and revised 1996 guidelines), website <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Table 18. U.S. methane emissions from energy sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 19. U.S. methane emissions from agricultural sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 20. U.S. methane emissions from waste management sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 21. U.S. methane emissions from industrial process sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Chapter 4: Nitrous oxide emissions

Table 22. U.S. nitrous oxide emissions, 1990-2009: Sources: EIA, published and unpublished data used to produce *Emissions of Greenhouse Gases in the United States 2009*, DOE/EIA-0573(2009) (Washington, DC, March 2011). Data in this table are revised from the data contained in *Emissions of Greenhouse Gases in the United States 2008*. Emissions calculations based on Intergovernmental Panel on Climate Change, *IPCC Guidelines for National Greenhouse Gas Inventories* (2006 and revised 1996 guidelines), website <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>; and U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Table 23. U.S. nitrous oxide emissions from agricultural sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 24. U.S. nitrous oxide emissions from energy sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 25. U.S. nitrous oxide emissions from industrial sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Table 26. U.S. nitrous oxide emissions from waste management sources, 1990-2009: Source: Estimates presented in this report. Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2008*, DOE/EIA-0573(2008) (Washington, DC, December 2009).

Chapter 5: High-GWP gases

Table 27. U.S. emissions of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, 1990-2009: Source: U.S. Environmental Protection Agency, Office of Air and Radiation, website www.epa.gov/globalwarming/ (preliminary estimates, November 2010).

Table 28. U.S. emissions of hydrofluorocarbons, 1990-2009: Source: U.S. Environmental Protection Agency, Office of Air and Radiation, website www.epa.gov/globalwarming/ (preliminary estimates, November 2010).

Table 29. U.S. emissions of perfluorocarbons, 1990-2009: Source: U.S. Environmental Protection Agency, Office of Air and Radiation, website www.epa.gov/globalwarming/ (estimates, November 2010). 2008 values are used as proxies for 2009.

Table 30. U.S. emissions of sulfur hexafluoride by source, 1990-2009: Source: U.S. Environmental Protection Agency, Office of Air and Radiation, website www.epa.gov/globalwarming/ (estimates, November 2010). 2008 values are used as proxies for 2009.

Chapter 6: Land use

Table 31. Net U.S. carbon dioxide sequestration from land use, land use change, and forestry, 1990-2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Table 32. Net carbon dioxide sequestration in U.S. forests and harvested wood pools, 1990-2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Table 33. Net carbon dioxide sequestration in U.S. croplands and grasslands, 1990-2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Table 34. Net carbon dioxide sequestration in U.S. urban trees, yard trimmings, and food scraps, 1990-2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Table 35. Emissions of carbon dioxide from biofuel/bioenergy use by sector and fuel, 1990-2009: Sources: U.S. Energy Information Administration, *January 2011 Monthly Energy Review* (Washington, DC: January 31, 2011), website www.eia.gov/emeu/mer; and U.S. Environmental Protection Agency, 40 CFR: Protection of the Environment, Part 98—Mandatory Greenhouse Gas Reporting, “Table C-1 to Subpart C of Part 98—Default CO₂ Emission Factors and High Heat Values for Various Types of Fuel,” Federal Register, Vol. 74, No. 209 (October 30, 2009), p. 56410, website www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-FinalRule.pdf.

A1.2. Figure Notes and Sources

Chapter 1: Greenhouse gas emissions overview

Figure 1. U.S. greenhouse gas emissions by gas, 2009: Source: Estimates presented in this report.

Figure 2. U.S. energy-related carbon dioxide emissions by major fuel, 2009: Source: Estimates presented in this report.

Figure 3. U.S. energy-related carbon dioxide emissions by sector, 2009: Source: Estimates presented in this report.

Figure 4. Annual changes in Kaya identity terms (GDP, Energy/GDP, CO₂/Energy) and energy-related carbon dioxide emissions, 2005-2009: Sources: Estimates presented in this report; and U.S. Department of Commerce, Bureau of Economic Analysis, website www.bea.gov (GDP, November 2010).

Figure 5. Greenhouse gas emissions in the U.S. economy: Source: Estimates presented in this report. Notes: CO₂ emissions by end-use sector are based on EIA’s estimates of energy consumption by sector and on industrial process emissions. CO₂ emissions from the electric power sector are allocated to the end-use sectors based on electricity sales to the sector. Non-CO₂ emissions by end-use sector are allocated by direct emissions in those sectors plus indirect emissions from the electric power sector allocated by electricity sales. Totals may not equal sum of components due to independent rounding.

Figure 6. World carbon dioxide emissions by region, 1990, 2007, 2025, and 2035: Sources: History: Energy Information Administration (EIA), International Energy Statistics, website www.eia.gov/emeu/international; and U.S. data presented in this report. Projections: EIA, *Annual Energy Outlook 2011 Early Release Overview*, DOE/EIA-0383ER(2011) (Washington, DC, December 2010), website www.eia.gov/aeo; and *International Energy Outlook 2010*, DOE/EIA-0484(2010) (Washington, DC, July 2010), Table A10, website www.eia.gov/oiaf/ieo. Note: Because newer U.S. values are used, the totals for North America, OECD, and the world in this report do not match the corresponding values in International Energy Outlook 2010.

Figure 7. Regional shares of world carbon dioxide emissions, 1990, 2007, 2025, and 2035: Sources: History: Energy Information Administration (EIA), International Energy Statistics, website www.eia.gov/emeu/international; and U.S. data presented in this report. Projections: EIA, *Annual Energy Outlook 2011 Early Release Overview*, DOE/EIA-0383ER(2011) (Washington, DC, December 2010), website www.eia.gov/aeo; and *International Energy Outlook 2010*, DOE/EIA-0484(2010) (Washington, DC, July 2010), Table A10, website www.eia.gov/oiaf/ieo. Note: Because newer U.S. values are used, the totals for North America, OECD, and the world in this report do not match the corresponding values in International Energy Outlook 2010.

Figure 8. U.S. emissions of black carbon by source, 2001 and 2020: Notes: Calculations based on PM_{2.5}. Sources: M.A. Bahner, K.A. Weitz, A. Zapata, and B. DeAngelo, "Use of Black Carbon and Organic Carbon Inventories for Projections and Mitigation Analysis," presentation at 16th Annual International Emission Inventory Conference (Raleigh, NC, May 14-17, 2007), website www.epa.gov/ttn/chief/conference/ei16/session3/k.weitz.pdf; and U.S. Environmental Protection Agency, "Reducing Particle Pollution," website www.epa.gov/oar/particulatepollution/reducing.html. It is difficult to compare black carbon with conventional greenhouse gases because of uncertainty related to GWPs. Figure 8 uses a 100-year GWP of 680 in order to be consistent with the GWP time horizon used elsewhere in this report. However, a 20-year GWP may be more appropriate. Year 2020 projections account for reductions due to implementation of existing rules.

Chapter 2: Carbon dioxide emissions

Figure 9. Annual change in U.S. carbon dioxide emissions, 1991-2009: Source: Estimates presented in this report.

Figure 10. Energy-related carbon dioxide emissions for selected sectors 1990-2009: Source: Estimates presented in this report.

Figure 11. Annual changes in U.S. heating degree-days and residential sector carbon dioxide emissions from direct fuel combustion, 1990-2009: Source: Estimates presented in this report.

Figure 12. U.S. commercial sector carbon dioxide emissions and per capita income, 1990-2009: Source: Estimates presented in this report.

Figure 13. U.S. industrial sector carbon dioxide emissions and major industrial fuel use, 1990-2009: Source: Estimates presented in this report.

Figure 14. U.S. vehicle miles traveled and carbon dioxide emissions from gasoline and diesel transportation fuel use, 1990-2009: Source: Estimates presented in this report.

Figure 15. U.S. electric power sector energy sales and losses and carbon dioxide emissions from primary fuel combustion, 1990-2009: Source: Estimates presented in this report.

