

Annex Q

Sources of Greenhouse Gas Emissions Excluded

Although this report is intended to be a comprehensive assessment of anthropogenic sources and sinks of greenhouse gas emissions for the United States, certain sources have been identified yet excluded from the estimates presented for various reasons. Before discussing these sources, however, it is important to note that processes or activities that are not *anthropogenic in origin* or do not result in a *net source or sink* of greenhouse gas emissions are intentionally excluded from a national inventory of greenhouse gas emissions. In general, processes or activities that are not anthropogenic are considered natural (i.e., not directly influenced by human activity) in origin and, as an example, would include the following:

- Volcanic eruptions
- CO₂ exchange (i.e., uptake or release) by oceans
- Natural forest fires¹⁹
- CH₄ emissions from wetlands not affected by human induced land-use changes

Some activities or process may be anthropogenic in origin but do not result in net emissions of greenhouse gases, such as the respiration of CO₂ by living organisms. Given a source category that is both anthropogenic and results in net greenhouse gas emissions, reasons for excluding a source related to an anthropogenic activity include one or more of the following:

- There is currently insufficient scientific understanding to develop a reliable method for estimating emissions at a national level.
- Although an estimating method has been developed, data was not adequately available to calculate emissions.
- Emissions were implicitly accounted for within another source category (e.g., CO₂ from fossil fuel combustion).

It is also important to note that the United States believes the exclusion of the sources discussed below introduces only a minor bias in its overall estimate of U.S. greenhouse gas emissions.

N₂O from the Combustion of Jet Fuel

The combustion of jet fuel by aircraft results in N₂O emissions. The N₂O emissions per mass of fuel combusted during landing/take-off (LTO) operations differ significantly from those during aircraft cruising. Accurate estimation of these N₂O emissions requires a detailed accounting of LTO cycles and fuel consumption during cruising by aircraft model (e.g., Boeing 747-400). Sufficient data for calculating such N₂O emissions were not available for this report. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, pp. 1.93 - 1.96)

Emissions from Bunker Fuels and Fossil Fuels Combusted Abroad by the U.S. Military

Emissions from fossil fuels combusted in military vehicles (i.e., ships, aircraft, and ground vehicles) may or may not be included in U.S. energy statistics. Domestic fuel sales to the military are captured in U.S. energy statistics; however, fuels purchased abroad for base operations and refueling of vehicles are not. It is not clear to what degree fuels purchased domestically are exported by the military to bases abroad.

¹⁹ In some cases forest fires that are started either intentionally or unintentionally are viewed as mimicking natural burning processes which have been suppressed by other human forest management activities. The United States does not consider forest fires within its national boundaries to be a net source of greenhouse emissions.

Fuels combusted by military ships and aircraft while engaged in international transport or operations in international waters or airspace (i.e., flying or cruising in international airspace or waters) that is purchased domestically is included in U.S. energy statistics. Therefore, the United States currently under reports its emissions of CO₂ from international bunker fuels, and most likely over reports its CO₂ emissions from transportation related fossil fuel combustion by the same amount. At this time, fuel consumption statistics from the Department of Defense are not adequately detailed to correct for this bias.²⁰

CO₂ from Burning in Coal Deposits and Waste Piles

Coal is periodically burned in deposits and waste piles. It has been estimated that the burning of coal in deposits and waste piles would represent less than 1.3 percent of total U.S. coal consumption (averaged over ten-years). Because there is currently no known source of data on the quantity of coal burned in waste piles and there is uncertainty as to the fraction of coal which is oxidized during such burnings, these CO₂ emissions are not currently estimated. Further research would be required to develop accurate emission factors and activity data for these emissions to be estimated. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, p. 1.112 - 1.113)

Fossil CO₂ from Petroleum and Natural Gas Wells, CO₂ Separated from Natural Gas, and CO₂ from Enhanced Oil Recovery (EOR)

Petroleum and natural gas well drilling, petroleum and natural gas production, and natural gas processing—including removal of CO₂—may result in emissions of CO₂ that was at one time stored in underground formations. Sufficient methodologies for estimating emissions of this “fossil” CO₂ at the national level have not been adequately developed.

Carbon dioxide is also injected into underground deposits to increase crude oil reservoir pressure in a field technique known as enhanced oil recovery (EOR). It is thought that much of the injected CO₂ may be effectively and permanently sequestered, but the fraction of injected CO₂ which is re-released remains uncertain. The fraction re-released varies from well to well depending upon the field geology and the gas capture/re-injection technology employed at the wellhead. Further research into EOR is required before the resulting CO₂ emissions can be adequately quantified. (see the discussion of the Carbon Dioxide Manufacture source category in the Industrial Processes sector)

Carbon Sequestration in Underground Injection Wells

Organic hazardous wastes are injected into underground wells. Depending on the source of these organic substances (e.g., derived from fossil fuels) the carbon in them may or may not be included in U.S. CO₂ emission estimates. Sequestration of carbon containing substances in underground injection wells may be an unidentified sink. Further research is required to if this potential sink is to be quantified.

