Appendix G. Waste Management

Overview

Greenhouse gas (GHG) emissions from waste management include:

- Solid waste management – methane (CH_4) emissions from municipal and industrial solid waste landfills (LFs), accounting for CH_4 that is flared or captured for energy production (this includes both open and closed landfills)[1];
- Solid waste combustion – CH_4, carbon dioxide (CO_2), and nitrous oxide (N_2O) emissions from the combustion of solid waste in incinerators or at open residential sites (i.e. backyard burn barrels); and
- Wastewater management – CH_4 and N_2O from municipal wastewater (WW) and CH_4 from industrial wastewater treatment facilities.

Inventory and Reference Case Projections

Solid Waste Management

For solid waste management, the United States Environmental Protection Agency's (US EPA) State Inventory Tool (SIT) software was used to estimate emissions. These emissions were based on state-specific data on waste emplacement ~~state population and national average landfilling rates.~~ obtained from the Florida Department of Environmental Protection (DEP) ~~has been contacted to provide state-specific data on waste emplacement and landfill controls~~. CCS did not apply the SIT assumption that 10% of CH_4 is oxidized as it travels through the surface layers of the landfill due to a lack of information to support this assumption.

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 landfill methane emissions are approximately 7% of municipal solid waste (MSW) emissions nationally. It was assumed that industrial waste emplacement occurs beyond that already addressed in the emplacement rates for MSW sites described above.

The amount of CH_4 captured for flaring and use in landfill gas-to-energy (LFGTE) plants was estimated ~~with~~ using the SIT software based on landfills controls data obtained from DEP and ~~defaults that are based on data collected from vendors of flaring equipment,~~ a database of landfill gas-to-energy (LFGTE) projects compiled by the EPA. ~~, and a database maintained by the Energy Information Administration (EIA) for the voluntary reporting of greenhouse gases.~~[2] The amount of landfill gas flared in Florida may be underestimated if Florida flaring and LFGTE controls have been underreported ~~in the~~to EPA and DEP. ~~and EIA data.~~

[1] CCS acknowledges that N_2O and CH_4 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] 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).~~

Growth rates were estimated by using the historic (2000-2005) growth rates of total net emissions from landfills. The annual growth rates are 5.0% for MSW landfills and 3.2% for industrial landfills.

Solid Waste Combustion

Sources of solid waste combustion include municipal solid waste (MSW) combustors, medical waste incinerators, and residential open burning. Emissions from municipal solid waste-to-energy combustors, of which Florida has twelve, are not inventoried here but are included in the energy supply sector inventory. Quantities of medical waste incinerated were obtained from Florida DEP.[3] The historic (1995-2005) growth rate of -1.7% for medical waste incineration was used to estimate future growth rates.

Open burning of MSW at residential sites (e.g. backyard burn barrels) was estimated using the US EPA's 2002 National Emissions Inventory (NEI) methodology for calculating the quantity of waste burned at residential sites in Florida.[4] Emissions from open burning were calculated using SIT emission factors and waste characteristics. The historic (1990-2005) growth rate of -1.7% for residential waste burning was used to estimate future growth rates.

Wastewater Management

GHG emissions from municipal wastewater treatment were also estimated. For municipal WW 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 N_2O and CH_4. 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 2.3% per year.

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
Florida residents not on septic	75%
Water treatment N_2O emission factor	4.0 g N_2O/person-yr
Biosolids emission factor	0.01 kg N_2O-N/kg sewage-N

Source: US EPA State Greenhouse Gas Inventory Tool (SIT) – Wastewater Module.

For industrial WW treatment 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,

[3] Yi Zhu, Florida Department of Environmental Protection, communicated via email to Rachel Anderson, CCS, March 6, 2008.
[4] EPA, ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/nonpoint/2002nei_final_nonpoint_documentation0206version.pdf.