Figure 16. U.S. carbon dioxide emissions from other sources, 2009: Source: Estimates presented in this report.

Chapter 3: Methane emissions

Figure 17. U.S. methane emissions by source, 1990-2009: Source: Estimates presented in this report.

Figure 18. U.S. methane emissions from energy sources, 1990-2009: Source: Estimates presented in this report.

Figure 19. U.S. methane emissions from agriculture by source, 2009: Source: Estimates presented in this report.

Figure 20. U.S. methane emissions from waste management by source, 1990-2009: Source: Estimates presented in this report.

Figure 21. U.S. methane emissions from industrial processes by source, 1990-2009: Source: Estimates presented in this report.

Chapter 4: Nitrous oxide emissions

Figure 22. U.S. nitrous oxide emissions by source, 1990-2009: Source: Estimates presented in this report.

Figure 23. U.S. nitrous oxide emissions from agriculture by source, 2009: Source: Estimates presented in this report.

Figure 24. U.S. nitrous oxide emissions from energy use by source, 1990-2009: Source: Estimates presented in this report.

Figure 25. U.S. nitrous oxide emissions from industry by source, 1990-2009: Source: Estimates presented in this report.

Figure 26. U.S. nitrous oxide emissions from waste management by source, 1990-2009: Source: Estimates presented in this report.

Chapter 5: High-GWP gases

Figure 27. U.S. emissions of high-GWP gases, 1990-2009: Source: U.S. Environmental Protection Agency estimates.

Figure 28. U.S. emissions of HFCs, 1990-2009: Source: U.S. Environmental Protection Agency estimates.

Figure 29. U.S. emissions of PFCs, 1990-2009: Source: U.S. Environmental Protection Agency estimates.

Figure 30. U.S. emissions of SF₆ by source, 1990-2009: Source: U.S. Environmental Protection Agency estimates.

Chapter 6: Land use

Figure 31. U.S. carbon sequestration from land use, land use change, and forestry, 1990-2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Figure 32. Carbon sequestration in U.S. forest lands and harvested wood pools, 2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Figure 33. Carbon sequestration in U.S. croplands and grasslands, 1990-2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

Figure 34. Carbon sequestration in U.S. urban trees, yard trimmings, and food scraps, 1990-2008: Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, EPA 430-R-10-006 (Washington, DC, April 2010), website <http://epa.gov/climatechange/emissions/usinventoryreport.html>.

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A2. Glossary

Acid stabilization: A circumstance where the pH of the waste mixture in an animal manure management system is maintained near 7.0, optimal conditions for methane production.

Aerobic bacteria: Microorganisms living, active, or occurring only in the presence of oxygen.

Aerobic decomposition: The breakdown of a molecule into simpler molecules or atoms by microorganisms under favorable conditions of oxygenation.

Aerosols: Airborne particles.

Afforestation: Planting of new forests on lands that have not been recently forested.

Agglomeration: The clustering of disparate elements.

Airshed: An area or region defined by settlement patterns or geology that results in discrete atmospheric conditions.

Albedo: The fraction of incident light or electromagnetic radiation that is reflected by a surface or body. See *Planetary albedo*.

Anaerobes: Organisms that live and are active only in the absence of oxygen.

Anaerobic bacteria: Microorganisms living, active, or occurring only in the absence of oxygen.

Anaerobic decomposition: The breakdown of molecules into simpler molecules or atoms by microorganisms that can survive in the partial or complete absence of oxygen.

Anaerobic lagoon: A liquid-based manure management system, characterized by waste residing in water to a depth of at least six feet for a period ranging between 30 and 200 days.

Anode: A positive electrode, as in a battery, radio tube, etc.

Anthracite: The highest rank of coal; used primarily for residential and commercial space heating. It is a hard, brittle, and black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter. The moisture content of fresh-mined anthracite generally is less than 15 percent. The heat content of anthracite ranges from 22 to 28 million Btu per ton on a moist, mineral-matter-free basis. The heat content of anthracite coal consumed in the United States averages 25 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter). Note: Since the 1980's, anthracite refuse or mine waste has been used for steam electric power generation. This fuel typically has a heat content of 15 million Btu per ton or less.

Anthropogenic: Made or generated by a human or caused by human activity. The term is used in the context of global climate change to refer to gaseous emissions that are the result of human activities, as well as other potentially climate-altering activities, such as deforestation.

API gravity: American Petroleum Institute measure of specific gravity of crude oil or condensate in degrees. An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API; it is calculated as follows: Degrees API = $(141.5/\text{sp.gr.}60 \text{ deg.F}/60 \text{ deg.F}) - 131.5$.

Asphalt: A dark brown-to-black cement-like material obtained by petroleum processing and containing bitumens as the predominant component; used primarily for road construction. It includes crude asphalt as well as the following finished products: cements, fluxes, the asphalt content of emulsions (exclusive of water), and petroleum distillates blended with asphalt to make cutback asphalts. Note: The conversion factor for asphalt is 5.5 barrels per short ton.

Associated natural gas: See *Associated-dissolved natural gas* and *Natural gas*.

Associated-dissolved natural gas: Natural gas that occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved gas). See *Natural gas*.

Aviation gasoline (finished): A complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in aviation reciprocating engines. Fuel specifications are provided in ASTM Specification D 910 and Military Specification MIL-G-5572. Note: Data on blending components are not counted in data on finished aviation gasoline.

Balancing item: Represents differences between the sum of the components of natural gas supply and the sum of the components of natural gas disposition. These differences may be due to quantities lost or to the effects of data reporting problems. Reporting problems include differences due to the net result of conversions of flow data metered at varying temperature and pressure bases and converted to a standard temperature and pressure base; the effect of variations in company accounting and billing practices; differences between billing cycle and calendar period time frames; and imbalances resulting from the merger of data reporting systems that vary in scope, format, definitions, and type of respondents.

Biofuels: Liquid fuels and blending components produced from biomass (plant) feedstocks, used primarily for transportation.

Biogas: The gas produced from the anaerobic decomposition of organic material in a landfill.

Biogenic: Produced by the actions of living organisms.

Biomass: Organic nonfossil material of biological origin constituting a renewable energy source.

Biosphere: The portion of the Earth and its atmosphere that can support life. The part of the global carbon cycle that includes living organisms and biogenic organic matter.

Bituminous coal: A dense coal, usually black, sometimes dark brown, often with well-defined bands of bright and dull material, used primarily as fuel in steam-electric power generation, with substantial quantities also used for heat and power applications in manufacturing and to make coke. Bituminous coal is the most abundant coal in active U.S. mining regions. Its moisture content usually is less than 20 percent. The heat content of bituminous coal ranges from 21 to 30 million Btu per ton on a moist, mineral-matter-free basis. The heat content of bituminous coal consumed in the United States averages 24 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

BOD₅: The biochemical oxygen demand of wastewater during decomposition occurring over a 5-day period. A measure of the organic content of wastewater.

Bromofluorocarbons (halons): Inert, nontoxic chemicals that have at least one bromine atom in their chemical makeup. They evaporate without leaving a residue and are used in fire extinguishing systems, especially for large computer installations.

Bunker fuel: Fuel supplied to ships and aircraft, both domestic and foreign, consisting primarily of residual and distillate fuel oil for ships and kerosene-based jet fuel for aircraft. The term "international bunker fuels" is used to denote the consumption of fuel for international transport activities. Note: For the purposes of greenhouse gas emissions inventories, data on emissions from combustion of international bunker fuels are subtracted from national emissions totals. Historically, bunker fuels have meant only ship fuel. See *Vessel bunkering*.

Calcination: A process in which a material is heated to a high temperature without fusing, so that hydrates, carbonates, or other compounds are decomposed and the volatile material is expelled.

Calcium sulfate: A white crystalline salt, insoluble in water. Used in Keene's cement, in pigments, as a paper filler, and as a drying agent.

Calcium sulfite: A white powder, soluble in dilute sulfuric acid. Used in the sulfite process for the manufacture of wood pulp.

