# 9. Recalculations and Improvements

Each year, emission and sink estimates are recalculated and revised for all years in the Inventory of U.S. Greenhouse Gas Emissions and Sinks, as attempts are made to improve both the analyses themselves, through the use of better methods or data, and the overall usefulness of the report. In this effort, the United States follows the *2006 IPCC Guidelines* (IPCC 2006), which states, "Both methodological changes and refinements over time are an essential part of improving inventory quality. It is *good practice* to change or refine methods" when: available data have changed; the previously used method is not consistent with the IPCC guidelines for that category; a category has become key; the previously used method is insufficient to reflect mitigation activities in a transparent manner; the capacity for inventory preparation has increased; new inventory methods become available; and for correction of errors."

The results of all methodological changes and historical data updates made in the current Inventory report are presented in this section; detailed descriptions of each recalculation are contained within each source's description found in this report, if applicable. Table 9-2 summarizes the quantitative effect of these changes on U.S. greenhouse gas emissions and sinks and Table 9-3 summarizes the quantitative effect on annual net $CO_2$ fluxes, both relative to the previously published U.S. Inventory (i.e., the 1990 through 2012 report). These tables present the magnitude of these changes in units of million metric tons of carbon dioxide equivalent (MMT $CO_2$ Eq.).

The Recalculations Discussion section of each source's description in the respective chapter of this Inventory presents the details of each recalculation. In general, when methodological changes have been implemented, the entire time series (i.e., 1990 through 2012) has been recalculated to reflect the change, per IPCC (2006). Changes in historical data are generally the result of changes in statistical data supplied by other agencies.

For the current Inventory, emission estimates have been revised to reflect the GWPs provided in the *IPCC Fourth Assessment Report* (AR4) (IPCC 2007). Revised UNFCCC reporting guidelines for national inventories now require the use of GWP values from AR4 (IPCC 2007),[298] which reflect an updated understanding of the atmospheric properties of each greenhouse gas. AR4 GWP values differ from those presented in the *IPCC Second Assessment Report* (SAR) (IPCC 1996) and used in the previous inventories as required by earlier UNFCCC reporting guidelines. The use of AR4 GWP values in this Inventory results in time-series recalculations for most inventory sources. In Table 9-1 below, recalculations are presented including both the quantitative effect of the data and methodological changes as well as the quantitative effect of the change in using the AR4 GWP.

The following ten emission sources and sinks, which are listed in absolute decending order of the average change in emissions or sequestration between 1990 and 2012, underwent some of the most significant methodological and historical data changes. These emission sources consider only methodological and historical data changes. A brief summary of the recalculations and/or improvements undertaken is provided for each of the ten sources.

- *Forest Land Remaining Forest Land ($CO_2$ sink).* Forest ecosystem stock and stock-change estimates differ from the previous Inventory (EPA 2014) principally due to some changes in data and methods. The net effect of the modifications was to slightly reduce net C uptake (i.e., lower sequestration) and C stocks from 1990 to the present. The estimate of net annual change in HWP C stock and total C stock in HWP were revised upward by small amounts. The increase in total net annual additions compared to estimates published in 2013 was 2 to 3

[298] See <http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2>.

percent for 2010 through 2012. This increase was mostly due to changes in the amount of pulpwood used for paper and composite panel products back to 2003. All the adjustments were made as a result of corrections in the database of forest products statistics used to prepare the estimates (Howard forthcoming). These changes resulted in an average annual increase of 76.7 MMT $CO_2$ Eq. relative to the previous Inventory.

- *Agricultural Soil Management ($N_2O$).* Methodological recalculations in the current Inventory were associated with the following improvements: 1) Driving the DAYCENT simulations with updated input data for the excretion of C and N onto PRP and N additions from managed manure based on national livestock population (note that revised total PRP N additions decreased from 4.4 to 4.1 MMT N on average and revised managed manure additions decreased from 2.9 to 2.7 MMT N on average); 2) properly accounting for N inputs from residues for crops not simulated by DAYCENT; (3) modifying the number of experimental study sites used to quantify model uncertainty for direct $N_2O$ emissions and bias correction; and (4) reporting indirect $N_2O$ emissions from forestland and settlements in their respective sections, instead of the agricultural soil management section. These changes resulted in an average annual decrease of 43.6 MMT $CO_2$ Eq. relative to the previous Inventory.

