New Jersey Statewide Greenhouse Gas Emissions Inventory Update: 2005, 2006, and 2007 Estimates

Introduction

This report, the New Jersey Statewide Greenhouse Gas Emissions Inventory Update: 2005, 2006, and 2007 Estimates (Inventory Update) provides estimated statewide greenhouse gas emissions for New Jersey for 2005, 2006 and 2007. The estimate for 2005 supersedes estimated 2005 emissions provided in the report "New Jersey Greenhouse Gas Inventory and Reference Case Projections 1990-2020" (Inventory and Projections) dated November 2008.[1] Estimates for 2006 and 2007 are provided as well.

This report fulfills three requirements of the Global Warming Response Act. First, it includes an inventory of the 1990 level of statewide greenhouse gas emissions as required by N.J.S.A. 26:2C-40b2. The 1990 statewide emissions establish the baseline for tracking progress towards the 2020 limit. This report also provides an inventory of the 2006 statewide greenhouse gas emissions as required by N.J.S.A. 26:2C-40b1. The 2006 statewide emissions establish the baseline for tracking progress towards the 2050 limit. This report also represents the first biennial report on greenhouse gas emission statistics required by N.J.A.C. 26:2C-43.

Methods

The most recent fuels use data and emissions factors available from the U.S. Department of Energy, Energy Information Administration (EIA)[2] were used. With two exceptions, the methods used to translate these data to greenhouse gas emissions and to otherwise develop the estimates presented herein are essentially identical to those described in the Inventory and Projections report. The exceptions to the use of the same methods are for the in-state electricity generation and the municipal solid waste (MSW) incineration sectors.

The estimate for the in-state electricity generation sector in the Inventory and Projections report was based on the EIA State Energy Data report for the electric power sector. In this Inventory Update, the carbon dioxide equivalents (CO_2eq) of the reported carbon dioxide (CO_2) and methane (CH_4) emissions from all the facilities that are included in the New Jersey DEP Emissions Statement database[3] with NAICS code 221112, Fossil Fuel Electric Power Generation, or with NAICS code 221119, Other Electric Power Generation, or which are otherwise known to be electric power generation facilities were

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[1] NJDEP, 2008, New Jersey Greenhouse Gas Inventory and Reference Case Projections: 1990-2020, New Jersey Department of Environmental Protection, Trenton, NJ October 31, 2008, http://www.state.nj.us/globalwarming/index.shtml

[2] USDOE/EIA, 2009, State Energy Data System, U.S. Department of Energy, Energy Information Administration, downloaded 1/21/09 from http://www.eia.doe.gov/emeu/states/state.html?q_state_a=nj&q_state=NEW%20JERSEY

[3] NJDEP, 2009, Emissions Statement Program, Danny Wong, personal communication.

totaled and this quantity was considered to represent the emissions from the in-state electric power production sector. This change was made because it is believed that the direct reports from NJ facilities more accurately reflect the actual emissions from this sector than basing the emissions estimates on EIA fuel use data as provided in the State Energy Data report.

A similar change in method has been made for MSW incineration. Data on total CO_2 emissions from the five New Jersey MSW incinerators as provided by the New Jersey DEP Emissions Statement database were used. These data were corrected to include only the estimated portion of the CO_2 emitted that comes from combustion of fossil-fuel derived materials (e.g., plastics and synthetic fibers). The portion of CO_2 emitted from biogenic sources (e.g. paper) was excluded in the inventory, as is consistent with other national and international inventories, with the assumption that wood and other biomass is grown in a sustainable manner and so the quantity of carbon released from combustion of these materials will be removed from the atmosphere soon by growth of new trees and biomass. The biogenic portion was estimated to be 59 percent based on a new method, ASTM D6866, that measures the portion of emssions that is the isotope C^{14}. This isotope is present in biologically-derived material that is relatively recent, such as wood and paper, but is not present in fossil fuels. The 59 percent biogenic portion is the mean value of four reported values.[4,5,6,7]

The estimated emissions for 2005, 2006, and 2007 are provided in Table 1. For certain sectors, 2006 and 2007 values were assumed to be equal to the estimates developed for 2005 included in the Inventory and Projections report. These sectors, noted in Table 1, are all relatively small, and are not expected to differ significantly over a time period of three years.

