

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)¹;
- 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 (WW) and CH₄ from industrial wastewater (WW) treatment facilities.

Inventory and Reference Case Projections

Solid Waste Management

For solid waste management, the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) software was used to estimate emissions. Landfill emplacement and emissions control data Annual disposal volumes for the state for 1996-2005 were obtained from the Michigan Department of Environmental Quality (MDEQ).² MDEQ These reports indicate that a significant fraction from MDEQ also included volumes of waste disposed of in Michigan that originated from other states or Canada.³ CCS did not apply the SIT assumption. Emissions were estimated for only the waste that 10% originated in Michigan. Waste volumes were converted to mass using the conversion factor of CH₄ is oxidized as it travels through the surface layers 3 tons per cubic yard of the landfill due to a lack of information to support this assumption. waste.⁴ The default annual waste disposal data from SIT were used for the years 1990-1995.

Emissions for industrial solid waste landfills were estimated using the SIT default activity data and emission factors. The activity data are based on national data indicating that industrial landfilled waste is emplaced at approximately 7% of the rate of municipal solid waste (MSW) emplacement. It was assumed that this additional industrial waste emplacement occurs beyond that already addressed in the emplacement rates for MSW sites described above.

¹ CCS acknowledges that N₂O and CH₄ emissions are also produced from the combustion of landfill gas; however, these emissions tend to be negligible for the purposes of developing a state-level inventory for policy analysis.

² Communicated to CCS by Timothy Unseld, MI DEQ, via email, January 2008. ³ Annual Reports of Solid Waste Landfilled, Michigan Department of Environmental Quality, <http://www.michigan.gov/deq/0,1607,7-135-3312-47581--,00.html>.

³ Annual Reports of Solid Waste Landfilled, Michigan Department of Environmental Quality, <http://www.michigan.gov/deq/0,1607,7-135-3312-47581--,00.html>.

⁴ Michigan Department of Environmental Quality, Waste and Hazardous Materials Division, "Combined Solid Waste Landfill Waste Receipt Report," lists conversion factor for MSW as 3 cubic yards per ton, <http://www.deq.state.mi.us/documents/deq-whm-stsw-SolidWasteLandfillWasteReceiptReportEQP5500.xls>.

Style Definition: Heading 7: Font: (Default) Cambria, 12 pt, Not Bold, Italic, Font color: Gray-75%, Right: 0 pt, Space Before: 10 pt, No bullets or numbering, Keep lines together

Style Definition: Caption

Formatted: Font: Times New Roman, 16 pt, Bold, Not Italic

Formatted: Font: Bold, No underline, Font color: Auto

Formatted: Space After: 6 pt

The amount of CH₄ captured for flaring and use in landfill gas-to-energy (LFGTE) plants was ~~calculated estimated with SIT defaults that are based on waste emplacement data for controlled landfills and data collected from vendors of emission capture flaring equipment installation.~~ Information on controlled landfills was obtained from MDEQ and a database of landfill gas-to-energy (LFGTE) projects compiled by the EPA. Emissions factors and landfill control efficiencies (quantity methane captured vs. escaped) were obtained from EPA's SIT, EPA, and a database maintained by the Energy Information Administration (EIA) for the voluntary reporting of greenhouse gases.⁵ The amount of landfill gas ~~captured~~ flared in Michigan may be underestimated if MI flaring and LFGTE controls have been underreported to MDEQ and EPA. CO₂ released upon thermal destruction of methane is not included in the inventory since it would be considered biogenic (originating from organic materials in the landfills). ~~the EPA and EIA.~~

Formatted: Font color: Auto

Formatted: Font color: Auto

Formatted: Font color: Auto

Growth rates were estimated by using the historic ~~(1999-2005)~~(1996-2005) growth rates of total net emissions from landfills. The annual growth rates are ~~3.0%~~2.6% for MSW landfills and ~~3.3%~~3.2% for industrial landfills. The years ~~1999~~1996 through 2005 were used to calculate these growth rates since ~~previous to that many flaring and LFGTE controls were not in place, these are the years for which State provided data were used to replace the SIT defaults, so the data used to calculate these growth rates are from a consistent non default source.~~