- *Petrochemical Production ($CO_2$).* Emission information from EPA's GHGRP was used to update estimates. Average country-specific $CO_2$ emission factors were derived from the 2010 through 2013 GHGRP data for carbon black, ethylene, ethylene dichloride, and ethylene oxide. Annual production and $CO_2$ emission factor data were obtained from EPA's GHGRP for 2010 through 2013, and were used to estimate emissions for 2010 through 2013. An average $CO_2$ emission factor was calculated from the 2010 through 2013 GHGRP data and was used to estimate emissions for 1990 through 2009 for carbon black, ethylene, ethylene dichloride, and ethylene oxide using historic production data compiled for 1990 through 2009 (ACC 2014a; ACC 2014b). Note, ethylene oxide is included in the IPCC petrochemical production source category but had not been included in previous versions of this Inventory due to lack of publicly-available data. Similarly, acrylonitrile is included in the IPCC Petrochemical Production source category but had not been included in the previous Inventory due to lack of publicly-available data. Annual acrylonitrile production data for 1990 through 2013 was obtained from ACC (ACC 2014b). These changes resulted in an average annual increase of 23.5 MMT $CO_2$ Eq. relative to the previous Inventory.

- *Landfills ($CH_4$).* Three major methodological recalculations were performed for the current Inventory. First, a new SOG survey was published allowing for the update of the annual quantities of waste generated and disposed and the amount of $CH_4$ generated for the years 2009 through 2012. Second, the percent of the U.S. population within the three precipitation ranges were updated for the year 2010 (see Table A-3 in Annex 3.14), which impacted the distribution for the years 2001 through 2013 in the waste model. Third, the EPA's GHGRP $CH_4$ recovery and destruction efficiency data were incorporated. These changes resulted in an average annual increase of 18.9 MMT $CO_2$ Eq. relative to the previous Inventory.

- *Petroleum Systems ($CH_4$).* For the current Inventory, EPA received information and data related to the emission estimates through the Inventory preparation process, previous Inventories' formal public notice periods, the latest GHGRP data, and new studies. EPA carefully evaluated relevant information available, and made several updates, such as updates to offshore platforms, pneumatic controllers, refineries, and well count data. In addition, revisions to use the latest activity data resulted in changes to emissions for several sources. The decrease in calculated emissions from this source is largely due to the recalculation for offshore platforms.

  The net impact of the changes (comparing 2012 estimate from previous (2014) Inventory and current (2015) Inventory) is a decrease in $CH_4$ emissions of around 14.5 MMT $CO_2$ Eq., or 38 percent. Recalculations in the offshore petroleum platforms estimates resulted in a large decrease in the 2012 $CH_4$ emission estimate from this source in the production segment, from 15.2 MMT $CO_2$ Eq. in the previous (2014) Inventory, to 4.7 MMT $CO_2$ Eq. in the current (2015) Inventory. Recalculations to the onshore petroleum production emissions estimates resulted in a small decrease in the 2012 $CH_4$ emission estimate for onshore sources, from 22.0 MMT $CO_2$ Eq. in the 2014 Inventory, to 19.5 MMT $CO_2$ Eq. in the 2015 Inventory. Methane emission estimates for other segments (i.e., refining and transport) changed by around 0.5 percent.

Across the 1990 through 2012 time series, compared to the previous (2014) Inventory, in the current (2015) Inventory, the $CH_4$ emission estimate decreased by 11.8 MMT $CO_2$ Eq. on average.[299]

- *Fossil Fuel Combustion ($CO_2$)* The Energy Information Administration (EIA 2015) updated energy consumption statistics across the time series relative to the previous Inventory. One such revision is the historical petroleum consumption in the residential sector in 2011 and 2012. These revisions primarily impacted the previous emission estimates from 2010 to 2012; however, additional revisions to industrial and transportation petroleum consumption as well as industrial natural gas and coal consumption impacted emission estimates across the time series. In addition, EIA revised the heat contents of motor gasoline, distillate fuel, and petroleum coke.
  For motor gasoline, heating values were previously based on the relative volumes of conventional and reformulated gasoline in the total motor gasoline product supplied to the United States. The revised heating values (first occurring in the January 2015 publication of the Monthly Energy Review) incorporated inputs of ethanol, methyl tert-butyl ether (MTBE) through April 2006, other oxygenates through 2006, and a single national hydrocarbon gasoline blend-stock from 1993 through 2013.

  Changes to the heat content of distillate fuel resulted in an annual average decrease of approximately 0.1 percent between 1994 through 2012. This decrease was a result of EIA's heat content revision from a constant sulfur content across the time series, to a weighted sulfur content. Additionally, in 2009, EIA began subtracting inputs of renewable diesel fuel from petroleum consumption before converting to energy units.

  Petroleum coke consumption decreased by an annual average of approximately 0.1 percent from 2004 to 2012. This decrease was a result of a similar heat content revision in which the EIA recalculated the historically constant petroleum coke heat content to include weighted petroleum coke heat contents (by the two categories of petroleum coke, catalyst and marketable) starting in 2004.

  Overall, these changes resulted in an average annual decrease of 9.6 MMT $CO_2$ Eq. (less than 0.2 percent) in $CO_2$ emissions from fossil fuel combustion for the period 1990 through 2012, relative to the previous report.