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[4] Mohn, J. et al., 2008, Determination of biogenic an fossil CO_2 emitted by waste incineration based on ^{14}CO2 and mass balances, Bioresource Technology 99, 6471-6479

[5] Themelis, Nickolas, Columbia University, personal communication to M. Aucott, 9/8/09

[6] Fellner, J., et al., 2007, A new method to determine the ratio of electricityproduction from fossil and biogenic sources in waste-to-energy plants, E, S & T, 41, 2579-2586

[7] USEPA, 9/23/09, www.epa.gov/RDEE/energy-and-you/affect/municipal-sw.html

Table 1
Estimated 1990, 2005, 2006, and 2007 NJ Statewide GHG Emissions
Million metric tons (MMT) carbon dioxide equivalents

Sector	1990	2005	2006	2007	Notes
Commercial	10.7	10.8	9.2	10.6	
Industrial	19.8	17.3	16.3	15.9	
Residential	15.2	16.3	13.7	15.6	
Transportation					
on-road gasoline	28.9	38.0	38.1	39.0	
distillate (primarily on-road diesel)	5.57	10.78	10.77	11.4	
jet fuel	1.00	1.00	1.00	1.0	set equal to 1 MMT in effort to account for in-state only
residual (primarily marine)	1.00	0.87	0.81	0.8	estimated to represent in-state only per methods of Ref. 1
other	0.36	0.28	0.25	0.3	
In-state electric	12.4	19.8	18.5	22.7	1990 value from Ref. 1, includes MSW incineration.
Imported electric	14.1	13.1	11.7	11.9	
MSW incineration	na	0.8	0.8	1.0	
Halogenated gases (ex. SF6)	0.02	2.9	3.0	3.1	
SF6	0.95	0.3	0.3	0.3	
Industrial non-fuel related	0.3	0.1	0.1	0.1	2005 value from Ref. 1; 2006 & 2007 assumed equal to 2005
Agriculture	0.6	0.5	0.5	0.5	2005 value from Ref. 1; 2006 & 2007 assumed equal to 2005
Natural gas T&D	2.5	2.4	2.6	2.6	2005 value from Ref. 1; 2006 & 2007 assumed equal to 2005
Landfills, in-state	11.7	3.6	3.5	3.5	
out-of-state	2.6	1.3	1.3	1.3	2005 value from Ref. 1; 2006 & 2007 assumed equal to 2005
industrial	1.1	0.3	0.2	0.2	
POTWs	0.5	0.5	0.5	0.5	2005 value from Ref. 1; 2006 & 2007 assumed equal to 2005
Released thru land clearing	1.1	1.1	1.1	1.1	2005 value from Ref. 1; 2006 & 2007 assumed equal to 2005
Total gross emissions, MMT	130.4	142.1	134.4	143.4	
Sequestered by forests	-7.5	-6.7	-6.7	-6.7	1990 value from Ref. 1
Total net emissions MMT CO2eq	**122.9**	**135.4**	**127.7**	**136.7**	

Reference 1 is NJ GHG Inventory & Reference Case Projections 1990-2020, NJDEP, Nov. 2008
All numbers are estimates; uncertainty of totals is likely in range of plus or minus 5 percent

Discussion

The estimated 2006 emissions are lower than the estimated 2005 emissions by nearly eight million metric tons. 2007 emissions are higher than both previous years. Possible reasons for this variation are discussed below. Also, there are numerous methodological issues that add uncertainty to the estimates and could benefit from additional focus in the future. These too are discussed below.

