# Mid-Hudson Regional Greenhouse Gas Emissions Inventory

## Final Report for Mid-Hudson Tier II Regional Greenhouse Gas Emissions (GHG) Inventory

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## List of Acronyms and Abbreviations

| | |
|---|---|
| ACS | American Community Survey |
| ANDOC | Anaerobically degradable carbon |
| $BOD_5$ | 5-day biological oxygen demand |
| COLE | Carbon OnLine Estimator |
| eGRID | Emissions & Generation Resource Integrated Database |
| EIA | Energy Information Administration |
| EPA | Environmental Protection Agency |
| FOD | First-order decay |
| GHG | Greenhouse gas |
| GHGRP | Greenhouse gas Reporting Program |
| C&D | Construction and demolition |
| $CH_4$ | Methane |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| FIDO | Forest Inventory Data Online |
| HDD | Heating degree days |
| HFCs | Hydrofluorocarbons |
| HPMS | Highway Performance Monitoring System |
| HU | Housing units |
| IPCC | Intergovernmental Panel on Climate Change |
| LFG | Landfill gas |
| LFGTE | Landfill gas to energy |
| LUAF | Lost and unaccounted for |
| LULUCF | Land-use, land-use change, and forestry |
| Mcf | Thousand cubic feet |
| MF | Multi-family |
| MMBTU | Million British thermal units |
| MSW | Municipal solid waste |
| $MTCO_2e$ | Metric tons carbon dioxide equivalent |
| MWh | Megawatt-hour |
| $N_2O$ | Nitrous oxide |

| | |
|---|---|
| NAICS | North American Industry Classification System |
| NASS | National Agricultural Statistics Service |
| NYCW | NPCC New York City/Westchester (eGRID subregion) |
| NYS DEC | New York State Department of Environmental Conservation |
| NYSDOT | New York State Department of Transportation |
| NYSERDA | New York State Energy Research and Development Authority |
| NYUP | NPCC Upstate New York (eGRID subregion) |
| ODS | Ozone-depleting substances |
| PFCs | Perfluorocarbons |
| $SF_6$ | Sulfur hexafluoride |
| SFA | Single-family attached |
| SFD | Single-family detached |
| SIC | Standard Industrial Classification |
| SIT | State Inventory Tool |
| T&D | Transmission and distribution |
| TAM | Typical animal mass |
| Tg | Teragrams |
| USDA | United States Department of Agriculture |
| VMT | Vehicle miles traveled |
| VS | Volatile solids |
| WWTPs | Wastewater treatment plants |

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# Preface

The purpose of this report is to transmit the Draft Tier II Regional Greenhouse Gas Emissions (GHG) Inventory for the Mid-Hudson Region. The report begins with a general background to the inventory, a discussion of key steps in establishing and defining a GHG inventory, and description of how the inventory is organized. For each source that follows, the inventory presents a description of each source and a discussion of the data and methods used. The municipal allocation methodology and results are presented in the appendix.

In order to align the methods used here with those used by other regions in New York State, the State convened the NYGHG Working Group to develop a standard New York GHG Protocol (NYGHG Protocol). This inventory was developed based on the latest methods determined by the NYGHG Working Group, as well as the latest data provided to that group. Protocols were not finalized for all sources, and several data sources requested through the NYGHG Working Group were not available in time for this submission. The data and calculations presented here are contained in a separate regional GHG inventory Excel workbook and supplementary files, as discussed in Section 1.3 below.

# 1. Background

## 1.1 Key Steps and Issues in Establishing an Inventory

A GHG inventory identifies activities that are responsible for GHG emissions, quantifies the level of each activity, and then calculates the associated emissions. Each of these steps—defining the activities, measuring the level of the activity, and determining the consequent emissions—must be carefully defined in order to result in a credible, transparent, and easily replicable inventory.

Because this GHG inventory is part of a state-wide effort to conduct inventories for all regions in New York State, the State convened the NYGHG Working Group to develop a standard New York GHG Protocol (NYGHG Protocol). This group began meeting in March 2012 to discuss and define these inventory parameters, data sources, methodologies, and reporting formats. While a formal NYGHG Protocol has not yet been released, the inventory steps described in this section and the data and methodologies described in subsequent sections are in compliance with the proposed New York GHG Protocol to the greatest extent possible. Differences have been noted where applicable.

The process of designing an inventory entails a number of decisions and procedural steps:

- **Inventory geography and boundaries:** This inventory estimates GHG emissions for the Mid-Hudson Region's seven counties: Dutchess, Orange, Putnam, Rockland, Sullivan, Ulster, and Westchester. It includes emissions from electricity imported into the region as well as emissions from waste exported from the region. Product life-cycle emissions (e.g., emissions associated with the production and distribution from imported goods and services) are not included.
- **Municipal boundaries:** The Mid-Hudson Region is comprised of 12 cities and 105 towns, in addition to 81 villages that lie within them. This municipal allocation reports total estimates for each city and town, *including* activity in the underlying villages. Activity and emissions for each village are also tracked and reported separately, but not counted in the totals. Some sectors, however, report activity data for towns *excluding* village activities. In these cases, the following method is applied:
    - **Village assignments** – The New York State Data Center provides information on which villages lie within each town.[1] When activity data are reported for towns (excluding villages) and villages, the town activity data are added with those of the village(s) within it.
    - **Split villages** – Ten villages in the Mid-Hudson Region are split between towns. To assign reported village activity data to the correct towns, the percentage of the village's population in each town is used. This population breakdown is available from the New York State Data Center.[2] The split activity data are then included in the totals for each town as appropriate.
- **Sources:** The activities selected for the regional inventory are based on those included in the NYGHG Protocol and defined by the US Environmental Protection Agency's US Inventory of Greenhouse Gases[3] and the Intergovernmental Panel on Climate Change.[4] These categories are:
    - **Stationary Energy Consumption**—use of energy in homes, businesses, and other non-mobile uses. In compliance with the NYGHG Protocol, these are reported separately for the Residential, Commercial, and Industrial sectors. Emissions are also calculated for Electricity

[1] New York State Data Center, Estimates of the Resident Population: New York State Governmental Units, 2000 to 2009 – Revised September 2010. http://www.empire.state.ny.us/NYSDataCenter/Data/Population_Housing/REVISED2000to2009SubcountyTotals.pdf

[2] Ibid.

[3] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010*, April 2012.

[4] IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories,

Generation, but these are not included in the regional total to avoid double-counting with indirect emissions from electricity consumption.

- **Transportation Energy Consumption**—use of energy in transportation, including on-road transportation, passenger and freight rail, aviation, marine transportation, and off-road vehicles. Aviation emissions are estimated but not included in the regional total because they are considered an optional source under the NYGHG Protocol.
- **Energy Generation and Supply—**fugitive emissions and energy losses due to the transmission and distribution of electricity and natural gas.
- **Agriculture**—non-energy emissions from agriculture, including both crops and livestock (e.g., methane emissions associated with livestock and nitrous oxide emissions associated with fertilizer application).
- **Waste Management**—non-energy emissions related to managing solid waste, including trash and wastewater (e.g., methane emissions associated with the anaerobic decay of waste disposed of in landfills). As discussed below, two types of solid waste emissions are calculated, but only one is included in the total to avoid double counting.
- **Industrial Processes**—non-energy emissions associated with industrial activity (e.g., carbon dioxide emissions associated with cement production or emissions associated with coolants for air conditioners) and fugitive emissions from fuel systems (leakages in the production, distribution, and transmission of fossil fuels).
- **Land Use, Land Use Change, and Forestry**—emissions from changes in the amount of carbon stored in soil and plants due to land use and forestry practices (e.g., from clearing forest land for residential, commercial, or agricultural use) This is also considered an optional source under the NYGHG Protocol, and it is not included in the regional totals.
- Under the NYGHG Protocol, these are further arranged into different categories for reporting. There, the "Built Environment" sector includes Stationary Energy Consumption, Energy Generation and Supply, and Industrial Process. The Transportation Energy, Waste Management, Agriculture, and Land Use and Forestry sectors all match the sectors identified above.

- **Greenhouse gases included:** This inventory evaluates the impact of the three gases which together comprise 98 percent of national emissions: carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$), as well as HFCs, PFCs, and $SF_6$ emissions from the substitution of ozone depleting substances.[5] Together, these six internationally recognized greenhouse gases accounted for 99.6 percent of national greenhouse gas emissions in 2010.[6]
- **Quantification approach:** This inventory uses a blend of top-down data (e.g., state fuel consumption estimates) and bottom-up data (customer utility data). This mix was dictated by data availability, existing protocols, and resource limitations.
- **Base year:** The base year for this analysis is 2010. The Working Group selected 2010 because it is the most current year for many of the data sets used in this report.

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[5] Different greenhouse gases have different capacities to trap heat in the atmosphere. In order to compare and sum the impacts of different gases, the United Nations' Intergovernmental Panel on Climate Change (IPCC) developed the Global Warming Potential (GWP) concept, where the GWP of each greenhouse gas is compared to that of $CO_2$, whose GWP is defined as 1. The GWP of methane ($CH_4$) is 21, and nitrous oxide ($N_2O$) is 310. GWPs for some gases are much higher—the GWP for $SF_6$, for example is 23,900. For more information, see US EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010*, April 2012.

[6] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010*, April 2012.

All emissions are reported in metric tons of carbon dioxide equivalent ($MTCO_2e$). To account for the difference in magnitude, region- or county-scale emissions were reported as million $MTCO_2e$, while per-capita emissions were reported as $MTCO_2e$. The units used are clearly identified. A metric ton is 1,000 kilograms, or 2,206 pounds – about 10 percent larger than the 2,000 pound ton commonly used in the United States.