Solid Waste Combustion

SIT defaults were used to estimate emissions from solid waste combustion. ~~The default volumes of waste combusted correlated well a limited dataset provided by MDEQ. An annual growth rate of 4.1% for 2005-2020 was estimated based on the historic (1995-2005) growth rate.~~

Open burning of MSW at residential sites (e.g. backyard burn barrels) also contributes to GHG emissions. ~~The US EPA's 2002 National Emissions Inventory estimates the quantity of waste burned at residential sites in Michigan.⁶ Emissions from open burning were calculated using SIT emissions factors and waste characteristics for municipal waste combustion. The historic (2000-2005) growth rate of 0.95% for combined municipal and residential waste combustion was used to estimate future growth rates, 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 wastewater treatment were also estimated. For municipal wastewater treatment, emissions are calculated in EPA's SIT based on state population, assumed biochemical oxygen demand (BOD) and protein consumption per capita, and emission factors for N₂O and CH₄. The key SIT default values are shown in Table G1 below. Municipal wastewater emissions were projected based on the historic growth rate for 1990-2005 for a growth rate of 0.76% per year.

⁵ See Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2005, Chapter 8 Waste, US EPA, Report #430-R-07-002, April 2007 (<http://epa.gov/climatechange/emissions/usinventoryreport.html>).

⁶ EPA, ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/nonpoint/2002nei_final_nonpoint_documentation0206_version.pdf

Table G1. SIT Key Default Values for Municipal Wastewater Treatment

Variable	Default Value
BOD	0.09 kilogram (kg) /day-person
Amount of BOD anaerobically treated	16.25%
CH ₄ emission factor	0.6 kg/kg BOD
Michigan 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 Greenhouse Gas Inventory Tool (SIT) – Wastewater Module.

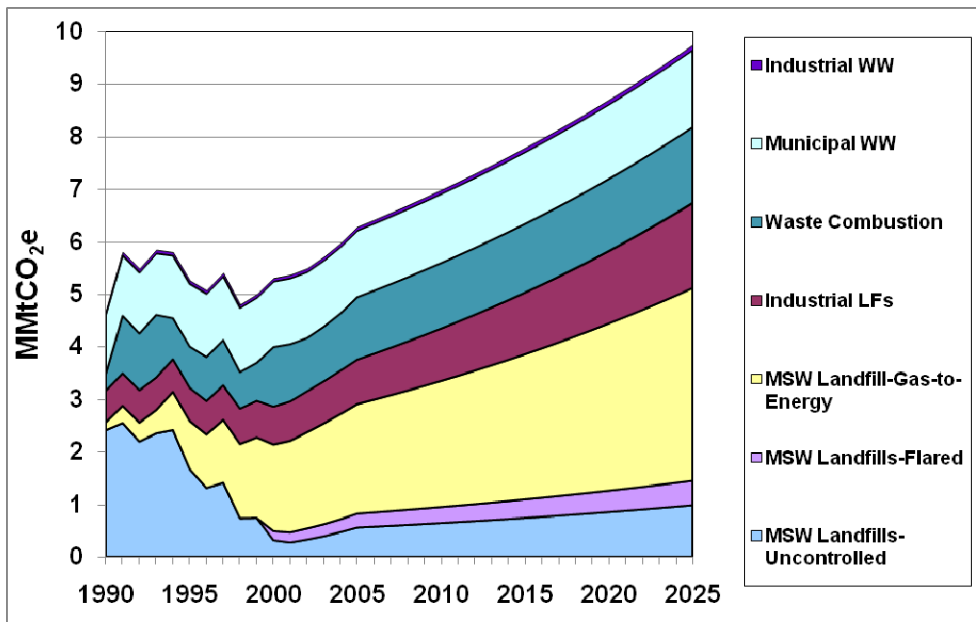
For industrial wastewater emissions, SIT provides default assumptions and emission factors for three industrial sectors: Fruits & Vegetables, Red Meat & Poultry, and Pulp & Paper. The SIT default activity data were used to estimate emissions for red meat production; however, default data were not available for the other sectors. Emissions were projected to ~~2025~~2020 based on the 1990-2005 annual growth rate (1.9%).

Formatted: Space After: 6 pt

Results

Figure G1 and Table G2 show the emission estimates for the waste management sector. Overall, the sector accounts for ~~6.28~~10.1 MMTCO₂e in 2005, and emissions are estimated to be ~~14.9~~7.4 MMTCO₂e/yr in ~~2025~~.