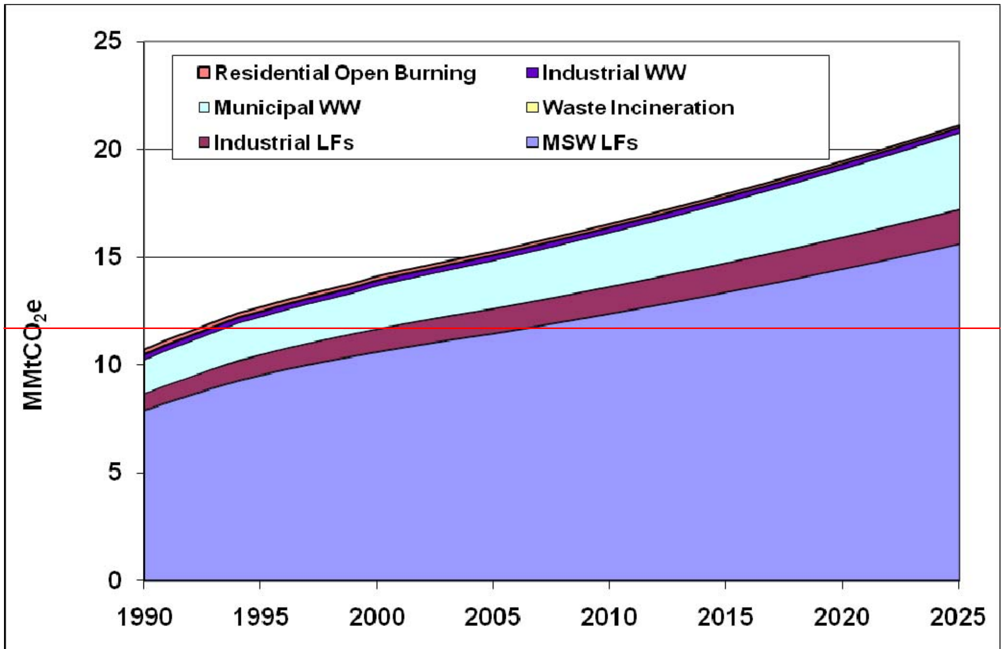
default data were not available for the other sectors (including poultry production). Emissions were projected to 2025 based on the 1990-2005 annual growth rate of 0.002%. See the Key Uncertainties section below for more information on industrial WW treatment.

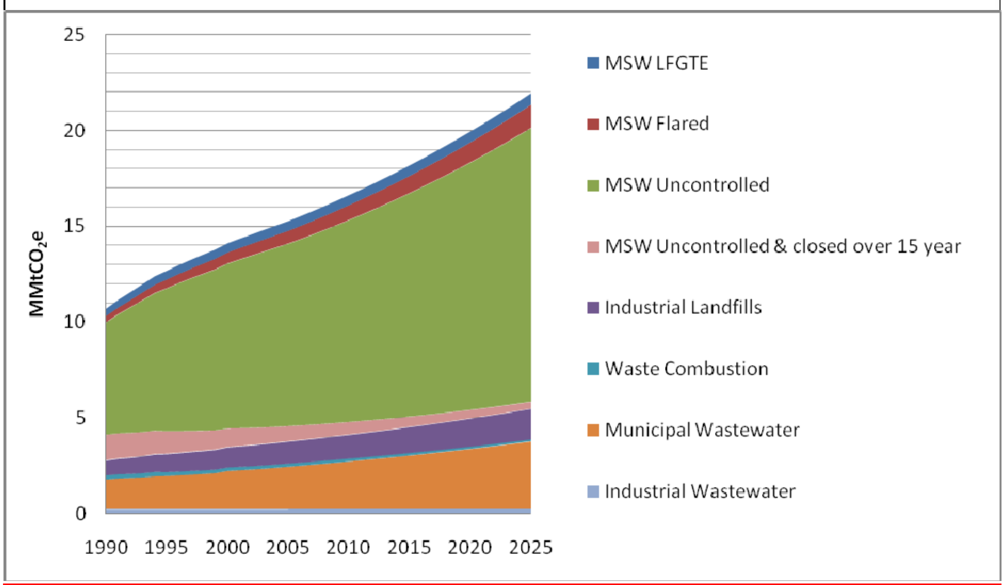
Results

Figure G1 and Table G2 show the emission estimates for the waste management sector. Overall, the sector accounts for 10.7 $MMtCO_2e$ in 2005, and emissions are estimated to be 21.~~1~~ 9 $MMtCO_2e$ in 2025. Emissions associated with waste management are grouped in three main categories: 1) solid waste management, 2) solid waste combustion, and 3) wastewater management. The first category ~~The largest contributor to waste management emissions is the solid waste sector, in particular, municipal landfills. In 2005, municipal landfills~~ accounted for 75% of total ~~waste management~~ carbon dioxide equivalent emissions; the contribution to total emissions in 2025 is also 75%. The second category, waste combustion, accounted for ~~a mere~~ 1% in 2005 and is projected to account for 1% of total emission by 2025. Thirdly, wastewater managements was responsible for the remaining 16% of emissions in 2005; projected emissions attribute 17% of total 2025 emissions to wastewater management practices~~By 2025, the contribution from these sites is expected to remain at approximately the same level (74%). Industrial landfills accounted for about 7% of waste management emissions in 2005 and 8% in 2025~~.

Due to its large contribution to total emissions, the solid waste management category was further divided into five different sources. One source is municipal solid waste land~~-~~filled in facilities equipped with methane gas recovery equipment, or~~. This aggregate source has been dominated as municipal solid waste~~ land fill gas-to-energy ~~or~~(MSW LFGTE). Another source relates to municipal solid waste managed in landfills operating with flaring equipment; this source has been noted as MSW Flared below. A third source relates to methane fugitive emission from uncontrolled municipal landfills; this source was labeled MSW Uncontrolled. A fourth source accounts for methane fugitive emissions from uncontrolled municipal landfills that ceased operations prior to 1983; this source is identified as MSW Uncontrolled & closed over 15 years in the figure and table below. The last source relates to methane emission from industrial landfills.