## 1.2 Organization of the Inventory Report

The inventory is organized by source and by "Scope." *Scope* refers to the degree of control that the regional community has over the emission source. Although the Scope framework was first developed for corporate-level GHG inventories, a similar principal can be applied here. The basic definition of the Scopes from a community perspective is as follows:

- Scope 1: All direct emissions from sources within the geopolitical boundary of the community.
- Scope 2: Energy-related indirect emissions that occur as a consequence of consumption/use of grid-supplied electricity, heating and/or cooling within the community boundary. These emissions can occur both inside and outside the community boundary.
- Scope 3: All other indirect emissions that occur outside the boundary as a result of activities within the community's geopolitical boundary, as well as trans-boundary emissions due to exchange/use/consumption of goods and services.[7]

In some cases, emissions may be calculated in two ways. Emissions associated with electricity are calculated under both Scope 1 (direct emissions from generation) and Scope 2 (indirect emissions from consumption), but only Scope 2 emissions are included in the total, while Scope 1 emissions are provided as an informational item. Similarly, emissions from waste management are calculated under both Scope 1 (direct emissions from landfills located within the community) and Scope 3 (indirect emissions from waste generation). Only Scope 3 emissions are included in the total.

The report below is organized by source and Scope, and the emission totals for each source are listed by county. The municipal-level downscaling of the regional inventory is presented in an appendix. Not all sources have a readily available method for allocation to the municipal level, and unallocated sources have been identified. Given the uncertainty in the allocation process, the allocation is intended as a starting point for estimating community emissions for all municipalities in the region, and individual municipal efforts can likely improve on the level of detail available.

## 1.3 Organization of the Inventory Spreadsheet

The data and calculations discussed in this report have been developed in the Excel workbook accompanying this report, "Mid-Hudson Region GHG Inventory_12-06-12.xlsx". This file is organized as follows:

- An Overview sheet describing with key information about the file and a Table of Contents with links to each sheet.
- Sheets containing summary tables and figures for the region, including all of the tables and figures presented in this report. These are based on the NYSERDA-provided reporting template.
- A series of color-coded sheets covering the inventory calculations. Each lists the source, Scope, and data sources used. The sheets are categorized by inventory sector:

[7] C40 Cities Climate Leadership Group and ICLEI-Local Governments for Sustainability. *Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC), Pilot Version 1.0 – May 2012.* http://www.iclei.org/fileadmin/user_upload/documents/Global/Progams/GHG/GPC_PilotVersion_1.0_May2012_20120514_01.pdf

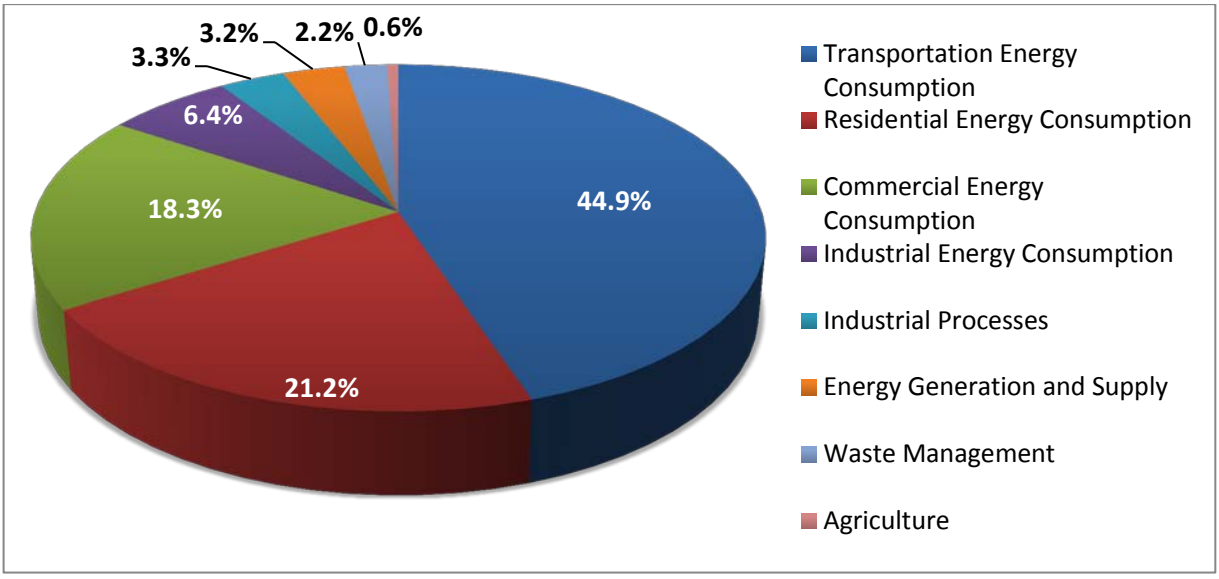
  - Red-tabbed sheets cover stationary energy;
  - Green-tabbed sheets cover mobile energy;
  - Brown-tabbed sheets cover solid waste and wastewater;
  - The yellow tab covers industrial processes;
  - The blue tab covers agriculture; and
  - The purple tab covers land-use, land-use change, and forestry (LULUCF).
- Lastly, the "Factors" tab at the end provides the emission, conversion, and other factors used throughout the file.

In some cases, supplementary workbooks are used to conduct supporting calculations. These include modules of the U.S. EPA's State Inventory Tool and the California Air Resources Board's Landfill Emissions Tool.