Capital stock: Property, plant and equipment used in the production, processing and distribution of energy resources.

Carbon black: An amorphous form of carbon, produced commercially by thermal or oxidative decomposition of hydrocarbons and used principally in rubber goods, pigments, and printer's ink.

Carbon budget: Carbon budget: The balance of the exchanges (incomes and losses) of carbon between carbon sinks (e.g., atmosphere and biosphere) in the carbon cycle. See *Carbon cycle* and *Carbon sink*.

Carbon cycle: All carbon sinks and exchanges of carbon from one sink to another by various chemical, physical, geological, and biological processes. See *Carbon sink* and *Carbon budget*.

Carbon dioxide (CO₂): A colorless, odorless, non-poisonous gas that is a normal part of Earth's atmosphere. Carbon dioxide is a product of fossil-fuel combustion as well as other processes. It is considered a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming. The global warming potential (GWP) of other greenhouse gases is measured in relation to that of carbon dioxide, which by international scientific convention is assigned a value of one (1). See *Global warming potential (GWP)* and *Greenhouse gases*.

Carbon dioxide equivalent: The amount of carbon dioxide by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another radiatively active gas. Carbon dioxide equivalents are computed by multiplying the weight of the gas being measured (for example, methane) by its estimated global warming potential (which is 25 for methane). "Carbon equivalent units" are defined as carbon dioxide equivalents multiplied by the carbon content of carbon dioxide (i.e., 12/44).

Carbon flux: See *Carbon budget*.

Carbon intensity: The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. See *Emissions coefficient* and *Carbon output rate*.

Carbon output rate: The amount of carbon by weight per kilowatthour of electricity produced.

Carbon sequestration: The fixation of atmospheric carbon dioxide in a carbon sink through biological or physical processes.

Carbon sink: A reservoir that absorbs or takes up released carbon from another part of the carbon cycle. The four sinks, which are regions of the Earth within which carbon behaves in a systematic manner, are the atmosphere, terrestrial biosphere (usually including freshwater systems), oceans, and sediments (including fossil fuels).

Catalytic converter: A device containing a catalyst for converting automobile exhaust into mostly harmless products.

Catalytic hydrocracking: A refining process that uses hydrogen and catalysts with relatively low temperatures and high pressures for converting middle boiling or residual material to high octane gasoline, reformer charge stock, jet fuel, and/or high grade fuel oil. The process uses one or more catalysts, depending on product output, and can handle high sulfur feedstocks without prior desulfurization.

Cesspool: An underground reservoir for liquid waste, typically household sewage.

Chlorofluorocarbon (CFC): Any of various compounds consisting of carbon, hydrogen, chlorine, and fluorine used as refrigerants. CFCs are now thought to be harmful to the earth's atmosphere.

Clean Development Mechanism (CDM): A Kyoto Protocol program that enables industrialized countries to finance emissions-avoiding projects in developing countries and receive credit for reductions achieved against their own emissions limitation targets. See *Kyoto Protocol*.

Climate: The average course or condition of the weather over a period of years as exhibited by temperature, humidity, wind velocity, and precipitation.

Climate change: A term that refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Clinker: Powdered cement, produced by heating a properly proportioned mixture of finely ground raw materials (calcium carbonate, silica, alumina, and iron oxide) in a kiln to a temperature of about 2,700°F.

Cloud condensation nuclei: Aerosol particles that provide a platform for the condensation of water vapor, resulting in clouds with higher droplet concentrations and increased albedo.

Coal coke: See *Coke (coal)*.

Coalbed methane: Methane is generated during coal formation and is contained in the coal microstructure. Typical recovery entails pumping water out of the coal to allow the gas to escape. Methane is the principal component of natural gas. Coalbed methane can be added to natural gas pipelines without any special treatment.

Coke (coal): A solid carbonaceous residue derived from low-ash, low-sulfur bituminous coal from which the volatile constituents are driven off by baking in an oven at temperatures as high as 2,000 degrees Fahrenheit so that the fixed carbon and residual ash are fused together. Coke is used as a fuel and as a reducing agent in smelting iron ore in a blast furnace. Coke from coal is grey, hard, and porous and has a heating value of 24.8 million Btu per ton.

Coke (petroleum): A residue high in carbon content and low in hydrogen that is the final product of thermal decomposition in the condensation process in cracking. This product is reported as marketable coke or catalyst coke. The conversion is 5 barrels (of 42 U.S. gallons each) per short ton. Coke from petroleum has a heating value of 6.024 million Btu per barrel.

Combustion: Chemical oxidation accompanied by the generation of light and heat.

Combustion chamber: An enclosed vessel in which chemical oxidation of fuel occurs.

Conference of the Parties (COP): The collection of nations that have ratified the Framework Convention on Climate Change (FCCC). The primary role of the COP is to keep implementation of the FCCC under review and make the decisions necessary for its effective implementation. See *Framework Convention on Climate Change (FCCC)*.

Cracking: The refining process of breaking down the larger, heavier, and more complex hydrocarbon molecules into simpler and lighter molecules.

Criteria pollutant: A pollutant determined to be hazardous to human health and regulated under EPA's National Ambient Air Quality Standards. The 1970 amendments to the Clean Air Act require EPA to describe the health and welfare impacts of a pollutant as the "criteria" for inclusion in the regulatory regime.

Crop residue: Organic residue remaining after the harvesting and processing of a crop.

Cultivar: A horticulturally or agriculturally derived variety of a plant.

Deforestation: The net removal of trees from forested land.

Degasification system: The methods employed for removing methane from a coal seam that could not otherwise be removed by standard ventilation fans and thus would pose a substantial hazard to coal miners. These systems may be used prior to mining or during mining activities.

Degradable organic carbon: The portion of organic carbon present in such solid waste as paper, food waste, and yard waste that is susceptible to biochemical decomposition.

Desulfurization: The removal of sulfur, as from molten metals, petroleum oil, or flue gases.

Diffusive transport: The process by which particles of liquids or gases move from an area of higher concentration to an area of lower concentration.

Distillate fuel: A general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in on-highway diesel engines,

such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation.

Efflux: An outward flow.

Electrical generating capacity: The full-load continuous power rating of electrical generating facilities, generators, prime movers, or other electric equipment (individually or collectively).

EMCON Methane Generation Model: A model for estimating the production of methane from municipal solid waste landfills.

Emissions: Anthropogenic releases of gases to the atmosphere. In the context of global climate change, they consist of radiatively important greenhouse gases (e.g., the release of carbon dioxide during fuel combustion).

Emissions coefficient: A unique value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g., pounds of carbon dioxide emitted per Btu of fossil fuel consumed).

Enteric fermentation: A digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream of an animal.

Eructation: An act or instance of belching.

ETBE (ethyl tertiary butyl ether): $(\text{CH}_3)_3\text{COC}_2\text{H}$: An oxygenate blend stock formed by the catalytic etherification of isobutylene with ethanol.

Ethylene: An olefinic hydrocarbon recovered from refinery processes or petrochemical processes. Ethylene is used as a petrochemical feedstock for numerous chemical applications and the production of consumer goods.

Ethylene dichloride: A colorless, oily liquid used as a solvent and fumigant for organic synthesis, and for ore flotation.

Facultative bacteria: Bacteria that grow equally well under aerobic and anaerobic conditions.

Flange: A rib or a rim for strength, for guiding, or for attachment to another object (e.g., on a pipe).

Flared: Gas disposed of by burning in flares usually at the production sites or at gas processing plants.

Flatus: Gas generated in the intestines or the stomach of an animal.

Flue gas desulfurization: Equipment used to remove sulfur oxides from the combustion gases of a boiler plant before discharge to the atmosphere. Also referred to as scrubbers. Chemicals such as lime are used as scrubbing media.