Figure G1. Michigan GHG Emissions from Waste Management, 1990-2025



Source: Based on approach described in text.

2020.

Table G2. Michigan GHG Emissions from Waste Management (MMtCO₂e)

Source	1990	1995	2000	2005	2010	2015	2020	2025
MSW Landfills - Gas-to-Energy	0.15	0.91	1.64	2.08	2.40	2.76	3.18	3.67
MSW Landfills - Flared	0.00	0.00	0.17	0.27	0.31	0.35	0.41	0.47
MSW Landfills - Uncontrolled	2.41	1.67	0.32	0.56	0.64	0.74	0.85	0.98
Industrial Landfills	0.60	0.63	0.73	0.85	1.00	1.17	1.38	1.62
Waste Combustion	0.33	0.80	1.14	1.20	1.26	1.32	1.38	1.45
Municipal Wastewater	1.13	1.19	1.25	1.27	1.32	1.37	1.42	1.47
Industrial Wastewater	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.09
Total	4.67	5.26	5.30	6.28	6.98	7.78	8.70	9.74

Formatted: Normal, Centered, Space After: 6 pt

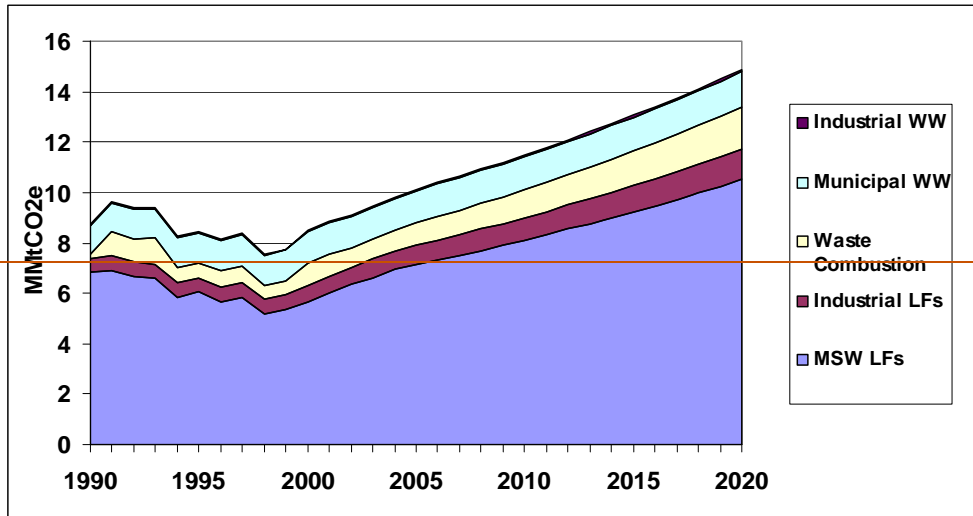
Formatted: Font: Bold

The largest contributor to waste management emissions is the solid waste sector, in particular, municipal landfills. In 2005, municipal landfills accounted for 46% of total waste management emissions. In 2005, 72% of municipal landfill emissions are from escaped from LFGTE landfills, 9% are escaped emissions from flared landfills, and the remaining 19% are from uncontrolled landfills. By 2025, 2020, the contribution from municipal landfills these sites is expected to increase slightly to about 53%. 71%. Industrial landfills accounted for about 14% of waste management emissions in 2005, and 17% also in 2025, 2020.

In 2005, about 20% 13% of the waste management sector emissions were contributed by municipal wastewater treatment systems and 1% 0.6% of emissions were contributed by the industrial wastewater subsector. Note that these estimates are based on the default parameters listed in Table G1 above, and might not adequately account for emissions, existing controls, or management practices (e.g. anaerobic digesters served by a flare or other combustion device). By 2025, 2020, municipal and industrial wastewater treatment subsectors are expected to contribute about 15% 10% and 1%, respectively 0.5% of the waste management sector emissions.

Emissions from waste combustion accounted for 19% of total waste management emissions in 2005 and are projected to account for 15% 11% in 2025, 2020.

Figure G1. Michigan GHG Emissions from Waste Management, 1990-2020



Source: Based on approach described in text.
 Notes: LF—landfill; WW—wastewater; LFGTE—landfill gas to energy.