- *Nitric Acid Production ($N_2O$).* GHGRP data from subpart V of regulation 40 CFR Part 98 were used to recalculate emissions from nitric acid production over the entire time series (EPA 2014), and used directly for emission estimates for 2010 through 2013. Nitric acid production and $N_2O$ emissions data were available for 2010 through 2013 from EPA's GHGRP, given nearly all nitric acid production facilities, with the exception of the strong acid facility, in the United States are required to report annual data under subpart V. Country-specific $N_2O$ emission factors were developed using the 2010 GHGRP emissions and production data for nitric acid production with abatement and without abatement. Due to differences in operational efficiencies and recent installation of abatement technology at some U.S. facilities, 2010 GHGRP production data were used for recalculating time series emissions (1990 through 2009) instead of average factors developed from 2010 through 2013 GHGRP data. As per the 2010 GHGRP data, 70.7 percent of total domestic nitric acid production was estimated to be produced without any abatement.

  Time series emissions for 1990 through 2009 were recalculated, and the revised emission estimates are approximately 30 percent lower than the prior estimates. Throughout the whole time series, these changes resulted in an average annual decrease of 5.3 MMT $CO_2$ Eq. relative to the previous Inventory.

- *Natural Gas Systems ($CH_4$).* For the current Inventory, EPA received information and data related to the emission estimates through the Inventory preparation process, previous Inventories' formal public notice periods, GHGRP data, and new studies. EPA carefully evaluated relevant information available, and made several updates, including revisions to offshore platforms, pneumatic controllers, well counts data, and hydraulically fractured gas well completions and workovers.

  In addition, revisions to activity data resulted in changes to emission estimates for several sources. For example, the 2014 Inventory used 2011 data as a proxy for condensate production for 2012. The 2015 Inventory was

[299] Additional information on recent changes to the Inventory can be found at: <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport/natural-gas-systems.html>.

updated to use the most recent data on condensate production. Large increases in production in the Rocky Mountain and Gulf Coast regions resulted in an increase in calculated 2012 $CH_4$ emissions from condensate tanks of 0.6 MMT $CO_2$ Eq., or 15 percent.

The combined impact of all revisions on 2012 natural gas production segment emissions compared to the previous (2014) Inventory, is a decrease in $CH_4$ emissions of approximately 0.2 MMT $CO_2$ Eq. Recalculations in the offshore gas platforms estimates resulted in a large decrease in the 2012 $CH_4$ emission estimate from this source in the production segment, from 7.2 MMT $CO_2$ Eq. in the previous (2014) Inventory, to 3.8 MMT $CO_2$ Eq. in the current (2015) Inventory. Recalculations to the onshore gas production emissions estimates resulted in an increase in the 2012 $CH_4$ emission estimate for onshore sources, from 42.6 MMT $CO_2$ Eq. in the previous (2014) Inventory, to 46.0 MMT $CO_2$ Eq. in the current (2015) Inventory. Methane emission estimates for other segments (i.e. processing, transmission and storage, and distribution) changed by less than 0.5 percent.

Across the 1990-2012 time series, compared to the previous (2014) Inventory, in the current (2015) Inventory, the total $CH_4$ emission estimate decreased by 5.2 MMT $CO_2$ Eq. on average (or 3 percent), with the largest decreases in the estimate occurring in early years of the time series.[300]

- *Petroleum Systems ($CO_2$).* EPA received information and data related to the emission estimates through the Inventory preparation process, previous Inventories' formal public notice periods, the latest GHGRP data, and new studies. EPA carefully evaluated relevant information available, and made several updates, such as updates to offshore platforms, pneumatic controllers, refineries, and well count data. In addition, revisions to use the latest activity data resulted in changes to emissions for several sources.

  The net impact of the changes (comparing 2012 estimate from previous (2014) Inventory and current (2015) Inventory) is an increase in $CO_2$ emissions of around 6 MMT $CO_2$, or 1,400 percent. The increase in the $CO_2$ emission estimates is due to the update to the petroleum refineries calculations.

  Across the 1990-2012 time series, compared to the previous (2014) Inventory, in the current (2015) Inventory, the $CO_2$ emissions estimate increased by 4.4 MMT $CO_2$ Eq. on average (or around 1,300 percent).[301]

- *Cropland Remaining Cropland ($CO_2$ sink).* Recalculations for the cropland remaining cropland source is divided up into three components: Refining parameters associated with simulating crop production and carbon inputs to the soil in the DAYCENT biogeochemical model; improving the model simulation of snow melt and water infiltration in soils; and driving the DAYCENT simulations with updated input data for managed manure based on national livestock population. These changes resulted in an average annual decrease of 4.3 MMT $CO_2$ Eq. relative to the previous Inventory.