Fluidized-bed combustion: A method of burning particulate fuel, such as coal, in which the amount of air required for combustion far exceeds that found in conventional burners. The fuel particles are continually fed into a bed of mineral ash in the proportions of 1 part fuel to 200 parts ash, while a flow of air passes up through the bed, causing it to act like a turbulent fluid.

Flux material: A substance used to promote fusion, e.g., of metals or minerals.

Fodder: Coarse food for domestic livestock.

Forestomach: See *Rumen*.

Fossil fuel: An energy source formed in the earth's crust from decayed organic material. The common fossil fuels are petroleum, coal, and natural gas.

Framework Convention on Climate Change (FCCC): An agreement opened for signature at the "Earth Summit" in Rio de Janeiro, Brazil, on June 4, 1992, which has the goal of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent significant anthropogenically forced climate change. See *Climate change*.

Fuel cycle: The entire set of sequential processes or stages involved in the utilization of fuel, including extraction, transformation, transportation, and combustion. Emissions generally occur at each stage of the fuel cycle.

Fugitive emissions: Unintended leaks of gas from the processing, transmission, and/or transportation of fossil fuels.

Gasification: A method for converting coal, petroleum, biomass, wastes, or other carbon-containing materials into a gas that can be burned to generate power or processed into chemicals and fuels.

Gate station: Location where the pressure of natural gas being transferred from the transmission system to the distribution system is lowered for transport through small diameter, low pressure pipelines.

Geothermal: Pertaining to heat within the Earth.

Global climate change: See *Climate change*.

Global warming: A gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions. See *Climate change*.

Global warming potential (GWP): An index used to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result

from the emission of one kilogram of a greenhouse gas to that from the emission of one kilogram of carbon dioxide over a fixed period of time, such as 100 years.

Greenhouse effect: The result of water vapor, carbon dioxide, and other atmospheric gases trapping radiant (infrared) energy, thereby keeping the earth's surface warmer than it would otherwise be. Greenhouse gases within the lower levels of the atmosphere trap this radiation, which would otherwise escape into space, and subsequent re-radiation of some of this energy back to the Earth maintains higher surface temperatures than would occur if the gases were absent. See *Greenhouse gases*.

Greenhouse gases: Those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride, that are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving the Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.

Gross gas withdrawal: The full-volume of compounds extracted at the wellhead, including nonhydrocarbon gases and natural gas plant liquids.

Gypsum: Calcium sulfate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), a sludge constituent from the conventional lime scrubber process, obtained as a byproduct of the dewatering operation and sold for commercial use.

Halogenated substances: A volatile compound containing halogens, such as chlorine, fluorine or bromine.

Halons: See *Bromofluorocarbons*.

Heating degree-days (HDD): A measure of how cold a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the average of the day's high and low temperatures from the base temperature (65 degrees), with negative values set equal to zero. Each day's heating degree-days are summed to create a heating degree-day measure for a specified reference period. Heating degree-days are used in energy analysis as an indicator of space heating energy requirements or use.

Herbivore: A plant-eating animal.

Hydrocarbon: An organic chemical compound of hydrogen and carbon in either gaseous, liquid, or solid phase. The molecular structure of hydrocarbon compounds varies from the simple (e.g., methane, a constituent of natural gas) to the very heavy and very complex.

Hydrochlorofluorocarbons (HCFCs): Chemicals composed of one or more carbon atoms and varying numbers of hydrogen, chlorine, and fluorine atoms.

Hydrofluorocarbons (HFCs): A group of man-made chemicals composed of one or two carbon atoms and varying numbers of hydrogen and fluorine atoms. Most HFCs have 100-year Global Warming Potentials in the thousands.

Hydroxyl radical (OH): An important chemical scavenger of many trace gases in the atmosphere that are greenhouse gases. Atmospheric concentrations of OH affect the atmospheric lifetimes of greenhouse gases, their abundance, and, ultimately, the effect they have on climate.

Intergovernmental Panel on Climate Change (IPCC): A panel established jointly in 1988 by the World Meteorological Organization and the United Nations Environment Program to assess the scientific information relating to climate change and to formulate realistic response strategies.

International bunker fuels: See *Bunker fuels*.

Jet fuel: A refined petroleum product used in jet aircraft engines. It includes kerosene-type jet fuel and naphtha-type jet fuel.

Joint Implementation (JI): Agreements made between two or more nations under the auspices of the Framework Convention on Climate Change (FCCC) whereby a developed country can receive "emissions reduction units" when it helps to finance projects that reduce net emissions in another developed country (including countries with economies in transition).

Kerosene: A light petroleum distillate that is used in space heaters, cook stoves, and water heaters and is suitable for use as a light source when burned in wick-fed lamps. Kerosene has a maximum distillation temperature of 400 degrees Fahrenheit at the 10-percent recovery point, a final boiling point of 572 degrees Fahrenheit, and a minimum flash point of 100 degrees Fahrenheit. Included are No. 1-K and No. 2-K, the two grades recognized by ASTM Specification D 3699 as well as all other grades of kerosene called range or stove oil, which have properties similar to those of No. 1 fuel oil. See *Kerosene-type jet fuel*.

Kerosene-type jet fuel: A kerosene-based product having a maximum distillation temperature of 400 degrees Fahrenheit at the 10-percent recovery point and a final maximum boiling point of 572 degrees Fahrenheit and meeting ASTM Specification D 1655 and Military Specifications MIL-T-5624P and MIL-T-83133D (Grades JP-5 and JP-8). It is used for commercial and military turbojet and turboprop aircraft engines.

Kyoto Protocol: The result of negotiations at the third Conference of the Parties (COP-3) in Kyoto, Japan, in December of 1997. The Kyoto Protocol sets binding greenhouse gas emissions targets for countries that sign and ratify the agreement. The gases covered under the Protocol include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride.

Ketone-alcohol (cyclohexanol): An oily, colorless, hygroscopic liquid with a camphor-like odor. Used in soapmaking, dry cleaning, plasticizers, insecticides, and germicides.

Leachate: The liquid that has percolated through the soil or other medium.

Lignite: The lowest rank of coal, often referred to as brown coal, used almost exclusively as fuel for steam-electric power generation. It is brownish-black and has a high inherent moisture content, sometimes as high as 45 percent. The heat content of lignite ranges from 9 to 17 million Btu per ton on a moist, mineral-matter-free basis. The heat content of lignite consumed in the United States averages 13 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Liquefied petroleum gases: A group of hydrocarbon-based gases derived from crude oil refining or natural gas fractionation. They include ethane, ethylene, propane, propylene, normal butane, butylene, isobutane, and isobutylene. For convenience of transportation, these gases are liquefied through pressurization.

Lubricants: Substances used to reduce friction between bearing surfaces, or incorporated into other materials used as processing aids in the manufacture of other products, or used as carriers of other materials. Petroleum lubricants may be produced either from distillates or residues. Lubricants include all grades of lubricating oils, from spindle oil to cylinder oil to those used in greases.

Methane: A colorless, flammable, odorless hydrocarbon gas (CH₄) which is the major component of natural gas. It is also an important source of hydrogen in various industrial processes. Methane is a greenhouse gas. See also *Greenhouse gases*.

Methanogens: Bacteria that synthesize methane, requiring completely anaerobic conditions for growth.

Methanol: A light alcohol that can be used for gasoline blending. See *Oxygenate*.

Methanotrophs: Bacteria that use methane as food and oxidize it into carbon dioxide.

Methyl chloroform (trichloroethane): An industrial chemical (CH₃CCl₃) used as a solvent, aerosol propellant, and pesticide and for metal degreasing.

Methyl tertiary butyl ether (MTBE): A colorless, flammable, liquid oxygenated hydrocarbon containing 18.15 percent oxygen.

Methylene chloride: A colorless liquid, nonexplosive and practically nonflammable. Used as a refrigerant in centrifugal compressors, a solvent for organic materials, and a component in nonflammable paint removers.

Mole: The quantity of a compound or element that has a weight in grams numerically equal to its molecular weight. Also referred to as gram molecule or gram molecular weight.

