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 waste to energy plants; and
- Wastewater management – CH_4 and N_2O from municipal wastewater and CH_4 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 Inventory Tool (SIT) software was used to estimate emissions. These emissions were based on state population and national average landfilling rates. Arkansas Department of Environmental Quality (ADEQ) has been contacted to provide state-specific data on waste emplacement and landfill emissions controls; however they do not have the necessary data.[2]. 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 SIT defaults that are based on data collected from vendors of flaring equipment, a database of LFGTE projects compiled by the EPA, and a database maintained by the Energy Information Administration (EIA) for the voluntary reporting of greenhouse gases.[3] The amount of landfill gas flared in Arkansas may be underestimated if Arkansas flaring and LFGTE controls have been underreported to the EPA and EIA.

Growth rates were estimated by using the historic (1996-2005) growth rates of total net emissions from landfills. The annual growth rates are 3.9% for MSW landfills and 2.7% for

[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] ADEQ, communicated to CCS from Bryan Leamons, Solid Waste Division via email, Feb 2008.
[3] 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).

industrial landfills. The years 1996 through 2005 were used to calculate these growth rates since these are the years when the SIT starts including flaring and LFGTE in the default data.

Solid Waste Combustion

ADEQ sources indicate that there is no combustion of MSW and no medical waste incineration.[4]

Likewise, open burning (e.g. residential burn barrels) was assumed to not contribute emissions after 1999 – the year it became illegal in the State of Arkansas.[5] Previous to 1999, the quantity of waste burned at residential sites in Arkansas was obtained from the 2002 National Emissions Inventory.[6] Emissions from open burning were calculated using SIT emission factors and waste characteristics. If unregulated open burning is occurring in a significant way, then the post-1999 emissions for this sector may be a slight underestimate. However, this is not expected to be the case.

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 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 1.3% 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
Arkansas 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 wastewater emissions, SIT provides default assumptions and emission factors for three industrial sectors: Fruits & Vegetables, Red Meat & Poultry, and Pulp & Paper. ADEQ provided 2005 industrial wastewater flow data for all fruits & vegetables, poultry, and pulp & paper. Historical flows for poultry and fruits and vegetables were estimated using 1992-2002 growth rates for broilers sold and fruits and vegetables harvested calculated from USDA data.[7] No data for growing the pulp and paper estimates were identified, so wastewater emissions from this sector were held constant for all analysis years. The SIT default activity data were used to

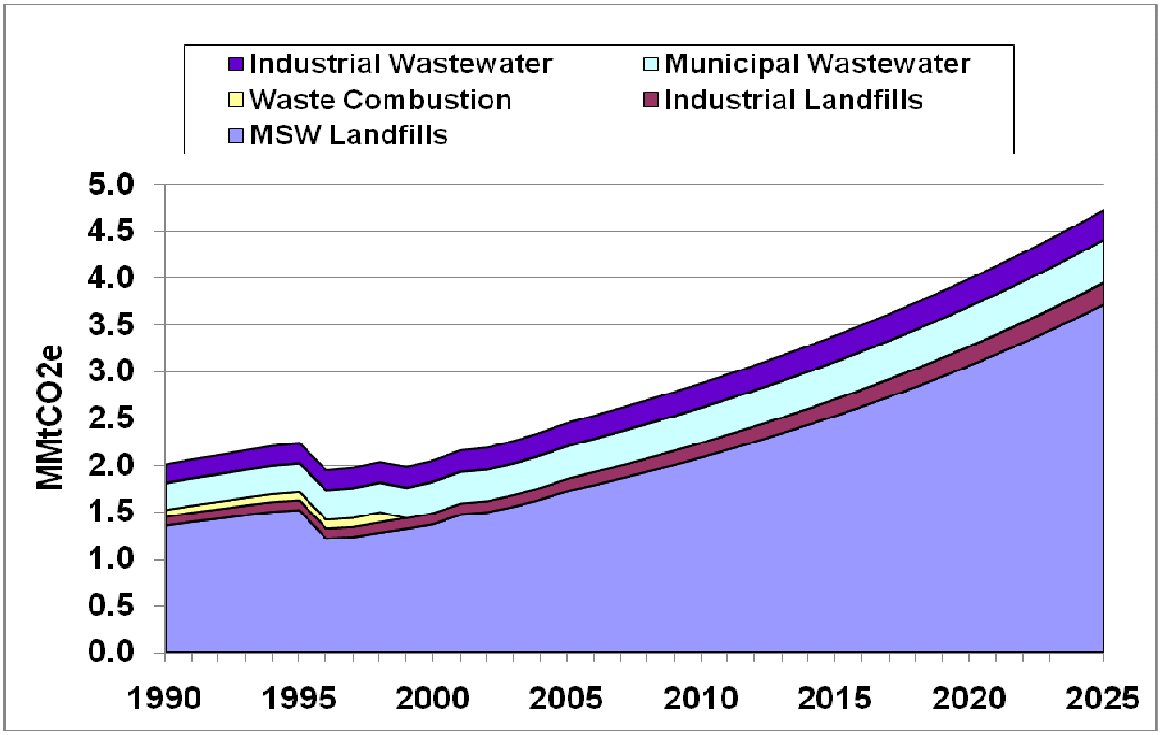
[4] ADEQ, communicated to CCS from Thomas Rheaume, Air Division via email, Feb 2008.
[5] See http://www.co.benton.ar.us/Environment/openburning.html, accessed Feb 2008.
[6] EPA, ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/nonpoint/2002nei_final_nonpoint_documentation0206version.pdf.
[7] USDA, http://www.nass.usda.gov/census/census02/volume1/ar/st05_1_001_001.pdf, accessed Feb 2008.