[300] Additional information on recent changes to the Inventory can be found at: <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport/natural-gas-systems.html.>

[301] Additional information on recent changes to the Inventory can be found at: http://www.epa.gov/climatechange/ghgemissions/usinventoryreport/natural-gas-systems.html.

**Table 9-1: Revisions to U.S. Greenhouse Gas Emissions, Including Quantitative Change Related to Use of AR4 GWP values (MMT $CO_2$ Eq.)**

| Gas/Source | 1990 | 2005 | 2009 | 2010 | 2011 | 2012 | Average Annual Change |
|---|---|---|---|---|---|---|---|
| **$CO_2$** | **15.0** | **21.7** | **(5.5)** | **(17.8)** | **(23.3)** | **(24.9)** | **15.3** |
| Fossil Fuel Combustion | (4.4) | (5.2) | (28.7) | (37.8) | (39.8) | (46.3) | (9.6) |
| Electricity Generation | NC | (1.3) | (0.8) | (0.8) | (0.8) | (0.5) | (0.4) |
| Transportation | (0.2) | (3.9) | (27.4) | (33.1) | (36.3) | (38.8) | (8.2) |
| Industrial | (2.6) | 0.2 | 0.2 | 0.1 | 5.4 | 10.1 | 0.5 |
| Residential | NC | (0.1) | + | (0.1) | 2.3 | (5.8) | (0.1) |
| Commercial | (1.6) | (0.1) | (0.4) | (0.5) | (0.5) | (0.3) | (0.3) |
| U.S. Territories | NC | + | (0.3) | (3.4) | (9.8) | (11.0) | (1.1) |
| Non-Energy Use of Fuels | (3.2) | (2.1) | (2.1) | (6.3) | (9.0) | (5.4) | (3.2) |
| Natural Gas Systems | (0.1) | + | + | + | 0.5 | (0.5) | + |
| Cement Production | NC | NC | NC | NC | NC | NC | NC |
| Lime Production | 0.3 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 |
| Other Process Uses of Carbonates | NC | NC | NC | NC | NC | + | + |
| Glass Production | NC | NC | NC | NC | NC | + | + |
| Soda Ash Production and Consumption | NC | NC | NC | NC | NC | NC | NC |
| Carbon Dioxide Consumption | 0.1 | 0.1 | + | (1.0) | (1.0) | (1.0) | (0.1) |
| Incineration of Waste | NC | NC | (0.4) | (1.0) | (1.6) | (1.8) | (0.2) |
| Titanium Dioxide Production | NC | NC | NC | NC | NC | (0.2) | + |
| Aluminum Production | NC | NC | NC | NC | NC | NC | NC |
| Iron and Steel Production & Metallurgical Coke Production | NC | NC | NC | NC | NC | + | + |
| Ferroalloy Production | NC | NC | NC | NC | 0.1 | 0.2 | + |
| Ammonia Production | NC | NC | NC | NC | (0.1) | + | + |
| Urea Consumption for Non-Agricultural Purposes | NC | NC | + | + | + | (0.8) | + |
| Phosphoric Acid Production | + | + | + | + | + | + | + |
| Petrochemical Production | 18.2 | 23.8 | 20.9 | 23.9 | 22.9 | 23.0 | 23.5 |
| Silicon Carbide Production and Consumption | NC | NC | NC | NC | NC | NC | NC |
| Lead Production | NC | NC | NC | NC | NC | NC | NC |
| Zinc Production | NC | NC | NC | NC | + | 0.1 | + |
| Liming of Agricultural Soils | NC | NC | NC | NC | NC | 1.8 | 0.1 |
| Peatlands Remaining Peatlands | + | + | (0.1) | + | + | + | + |
| Petroleum Systems | 4.1 | 4.6 | 4.3 | 3.8 | 4.1 | 4.7 | 4.4 |
| Magnesium Production and Processing | NC* | NC* | NC* | NC* | NC* | NC* | NC* |
| Urea Fertilization | NC | NC | NC | + | 0.1 | 0.8 | + |
| *Land Use, Land-Use Change, and Forestry (Sink)*[a] | *55.3* | *118.8* | *90.7* | *96.4* | *99.3* | *98.9* | *72.2* |
| *Biomass – Wood*[a] | *NC* | *NC* | *NC* | *NC* | *NC* | *0.9* | + |
| *International Bunker Fuels*[a] | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* |
| *Biomass – Ethanol*[a] | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* |
| **$CH_4$** | **109.8** | **122.1** | **113.0** | **81.6** | **82.6** | **80.4** | **111.7** |
| Stationary Combustion | 1.0 | 0.8 | 0.7 | 0.7 | 0.7 | 0.9 | 0.9 |
| Mobile Combustion | 1.1 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.8 |
| Coal Mining | 15.4 | 10.5 | 12.8 | 13.2 | 11.4 | 10.6 | 11.9 |
| Abandoned Underground Coal Mines | 1.2 | 1.1 | 1.2 | 1.6 | 1.6 | 1.5 | 1.3 |
| Natural Gas Systems | 22.7 | 24.3 | 25.1 | 24.9 | 26.1 | 24.5 | 23.9 |
