

Appendix G. Waste Management

Overview

Greenhouse gas (GHG) emissions from waste management include:

- Solid waste management – methane (CH₄) emissions from municipal and industrial solid waste landfills (LFs), accounting for CH₄ that is flared or captured for energy production (this includes both open and closed landfills);
- Solid waste combustion – CH₄, carbon dioxide (CO₂), and nitrous oxide (N₂O) emissions from the combustion of solid waste in incinerators or waste to energy plants; and
- Wastewater management – CH₄ and N₂O from municipal wastewater and CH₄ from industrial wastewater (WW) treatment facilities.

Inventory and Reference Case Projections

Solid Waste Management

For solid waste management, we used the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SGIT) and the US EPA Landfill Methane Outreach Program (LMOP) landfills database¹ as starting points to estimate emissions. The LMOP data serve as input data to estimate annual waste emplacement for each landfill needed by SGIT. SGIT then estimates CH₄ generation for each landfill site. Additional post-processing outside of SGIT to account for controls is then performed to estimate CH₄ emissions.

The LMOP database was shared with South Carolina Department of Health and Environmental Control's (SCDHEC) solid waste staff, and the Center for Climate Strategies (CCS) was supplied with additional data on South Carolina landfills. These additional data included information on sites that were not present in the LMOP database, as well as updated information on sites that were present in the database (e.g., waste emplacement data, information on controls).² In the combined LMOP and SCDHEC dataset for South Carolina, there are over 50 sites represented (both open and closed landfills).

To obtain the annual waste emplacement rate needed by SGIT for each landfill, the waste-in-place estimate was divided by the number of years of operation. This average annual disposal rate for each landfill was assumed for all years that the landfill was operating. Data were available to calculate the average emplacement rate for each of the 13 controlled sites and 38 of the uncontrolled sites.

CCS performed three different runs of SGIT to estimate emissions from municipal solid waste (MSW) landfills: (1) uncontrolled landfills; (2) landfills with a landfill gas collection system and landfill gas to energy (LFGTE) plant; and (3) landfills with landfill gas collection and a flare.

¹ LMOP database is available at: <http://www.epa.gov/lmop/proj/index.htm>. Updated version of the database provided by Rachel Goldstein, Program Manager, EPA Landfill Methane Outreach Program, October 2006.

² John McCain, Solid Waste Permitting Section, Bureau of Land and Waste Management, South Carolina Department of Health and Environmental Control, personal communication with H. Lindquist, CCS, February 2007.

SGIT produced annual estimates of CH₄ emissions through 2005 for each of these landfill categories. CCS then performed post-processing of the landfill emissions to account for landfill gas controls (at LFGTE and flared sites) and to project the emissions through 2020. CCS assumed that 10% of CH₄ emissions are oxidized before being emitted to the atmosphere (consistent with the SGIT default). For the controlled landfills, CCS assumed that the overall CH₄ collection and control efficiency is 75%.³

Growth rates were estimated by using the historic (2000-2005) growth rates of emissions in both the controlled and uncontrolled landfill categories. The period from 2000 to 2005 was used since there were a large number of landfill closures during the period from 1990 to 2000 (which could have affected waste management practices). Hence, the post-2000 period is thought to be most representative of waste emplacement rates and subsequent emissions. The annual growth rates are: 0.2% for uncontrolled sites and 4.5% for controlled landfills. The small growth for the uncontrolled category is due to smaller rates of waste emplacement at these sites in the post-2000 period.

CCS used the SGIT default for industrial landfills. This default is based on national data indicating that industrial landfilled waste is emplaced at approximately 7% of the rate of MSW emplacement. We assumed that this additional industrial waste emplacement occurs beyond that already addressed in the emplacement rates for MSW sites. Due to a lack of data, no controls were assumed for industrial waste landfilling. For industrial landfills, the growth rate in emissions from 2000 to 2005 (2.3%/yr) was used to project emissions to 2010 and 2020 (equal to the overall growth in MSW landfill emissions).

Solid Waste Combustion

SCDHEC provided throughput data for the only municipal waste combustion facility currently operating in South Carolina.⁴ SGIT defaults (emission factors, waste characteristics) were used to estimate emissions using these data. No information was identified on plans for additional plants in the future or expanded capacity at the existing plant, so emissions were held constant in the forecast years.