# 2. Summary of Results

In the Mid-Hudson Region, the results of this analysis indicate that regions total emissions across all sectors in 2010 were approximately 26.5 million $MTCO_2e$. The single largest source of GHG emissions is the energy consumption for transportation, which is responsible for 45 percent of regional emissions, or 11.9 million $MTCO_2e$. Among transportation-related emissions, on-road vehicles (cars, trucks, buses, motorcycles) account for 10.3 million $MTCO_2e$ (86 percent of total transportation emissions). The second largest contributor is that from residential stationary energy combustion (such as home heating and lighting), which is responsible for 21 percent of emissions, or 5.6 million $MTCO_2e$. The next largest contributor is commercial energy consumption (18 percent or 4.9 million $MTCO_2e$). The remaining significant GHG contributors in the region are emissions related to industrial energy use, electricity generation and supply,[8] waste management, and industrial processes.[9]

**Figure 1 - 2010 GHG Emissions in the Mid-Hudson Region, per Sector (percentages of total)**



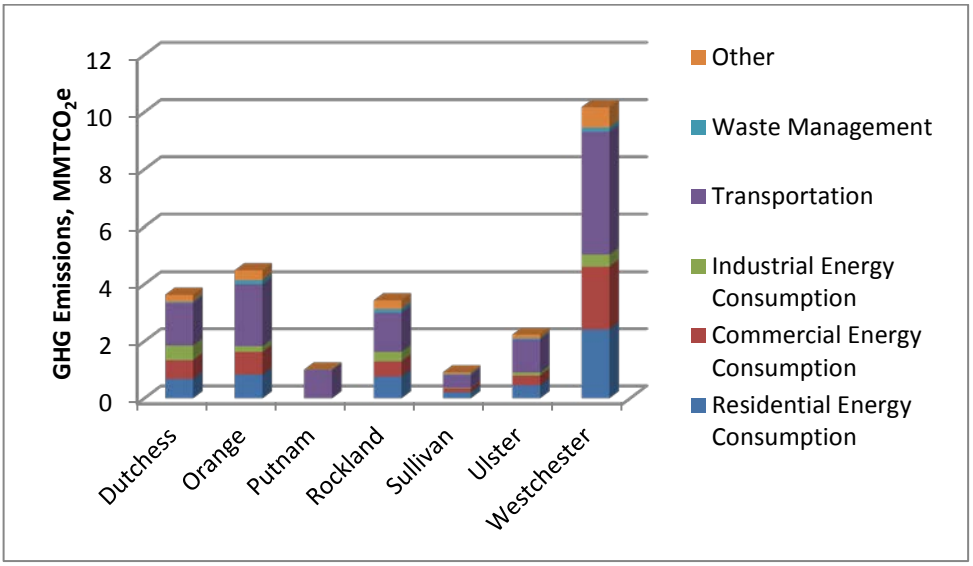

Note: Totals may not sum due to independent rounding.

Additionally, although more emissions overall can be allocated to Westchester County than to any other county, the greatest emissions per capita occur in Putnam County, primarily due to greater transportation emissions. Graphical depictions of emissions per sector and locale are provided in the charts below (Figure 1 through Figure 3 below). More detailed information for each sector, including the sources of emissions, is contained within each sector discussion.

[8] At the county level, emissions from electricity generation are distributed among end use (commercial, residential, industrial energy consumption) and industrial process /ODS Substitute emissions are omitted because they are negligible.

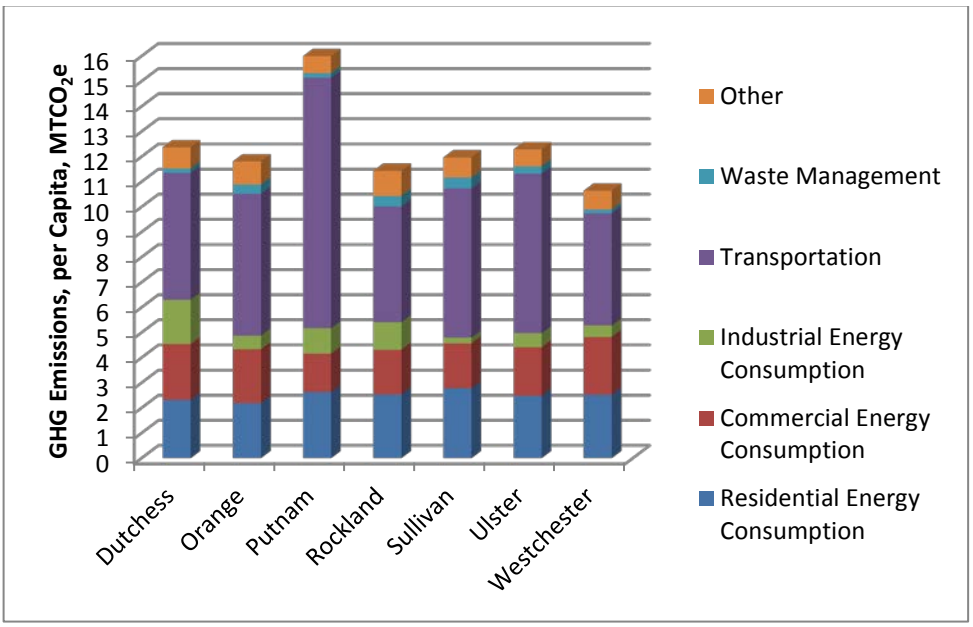
[9] An additional significant contributor to net emissions in the region is the loss of carbon storage in previously-forested land, but since loss of storage is not considered an emissions source for this inventory we have not formally included it here. Land use changes in 2010 are estimated to have reduced carbon storage by over 5 million $MTCO_2e$. This loss can be primarily tied to economic development such as the construction of new housing and businesses, as well as public infrastructure. It is also worth noting that for this allocation that aviation emissions—an optional source under the NYGHG Protocol—are not included here.