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





Source: Based on approach described in text.

Table G2. Florida GHG Emissions from Waste Management ($MMtCO_2e$)

~~Source~~	~~1990~~	~~1995~~	~~2000~~	~~2005~~	~~2010~~	~~2015~~	~~2020~~	~~2025~~

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~~MSW Landfills~~	~~7.92~~	~~9.55~~	~~10.63~~	~~11.49~~	~~12.41~~	~~13.41~~	~~14.48~~	~~15.65~~
~~Industrial Landfills~~	~~0.76~~	~~0.93~~	~~1.05~~	~~1.14~~	~~1.24~~	~~1.35~~	~~1.46~~	~~1.59~~
~~Waste Incineration~~	~~0.01~~	~~0.02~~	~~0.01~~	~~0.02~~	~~0.02~~	~~0.01~~	~~0.01~~	~~0.01~~
~~Municipal Wastewater~~	~~1.57~~	~~1.75~~	~~2.01~~	~~2.23~~	~~2.50~~	~~2.81~~	~~3.15~~	~~3.54~~
~~Industrial Wastewater~~	~~0.22~~	~~0.22~~	~~0.22~~	~~0.22~~	~~0.22~~	~~0.22~~	~~0.22~~	~~0.22~~
~~Residential Open Burning~~	~~0.22~~	~~0.20~~	~~0.18~~	~~0.17~~	~~0.16~~	~~0.14~~	~~0.13~~	~~0.12~~
~~Total~~	**~~10.70~~**	**~~12.68~~**	**~~14.11~~**	**~~15.26~~**	**~~16.54~~**	**~~17.94~~**	**~~19.47~~**	**~~21.13~~**

Source	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
MSW LGTE	0.39	0.46	0.49	0.51	0.53	0.55	0.57	0.59
MSW Flared	0.35	0.47	0.58	0.68	0.78	0.90	1.04	1.21
MSW Uncontrolled	5.86	7.45	8.60	9.52	10.5	11.7	12.9	14.3
MSW Uncontrolled & closed over 15 year	1.33	1.18	0.97	0.79	0.65	0.53	0.43	0.36
Industrial Landfills	0.76	0.93	1.05	1.14	1.24	1.35	1.46	1.59
Waste Combustion	0.23	0.22	0.20	0.19	0.17	0.16	0.15	0.14
Municipal Wastewater	1.57	1.75	2.01	2.23	2.50	2.81	3.15	3.54
Industrial Wastewater	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Total	**10.7**	**12.7**	**14.1**	**15.3**	**16.6**	**18.2**	**19.9**	**21.9**

~~In 2005, about 15% of the waste management sector emissions were contributed by municipal WW treatment systems and 1% was contributed by the industrial WW treatment 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, municipal WW treatment systems are expected to contribute about 17% and industrial WW treatment is expected to contribute about 1% to the waste management sector emissions.~~

~~Emissions from waste combustion contributed less than 1% of waste sector emissions in 2005 and 2025.~~

Key Uncertainties

For many landfills the point in time when control equipment was installed was not available so it was estimated based on average installation dates. ~~Municipal solid waste landfilling emissions were estimated with SIT default data, which 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 Florida DEP 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. This characterization of emissions by landfill type also provides better information for policy analysis. Since this is a state-level assessment, 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.

Florida DEP has been contacted to provide data on waste emplacement and landfill emissions controls. Also, although waste emplacement data do capture waste imports from other states, additional details will be incorporated as data are available to characterize the emissions from imported waste separately from that generated in-state. Finally, 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 import and export will be incorporated based on available data from Florida DEP or other sources.

For industrial landfills, emissions were estimated using national defaults (with industrial landfill emissions approximately 7% of MSW emissions). Depending on actual industrial landfill emissions in Florida, this could be an over- or underestimate.

SIT MSW defaults including waste composition and emissions factors were used to estimate medical waste incineration emissions in FL. To the extent that the fossil carbon content of medical waste differs from municipal solid waste, this could be an over- or underestimate. Open burning of waste at residential sites was estimated using a US EPA NEI methodology. Depending on actual burn rates, 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 CH_4 and N_2O emissions would be of interest here, since the CO_2 would be considered to be biogenic).

For the municipal WW treatment 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 Florida population on septic; fraction of BOD which is anaerobically decomposed). The SIT defaults were derived from national data.

For industrial WW treatment, 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 WW treatment are likely to be underestimated. FL DEP has been contacted to provide more complete WW treatment data.

This emission inventory for the waste management sector will be revised to address the issues discussed above. In addition, the Florida Action Team and the agriculture, forestry, and waste technical work group will be asked to provide additional data, where available, that can be used to refine this waste management inventory.

This inventory in its current state does not quantify current actions taken by the State of Florida that may lower future emissions. CCS is not aware of any current actions that would have an impact on the emissions forecast.