

**INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS:  
1990 – 2005**

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### 3.7. Natural Gas Systems (IPCC Source Category 1B2b)

The U.S. natural gas system encompasses hundreds of thousands of wells, hundreds of processing facilities, and over a million miles of transmission and distribution pipelines. Overall, natural gas systems emitted 111.1 Tg CO<sub>2</sub> Eq. (5,292 Gg) of CH<sub>4</sub> in 2005, an 11 percent decrease over 1990 emissions (see **Error! Reference source not found.** and **Error! Reference source not found.**), and 28.2 Tg CO<sub>2</sub> Eq. (28,185Gg) of non-energy CO<sub>2</sub> in 2005, a 16 percent decrease over 1990 emissions (see **Error! Reference source not found.**). Improvements in management practices and technology, along with the replacement of older equipment, have helped to stabilize emissions.

CH<sub>4</sub> and non-energy CO<sub>2</sub> emissions from natural gas systems are generally process related, with normal operations, routine maintenance, and system upsets being the primary contributors. Emissions from normal operations include: natural gas engines and turbine uncombusted exhaust, bleed and discharge emissions from pneumatic devices, and fugitive emissions from system components. Routine maintenance emissions originate from pipelines, equipment, and wells during repair and maintenance activities. Pressure surge relief systems and accidents can lead to system upset emissions. Below is a characterization of the four major stages of the natural gas system. Each of the stages is described and the different factors affecting CH<sub>4</sub> and non-energy CO<sub>2</sub> emissions are discussed.

*Field Production.* In this initial stage, wells are used to withdraw raw gas from underground formations. Emissions arise from the wells themselves, gathering pipelines, and well-site gas treatment facilities such as dehydrators and separators. Fugitive emissions and emissions from pneumatic devices account for the majority of CH<sub>4</sub> emissions. Flaring emissions account for the majority of the non-energy CO<sub>2</sub> emissions. Emissions from field production accounted for approximately 32 percent of CH<sub>4</sub> emissions and about 23 percent of non-energy CO<sub>2</sub> emissions from natural gas systems in 2005.

*Processing.* In this stage, natural gas liquids and various other constituents from the raw gas are removed, resulting in “pipeline quality” gas, which is injected into the transmission system. Fugitive CH<sub>4</sub> emissions from compressors, including compressor seals, are the primary emission source from this stage. The majority of non-energy CO<sub>2</sub> emissions come from acid gas removal units, which are designed to remove CO<sub>2</sub> from natural gas. Processing plants account for about 11 percent of CH<sub>4</sub> emissions and approximately 77 percent of non-energy CO<sub>2</sub> emissions from natural gas systems.

*Transmission and Storage.* Natural gas transmission involves high pressure, large diameter pipelines that transport gas long distances from field production and processing areas to distribution systems or large volume customers such as power plants or chemical plants. Compressor station facilities, which contain large reciprocating and turbine compressors, are used to move the gas throughout the United States transmission system. Fugitive CH<sub>4</sub> emissions from these compressor stations and from metering and regulating stations account for the majority of the emissions from this stage. Pneumatic devices and engine uncombusted exhaust are also sources of CH<sub>4</sub> emissions from transmission facilities.

Natural gas is also injected and stored in underground formations, or liquefied and stored in above ground tanks, during periods of low demand (e.g., summer), and withdrawn, processed, and distributed during periods of high demand (e.g., winter). Compressors and dehydrators are the primary contributors to emissions from these storage facilities. CH<sub>4</sub> emissions from the transmission and storage sector account for approximately 34 percent of emissions from natural gas systems, while CO<sub>2</sub> emissions from transmission and storage account for less than 1 percent of the non-energy CO<sub>2</sub> emissions from natural gas systems.

*Distribution.* Distribution pipelines take the high-pressure gas from the transmission system at “city gate” stations, reduce the pressure and distribute the gas through primarily underground mains and service lines to individual end users. There were over 1,034,000 miles of distribution mains in 2005, an increase from just over 888,000 miles in 1990 (OPS 2006b). Distribution system emissions, which account for approximately 25 percent of CH<sub>4</sub> emissions

from natural gas systems and less than 1 percent of non-energy CO<sub>2</sub> emissions, result mainly from fugitive emissions from gate stations and non-plastic piping (cast iron, steel).<sup>43</sup> An increased use of plastic piping, which has lower emissions than other pipe materials, has reduced emissions from this stage. Distribution system CH<sub>4</sub> emissions in 2005 were 12 percent lower than 1990 levels.