**Figure 2 - 2010 GHG Emissions in Each County of the Mid-Hudson Region, per Sector (million $MTCO_2e$)**




Note: "Other" included industrial processes, agriculture, and energy generation and supply.

**Figure 3 - 2010 GHG Emissions in Each County of the Mid- Hudson Region, per Capita, per Sector ($MTCO_2e$)**




Note: "Other" included industrial processes, agriculture, and energy generation and supply.

# 3. Stationary Energy Consumption

Stationary energy consumption includes direct emissions from the combustion of natural gas, coal, kerosene, distillate, motor gasoline and other fuels, as well as indirect emissions from electricity consumption. Direct emissions from residential, commercial, industrial, and electricity generating activities in the region are included in Scope 1. Indirect emissions from the consumption of electricity are included in Scope 2. To avoid double-counting, Scope 1 emissions from electricity generation are not included in the regional total, but are reported here for informational purposes.

## 3.1 Electricity – Scope 1

### Data & Methods

The primary data source for electricity generation is the U.S. Energy Information Administration's (EIA) Form 923 facility production data for 2010.[10] This dataset reports total fuel consumption (in physical units and BTUs) and total net generation in MWh. This data can be gathered through EIA's web data query portal.

Emissions from electricity generation are estimated by multiplying total fuel consumption for each plant by the appropriate $CO_2$, $CH_4$, and $N_2O$ emission factors to calculate the total emission by gas. These emissions are summarized by county in Table 1 to provide total electricity generation emissions for the region.

### Results

Emissions by county are presented in Tables 1 and 2. The majority of the region's fossil fuel-based electricity generation is located in Orange and Westchester Counties. Generation by resource is also presented below. Nuclear energy accounts for the majority of the region's energy generation, followed by coal.

**Table 1 – 2010 Electricity Generation GHG Emissions ($MTCO_2e$)**

| County | $CO_2$ | $CH_4$ | $N_2O$ | Total | Percent of Total |
|---|---|---|---|---|---|
| **Dutchess** | 55,490 | 916 | 1,775 | 58,181 | 2% |
| **Orange** | 1,965,371 | 4,217 | 9,006 | 1,978,595 | 74% |
| **Putnam** | 423 | 0 | 0 | 423 | 0% |
| **Rockland** | 323,357 | 130 | 195 | 323,682 | 12% |
| **Sullivan** | - | - | - | - | 0% |
| **Ulster** | - | - | - | - | 0% |
| **Westchester** | 288,723 | 4,862 | 9,419 | 303,004 | 11% |
| **Mid-Hudson Region Total** | **2,633,364** | **10,125** | **20,396** | **2,663,885** | **100%** |

Note: Totals may not sum due to independent rounding.

[10] U.S. Energy Information Administration, 2012. Form EIA-923 detailed data merged with 860 form data. http://www.eia.gov/electricity/data/eia923/

**Table 2 - 2010 Electricity Generation by Fuel (MWh)**

| | Coal | Natural Gas | Petroleum | MSW | Nuclear | Hydro |
|---|---|---|---|---|---|---|
| **Dutchess** | - | 722 | - | 46,902 | - | 4,329 |
| **Orange** | 1,667,963 | 461,826 | 44,024 | - | - | 3,194 |
| **Putnam** | - | 526 | 44 | - | - | - |
| **Rockland** | - | 439,622 | 1,453 | - | - | - |
| **Sullivan** | - | - | - | - | - | 207,869 |
| **Ulster** | - | - | - | - | - | 72,381 |
| **Westchester** | - | - | - | 406,344 | 16,320,636 | 39 |
| **Mid-Hudson Region Total** | **1,667,963** | **902,696** | **45,522** | **453,246** | **16,320,636** | **287,812** |
| **Percent of Total** | 8% | 5% | 0% | 2% | 83% | 1% |

Note: Totals may not sum due to independent rounding.

## 3.2 Electricity – Scope 2

### Data and Methods

Scope 2 emissions from electricity consumption are calculated using a combination of reported usage from utilities and, where utility data are unavailable, consumption estimates. Electricity consumption estimates are calculated along with the fuels discussed in the Scope 1 fuels section (Section 3.3). Central Hudson Gas & Electric, ConEdison, NYSEG, and Orange & Rockland Utilities provided their electricity usage data for this analysis. The data cover 197 municipalities (towns and villages) fully, while one municipality is not covered by the data at all.

For the locations fully served by the utility, the reported usage for that area (in MWh) serves as the full electricity data for that town or village. If utilities did not provide data broken out into Residential, Commercial, and Industrial sectors, the statewide breakdown in electricity consumption was used based (36% residential, 55% commercial, and 10% industrial; or if utilities provided Residential and Commercial/Industrial, commercial and industrial were broken out using the same method, 85% commercial, 15% industrial).