Montreal Protocol: The Montreal Protocol on Substances that Deplete the Ozone Layer (1987). An international agreement, signed by most of the industrialized nations, to substantially reduce the use of chlorofluorocarbons (CFCs). Signed in January 1989, the original document called for a 50-percent reduction in CFC use by 1992 relative to 1986 levels. The subsequent London Agreement called for a complete elimination of CFC use by 2000. The Copenhagen Agreement, which called for a complete phaseout by January 1, 1996, was implemented by the U.S. Environmental Protection Agency.

Motor gasoline (finished): A complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D 4814 or Federal Specification VV-G-1690C, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10 percent recovery point to 365 to 374 degrees Fahrenheit at the 90 percent recovery point. "Motor Gasoline" includes conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline, but excludes aviation gasoline. Note: Volumetric data on blending components, such as oxygenates, are not counted in data on finished motor gasoline until the blending components are blended into the gasoline.

Multiple cropping: A system of growing several crops on the same field in one year.

Municipal solid waste: Residential solid waste and some nonhazardous commercial, institutional, and industrial wastes.

Naphtha less than 401 degrees Fahrenheit: A naphtha with a boiling range of less than 401 degrees Fahrenheit that is intended for use as a petrochemical feedstock. Also see *Petrochemical feedstocks*.

Naphtha-type jet fuel: A fuel in the heavy naphtha boiling range having an average gravity of 52.8 degrees API, 20 to 90 percent distillation temperatures of 290 degrees to 470 degrees Fahrenheit, and meeting Military Specification MIL-T-5624L (Grade JP-4). It is used primarily for military turbojet and turboprop aircraft engines because it has a lower freeze point than other aviation fuels and meets engine requirements at high altitudes and speeds.

Natural gas: A mixture of hydrocarbons and small quantities of various nonhydrocarbons in the gaseous phase or in solution with crude oil in natural underground reservoirs.

Natural gas liquids (NGLs): Those hydrocarbons in natural gas that are separated as liquids from the gas. Includes natural gas plant liquids and lease condensate.

Natural gas, pipeline quality: A mixture of hydrocarbon compounds existing in the gaseous phase with sufficient energy content, generally above 900 Btu, and a small enough share of impurities for transport through commercial gas pipelines and sale to end-users.

Nitrogen oxides (NO_x): Compounds of nitrogen and oxygen produced by the burning of fossil fuels.

Nitrous oxide (N₂O): A colorless gas, naturally occurring in the atmosphere.

Nonmethane volatile organic compounds (NMVOCs): Organic compounds, other than methane, that participate in atmospheric photochemical reactions.

Octane: A flammable liquid hydrocarbon found in petroleum. Used as a standard to measure the anti-knock properties of motor fuel.

Oil reservoir: An underground pool of liquid consisting of hydrocarbons, sulfur, oxygen, and nitrogen trapped within a geological formation and protected from evaporation by the overlying mineral strata.

Organic content: The share of a substance that is of animal or plant origin.

Organic waste: Waste material of animal or plant origin.

Oxidize: To chemically transform a substance by combining it with oxygen.

Oxygenates: Substances which, when added to gasoline, increase the amount of oxygen in that gasoline blend. Ethanol, Methyl Tertiary Butyl Ether (MTBE), Ethyl Tertiary Butyl Ether (ETBE), and methanol are common oxygenates.

Ozone: A molecule made up of three atoms of oxygen. Occurs naturally in the stratosphere and provides a protective layer shielding the Earth from harmful ultraviolet radiation. In the troposphere, it is a chemical oxidant, a greenhouse gas, and a major component of photochemical smog.

Ozone precursors: Chemical compounds, such as carbon monoxide, methane, nonmethane hydrocarbons, and nitrogen oxides, which in the presence of solar radiation react with other chemical compounds to form ozone.

Paraffinic hydrocarbons: Straight-chain hydrocarbon compounds with the general formula C_nH_{2n+2}.

Perfluorocarbons (PFCs): A group of man-made chemicals composed of one or two carbon atoms and four to six fluorine atoms, containing no chlorine. PFCs have no commercial uses and are emitted as a byproduct of aluminum smelting and semiconductor manufacturing. PFCs have very high 100-year Global Warming Potentials and are very long-lived in the atmosphere.

Perfluoromethane: A compound (CF₄) emitted as a byproduct of aluminum smelting.

Petrochemical feedstocks: Chemical feedstocks derived from petroleum principally for the manufacture of chemicals, synthetic rubber, and a variety of plastics.

Petroleum: A broadly defined class of liquid hydrocarbon mixtures. Included are crude oil, lease condensate, unfinished oils, refined products obtained from the processing of crude oil, and natural gas plant liquids. Note: Volumes of finished petroleum products include nonhydrocarbon compounds, such as additives and detergents, after they have been blended into the products.

Petroleum coke: See *Coke (petroleum)*.

Photosynthesis: The manufacture by plants of carbohydrates and oxygen from carbon dioxide and water in the presence of chlorophyll, with sunlight as the energy source. Carbon is sequestered and oxygen and water vapor are released in the process.

Pig iron: Crude, high-carbon iron produced by reduction of iron ore in a blast furnace.

Pipeline, distribution: A pipeline that conveys gas from a transmission pipeline to its ultimate consumer.

Pipeline, gathering: A pipeline that conveys gas from a production well/field to a gas processing plant or transmission pipeline for eventual delivery to end-use consumers.

Pipeline, transmission: A pipeline that conveys gas from a region where it is produced to a region where it is to be distributed.

Planetary albedo: The fraction of incident solar radiation that is reflected by the Earth-atmosphere system and returned to space, mostly by backscatter from clouds in the atmosphere.

Pneumatic device: A device moved or worked by air pressure.

Polystyrene: A polymer of styrene that is a rigid, transparent thermoplastic with good physical and electrical insulating properties, used in molded products, foams, and sheet materials.

Polyvinyl chloride (PVC): A polymer of vinyl chloride. Tasteless, odorless, insoluble in most organic solvents. A member of the family vinyl resin, used in soft flexible films for food packaging and in molded rigid products, such as pipes, fibers, upholstery, and bristles.

Post-mining emissions: Emissions of methane from coal occurring after the coal has been mined, during transport or pulverization.

Radiative forcing: A change in average net radiation at the top of the troposphere (known as the tropopause) because of a change in either incoming solar or exiting infrared radiation. A positive radiative forcing tends on average to warm the earth's surface; a negative radiative forcing on average tends to cool the earth's surface. Greenhouse gases, when emitted into the atmosphere, trap infrared energy radiated from the earth's surface and therefore tend to produce positive radiative forcing. See *Greenhouse gases*.

Radiatively active gases: Gases that absorb incoming solar radiation or outgoing infrared radiation, affecting the vertical temperature profile of the atmosphere. See *Radiative forcing*.

Ratoon crop: A crop cultivated from the shoots of a perennial plant.

Redox potential: A measurement of the state of oxidation of a system.

Reflectivity: The ratio of the energy carried by a wave after reflection from a surface to its energy before reflection.

Reforestation: Replanting of forests on lands that have recently been harvested or otherwise cleared of trees.

Reformulated gasoline: Finished motor gasoline formulated for use in motor vehicles, the composition and properties of which meet the requirements of the reformulated gasoline regulations promulgated by the U.S. Environmental Protection Agency under Section 211(k) of the Clean Air Act. Note: This category includes oxygenated fuels program reformulated gasoline (OPRG) but excludes reformulated gasoline blendstock for oxygenate blending (RBOB).

Renewable energy resources: Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

Residual fuel oil: A general classification for the heavier oils, known as No. 5 and No. 6 fuel oils, that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations. It conforms to ASTM Specifications D 396 and D 975 and Federal Specification VV-F-815C. No. 5, a residual fuel oil of medium viscosity, is also known as Navy Special and is defined in Military Specification MIL-F-859E, including Amendment 2 (NATO Symbol F-770). It is used in steam-powered vessels in government service and inshore powerplants. No. 6 fuel oil includes Bunker C fuel oil and is used for the production of electric power, space heating, vessel bunkering, and various industrial purposes.