estimate emissions for red meat production. SIT emission factors were used to calculate emissions. Emissions were projected to 2025 based on the 1990-2005 annual growth rate (1.3%).

Results

Figure G1 and Table G2 show the emission estimates for the waste management sector. Overall, the sector accounts for 2.45 $MMtCO_2e$ in 2005, and emissions are estimated to be 4.72 $MMtCO_2e$/yr in 2025.

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



Source: Based on approach described in text.

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

Source	1990	1995	2000	2005	2010	2015	2020	2025
MSW Landfills	1.36	1.52	1.37	1.72	2.09	2.53	3.07	3.72
Industrial Landfills	0.09	0.11	0.12	0.14	0.16	0.18	0.20	0.23
Waste Combustion	0.07	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Municipal Wastewater	0.29	0.31	0.34	0.35	0.37	0.40	0.42	0.45
Industrial Wastewater	0.20	0.21	0.22	0.24	0.26	0.27	0.29	0.31
Total	**2.01**	**2.24**	**2.05**	**2.45**	**2.87**	**3.38**	**3.99**	**4.72**

The largest contributor to waste management emissions is the solid waste sector, in particular, municipal landfills. In 2005, municipal landfills accounted for 70% of total waste management emissions. By 2025, the contribution from these sites is expected to increase slightly to about

79%. Industrial landfills accounted for about 6% of waste management emissions in 2005, and 5% in 2025.

In 2005, about 14% of the waste management sector emissions were contributed by municipal wastewater treatment systems and 10% were contributed by industrial wastewater. 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, the municipal wastewater treatment sector is expected to contribute about 10% and industrial wastewater 7% to the waste management sector total.

Emissions from waste combustion did not contribute to waste management emissions after 1999.

Key Uncertainties

Municipal solid waste emissions were estimated with 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 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. ADEQ was contacted to provide more complete landfill and emissions controls data; however they do not have that data.[8] 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. Data on solid waste imports from other states or exports was not available from ADEQ.

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 AR, this could be an over- or underestimate.

ADEQ indicated that there is no waste combustion or waste-to-energy conversion in Arkansas. Although open residential burning is illegal, there is likely some occurring, particularly in rural areas. The Agriculture, Forestry, and Waste Technical Working Group has been asked to provide estimates of illegal open burning. To the extent that unreported waste burning is occurring in Arkansas, the emissions reported in this inventory and forecast may be underestimated.

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 Arkansas population on septic; fraction of BOD which is anaerobically decomposed). The SIT defaults were derived from national data.

[8] ADEQ, communicated to CCS from Bryan Leamons, Solid Waste Division via email, Feb 2008.

For industrial wastewater, key uncertainties are associated with the use of SIT emission factors and wastewater chemical oxygen demand estimates for each industry.

This emission inventory for the waste management sector will be revised to address the issues discussed above. In addition, the Arkansas Governor's Commission 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 Arkansas that may lower future emissions. These include Recycling Legislation (Act 94, HB1055) and the Solid Waste Management and Recycling Fund (Act 1325, SB575).