Table 3-33. CH<sub>4</sub> Emissions from Natural Gas Systems (Tg CO<sub>2</sub> Eq.)\*

Stage	1990	1995	2000	2001	2002	2003	2004	2005
Field Production	31.8	36.6	38.5	41.2	42.4	40.9	38.0	35.2
Processing	14.8	14.9	14.5	14.7	14.1	13.5	13.5	11.9
Transmission and Storage	46.8	46.3	44.1	41.0	42.5	42.3	40.6	36.8
Distribution	31.0	30.3	29.4	28.6	25.9	27.0	26.9	27.4
<b>Total</b>	<b>124.5</b>	<b>128.1</b>	<b>126.6</b>	<b>125.4</b>	<b>125.0</b>	<b>123.7</b>	<b>119.0</b>	<b>111.1</b>

\*Including CH<sub>4</sub> emission reductions achieved by the Natural Gas STAR program and NESHAP regulations.

Note: Totals may not sum due to independent rounding.

Table 3-34. CH<sub>4</sub> Emissions from Natural Gas Systems (Gg)\*

Stage	1990	1995	2000	2001	2002	2003	2004	2005
Field Production	1,514	1,745	1,832	1,963	2,021	1,949	1,811	1,675
Processing	706	709	692	698	673	645	643	564
Transmission and Storage	2,230	2,205	2,102	1,950	2,025	2,013	1,934	1,751
Distribution	1,477	1,442	1,401	1,360	1,231	1,284	1,281	1,303
<b>Total</b>	<b>5,927</b>	<b>6,101</b>	<b>6,027</b>	<b>5,971</b>	<b>5,951</b>	<b>5,891</b>	<b>5,669</b>	<b>5,292</b>

\*Including CH<sub>4</sub> emission reductions achieved by the Natural Gas STAR program and NESHAP regulations.

Note: Totals may not sum due to independent rounding.

Table 3-35. Non-energy CO<sub>2</sub> Emissions from Natural Gas Systems (Tg CO<sub>2</sub> Eq.)

Stage	1990	1995	2000	2001	2002	2003	2004	2005
Field Production	5.9	9.1	6.0	6.3	6.5	6.3	6.3	6.4
Processing	27.8	24.6	23.3	22.4	23.1	22.0	21.8	21.7
Transmission and Storage	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Distribution	+	+	+	+	+	+	+	+
<b>Total</b>	<b>33.7</b>	<b>33.8</b>	<b>29.4</b>	<b>28.8</b>	<b>29.6</b>	<b>28.4</b>	<b>28.2</b>	<b>28.2</b>

Note: Totals may not sum due to independent rounding.

Table 3-36. Non-energy CO<sub>2</sub> Emissions from Natural Gas Systems (Gg)

Stage	1990	1995	2000	2001	2002	2003	2004	2005
Field Production	5,876	9,083	5,955	6,307	6,462	6,341	6,309	6,350
Processing	27,752	24,621	23,333	22,387	23,066	22,002	21,780	21,736
Transmission and Storage	58	60	61	59	62	61	62	60
Distribution	43	42	41	40	40	40	40	39
<b>Total</b>	<b>33,729</b>	<b>33,807</b>	<b>29,390</b>	<b>28,793</b>	<b>29,630</b>	<b>28,445</b>	<b>28,190</b>	<b>28,185</b>

Note: Totals may not sum due to independent rounding.

## Methodology

The primary basis for estimates of CH<sub>4</sub> and non-energy-related CO<sub>2</sub> emissions from the U.S. natural gas industry is a detailed study by the Gas Research Institute and EPA (EPA/GRI 1996). The EPA/GRI study developed over 80

<sup>43</sup> The percentages of total emissions from each stage may not sum to 100 percent due to independent rounding.

### 3.8. Petroleum Systems (IPCC Source Category 1B2a)

CH<sub>4</sub> emissions from petroleum systems are primarily associated with crude oil production, transportation, and refining operations. During each of these activities, CH<sub>4</sub> is released to the atmosphere as fugitive emissions, vented emissions, emissions from operational upsets, and emissions from fuel combustion. Total CH<sub>4</sub> emissions from petroleum systems in 2005 were 28.5 Tg CO<sub>2</sub> Eq. (1,357 Gg). Since 1990, emissions have declined by 17 percent, due to a decline in domestic oil production and industry efforts to reduce emissions (see Table 3-38 and Table 3-39). The emission increase exhibited between 2004 and 2005 resulted from an increase in the number of offshore platforms (primarily shallow water, but also deep water). The various sources of emissions are detailed below.