| Petroleum Systems | (4.2) | (5.4) | (7.6) | (8.2) | (8.6) | (8.5) | (5.8) |
| Petrochemical Production | (2.0) | (3.0) | (2.8) | (3.0) | (3.1) | (3.0) | (2.8) |
| Silicon Carbide Production and Consumption | + | + | + | + | + | + | + |
| Iron and Steel Production & Metallurgical Coke Production | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 |
| Ferroalloy Production | + | + | + | + | + | + | + |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Enteric Fermentation | 26.3 | 26.4 | 26.6 | 26.2 | 25.8 | 25.3 | 26.7 |
| Manure Management | 5.7 | 8.8 | 9.2 | 9.1 | 9.4 | 10.8 | 7.9 |
| Rice Cultivation | 1.5 | 1.4 | 1.5 | 1.8 | 1.4 | 1.9 | 1.5 |
| Field Burning of Agricultural Residues | 0.1 | + | + | + | + | + | + |
| Forest Fires | + | 0.2 | 0.1 | + | 0.6 | 0.4 | 0.2 |
| Peatlands Remaining Peatlands | NC | NC | NC | NC | NC | NC | NC |
| Landfills | 38.5 | 53.4 | 42.8 | 11.9 | 13.9 | 12.4 | 42.2 |
| Wastewater Treatment | 2.5 | 2.5 | 2.5 | 2.5 | 2.4 | 2.4 | 2.6 |
| Composting | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 |
| Incineration of Waste | + | + | + | + | + | + | + |
| *International Bunker Fuels*[a] | + | + | + | + | + | + | + |
| **$N_2O$** | **(68.7)** | **(59.9)** | **(56.1)** | **(49.3)** | **(45.3)** | **(44.5)** | **(63.4)** |
| Stationary Combustion | (0.3) | (0.4) | (0.3) | (0.4) | (0.3) | (0.6) | (0.4) |
| Mobile Combustion | (2.8) | 1.2 | 1.9 | 3.0 | 4.0 | 3.7 | (0.4) |
| Adipic Acid Production | (0.6) | (0.3) | (0.1) | (0.2) | (0.4) | (0.2) | (0.3) |
| Nitric Acid Production | (6.0) | (5.6) | (4.4) | (5.2) | (5.0) | (4.8) | (6.0) |
| Manure Management | (0.6) | (0.7) | (0.7) | (0.7) | (0.7) | (0.7) | (0.6) |
| Agricultural Soil Management | (58.1) | (53.7) | (52.3) | (45.8) | (42.0) | (40.6) | (55.2) |
| Field Burning of Agricultural Residues | + | + | + | + | + | + | + |
| Wastewater Treatment | (0.1) | (0.1) | (0.2) | (0.2) | (0.2) | (0.2) | (0.1) |
| $N_2O$ from Product Uses | (0.2) | (0.2) | (0.2) | (0.2) | (0.2) | (0.2) | (0.2) |
| Incineration of Waste | + | + | + | + | (0.1) | (0.1) | + |
| Settlement Soils | 0.4 | 0.9 | 0.8 | 0.9 | 1.0 | 1.1 | 0.8 |
| Forest Fires | (0.4) | (1.1) | (0.9) | (0.7) | (1.8) | (2.1) | (1.0) |
| Forest Soils | + | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Composting | + | (0.1) | (0.1) | (0.1) | (0.1) | + | + |
| Peatlands Remaining Peatlands | + | + | + | + | + | + | + |
| Semiconductor Manufacture | NC* | NC* | NC* | NC* | NC* | NC* | NC* |
| *International Bunker Fuels*[a] | + | + | + | + | + | + | + |
| **HFCs** | **9.7** | **11.6** | **7.8** | **8.6** | **8.8** | **8.0** | **11.9** |
| Substitution of Ozone Depleting Substances | + | 7.3 | 6.4 | 6.9 | 6.9 | 6.8 | 5.9 |
| HCFC-22 Production | 9.7 | 4.2 | 1.4 | 1.7 | 1.8 | 1.1 | 6.0 |
| Semiconductor Manufacture | + | + | + | + | + | + | 0.1 |
| Magnesium Production and Processing | NC* | NC* | NC* | NC* | NC* | NC* | NC* |
| **PFCs** | **3.6** | **1.1** | **0.6** | **0.7** | **0.9** | **0.6** | **2.0** |
| Aluminum Production | 3.0 | 0.5 | 0.3 | 0.3 | 0.5 | 0.4 | 1.2 |
| Semiconductor Manufacture | 0.6 | 0.6 | 0.3 | 0.4 | 0.4 | 0.1 | 0.8 |
| **$SF_6$** | **(1.6)** | **(0.6)** | **(0.3)** | **(0.3)** | **(0.8)** | **(0.7)** | **(0.9)** |
| Electrical Transmission and Distribution | (1.3) | (0.5) | (0.2) | (0.2) | (0.4) | (0.3) | (0.7) |
| Semiconductor Manufacture | + | + | + | + | (0.3) | (0.3) | (0.1) |
| Magnesium Production and Processing | (0.3) | (0.1) | (0.1) | (0.1) | (0.1) | (0.1) | (0.2) |
| **$NF_3$** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** |
| Semiconductor Manufacture | NC* | NC* | NC* | NC* | NC* | NC* | NC* |
| **Net Change in Total Emissions**[b] | **67.8** | **96.4** | **59.9** | **24.1** | **23.6** | **19.5** | |
| **Percent Change** | **1.1%** | **1.3%** | **0.9%** | **0.4%** | **0.4%** | **0.3%** | |