Rumen: The large first compartment of the stomach of certain animals in which cellulose is broken down by the action of bacteria.

Sample: A set of measurements or outcomes selected from a given population.

Sequestration: See *Carbon sequestration*.

Septic tank: A tank in which the solid matter of continuously flowing sewage is disintegrated by bacteria.

Sinter: A chemical sedimentary rock deposited by precipitation from mineral waters, especially siliceous sinter and calcareous sinter.

Sodium silicate: A grey-white powder soluble in alkali and water, insoluble in alcohol and acid. Used to fireproof textiles, in petroleum refining and corrugated paperboard manufacture, and as an egg preservative. Also referred to as liquid glass, silicate of soda, sodium metasilicate, soluble glass, and water glass.

Sodium tripolyphosphate: A white powder used for water softening and as a food additive and texturizer.

Stabilization lagoon: A shallow artificial pond used for the treatment of wastewater. Treatment includes removal of solid material through sedimentation, the decomposition of organic material by bacteria, and the removal of nutrients by algae.

Still gas (refinery gas): Any form or mixture of gases produced in refineries by distillation, cracking, reforming, and other processes. The principal constituents are methane, ethane, ethylene, normal butane, butylene, propane, propylene, etc. Still gas is used as a refinery fuel and a petrochemical feedstock. The conversion factor is 6 million Btu per fuel oil equivalent barrel.

Stratosphere: The region of the upper atmosphere extending from the tropopause (8 to 15 kilometers altitude) to about 50 kilometers. Its thermal structure, which is determined by its radiation balance, is generally very stable with low humidity.

Stripper well: An oil or gas well that produces at relatively low rates. For oil, stripper production is usually defined as production rates of between 5 and 15 barrels of oil per day. Stripper gas production would generally be anything less than 60 thousand cubic feet per day.

Styrene: A colorless, toxic liquid with a strong aromatic aroma. Insoluble in water, soluble in alcohol and ether; polymerizes rapidly; can become explosive. Used to make polymers and copolymers, polystyrene plastics, and rubber.

Subbituminous coal: A coal whose properties range from those of lignite to those of bituminous coal and used primarily as fuel for steam-electric power generation. It may be dull, dark brown to black, soft and crumbly, at the lower end of the range, to bright, jet black, hard, and relatively strong, at the upper end. Subbituminous coal contains 20 to 30 percent inherent moisture by weight. The heat content of subbituminous coal ranges from 17 to 24 million Btu per ton on a moist, mineral-matter-free basis. The heat content of subbituminous coal consumed in the United States averages 17 to 18 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Sulfur dioxide (SO₂): A toxic, irritating, colorless gas soluble in water, alcohol, and ether. Used as a chemical intermediate, in paper pulping and ore refining, and as a solvent.

Sulfur hexafluoride (SF₆): A colorless gas soluble in alcohol and ether, and slightly less soluble in water. It is used as a dielectric in electronics.

Sulfur oxides (SO_x): Compounds containing sulfur and oxygen, such as sulfur dioxide (SO₂) and sulfur trioxide (SO₃).

Tertiary amyl methyl ether ((CH₃)₂(C₂H₅)COCH₃): An oxygenate blend stock formed by the catalytic etherification of isoamylene with methanol.

Troposphere: The inner layer of the atmosphere below about 15 kilometers, within which there is normally a steady decrease of temperature with increasing altitude. Nearly all clouds form and weather conditions manifest themselves within this region. Its thermal structure is caused primarily by the heating of the earth's surface by solar radiation, followed by heat transfer through turbulent mixing and convection.

Uncertainty: A measure used to quantify the plausible maximum and minimum values for emissions from any source, given the biases inherent in the methods used to calculate a point estimate and known sources of error.

Vapor displacement: The release of vapors that had previously occupied space above liquid fuels stored in tanks. These releases occur when tanks are emptied and filled.

Ventilation system: A method for reducing methane concentrations in coal mines to non-explosive levels by blowing air across the mine face and using large exhaust fans to remove methane while mining operations proceed.

Vessel bunkering: Includes sales for the fueling of commercial or private boats, such as pleasure craft, fishing boats, tugboats, and ocean-going vessels, including vessels operated by oil companies. Excluded are volumes sold to the U.S. Armed Forces.

Volatile organic compounds (VOCs): Organic compounds that participate in atmospheric photochemical reactions.

Volatile solids: A solid material that is readily decomposable at relatively low temperatures.

Waste flow: Quantity of a waste stream generated by an activity.

Wastewater: Water that has been used and contains dissolved or suspended waste materials.

Wastewater, domestic and commercial: Wastewater (sewage) produced by domestic and commercial establishments.

Wastewater, industrial: Wastewater produced by industrial processes.

Water vapor: Water in a vaporous form, especially when below boiling temperature and diffused (e.g., in the atmosphere).

Wax: A solid or semi-solid material derived from petroleum distillates or residues by such treatments as chilling, precipitating with a solvent, or de-oiling. It is a light-colored, more-or-less translucent crystalline mass, slightly greasy to the touch, consisting of a mixture of solid hydrocarbons in which the paraffin series predominates. Includes all marketable wax, whether crude scale or fully refined. The three grades included are microcrystalline, crystalline-fully refined, and crystalline-other. The conversion factor is 280 pounds per 42 U.S. gallons per barrel.

Weanling system: A cattle management system that places calves on feed starting at 165 days of age and continues until the animals have reached slaughter weight.

Wellhead: The point at which the crude (and/or natural gas) exits the ground. Following historical precedent, the volume and price for crude oil production are labeled as "wellhead," even though the cost and volume are now generally measured at the lease boundary. In the context of domestic crude price data, the term "wellhead" is the generic term used to reference the production site or lease property.

Wetlands: Areas regularly saturated by surface or groundwater and subsequently characterized by a prevalence of vegetation adapted for life in saturated-soil conditions.

Wood energy: Wood and wood products used as fuel, including roundwood (cordwood), limbwood, wood chips, bark, sawdust, forest residues, charcoal, pulp waste, and spent pulping liquor.

Yearling system: A cattle management system that includes a stocker period from 165 days of age to 425 days of age followed by a 140-day feedlot period.

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- [Laws & Regulations Home](#) →
- [Air Bags](#) →
- [Brakes](#) →
- [CAFE - Fuel Economy](#) →
- [Child Passenger Safety](#) →
- [Disabled Drivers and Passengers](#) →
- [Electronic Stability Control \(ESC\)](#) →
- [Manufacturer Info](#) →
- [Other Equipment](#) →
- [Seat Belts](#) →
- [Tires](#) →
- [Vehicles](#) →

- Fuel Economy Program Reports**
- » [2004 Report](#)
 - » [2003 Report](#)
 - » [2002 Report](#)
 - » [2001 Report](#)
 - » [2000 Report](#)
 - » [1999 Report](#)

CAFE - Fuel Economy

Corporate Average Fuel Economy (CAFE)

First enacted by Congress in 1975, the purpose of CAFE is to reduce energy consumption by increasing the fuel economy of cars and light trucks. NHTSA has recently set standards to increase CAFE levels rapidly over the next several years, which will improve our nation's energy security and save consumers money at the pump. This site contains an immense amount of information about the CAFE program including a CAFE overview, rulemaking actions, fleet characteristics data, compliance activities, summaries of manufacturers' fuel economy performances since 1978, and related studies.

LATEST NEWS

February 20, 2014: Proposed Rule Alternative Fuel Badging and Consumer Information

NHTSA is proposing to require badges, labels and owner's manual information for new passenger cars, low-speed vehicles (LSVs) and light-duty trucks rated at not more than 8,500 pounds gross vehicle weight, in order to increase consumer awareness regarding the use and benefits of alternative fuels.