Decline from 2005 to 2006; Normalizing for Weather

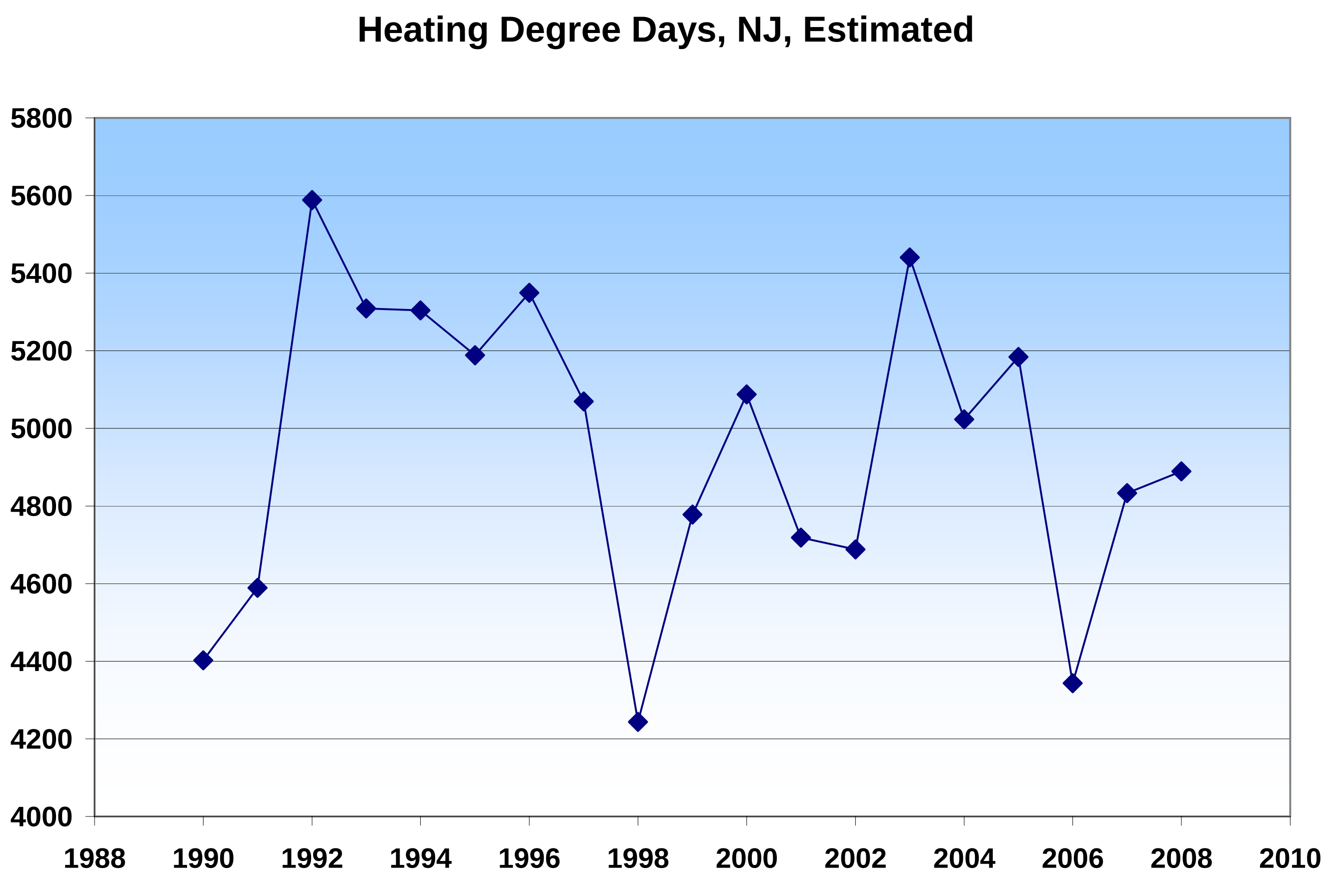
A decline in greenhouse gas emissions from 2005 to 2006 of approximately 8 million metric tons, nearly 6 percent, is apparent. A decline from 2005 to 2006 of 1.5 percent was estimated by the USEPA at the national level as well. EPA stated that there were three main contributors to this decrease: 1) 2006 had warmer winter conditions, which decreased consumption of heating fuels, and cooler summer conditions, which reduced demand for electricity; 2) there was some restraint on fuel consumption caused by rising fuel prices, especially in the transportation sector; and 3) there was increased used of natural gas and renewable energy sources by the electric power sector. [8]

These same factors appear to also have played a major role in the New Jersey reductions. As shown in Table 1, 4.2 million metric tons (MMT) of the overall 7.9 MMT reduction was accounted for by the residential and commercial sectors. With both of these sectors a relatively large portion of the total energy consumption is accounted for by consumption of fuels for heating. Heating degree days[9] show a marked decline from 2005 for 2006. See Figure 1.