Note: Emissions values are presented in $CO_2$ equivalent mass units using IPCC AR4 GWP values.
Note: Totals may not sum due to independent rounding. Parentheses indicate negative values.
NC (No Change)
+ Absolute value does not exceed 0.05 MMT $CO_2$ Eq. or 0.05 percent
* Indicates a new source for the current Inventory year
[a] Not included in emissions total.
[b] Excludes net $CO_2$ flux from Land Use, Land-Use Change, and Forestry, and emissions from International Bunker Fuels.

**Table 9-2: Revisions to U.S. Greenhouse Gas Emissions due only to Methodology and Data Changes, with the AR4 GWP values applied across the time series (MMT $CO_2$ Eq.)**

| Gas/Source | 1990 | 2005 | 2009 | 2010 | 2011 | 2012 | Average Annual Change |
|---|---|---|---|---|---|---|---|
| **$CO_2$** | **15.0** | **21.7** | **(5.5)** | **(17.8)** | **(23.3)** | **(24.9)** | **15.3** |
| Fossil Fuel Combustion | (4.4) | (5.2) | (28.7) | (37.8) | (39.8) | (46.3) | (9.6) |
| Electricity Generation | NC | (1.3) | (0.8) | (0.8) | (0.8) | (0.5) | (0.4) |
| Transportation | (0.2) | (3.9) | (27.4) | (33.1) | (36.3) | (38.8) | (8.2) |
| Industrial | (2.6) | 0.2 | 0.2 | 0.1 | 5.4 | 10.1 | 0.5 |
| Residential | NC | (0.1) | + | (0.1) | 2.3 | (5.8) | (0.1) |
| Commercial | (1.6) | (0.1) | (0.4) | (0.5) | (0.5) | (0.3) | (0.3) |
| U.S. Territories | NC | + | (0.3) | (3.4) | (9.8) | (11.0) | (1.1) |
| Non-Energy Use of Fuels | (3.2) | (2.1) | (2.1) | (6.3) | (9.0) | (5.4) | (3.2) |
| Natural Gas Systems | (0.1) | + | + | + | 0.5 | (0.5) | + |
| Cement Production | NC | NC | NC | NC | NC | NC | NC |
| Lime Production | 0.3 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 |
| Other Process Uses of Carbonates | NC | NC | NC | NC | NC | + | + |
| Glass Production | NC | NC | NC | NC | NC | + | + |
| Soda Ash Production and Consumption | NC | NC | NC | NC | NC | NC | NC |
| Carbon Dioxide Consumption | 0.1 | 0.1 | + | (1.0) | (1.0) | (1.0) | (0.1) |
| Incineration of Waste | NC | NC | (0.4) | (1.0) | (1.6) | (1.8) | (0.2) |
| Titanium Dioxide Production | NC | NC | NC | NC | NC | (0.2) | + |
| Aluminum Production | NC | NC | NC | NC | NC | NC | NC |
| Iron and Steel Production & Metallurgical Coke Production | NC | NC | NC | NC | NC | + | + |
| Ferroalloy Production | NC | NC | NC | NC | 0.1 | 0.2 | + |
| Ammonia Production | NC | NC | NC | NC | (0.1) | + | + |
| Urea Consumption for Non-Agricultural Purposes | NC | NC | + | + | + | (0.8) | + |
| Phosphoric Acid Production | + | + | + | + | + | + | + |
| Petrochemical Production | 18.2 | 23.8 | 20.9 | 23.9 | 22.9 | 23.0 | 23.5 |
| Silicon Carbide Production and Consumption | NC | NC | NC | NC | NC | NC | NC |
| Lead Production | NC | NC | NC | NC | NC | NC | NC |
| Zinc Production | NC | NC | NC | NC | + | 0.1 | + |
| Liming of Agricultural Soils | NC | NC | NC | NC | NC | 1.8 | 0.1 |
| Peatlands Remaining Peatlands | + | + | (0.1) | + | + | + | + |
| Petroleum Systems | 4.1 | 4.6 | 4.3 | 3.8 | 4.1 | 4.7 | 4.4 |
| Magnesium Production and Processing | NC* | NC* | NC* | NC* | NC* | NC* | NC* |
| Urea Fertilization | NC | NC | NC | + | 0.1 | 0.8 | + |
| *Land Use, Land-Use Change, and Forestry (Sink)[a]* | *55.3* | *118.8* | *90.7* | *96.4* | *99.3* | *98.9* | *NC* |
| *Biomass – Wood[a]* | *NC* | *NC* | *NC* | *NC* | *NC* | *0.9* | + |
| *International Bunker Fuels[a]* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* |
| *Biomass – Ethanol[a]* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* |
| **$CH_4$** | **(11.3)** | **10.5** | **(0.7)** | **(29.9)** | **(27.5)** | **(27.7)** | **(3.7)** |
| Stationary Combustion | (0.4) | (0.5) | (0.5) | (0.5) | (0.5) | (0.2) | (0.4) |
| Mobile Combustion | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 |
| Coal Mining | NC | 0.3 | NC | NC | NC | NC | + |
| Abandoned Underground Coal Mines | NC | NC | 0.3 | 0.6 | 0.7 | 0.6 | 0.1 |