CH₄ from Abandoned Coal Mines

Abandoned coal mines are a source of CH₄ emissions. In general, many of the same factors that affect emissions from operating coal mines will affect emissions from abandoned mines such as the permeability and gassiness of the coal, the mine’s depth, geologic characteristics, and whether it has been flooded. A few gas developers have recovered methane from abandoned mine workings; therefore, emissions from this source may not be insignificant. Further research and methodological development is needed if these emissions are to be estimated.

CO₂ from Unaccounted for Natural Gas

There is a discrepancy between the amount of natural gas sold by producers and that reported as purchased by consumers. This discrepancy, known as unaccounted for or unmetered natural gas, was assumed to be the sum of

²⁰ See the Defense Energy Support Center (formerly the Defense Fuel Supply Center), *Fact Book 1997*.
[<http://www.desc.dla.mil/main/pulicati.htm>]

leakage, measurement errors, data collection problems, undetected non-reporting, undetected overreporting, and undetected underreporting. Historically, the amount of gas sold by producers has always exceeded that reportedly purchased by consumers; therefore, some portion of unaccounted for natural gas was assumed to be a source of CO₂ emissions. (It was assumed that consumers were underreporting their usage of natural gas.) In DOE/EIA's energy statistics for 1996, however, reported consumption of natural gas exceeded the amount sold by producers. Therefore, the historical explanation given for this discrepancy has lost credibility and unaccounted for natural gas is no longer used to calculate CO₂ emissions. (see section on Changes in the U.S. Greenhouse Gas Inventory Report)

CO₂ from Shale Oil Production

Oil shale is shale saturated with kerogen.²¹ It can be thought of as the geological predecessor to crude oil. Carbon dioxide is released as a by-product of the process of producing petroleum products from shale oil. As of now, it is not cost-effective to mine and process shale oil into usable petroleum products. The only identified large-scale oil shale processing facility in the U.S. was operated by Unocal during the year of 1985 to 1990. There have been no known emissions from shale oil processing in the United States since 1990 when the Unocal facility closed.

CH₄ from the Production of Carbides other than Silicon Carbide

Methane may be emitted from the production of carbides because the petroleum coke used in the process contains volatile organic compounds which form methane during thermal decomposition. Methane emissions from the production of silicon carbide were estimated and accounted for, but emissions from the production of calcium carbide and other carbides were not. Further research is needed to estimate CH₄ emissions from the production of calcium carbide and other carbides other than silicon carbide. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, pp. 2.20 - 2.21)

CO₂ from Calcium Carbide and Silicon Carbide Production

Carbon dioxide is formed by the oxidation of petroleum coke in the production of both calcium carbide and silicon carbide. These CO₂ emissions are implicitly accounted for with emissions from the combustion of petroleum coke under the Energy sector. There is currently not sufficient data on coke consumption to estimate emissions from these sources explicitly. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, pp. 2.20 - 2.21)

CO₂ from Graphite Consumption in Ferroalloy and Steel Production

The CO₂ emissions from the three reducing agents used in ferroalloy and steel production—coke, wood (or biomass), and graphite—are accounted for as follows:

- Emissions resulting from the use of coke are accounted for in the Energy sector under fossil fuel combustion.
- Estimating emissions from the use of wood or other biomass materials is unnecessary because these emissions should be accounted for under Land-Use Change and Forestry sector if the biomass is harvested on an unsustainable basis.
- The CO₂ emissions from the use of graphite, which is produced from petroleum by-products, may be accounted for in the Energy sector (further analysis is required to determine if these emissions are being properly estimated). The CO₂ emissions from the use of natural graphite, however, have not been accounted for in the estimate.

Emissions from graphite electrode consumption—versus its use as a reducing agent—in ferroalloy and steel production may at present only be accounted for in part under fossil fuel combustion if the graphite used was derived from a fossil fuel substrate (versus natural graphite ore). Further research into the source and total consumption of

²¹ Kerogen is fossilized insoluble organic material found in sedimentary rocks, usually shales, which can be converted to petroleum products by distillation.

graphite for these purposes is required to explicitly estimate emissions. (see Iron and Steel Production and Ferroalloy Production in the Industrial Processes sector)

N₂O from Caprolactam Production

Caprolactam is a widely used chemical intermediate, primarily to produce nylon-6. All processes for producing caprolactam involve the catalytic oxidation of ammonia, with N₂O being produced as a by-product. Caprolactam production could be a significant source of N₂O—it has been identified as such in the Netherlands. More research is required to determine this source's significance because there is currently insufficient information available on caprolactam production to estimate emissions in the United States. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, pp. 2.22 - 2.23)