This proposed rule would implement specific statutory mandates that manufacturers be required to: identify each vehicle capable of running on an alternative fuel by means of a permanent and prominent display affixed to the exterior of the vehicle; add proposed text describing the capabilities and benefits of using alternative fuels to the owners' manuals provided for alternative fuel vehicles; and identify each vehicle that is capable of running on an alternative fuel by means of a label in the fuel filler compartment.

- [View or download a copy of the proposed rule](#)
- Please submit any comments on or before April 21, 2014, to docket number: [NHTSA-2010-0134](#)

February 18, 2014: Phase 2 of the DOT and EPA Fuel Efficiency and GHG Emission Program for Medium- and Heavy-Duty Vehicles announced

President Obama directs the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) to develop and issue the next phase ("Phase 2") of medium- and heavy-duty vehicle fuel efficiency and greenhouse gas (GHG) standards by March 2016. Under this timeline, the agencies are expected to issue a Notice of Proposed Rulemaking (NPRM) by March 2015. This second round of fuel efficiency standards will build on the first-ever standards for medium- and heavy-duty vehicles (model years 2014 through 2018).

- [FACT SHEET -- Opportunity For All: Improving the Fuel Efficiency of American Trucks - Bolstering Energy Security, Cutting Carbon Pollution, Saving Money and Supporting Manufacturing Innovation](#)
- [WHITE HOUSE REPORT -- Improving the Fuel Efficiency of American Trucks](#)
- More information on "Phase 1" is below

Phase 1 of Fuel Efficiency and GHG Emission Program for Medium- and Heavy-Duty Trucks, MYs 2014-2018

[Technical Amendments](#)



NHTSA Consumer Research on Fuel Economy, GHG and Alternative Fuels

Read the final reports and webinar presentation for focus groups and online surveys NHTSA conducted to inform development of a consumer education campaign.

- » [Focus Groups Details and Results](#)
- » [Online Survey Details and Results](#)
- » [Webinar Materials on Research](#)

Requests for Product Plan Info

NHTSA periodically requests future product plan information from auto manufacturers to help the agency in its CAFE rulemaking analyses.

- » [Current and past product plan requests](#)

Summary of Fuel Economy Performance

- » [April 2013 Summary of Fuel Economy Performance](#)
- » [Flexible Fuel Credits \(2003-2013\)](#)
- » [Summary of CAFE fines \(Updated April 2013\)](#)
- » [CAFE Credit Status for Models Year 2008 through 2011](#)
- » [New Passenger Car Fleet Characteristics](#)
- » [Domestic Passenger Car Fleet Characteristics](#)
- » [Imported Passenger Car Fleet Characteristics](#)
- » [Light Truck Fleet Characteristics](#)
- » [2WD Light Truck Fleet Characteristics](#)
- » [4WD Light Truck Fleet Characteristics](#)
- » [Asian Imported Passenger Car Fleet Characteristics](#)
- » [European Imported Passenger Car Fleet Characteristics](#)
- » [Historical Passenger Car Fleet Characteristics](#)



» [Partial Withdrawal of Heavy-Duty Engine and Vehicle, and Nonroad Technical Amendments](#)

» [Heavy-Duty Engine and Vehicle, and Nonroad Technical Amendments](#)

» [Final Rule](#)

» [Final rule](#)

» [Correcting Amendments for Base Tire Definition](#)

» [Final Regulatory Impact Analysis](#)

» [Read the Aug. 9, 2011, News Release](#)

» [Fact Sheet](#)

» [NEPA Process](#)

» [Environmental Impact Statements \(FEIS & DEIS\)](#)

» [Notice of Proposed Rulemaking](#)

» [Fact Sheet](#)

» [Correction Notice for Notice of Proposed Rulemaking](#)

» [Notice of Proposed Rulemaking](#)

» [Draft Regulatory Impact Analysis](#)

» [NHTSA Study: Factors and Considerations for Establishing a Fuel Efficiency Regulatory Improvement Program for Commercial Medium- and Heavy-Duty Vehicles](#)

» [Notice of Public Hearings for Proposal on Nov. 15 & 18](#)

» [NAS Study: Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles](#)

» [Read the News Release](#)

NHTSA Holds Workshop on Vehicle Mass-Size-Safety

NHTSA conducted a workshop on May 13-14 on issues related to fuel economy, vehicle mass reduction and the effects of vehicle mass and size on vehicle safety.

» [Workshop Reports and Presentations](#)

» [Recap of February 2011 Workshop](#)

DOT and EPA Establish CAFE and GHG Emissions Standards for Model Years 2017 and Beyond

Following the direction set by President Obama on May 21, 2010, NHTSA and EPA have issued joint Final Rules for Corporate Average Fuel Economy and Greenhouse Gas emissions regulations for model years 2017 and beyond, that will help address our country's dependence on imported oil, save consumers money at the pump, and reduce emissions of greenhouse gases that contribute to global climate change.

» [Read the Aug. 28, 2012, News Release](#)

» [Final Rule \(Federal Register version\)](#)

» [Correction Notice for Final Rule, Part 536 \(Oct. 18, 2012\)](#)

» [Final Regulatory Impact Analysis \(FRIA\)](#)

» [Joint Technical Support Document \(TSD\)](#)

» [Environmental Impact Statements: Final \(July 2012\) & Draft \(Nov. 2011\)](#)

» [Fact Sheet](#)

» [CAFE Compliance and Effects Modeling System: The Volpe Model](#)

- » [Other NHTSA Research Supporting the Final Rule](#)
- » [Transcripts for Public Hearings in Detroit, Philadelphia, and San Francisco](#)
- » [Documents Associated with the Dec. 2011 Proposal](#)
- » [Documents Leading Up to the Proposal](#)

DOT and EPA Unveil New Fuel Economy Labels

NHTSA and EPA have jointly issued a final rule establishing new requirements for a fuel economy and environment label that will be posted on the window sticker of all new automobiles sold in the U.S. The redesigned label provides expanded information to American consumers about new vehicle fuel economy and fuel consumption, greenhouse gas and smog-forming emissions, and projected fuel costs and savings, and also includes a smartphone interactive code that permits direct access to additional web resources. Click the link below for more information.

- » [Complete Information on the New Label](#)

New Fuel Efficiency Program Announced

At the direction of President Obama on May 21, 2010, NHTSA and EPA are taking the next steps to improve fuel efficiency and reduce greenhouse gas (GHG) emissions from mobile sources.

- » [Notice of Intent to Prepare an Environmental Impact Statement](#)
- » [Read the Presidential Memorandum](#)
- » [Fact Sheet](#)
- » [Stakeholder Commitment Letters](#)

Joint Rulemaking to Establish CAFE and GHG Emissions Standards, MY 2012-2016

There is a critically important need for our country to address global climate change and to reduce oil consumption. In this context, DOT and EPA worked in coordination to establish standards for CAFE and emissions of greenhouse gases (GHG) for Model Years 2012-2016.

- » [Final Rule](#)
- » [Notice of Proposed Rulemaking \(NPRM\)](#)
- » [Environmental Impact Statements \(Final and Draft\)](#)

Average Fuel Economy Standards, Passenger Cars and Light Trucks, MY 2011-2015

Proposes substantial increases in CAFE standards for passenger cars and light trucks that would enhance energy security by improving fuel economy. Since carbon dioxide (CO₂) is the natural by-product of the combustion of fuel, the increased standards would also address climate change by reducing tailpipe emissions of CO₂. Those emissions represent 97 percent of the total greenhouse gas emissions from motor vehicles. Implementation of the new standards would dramatically add to the billions of barrels of fuel already saved since the beginning of the CAFE program in 1975.

- » [Final Environmental Impact Statement](#)
- » [NHTSA Public Hearing on the CAFE DEIS](#)
- » [Draft Environmental Impact Statement](#)

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Average Fuel Economy Standards, Passenger Cars and Light

Trucks, MY 2011

NHTSA estimates that the MY 2011 standards will raise the industry-wide combined average to 27.3 mpg, save 887 million gallons of fuel over the lifetime of the MY 2011 cars and light trucks, and reduce CO2 emissions by 8.3 million metric tons during that period.