Table G2. Michigan GHG Emissions from Waste Management (MMtCO₂e)

Source	1990	1995	2000	2005	2010	2015	2020
MSW Landfills	6.84	6.04	5.63	7.12	8.11	9.23	10.50
Industrial Landfills	0.54	0.57	0.66	0.76	0.89	1.05	1.22
Waste Combustion	0.18	0.64	0.94	0.94	1.11	1.36	1.66
Municipal Wastewater	1.13	1.19	1.25	1.27	1.32	1.37	1.42
Industrial Wastewater	0.04	0.05	0.05	0.06	0.06	0.07	0.08
Total	8.73	8.47	8.50	10.12	11.49	13.07	14.88

Formatted: Font: Bold
 Formatted: Normal, Centered, Space After: 6 pt

Key Uncertainties

For municipal waste landfills, the waste emissions were estimated based on default data, except for MSW annual disposal data for 1996–2005. There is a discontinuity between the default annual MSW disposal in 1995 (8.8 million tons) and the MDEQ annual MSW disposal data for 1996 (12.2 million tons), which suggests that the default data underestimates the MSW disposal. The default data are based on a per capita approach to estimating waste tonnage. In addition, this inventory was calculated using default data in all of the historical years for MSW controls. A more accurate approach would involve allocating the MDEQ landfill emplacement volumes by the portion of waste going to uncontrolled landfills, landfills with flares, and LFGTE facilities, so that control factors could more accurately be applied. The methods also do not adequately account for the points in time when controls were applied at individual sites. The modeling also does not account for uncontrolled landfills that will need to apply controls during the period of analysis due to triggering requirements of the federal New Source Performance Standards/Emission Guidelines.

The inventory and forecast accounts for all waste emplaced in MI, regardless of state or country of origin. Although MDEQ reports indicate that a significant percentage of waste emplaced in Michigan is imported from other states and Canada (approximately 29% in FY 2005), insufficient historical data is available to simultaneously account for imported waste and landfill controls. Estimates of waste emissions whose origin is imported can be calculated but will be overestimated because they will not include landfill control information. To the extent that any waste is exported out of state for management, the inventory and forecast should attempt to capture these emissions as well. This additional detail on waste exports will be incorporated based on available data from MDEQ.

For industrial landfills, emissions were estimated using national defaults (with industrial landfill emissions ~~approximately wastes buried at 7% of the rate of MSW emissions~~). MDEQ has ~~provided waste emplacement~~. A review of the draft waste inventory emissions by MDEQ waste staff has identified that the data used to represent MSW annual disposal rates for 1996 through 2005 ~~actually include waste landfilled at industrial landfills~~. However, emissions factors ~~for~~ ~~in~~ addition, some of this industrial waste ~~are~~ includes nondegradable waste, which should not currently available ~~be included in the EPA SIT, this inventory~~. As a result, the total landfill emissions presented here ~~overestimate emissions from landfills in Michigan~~.

Open burning of waste at residential sites was estimated using a US EPA NEI methodology and SIT emissions factors and waste composition defaults. Depending on actual burn rates and waste composition, this could be an over- or underestimate. Emissions from open burning of yard waste were not estimated but are expected to be small (only the CH₄ and N₂O emissions would be of interest here, since the CO₂ would be considered to be biogenic).

For the wastewater sector, the key uncertainties are associated with the application of SIT default values for the parameters listed in Table G1 above (e.g. fraction of the Michigan population on septic; fraction of BOD which is anaerobically decomposed). The SIT defaults were derived from national data.

For industrial wastewater, emissions were only estimated for the red meat industry using default data; default data for fruits and vegetables, poultry, and pulp and paper were not available. Therefore, emissions from industrial wastewater are likely to be underestimated. MDEQ has been contacted to provide wastewater data.

This emission inventory for the waste management sector will be revised to address the issues discussed above. In addition, the MCAC and the agriculture, forestry, and waste technical work group will be asked to provide ~~guidance on whether emissions from waste imported into or exported out of Michigan should be included in this inventory, as well as to provide~~ additional data, where available, that can be used to refine this waste management inventory.

Formatted: Font: Not Bold, Not Highlight

Formatted: Left