For areas only partially covered by the utility data, the portion of that area represented in the utility data is estimated comparing the number of utility data residential accounts with the number of total housing units (occupied + vacant) in the area. The full electricity usage for the partially covered areas is estimated as follows:

$$MWh_{total} = MWh_{partial} \times \frac{Total\ Housing\ Units}{Residential\ Utility\ Accounts}$$

Electricity usage information from the utilities separated usage between non-village components of towns and villages. To aggregate all activity data to the city and town level (to include village activity), the method of assigning villages and village components to towns, described in *'Appendix – Municipal-Level Allocation'* was used. This method was applied to both electricity usage and households.

The process resulted in a sum of reported electricity consumption for each city and town in the Mid-Hudson Region, along with the number of households the reported data applied to. If 100% of any town or village was represented in the utility data, the utility-reported usage was used. If a non-zero portion of any town or city was represented in the utility data, the reported usage was divided by the percentage of housing units

represented to estimate total usage. If no utility data were available for the town or city, the electricity usage estimates generated using the methods for Residential, Commercial, and Industrial fuels described in section 3.3 were used.

Electricity usage in MWh was then converted to MMBTU and emissions using the EPA's Emissions & Generation Resource Integrated Database (eGRID) 2009 emission factors for the Upstate New York (NYUP) and New York City/Westchester (NYCW) sub-regions. NYCW emission factors were applied to electricity consumption in Westchester County. The NYUP factor was applied to all other counties. Finally, county-level electricity consumption and emissions estimates were calculated by summing the results for all cities and towns within each county.

### Results

Results are displayed along with other stationary fuel consumption in Table 3 and Table 4 (see "Scope 2"). Total electricity consumption in the Mid-Hudson Region in 2010 was estimated to be 16.7 million MWh. Westchester County had the largest share of that electricity use, with 42 percent. Total emissions from electricity in the region are 4,109,338 $MTCO_2e$.

## 3.3 Fuels – Scope 1

### Data & Methods

Different methods are used to estimate consumption and estimates from natural gas (for all sectors), residential stationary fuels, commercial stationary fuels, and industrial stationary fuels. Each method is described here.

Natural gas consumption was estimated using a combination of reported usage from utilities and, where utility data are unavailable, consumption estimates. Central Hudson Gas & Electric and Orange & Rockland Utilities provided natural gas utility data for the 39 municipalities they serve in the Mid-Hudson Region. The two utilities are the only ones that serve 88 of those municipalities, and partially serve 2 municipalities. As of December 6, 2012, natural gas data have not yet been received from ConEdison as part of the statewide request through the NYGHG Working Group through a regional request.

For locations fully served by the utilities reporting, the reported usage for that area (converted to MMBTU) serves as the full natural gas consumption for that city, town, or village. If no utility data were available for the city, town, or village, the usage estimates were generated for the residential and commercial sectors using the methods for other Scope 1 fuels described below. For industrial natural gas, consumption was estimated using the method described below for other Scope 1 fuels. If a county's total consumption reported in the utility data was greater than the estimated amount, then the utility data was used.

For all Scope 1 stationary fuels other than natural gas, the primary data sources for residential stationary combustion include the US Census Bureau Redistricting data for 2010, the American Community Survey (ACS) 5-year housing characteristic estimate for 2010,[11] and the Energy Information Administration's (EIA) state energy consumption data by sector for New York in 2010.[12] Calculation guidance was provided by the NYGHG Working Group to develop a weighted estimate based on the occupancy of single-family detached (SFD),

[11] U.S. Census Bureau, 2012. American Fact Finder.

[12] U.S. Energy Information Administration, 2012. (SEDS) State Energy Data System for New York. http://205.254.135.7/state/seds/seds-states.cfm?q_state_a=NY&q_state=New%20York

single-family attached (SFA), or multi-family (MF) dwellings, energy use per housing unit by different types of dwellings, the average Heating Degree Days (HDD) for each region in the state, and the use of household heating fuels by household count. This method was calculated for all fuels, but electricity and natural gas consumption provided by utilities was preferred. Utility data was used in lieu of the estimation method when available, and is discussed below.

Residential stationary combustion emissions are estimated by first estimating fuel consumption, and then multiplying estimated fuel consumption by fuel-specific emission factors. To estimate consumption, housing data—number of housing units by type (SFD, SFA, or MF) and household heating fuel usage counts (oil, natural gas, propane, electricity, coal or coke, wood, and solar)—from the American Community Survey was collected for each county in the state and for each municipality in the region. Total SFD and SFA housing units were indicated in the data. Total MF housing units were assumed to equal categories for 2 or more units, plus mobile home, boat, RV, van, and other. These counts, which included both occupied and vacant housing units, were multiplied by the percentage of occupied housing units in each municipality to convert the housing units by type to occupied units by type. The heating fuel counts were based only on occupied units.