*Production Field Operations.* Production field operations account for over 97 percent of total CH<sub>4</sub> emissions from petroleum systems. Vented CH<sub>4</sub> from field operations account for approximately 91 percent of the emissions from the production sector, fugitive emissions account for 3.5 percent, combustion emissions 5.3 percent, and process upset emissions, slightly over one-tenth of a percent. The most dominant sources of vented emissions are offshore oil platforms (shallow and deep water platforms), field storage tanks and natural-gas-powered pneumatic devices (low bleed and high bleed). These five sources alone emit over 86 percent of the production field operations emissions. Offshore platform emissions are a combination of fugitive, vented, and combustion emissions from all equipment housed on the platform for both oil and associated gas on those labeled as oil platforms. Emissions from storage tanks occur when the CH<sub>4</sub> entrained in crude oil under pressure volatilizes once the crude oil is put into storage tanks at atmospheric pressure. Emissions from high and low-bleed pneumatics occur when pressurized gas that is used for control devices is bled to the atmosphere as they cycle open and closed to modulate the system. Two additional large sources, chemical injection pumps and gas engines, together account for nine percent of emissions from the production sector. The remaining five percent of the emissions are distributed among 26 additional activities within the four categories: vented, fugitive, combustion and process upset emissions. For more detailed, source-level, data on methane emissions in production field operations refer to Annex 3.5.

*Crude Oil Transportation.* Crude oil transportation activities account for less than one percent of total CH<sub>4</sub> emissions from the oil industry. Venting from tanks and marine vessel loading operations accounts for 65 percent of CH<sub>4</sub> emissions from crude oil transportation. Fugitive emissions, almost entirely from floating roof tanks, account for 18 percent. The remaining 17 percent is distributed among seven additional sources within these two categories. Emissions from pump engine drivers and heaters were not estimated due to lack of data.

*Crude Oil Refining.* Crude oil refining processes and systems account for slightly over two percent of total CH<sub>4</sub> emissions from the oil industry because most of the CH<sub>4</sub> in crude oil is removed or escapes before the crude oil is delivered to the refineries. There is an insignificant amount of CH<sub>4</sub> in all refined products. Within refineries, vented emissions account for about 87 percent of the emissions, while fugitive and combustion emissions account for approximately six and seven percent respectively. Refinery system blowdowns for maintenance and the process of asphalt blowing—with air, to harden the asphalt—are the primary venting contributors. Most of the fugitive CH<sub>4</sub> emissions from refineries are from leaks in the fuel gas system. Refinery combustion emissions include small amounts of unburned CH<sub>4</sub> in process heater stack emissions and unburned CH<sub>4</sub> in engine exhausts and flares.

Table 3-38: CH<sub>4</sub> Emissions from Petroleum Systems (Tg CO<sub>2</sub> Eq.)

Activity	1990	1995	2000	2001	2002	2003	2004	2005
<b>Production Field Operations</b>	<b>33.8</b>	<b>30.5</b>	<b>27.1</b>	<b>26.7</b>	<b>26.1</b>	<b>25.1</b>	<b>24.7</b>	<b>27.8</b>
Pneumatic device venting	10.3	9.7	9.0	8.9	8.9	8.7	8.6	8.5
Tank Venting	3.8	3.4	3.2	3.2	3.2	3.2	3.0	2.8
Combustion & process upsets	1.9	1.7	1.6	1.6	1.6	1.5	1.5	1.5
Misc. venting & fugitives	17.4	15.1	12.8	12.5	12.0	11.3	11.2	14.5
Wellhead fugitives	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4
<b>Crude Oil Transportation</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>	<b>0.1</b>
<b>Refining</b>	<b>0.5</b>	<b>0.5</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>	<b>0.6</b>
<b>Total</b>	<b>34.4</b>	<b>31.1</b>	<b>27.8</b>	<b>27.4</b>	<b>26.8</b>	<b>25.8</b>	<b>25.4</b>	<b>28.5</b>

Note: Totals may not sum due to independent rounding.