[8] USEPA, 2008, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007, public review draft, downloaded 3/1/2008 from http://www.epa.gov/climatechange/emissions/usgginventory.html

[9] A heating degree day is the difference in degrees Fahrenheit between the mean daily temperature and 65 degrees. For example, a day with a mean temperature of 40^{o} F. represents 25 heating degree days. Yearly heating degree days were estimated from monthly mean temperatures available from the New Jersey State Climatologist, at http://climate.rutgers.edu/stateclim/

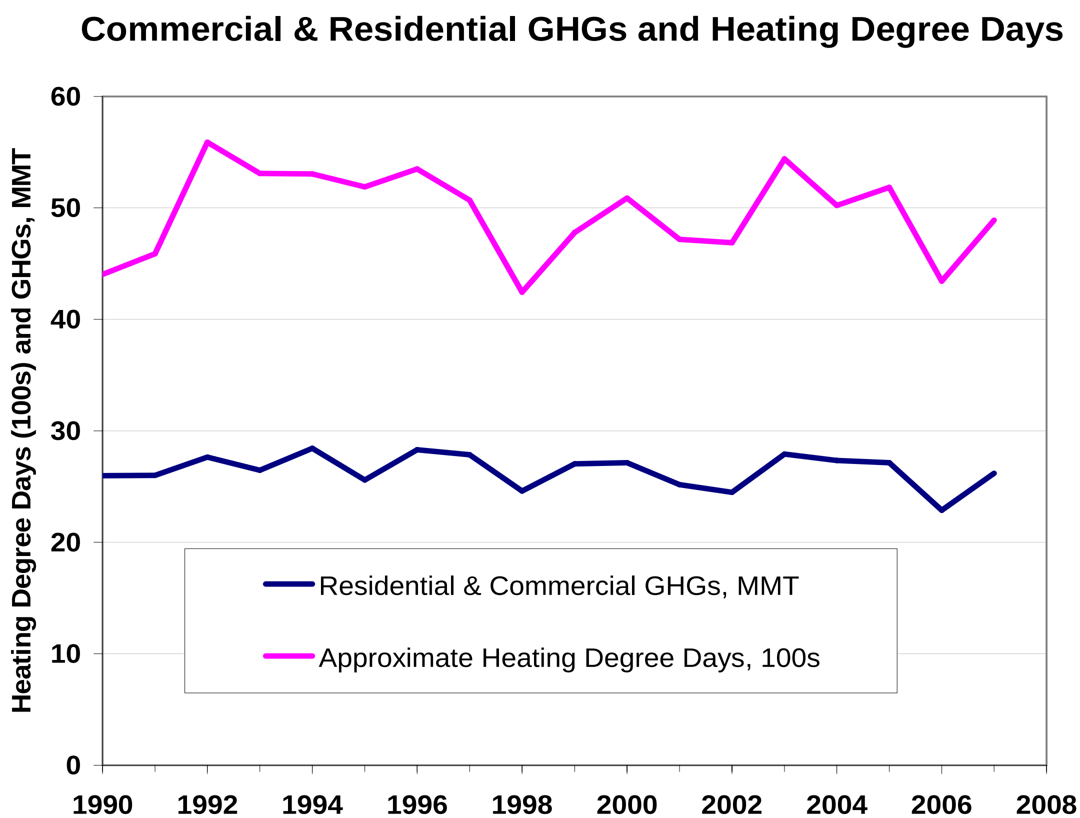
Figure 1



Heating Degree Days, NJ, Estimated
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

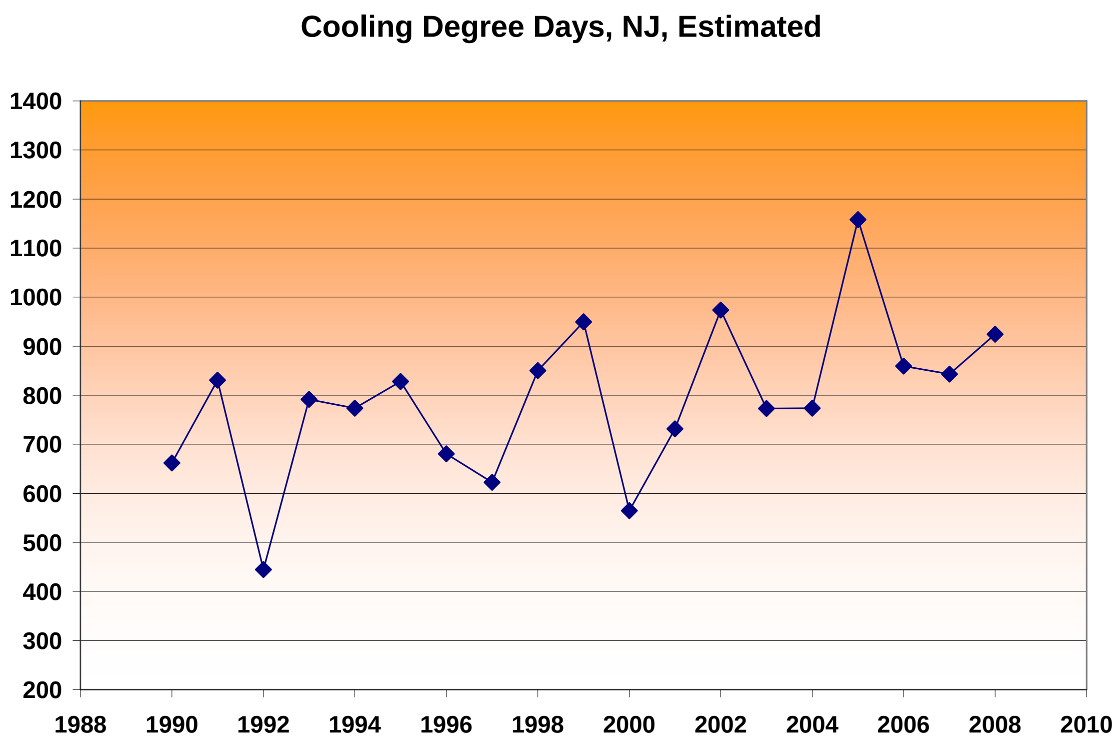
Historically, lower heating degree day totals correlate with lower greenhouse gas emissions from the combined residential and commercial sectors. See Figure 2.