Next, the occupied housing units were adjusted to account for the difference in energy use per housing unit by dwelling type, as provided by the NYGHG Working Group: a SFD uses 108 MMBTU per year, while a SFA uses 89 MMBTU per year, and a MF uses 54 MMBTU per year. The adjusted housing units for each county were calculated as:

$$Adjusted\ HU = \frac{108}{108} \times \mathrm{SFDHU} + \frac{89}{108} \times \mathrm{SFAHU} + \frac{54}{108} \times \mathrm{MFHU}$$

Where:

HU = “housing units”, the total number of housing units by county
SFDHU = “single-family detached housing units”, the number of single family detached units by county
SFAHU = “single-family attached housing units”, the number of single family attached units by county
MFHU = “multi-family housing units”, the number of multi-family units by county (defined as 2+ family houses, plus mobile home, boat, RV, van, and other)

The following process was developed to estimate total fuel use by county for fuel oil but has been applied to estimate the other six fuel types:

$$Adjusted\ HU_{oil} = HU_{oil} \times \frac{Adjusted\ HU}{HU}$$

Where:

HU = “housing units”, the total number of housing units by county
$HU_{oil}$ = total number of housing units that heat with oil by county

The residential consumption for each county weighted by structure type and county- specific heating degree day (HDD) was calculated as:

$$Oil\ Use_{county} = Total\ Oil\ Use_{statewide} \times \frac{(Adjusted\ HU_{oil} \times HDD)_{county}}{(Adjusted\ HU_{oil} \times HDD)_{statewide}}$$

Once energy use was established for each fuel as described above, it was multiplied by the emission factors to estimate total emissions. Emission factors for $CO_2$, $CH_4$, and $N_2O$ for each of the seven fuel types have been gathered from guidance based EPA's Mandatory Reporting of Greenhouse Gases program. Total emissions are calculated by gas and are rolled up into a total for each county.

Electricity consumption was applied to all households, rather than to just those using electricity as a heating fuel, to capture the total emissions, and is considered to be Scope 2. HDD weighting was not applied to electricity consumption, since the weighting should only affect the portion that heats with electricity, but that was not identified here. All other fuels considered here are Scope 1.

A modest number of households reported using coal or coke, yet the statewide residential consumption was not available. Energy per housing unit values for fuel oil was used as a proxy to calculate coal or coke to correct for the unreported data.

$$Coal\ Use_{county} = Adjusted\ HU_{coal} \times \frac{Oil\ Use_{county}}{Adjusted\ HU_{oil}}$$

Where:

$HU_{oil}$ = total number of housing units that heat with oil statewide
$HU_{coal}$ = total number of housing units that heat with coal statewide

Commercial stationary combustion is estimated using a similar apportionment of the state energy consumption in the commercial sector reported by the EIA in a process similar to that described above for residential stationary combustion. First, the amount of commercial square footage by county was determined by multiplying the total number of commercial-sector jobs in each county (collected from the New York State Data Center and provided by the NYGHG Working Group) times the average square footage per worker per building type (collected from the Commercial Building Energy Consumption Survey and provided by the NYGHG Working Group). These were multiplied by the percentage housing units by fuel type as reported in the ACS served to estimate the amount of space heated by each fuel. Finally, the calculated consumption was weighted by HDD: the consumption of each fuel in each county equaled the commercial building area using that fuel times the regional HDD, divided by the sum of the products of commercial building area times HDD for all counties in the state. These estimates were overwritten with electricity and natural gas consumption data collected from the utilities wherever possible.

The primary data source for industrial stationary combustion is EPA's Greenhouse Gas Reporting Program (GHGRP) data for calendar year 2010.[13] This dataset includes emission information from large facilities (defined as those that emit at least 25,000 $MTCO_2e$ per year) in nine industry groups, including: power plants, landfills, metals manufacturing, mineral production, petroleum refineries, pulp and paper manufacturing, chemicals manufacturing, government and commercial facilities, and other industrial facilities. These groups cover 29 source categories of emissions. This data is available through a web tool or for download. This project used the most comprehensive dataset available, the full 2010 GHG Dataset. Late in 2012, this EPA dataset will be expanded to include 12 additional industry groups for calendar year 2011.

Total statewide industrial fuel consumption for 2010 from EIA's State Energy Data System, Table CT6 and manufacturing employment in New York State and the Mid-Hudson Region counties were also used to

[13] Dataset is available at: http://epa.gov/climatechange/emissions/ghgdata/index.html.

supplement the GHGRP dataset. Manufacturing employment data came from the U.S. Census Bureau's 2007 Economic Census, Employment by the North American Industry Classification System (NAICS) Code, codes 31–33.

Industrial stationary combustion emissions are estimated using a combination of reported direct emissions from the Mid-Hudson Region and a method to allocate statewide industrial fuel consumption to the Mid-Hudson Region counties.

First, data were pulled for known industrial emissions in the Mid-Hudson Region from EPA's GHGRP dataset. To identify industrial facilities located in the Mid-Hudson Region, facilities were filtered by state and county. The process also checked, using the facility city, whether any facilities that did not have county designations were actually located in the Mid-Hudson Region. Finally, non-industrial facilities were removed from the list by NAICS code. Facilities that were removed from consideration were Utilities (with NAICS codes beginning with 22-), Lessors of Real Estate (531120), Solid Waste Landfills (562212), Solid Waste Combustors and Incinerators (562213), and Universities (611310). The result was a set of eight industrial facilities from the GHGRP dataset located in the Mid-Hudson Region.