» [Final Rule](#)

» [Final Regulatory Impact Analysis](#)

Light Truck Fuel Economy Standard Rulemaking, MY 2008-2011

This final rule reforms the structure of the CAFE program for light trucks and establishes higher CAFE standards for model year (MY) 2008-2011 light trucks. Manufacturers may comply with CAFE standards established under the reformed structure (Reformed CAFE) or with standards established in the traditional way (Unreformed CAFE) during a transition period of MYs 2008-2010. In MY 2011, all manufacturers will be required to comply with a Reformed CAFE standard. Under Reformed CAFE, fuel economy standards are restructured so they are based on a measure of vehicle size called "footprint," the product of multiplying a vehicle's wheelbase by its track width. A target level of fuel economy is established for each increment in footprint. Smaller footprint light trucks have higher targets and larger ones, lower targets.

» [New Light Truck Economy Standards to Save 10.7 Billion Gallons of Fuel](#)














» [Final Rule](#)

» [Final Environmental Assessment](#)

» [Final Regulatory Impact Analysis](#)

Rules

FMVSS ▲	Part ▲	Details	Actions
	49 CFR Parts 523, 533 and 537	Light Truck Average Fuel Economy Standards, Model Years 2008-2011 This final rule reforms the structure of the corporate average fuel economy (CAFE) program for light trucks and establishes higher CAFE standards for model year (MY) 2008-2011 light trucks. Reforming the CAFE program will enable it to achieve larger fuel savings, while enhancing safety and preventing adverse economic consequences.	Final rule Final Environmental Assessment Final Regulatory Impact Analysis
	49 CFR Parts 523, 531, 534, 536, 537	Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011-2015 Proposes substantial increases in the Corporate Average Fuel Economy (CAFE) standards for passenger cars and light trucks that would enhance energy security by improving fuel economy. Since the carbon dioxide (CO2) emitted from the tailpipes of new motor vehicles is the natural by-product of the combustion of fuel, the increased standards would also address climate change by reducing tailpipe emissions of CO2. Those emissions represent 97 percent of the total greenhouse gas emissions from motor vehicles. Implementation of the new standards would dramatically add to the billions of barrels of fuel already saved since the beginning of the CAFE program in 1975.	Supplemental Scoping Notice Draft Environmental Impact Statement, Appendix C Draft Environmental Impact Statement, Appendix B Request for Product Plan Information Draft Environmental Impact Statement, Appendix A Draft Environmental Impact Statement Preliminary Regulatory Impact Analysis Notice of Proposed Rulemaking (NPRM)
	49 CFR Part 533	Reforming the Automobile Fuel Economy Standards Program This document seeks comment on various issues relating to the corporate average fuel economy (CAFE) program. In particular, this document seeks comments relating to possible enhancements to the program that will assist in furthering fuel conservation while protecting motor vehicle safety and the economic vitality of the auto industry. The agency is particularly interested in improvements to the structure of the CAFE program authorized under current statutory authority. The focus of this document is to solicit comments on the structure of the CAFE program, not the stringency level for a future CAFE standard.	Request for Comments Advance Notice of Proposed Rulemaking
	49 CFR Part 538	Automobile Fuel Economy Manufacturing Incentives for Alternative Fueled Vehicles This final rule extends the incentive created by the Alternative Motor Fuels Act of 1988 (AMFA) to encourage the continued production of motor vehicles capable of operating	Final Rule

	<p>on alternative fuels for four additional model years covering model years (MY) 2005 to MY 2008. Under the special procedures for calculating the fuel economy of those vehicles contained in AMFA, alternative and dual fueled vehicles are assigned a higher fuel economy value for CAFE purposes, which can result in manufacturers earning credits for their fleets. The final rule limits the maximum amount of credit that may be applied to any manufacturers' fleet to 0.9 mpg per fleet during MY 2005 - MY 2008.</p>	
49 CFR Part 538	<p>Under 49 CFR Part 538, Automotive Fuel Economy Manufacturing Incentives for Alternative Fuel Vehicles</p> <p>To provide an incentive for the production of vehicles that can operate on certain alternative fuels as well as on regular petroleum fuels, Congress established a special procedure for calculating the fuel economy of those vehicles for determining compliance with the Corporate Average Fuel Economy standards.</p>	<p> Notice of proposed rulemaking (NPRM)</p>
	<p>Draft Environmental Assessment</p> <p>The draft environmental assessment evaluates the potential environmental impacts associated with NHTSA's proposed action to set Corporate Average Fuel Economy Standards for model year 2008-2011 light trucks. This document describes the environment and resources that might be affected by the proposed light truck CAFE standards for model years 2008-2011, and assesses estimated impacts of alternative actions.</p>	<p> Draft of the Environmental Assessment proposed action to set CAFE standards for model year 2008-2011 light trucks</p>
NHTSA: 49 CFR Parts 531, 533, and 537; EPA: 40 CFR Parts 86 and 600	<p>Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and CAFE Standards</p> <p>EPA and NHTSA are issuing this joint proposal to establish a National Program consisting of new standards for light-duty vehicles that will reduce greenhouse gas emissions and improve fuel economy. EPA is proposing greenhouse gas emissions standards under the Clean Air Act, and NHTSA is proposing Corporate Average Fuel Economy standards under the Energy Policy and Conservation Act, as amended. These standards apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles, covering model years 2012 through 2016, and represent a harmonized and consistent National Program. Under the National Program, automobile manufacturers would be able to build a single light-duty national fleet that satisfies all requirements under both programs while ensuring that consumers still have a full range of vehicle choices.</p>	<p> Draft Environmental Impact Statement</p> <p> Notice of Intent</p> <p> Preliminary Regulatory Impact Analysis</p> <p> Draft Joint Technical Support Document</p> <p> Notice of Proposed Rulemaking</p>
	<p>Nissan North America, Inc. Petition for Exemption from Two-Fleet Rule Affecting Compliance with Passenger Automobile Fuel Economy Standards</p> <p>Nissan filed a petition requesting exemption from the two fleet rule for the 2006-2010 model years. The two fleet rule, which is contained in the CAFE statute, requires that a manufacturer divide its passenger automobiles into two fleets, a domestically-manufactured fleet and a non-domestically manufactured fleet, and ensure that each fleet separately meets the CAFE standards for passenger automobiles. The CAFE statute requires NHTSA to grant such a petition unless it finds that doing so would result in reduced employment in the U.S. related to motor vehicle manufacturing. NHTSA's analysis does not support a finding that granting the petition would reduce automotive manufacturing employment in the United States. Accordingly, in this notice, NHTSA is granting Nissan's petition.</p>	<p> Grant of petition for exemption from two-fleet rule</p>
49 CFR Parts 523, 531, 533, 534, 536 and 537	<p>Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Year 2011</p> <p>NHTSA estimates that the MY 2011 standards will raise the industry-wide combined average to 27.3 mpg, save 887 million gallons of fuel over the lifetime of the MY 2011 cars and light trucks, and reduce CO2 emissions by 8.3 million metric tons during that period.</p>	<p> Final Regulatory Impact Analysis</p> <p> Final Rule, Record of Decision</p>
49 CFR Part 533	<p>Light Truck Average Fuel Economy Standards, Model Years 2005-2007</p> <p>This final rule established the average fuel economy standards for light trucks that will be manufactured in the 2005-2007 model years (MYs). Chapter 329 of Title 49 of the United States Code requires the issuance of these standards. The standards for all light trucks manufactured by a manufacturer is set at 21.0 mpg for MY 2005, 21.6 mpg for MY 2006, and 22.2 mpg for MY 2007. This rule is effective May 5, 2003.</p>	<p> Final Environmental Assessment</p> <p> Final Economic Assessment</p> <p> Final Rule</p>