Open burning of MSW at residential or municipal sites can also contribute GHG emissions. If data are available, future inventory work should attempt to capture this source of emissions.

Wastewater Management

GHG emissions from municipal and industrial wastewater treatment were also estimated. For municipal wastewater treatment, emissions were calculated in SGIT based on State population, assumed biochemical oxygen demand (BOD) and protein consumption per capita, and emission factors for N₂O and CH₄. The key SGIT default values are shown in Table G1.

³ As per EPA's AP-42 Section on Municipal Solid Waste Landfills:
<http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf>.

⁴ John McCain, Solid Waste Permitting Section, Bureau of Land and Waste Management, South Carolina Department of Health and Environmental Control, personal communication with H. Lindquist, CCS, February 2007.

For industrial wastewater emissions, SGIT provides default assumptions and emission factors for three industrial sectors: Fruits & Vegetables, Red Meat & Poultry, and Pulp & Paper. There is only one facility of significant size operating in South Carolina in any of these industries. SCDHEC was able to provide information on flows for this fruit and vegetable processing facility.⁵ The data on annual wastewater flows from SCDHEC were used to back-calculate an annual production value using SGIT data (3.8 cubic meters of wastewater for every ton processed; SGIT requires annual production data). The resulting emission estimates for this facility are very small [less than 0.0002 million metric tons (MMt) of CO₂ equivalent (CO₂e) per year] and are not significant compared to the total waste sector emissions.

Table G1. SGIT Key Default Values for Municipal Wastewater Treatment

Variable	Value
BOD	0.065 kg /day-person
Amount of BOD anaerobically treated	16.25%
CH ₄ emission factor	0.6 kg/kg BOD
SC residents not on septic	75%
Water treatment N ₂ O emission factor	4.0 g N ₂ O/person-yr
Biosolids emission Factor	0.01 kg N ₂ O-N/kg sewage-N
Source: US EPA State Inventory Tool – Wastewater Module; methodology and factors taken from US EPA, Emission Inventory Improvement Program, Volume 8, Chapter 12, October 1999: www.epa.gov/ttn/chiep/eiip/techreport/volume08/ .	