| Natural Gas Systems | (7.1) | (4.7) | (2.1) | (0.8) | 0.7 | (0.2) | (5.2) |
| Petroleum Systems | (11.1) | (10.9) | (13.2) | (13.8) | (14.4) | (14.5) | (11.8) |
| Petrochemical Production | (2.5) | (3.6) | (3.4) | (3.6) | (3.7) | (3.6) | (3.4) |
| Silicon Carbide Production and Consumption | NC | NC | NC | NC | NC | NC | NC |
| Iron and Steel Production & Metallurgical Coke Production | NC | NC | NC | NC | NC | NC | NC |
| Ferroalloy Production | NC | NC | NC | NC | + | + | + |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Enteric Fermentation | NC | (0.7) | (1.2) | (1.4) | (1.5) | (1.5) | (0.7) |
| Manure Management | (0.3) | (0.3) | (0.4) | (0.7) | (0.5) | 0.7 | (0.3) |
| Rice Cultivation | NC | NC | NC | NC | NC | 0.5 | + |
| Field Burning of Agricultural Residues | NC | NC | NC | NC | NC | NC | NC |
| Forest Fires | (0.5) | (1.4) | (1.0) | (0.9) | (2.0) | (2.5) | (1.2) |
| Peatlands Remaining Peatlands | NC | NC | NC | NC | NC | NC | NC |
| Landfills | 10.3 | 32.0 | 20.8 | (9.0) | (6.5) | (7.2) | 18.9 |
| Wastewater Treatment | + | + | + | + | + | + | + |
| Composting | NC | NC | NC | NC | + | + | + |
| Incineration of Waste | NC | NC | + | + | + | + | + |
| *International Bunker Fuels*[a] | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* |
| **$N_2O$** | **(53.3)** | **(43.8)** | **(40.2)** | **(33.4)** | **(29.2)** | **(28.6)** | **(47.1)** |
| Stationary Combustion | 0.1 | 0.4 | 0.5 | 0.5 | 0.5 | 0.2 | 0.3 |
| Mobile Combustion | (1.1) | 2.6 | 2.8 | 3.8 | 4.7 | 4.3 | 1.2 |
| Adipic Acid Production | NC | NC | NC | NC | NC | + | + |
| Nitric Acid Production | (5.3) | (5.0) | (3.8) | (4.5) | (4.3) | (4.2) | (5.3) |
| Manure Management | NC | NC | + | + | + | + | + |
| Agricultural Soil Management | (47.2) | (42.2) | (40.0) | (33.8) | (30.0) | (28.8) | (43.6) |
| Field Burning of Agricultural Residues | NC | NC | NC | NC | NC | NC | NC |
| Wastewater Treatment | + | + | + | + | + | + | + |
| $N_2O$ from Product Uses | NC | NC | NC | NC | NC | NC | NC |
| Incineration of Waste | NC | NC | + | + | + | + | + |
| Settlement Soils | 0.4 | 0.9 | 0.9 | 0.9 | 1.0 | 1.1 | 0.8 |
| Forest Fires | (0.3) | (0.9) | (0.7) | (0.6) | (1.3) | (1.7) | (0.8) |
| Forest Soils | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Composting | NC | NC | NC | NC | + | + | + |
| Peatlands Remaining Peatlands | + | + | + | + | + | + | + |
| Semiconductor Manufacture | NC* | NC* | NC* | NC* | NC* | NC* | NC* |
| *International Bunker Fuels*[a] | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* | *NC* |
| **HFCs** | **+** | **(1.6)** | **(5.5)** | **(6.3)** | **(7.1)** | **(8.3)** | **(0.9)** |
| Substitution of Ozone Depleting Substances | + | (1.6) | (5.5) | (6.3) | (7.1) | (8.3) | (0.9) |
| HCFC-22 Production | NC | NC | NC | NC | NC | NC | NC |
| Semiconductor Manufacture | NC | + | + | + | + | + | + |
| Magnesium Production and Processing | NC* | NC* | NC* | NC* | NC* | NC* | NC* |
| **PFCs** | **+** | **(0.5)** | **(0.5)** | **(0.5)** | **(0.7)** | **(0.9)** | **(0.3)** |
| Aluminum Production | NC | NC | NC | NC | NC | NC | NC |
| Semiconductor Manufacture | + | (0.5) | (0.5) | (0.5) | (0.7) | (0.9) | (0.3) |
| **$SF_6$** | **(0.1)** | **+** | **0.1** | **0.1** | **(0.3)** | **(0.3)** | **+** |
| Electrical Transmission and Distribution | (0.1) | + | 0.2 | 0.1 | + | + | + |
| Semiconductor Manufacture | NC | + | + | + | (0.2) | (0.2) | + |
| Magnesium Production and Processing | NC | NC | + | + | + | + | + |
| **$NF_3$** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** |
| Semiconductor Manufacture | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** | **NC*** |
| **Net Change in Total Emissions**[b] | **(49.6)** | **(13.1)** | **(51.8)** | **(87.3)** | **(87.4)** | **(90.1)** | |
| **Percent Change** | **-0.8%** | **-0.2%** | **-0.8%** | **-1.2%** | **-1.3%** | **-1.4%** | |