Figure 2.



Cooling degree day[10] totals were also lower in 2006 relative to 2005. See Figure 3.

Figure 3.



A significant portion of residential and commercial electricity use is associated with operation of air conditioning equipment. The lower cooling needs of 2006 relative to 2005 likely contributed to a lower electricity use in 2006, as reflected in a reduction in greenhouse gas emissions for the combined imported and in-state electricity generation sector from 32.9 MMT to 30.2 MMT, a drop of 2.7 MMT.

It is also likely that a lessening of the carbon intensity of fuels used by the electricity sector (e.g. more use of natural gas and renewable sources) played a role, because, while there was a drop in total retail sales of electricity from 81,896,813 megawatt hours in 2005 to 79,680,947 megawatt hours in 2006,[11] this represents a 3 percent reduction whereas the drop in greenhouse gas emissions was about 8 percent.

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[11] USDOE/EIA, 2009, State Electricity Profiles, 2005 and 2006, U.S. Department of Energy, Energy Information Administration, http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html

Methodological issues

Methodological issues exist with this inventory and previous inventories as well. Depending on the availability of relevant data and progress in estimation methods, the Department expects to revise future inventories to address methodological issues. Earlier inventories may be revised retroactively. The most pertinent methodological issues apparent at this time are discussed below.

Halogenated Gases

Estimates of emissions of halogenated gases such as HFC-134a and SF_6 were made by apportioning to New Jersey based on population the national data obtained from USEPA.[12] Clearly, this approach lacks any direct relationship to local conditions, and provides little detail to inform the development of potential emissions reduction measures. With the implementation of New Jersey-specific reporting rules pursuant to the Global Warming Response Act, more detailed and useful data should be available.

Jet fuel

Estimating greenhouse gas emissions from combustion of jet fuel presents a problem in that the fuel consumption data provided by the EIA is considered by the Department to represents, to some degree, jet fuel consumed at airports that are outside of New Jersey, such as the LaGuardia and John F. Kennedy airports in New York City. Further, even if they take off from New Jersey airports, most fuel consumption by planes takes place outside the geographical confines of New Jersey. In the Inventory and Projections report noted above, greenhouse gas emissions from jet fuel combustion have been estimated to be 1 MMT. This estimate is very approximate and is an attempt to account for just that portion of jet fuel that is consumed in the state. Only this portion of the fuel consumed is potentially under the regulatory control of New Jersey or at least potentially influenced by State policy. Another approach that would retain some relationship to behavior that could, at least in part, be influenced by State policy would be to apportion national jet fuel consumption to New Jersey based on the State's portion of national gross domestic product (GDP). GDP can be expected to correlate well with air travel. Such an approach results in a GHG emission associated with jet fuel consumption of 8.54 MMT CO_2eq in 2005 and 8.23 MMT CO_2eq in 2006. An advantage of the GDP approach is that the total of each state's value produced by this method would equal the national total, which would not be the case if each state accounted only for the estimated portion of jet fuel that was consumed within its borders.