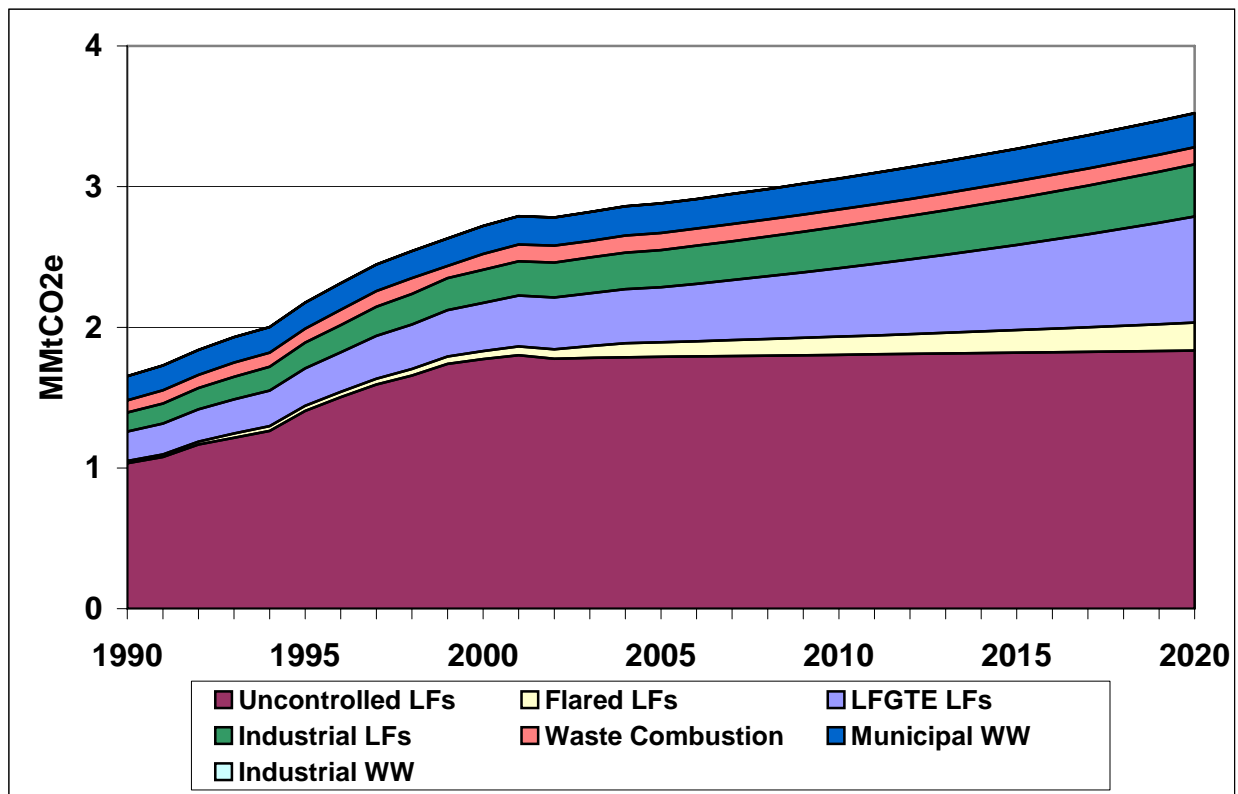
Results

Figure G1 shows the emission estimates for the waste management sector. Overall, the sector accounts for 2.9 MMtCO₂e in 2005. By 2020, emissions are expected to grow to 3.5 MMtCO₂e/yr. In 2005, 62% of the emissions were contributed by the uncontrolled landfills sector; however, by 2020 the contribution from these sites is expected to decline to about 52%. Controlled landfills (flared and LFGTE sites) contributed 17% of total waste emissions in 2005 and are expected to grow to 27% in 2020.

As mentioned above, CCS modeled only emissions from fruit and vegetable processors in the industrial wastewater treatment sector. Less than 0.01% of the emissions were contributed by the industrial wastewater treatment sector. In 2005, 7% of the waste management sector emissions were contributed from municipal wastewater treatment systems. The contribution is expected to remain the same through 2020. Note that these estimates are based on the default parameters listed in Table G1 and might not adequately account for existing controls (e.g., anaerobic digesters served by a flare or other combustion device) or specific wastewater treatment methods in SC (e.g., anaerobic digestion versus aerobic digestion).

⁵ Melinda Vickers, Wastewater Section, Bureau of Land and Waste Management, South Carolina Department of Health and Environmental Control, personal communication with S. Roe, CCS, December 2006.

Figure G1. South Carolina GHG Emissions from Waste Management



Source: CCS calculations based on approach described in text.
 Notes: LF – landfill; WW – wastewater; LFGTE – landfill gas to energy.

Key Uncertainties

The methods used to model landfill gas emissions do not adequately account for the points in time when controls were applied at individual sites. Hence, for landfills, the historical emissions are less certain than current emissions and future emissions for this reason (since each site that is currently controlled was modeled as always being controlled, the historic emissions are low as a result). The modeling also does not account for uncontrolled sites that will need to apply controls during the period of analysis due to triggering requirements of the federal New Source Performance Standards/Emission Guidelines.

For industrial landfills, these were estimated using national defaults (7% of the rate of MSW emplacement). It could be that the available MSW emplacement data within the combined LMOP/SCDHEC data used to model the MSW emissions already captures industrial LF waste emplacement. As with overall MSW landfill emissions, industrial landfill emissions are projected to increase between 2005 and 2020. Hence, the industrial landfill inventory and forecast has a significant level of uncertainty and should be investigated further. For example, the existence of active industrial landfills that are not already represented in the LMOP database should be determined.

For the wastewater sector, the key uncertainties are associated with the application of SGIT default values for the parameters listed in Table G1 (e.g., fraction of the SC population on septic; fraction of BOD which is anaerobically decomposed). The SGIT defaults were derived from national data. Hence, they may not adequately characterize the wastewater treatment processes currently employed or to be employed in the future.