N₂O from Cracking of Certain Oil Fractions

In order to improve the gasoline yield in crude oil refining, certain oil fractions are processed in a catcracker. Because crude oil contains some nitrogen, N₂O emissions may result from this cracking process. There is currently insufficient data to develop a methodology for estimating these emissions. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, p. 2.23)

CH₄ from Coke Production

Coke production may result in CH₄ emissions. Detailed coke production statistics were not available for the purposes of estimating CH₄ emissions from this minor source. (see Petrochemical Production under the Industrial Processes sector and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, p. 2.23)

CO₂ from Metal Production

Coke is used as a reducing agent in the production of some metals from their ores, including magnesium, chromium, lead, nickel, silicon, tin, titanium, and zinc. Carbon dioxide may be emitted during the metal's production from the oxidization of the coke used as a reducing agent and, in some cases, from the carbonate ores themselves (e.g., some magnesium ores contain carbonate). The CO₂ emissions from coke oxidation are accounted for in the Energy sector under Fossil Fuel Combustion. The CO₂ emissions from the carbonate ores are not presently accounted for, but their quantities are thought to be minor. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, p. 2.37 - 2.38)

N₂O from Acrylonitrile Production

Nitrous oxide may be emitted during acrylonitrile production. No methodology was available for estimating these emissions, and therefore further research is needed if these emissions are to be included. (see *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, p. 2.22)

Miscellaneous SF₆ Uses

Sulfur hexafluoride may be used in gas-filled athletic shoes, in foam insulation, for dry etching, in laser systems, as an atmospheric tracer gas, for indoor air quality testing, for laboratory hood testing, for chromatography, in tandem accelerators, in sound-insulating windows, in tennis balls, in loudspeakers, in shock absorbers, and for certain biomedical applications. Data need to be gathered and methodologies developed if these emissions are to be estimated.

CO₂ from Solvent Incineration

CO₂ may be released during the incineration of solvents. Although emissions from this source are believed to be minor, data need to be gathered and methodologies developed if these emissions are to be estimated.

CO₂ from Non-Forest Soils

Non-forest soils emit CO₂ from decaying organic matter and carbonate minerals—the latter may be naturally present or mined and later applied to soils as a means to adjust their acidity. Soil conditions, climate, and land-use practices interact to affect the CO₂ emission rates from non-forest soils. The U.S. Forest Service has developed a model to estimate CO₂ emissions from forest soils, but no such model has been adequately developed for non-forest soils. Further research and methodological development is needed if these emissions are to be accurately estimated. (see Changes in Non-Forest Carbon Stocks under the Land-Use Change and Forestry sector)

CH₄ from Land-Use Changes Including Wetlands Creation or Destruction

Wetlands are a known source of CH₄ emissions. When wetlands are destroyed, CH₄ emissions may be reduced. Conversely, when wetlands are created (e.g., during the construction of hydroelectric plants), CH₄ emissions may increase. Grasslands and forest lands may also be weak sinks for CH₄ due to the presence of methanotrophic bacteria that use CH₄ as an energy source (i.e., they oxidize CH₄ to CO₂). Currently, an adequate scientific basis for estimating these emissions and sinks does not exist, and therefore further research and methodological development is required.

CH₄ from Septic Tanks and Drainfields

Methane is produced during the biodegradation of organics in septic tanks if other suitable electron-acceptors (i.e., oxygen, nitrate, or sulfate) besides CO₂ are unavailable. Such conditions are called methanogenic. There were insufficient data and methodological developments available to estimate emissions from this source.

N₂O from Wastewater Treatment

As a result of nitrification and denitrification processes, N₂O may be produced and emitted from wastewater treatment plants. Nitrogen-containing compounds are found in wastewater due to the presence of both human excrement and other nitrogen-containing constituents (e.g. garbage, industrial wastes, dead animals, etc.). The portion of emitted N₂O which originates from human excrement is currently estimated under the Human Sewage source category—based upon average dietary assumptions. The portion of emitted N₂O which originates from other nitrogen-containing constituents is not currently estimated. Further research and methodological development is needed if these emissions are to be accurately estimated.

CH₄ from Industrial Wastewater

Methane may be produced during the biodegradation of organics in wastewater treatment if other suitable electron-acceptors (i.e. oxygen, nitrate, or sulfate) besides CO₂ are unavailable. Such conditions are called methanogenic. Methane produced from domestic wastewater treatment plants is accounted for under the Waste sector. These emissions are estimated by assuming an average 5-day biological oxygen demand (BOD₅) per capita contribution in conjunction with the approximation that 15 percent of wastewater's BOD₅ is removed under methanogenic conditions. This method itself needs refinement. It is not clear if industrial wastewater sent to domestic wastewater treatment plants, which may contain biodegradable material, would be accounted for in the average BOD₅ per capita number. Additionally, CH₄ emissions from methanogenic processes at industrial wastewater treatment plants are not currently estimated. Further research and methodological development is needed if these emissions are to be accurately estimated. (see Wastewater Treatment under the Waste sector)