This approach, when applied to the baseline year 1990, results in a very similar value of 8.45 MMT CO_2eq. The closeness of the 1990 value to the later values is a result of two diverging trends; planes have become much more fuel efficient, and air travel has grown. The numbers are similar enough that, in terms of tracking the overall GHG trend since 1990, it makes little difference whether a constant 1 MMT is used to represent jet fuel, as has been done in this current report, or whether the apportionment based on GDP

[12] USEPA, 2008

approach is used. In either case, jet fuel consumption does not influence the trend. However, it should be noted that a constant value for jet fuel cannot be assumed into the future.

Another approach is to use data that are expected to become available in the future in connection with the Department's efforts to assess criteria pollutant emissions from aircraft and ships. The Department is optimistic that these data may lend themselves to assessing CO_2 emissions associated with in-state activity of aircraft and ships as well. .

Landfills

In the anaerobic environment of a landfill, a portion of organic waste decomposes to methane, CH_4. According to the most recent report from the Intergovernmental Panel on Climate Change (IPCC)[13] this gas has a global warming potential, calculated using a 100-year time frame, of 25. This factor has been used to weight CH_4 emissions in this Inventory Update report.

Emissions of CH_4 were calculated for the 100 largest New Jersey landfills, including both active and inactive sites, using a first order decay formula[14] and landfill data from the DEP's Division of Solid and Hazardous Waste.[15] In addition to the assumptions built into this formula, the calculation also assumed that, for inactive landfills, density of waste in place was 2000 lbs. per cubic yard and that waste had been received at a uniform rate throughout that landfill's period of operation. This period was assumed to be 20 years where site-specific data did not exist. Also, it was assumed that 10 percent of any methane generated by a landfill was oxidized before it was either released to the air or captured by a gas collection system. Further, it was assumed that where a gas capture system existed, it captured 75 percent of the remaining (un-oxidized) CH_4. It was also assumed that a flaring or combustion system destroyed 100 percent of the captured methane. Emissions from 300 additional smaller landfills, none of which are known to have active gas collection and flaring, were estimated based on estimates of their relative size based on a size distribution of the 100 largest landfills. The CH_4 emissions of out-of-state landfills resulting from waste generated in New Jersey deposited in these landfills were assumed to be proportional to the emissions from the active in-state landfills, based on the portion of municipal solid waste generated in-state that is disposed at in-state landfills vs. the portion disposed at out-of-state landfills.

While the assumptions used to generate emissions from landfills are consistent with current guidelines and protocols, there is considerable uncertainty associated with many of the assumptions used. For example, one study reported that the efficiency of gas

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[13] Intergovernmental Panel on Climate Change (IPCC), 2007, Fourth Assessment Report, Working Group One, Physical Science Basis, Chapter 2, Table 2.14, http://www.ipcc.ch).

[14] Formula used is from USEPA, 1996, *Turning a Liability into an Asset* ,EPA 430-B-96-0004 , with values of k = 0.04/yr and Lo = 1.765 cf/lb. With this formula, CH_4 $ft^3/yr = Lo * R * (e^{-kc} - e^{-kt})$, where c = time (yrs) since closure, t = time since opening, and R = waste received/yr, lbs.

[15] http://www.nj.gov/dep/dshw/swr/

collection systems varies from 35% to 90% depending on a variety of parameters.[16] Another study, however, indicated that gas collection efficiencies of better than 90% are typical of modern landfills with active gas collection systems.[17] As more data become available, it should be possible to improve estimation methods for this sector.

Residual and diesel fuel; marine transportation sector

Ships and boats consume residual fuel, and distillate (diesel) fuel. Estimating emissions from ocean-going ships presents the same difficulties as aircraft, as discussed above, because a portion of the consumed fuel is consumed during national and international journeys that are outside of the State's purview. Methods to account for the New Jersey-only portion of emissions from this sector for 2005 are discussed in the referenced "Inventory and Projections" report.

An alternate approach based on apportionment of national residual fuel consumption in the transportation sector to New Jersey based on the state's portion of national GDP, as discussed above for jet fuel, could be applied to this sector as well. Doing so results in a 1990 estimate of 3.05 MMT CO_2eq, a 2005 estimate of 2.29 MMT, and a 2006 estimate of 2.46 MMT. Again, as with jet fuel, the numbers are similar enough that using this approach would not significantly affect the overall statewide emission trend during the period. As with jet fuel, an advantage of this GDP-based approach in addition to its simplicity is that the total of each state's value produced by this method would equal the national total, which would not be the case if each state accounted only for the estimated portion of jet fuel that was consumed within its borders.