Note: Emissions values are presented in $CO_2$ equivalent mass units using IPCC AR4 GWP values.
Note: Totals may not sum due to independent rounding. Parentheses indicate negative values.
+ Absolute value does not exceed 0.05 MMT $CO_2$ Eq. or 0.05 percent
NC (No Change)
* Indicates a new source for the current Inventory year
[a] Not included in emissions total.
[b] Excludes net $CO_2$ flux from Land Use, Land-Use Change, and Forestry, and emissions from International Bunker Fuels.

**Table 9-3: Revisions to Annual Sinks (C Sequestration) from Land Use, Land-Use Change, and Forestry (MMT $CO_2$ Eq.)**

| Component: Sinks from Land Use, Land-Use Change, and Forestry[a] | 1990 | 2005 | 2009 | 2010 | 2011 | 2012 | Average Annual Change |
|---|---|---|---|---|---|---|---|
| Forest Land Remaining Forest Land: Changes in Forest Carbon Stock | 65.1 | 120.2 | 84.5 | 90.2 | 93.2 | 93.4 | **76.7** |
| Cropland Remaining Cropland: Changes in Agricultural Soil Carbon Stock | (13.3) | 1.1 | 1.8 | 1.8 | 1.8 | 1.5 | **(4.3)** |
| Land Converted to Cropland | (2.4) | (1.0) | (0.6) | (0.6) | (0.6) | (0.7) | **(1.0)** |
| Grassland Remaining Grassland | 7.6 | (1.4) | 4.9 | 4.9 | 4.9 | 4.8 | **1.8** |
| Land Converted to Grassland | (0.1) | (0.7) | (0.3) | (0.3) | (0.3) | (0.2) | **(0.2)** |
| Settlements Remaining Settlements: Changes in Urban Tree Carbon Stock | NC | NC | NC | NC | NC | NC | **NC** |
| Other (Landfilled Yard Trimmings and Food Scraps) | (1.8) | 0.6 | 0.4 | 0.4 | 0.3 | 0.3 | **(0.7)** |
| **Net Change in Sinks[a]** | **55.3** | **118.8** | **90.7** | **96.4** | **99.3** | **98.9** | |
| **Percent Change** | **6.7%** | **11.5%** | **9.4%** | **10.0%** | **10.1%** | **10.1%** | |

NC (No Change)
Note: Numbers in parentheses indicate an increase in C sequestration.
[a] The sinks value includes the positive C sequestration reported for *Forest Land Remaining Forest Land*, *Cropland Remaining Cropland*, *Land Converted to Grassland*, *Settlements Remaining Settlements*, and *Other Land* plus the loss in C sequestration reported for *Land Converted to Cropland* and *Grassland Remaining Grassland*.
Note: Totals may not sum due to independent rounding.