The Department is optimistic that data that are expected to become available in the future in connection with the Department's efforts to assess criteria pollutant emissions from aircraft and ships will be helpful in refining this estimate. For this report, the same approach has been used as for the 2005 estimate.

Wastewater Treatment

Wastewater treatment plants emit CH_4 and nitrous oxide, N_2O. During the preparation of the Inventory and Projections report, emissions of CH_4 estimated using EPA's SIT procedures were compared with reports of CH_4 emissions from the 13 large wastewater treatment plants that were included in the New Jersey DEP Emissions Statement database.[18] The estimate based on SIT was larger than the data provided by the DEP database. Since the DEP data were New Jersey-specific and considered to be valid per requirements of the Emissions Statement Program, these data were used as the basis for the emissions estimate, which was augmented with the assumption that CH_4 emissions

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[16] Spokas, K., J. Bogner, J.P. Chanton, M. Morcet, C. Aran, C. Graff, Y. Moreau-Le Golvan, and I. Hebe, 2006, Methane mass balance at three landfill sites: What is the efficiency of capture by gas collection systems?, *Waste Management*, 26, 516-525.
[17] Solid Waste Association of North America (SWANA), 2007, Landfill Gas Collection System Efficiencies, SWANA Applied Research Foundation, Jeremy O'Brien, Director of Applied Research, 301-585-2898.
[18] NJDEP, 2008, Emissions Statement Program, Danny Wong, personal communication.

from the wastewater plants that were too small to report through the Emissions Statement Program were proportional, based on wastewater flow, to those plants that did report.

N_2O emissions were not included in the DEP data, however, and so the default estimate using the SIT procedure was used. Some recent research, still underway, suggests that N_2O emissions from wastewater plants may be greater than indicated by the SIT procedure.[19,20] Since N_2O has a 100-year global warming potential of 298,[21] even relatively small emissions quantities can have a big impact on the overall GHG emissions inventory. Research findings on emissions of this gas from wastewater plants could lead to the need for significant modifications of estimates of emissions from this sector in the future.

Progress in Addressing Uncertainties

Methodological issues as well as lack of precision and accuracy in underlying data add uncertainty to these estimated emissions. Since the issuance of the Inventory and Projections last year, research efforts have been undertaken or proposed in an effort to address some of these uncertainties. These research efforts are expected to generate data that may help address some of the key uncertainties, in particular relating to estimation of carbon emissions or sequestration from the land-use related sectors (agriculture, land clearing and forest growth). In agriculture, emissions estimates from cultivation of organic soils (e.g., *histosols)* have not been developed. However, a research study[22] will generate data on carbon loss from forested wetlands that had been converted to agricultural land-use over the years. It is important to have this type of research as global data indicate that agricultural soils now contain a lower soil organic carbon pool than their potential, and thus have a carbon sink capacity. In addition, the 2003 National Resources Inventory (NRI) of the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service makes available updated data on crop, pasture, forest and other lands.[23] Complementing this is the current DEP/GIS effort to update the 2002 statewide land use land cover data with work on two (2) counties already completed. Estimation of emissions from land clearing due to development will be improved with the availability of new data. Relating to carbon sequestration by forests, there is on-going DEP-supported research on the sequestration capacity of New Jersey forests. This initiative is well advanced and will provide more refined and up-to-date information on the amount of above-ground and below-ground forest biomass and soil carbon in the state.

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[19] Giraldo, Eugenio, American Water, 2009, presentation "Greenhouse gas production during BNR in wastewater treatment plants, nitrous oxide, a balancing act" at New Jersey Water Environment Association (NJWEA) Annual Meeting, Atlantic City, NJ, May 12, 2009, http://www.njwea.org/

[20] Rahm, Brian, Columbia University, 2009, presentation "Nationwide inventory of nitrogen greenhouse gas emissions from wastewater treatment plants: Development and application of a standard protocol" at New Jersey Water Environment Association (NJWEA) Annual Meeting, Atlantic City, NJ, May 12, 2009, http://www.njwea.org/

[21] IPCC, 2007

[22] This project is being carried out by the Midwest Regional Carbon Sequestration Partnership, under the auspices of the U.S. Department of Energy. See www.mrcsp.org

[23] See http://www.nrcs.usda.gov/technical/NRI/2003/statereports/all.html