The same process was completed for New York State, where non-industrial facilities were removed by NAICS code. The result was a final list of 53 industrial facilities in New York State, with NAICS codes related to manufacturing (beginning with 31-, 32-, or 33-) and pipeline transportation of natural gas (486210).

Second, the industrial facilities from EPA's GHGRP dataset were cross-checked with those in the Title V air permit data from the New York State Department of Environmental Conservation. To identify industrial facilities from the Title V dataset located in the Mid-Hudson Region, facilities were filtered by state and county. Non-industrial facilities were then removed from the list based on the listed Standard Industrial Classification (SIC) code, a related set of classification codes. Only facilities with SIC codes for Manufacturing (beginning with 20- to 39-), and Gas Production and Distribution (beginning with 492-) were kept. Facilities that were already included in the EPA's GHGRP were removed. The result was a list of nine additional facilities located in the Mid-Hudson Region. Added to the eight GHGRP facilities, this resulted in a final list of 17 industrial facilities located in the Mid-Hudson Region.

With the list of industrial facilities and their stationary combustion emissions thus finalized, remaining industrial emissions (for example, from smaller industrial sources) are estimated using a process to allocate statewide industrial fuel consumption emissions to the Mid-Hudson Region counties based on industrial employment. Using 2010 industrial fuel consumption data[14] (in trillion BTU) from EIA's State Energy Data System, total New York State emissions, by fuel, were calculated using the default emission factors per MMBTU established by the NYGHG Protocol. The remaining emissions, statewide, were then allocated to the county level by the portion of statewide industrial manufacturing employment in that county (based on employment data by NAICS code from the 2007 Economic Census). Total emissions in each county represent the sum of reported emissions and the allocated emissions.

[14] 2010 New York industrial fuel consumption data from EIA's SEDS Table CT6 were used directly with one exception; the fuel type "Other Petroleum Products" was adjusted to remove Asphalt and Road Oil, which are non-energy products. Asphalt and Road Oil makes up about 62% of the Other Petroleum Products category, so 38% of the 52.9 trillion BTU (20.1 trillion BTU) was used to distribute among the Mid-Hudson counties.

The following process was followed **for each fuel type**:

$$NYS\ Industrial\ Stationary\ Combustion\ Emissions = \sum_{by\ fuel} (trillion\ Btu\ consumed\ \times 10^{-6} \times {}^{MT\ CO2e}/_{mmBtu})$$

$$Remaining\ emissions_{State} = NYS\ Industrial\ Stationary\ Combustion\ Emissions - Reported\ LHV\ Stationary\ Combustion\ Emissions$$

$$Remaining\ emissions_{County} = Remaining\ emissions_{State} \times \frac{Industrial\ Employment_{County}}{Industrial\ Employment_{State}}$$

$$Total\ Industrial\ Stationary\ Combustion\ Emissions_{County} = Reported\ Emissions_{County} + Remaining\ Emissions_{County}$$

Currently, statewide industrial stationary combustion emissions are broken down into fuel types using the statewide GHGRP industrial stationary combustion emissions total, apportioned to fuel types based on EIA's statewide fuel consumption data. This method could be improved using fuel-specific emission data from the GHGRP.

### Results

Total emissions from stationary combustion are about 12,162,375 $MTCO_2e$. Emissions by end use sector and by fuel are presented in Table 3 and Table 4. Natural gas and electricity are the dominant fuels in the region, representing 69% of emissions from stationary combustion.

**Table 3 – 2010 Stationary Fuel Consumption GHG Emissions by County ($MTCO_2e$)**

| | | Emissions ($MTCO_2e$) | | | |
|---|---|---|---|---|---|
| **County** | **Scope** | **Residential** | **Commercial** | **Industrial** | **Total** |
| **Dutchess** | 1 | 449,020 | 436,741 | 323,686 | 1,209,447 |
| | 2 | 230,451 | 217,156 | 193,993 | 641,600 |
| **Orange** | 1 | 580,673 | 532,981 | 152,457 | 1,266,111 |
| | 2 | 257,596 | 290,759 | 55,423 | 603,777 |
| **Putnam** | 1 | 151,562 | 89,045 | 88,234 | 328,841 |
| | 2 | 109,322 | 63,509 | 11,460 | 184,291 |
| **Rockland** | 1 | 553,786 | 292,862 | 283,896 | 1,130,545 |
| | 2 | 206,622 | 242,919 | 42,375 | 491,916 |
| **Sullivan** | 1 | 125,926 | 65,803 | 7,033 | 198,762 |
| | 2 | 84,923 | 70,100 | 9,643 | 164,665 |
| **Ulster** | 1 | 307,725 | 222,462 | 82,795 | 612,982 |
| | 2 | 143,531 | 127,457 | 17,495 | 288,483 |
| **Westchester** | 1 | 1,621,317 | 1,374,545 | 310,486 | 3,306,348 |
| | 2 | 793,731 | 827,019 | 113,856 | 1,734,606 |
| **Mid-Hudson Region Total** | **1** | **3,790,010** | **3,014,440** | **1,248,587** | **8,053,037** |
| | **2** | **1,826,175** | **1,838,920** | **444,244** | **4,109,338** |
| | **Total** | **5,616,185** | **4,853,360** | **1,692,830** | **12,162,375** |

Note: Totals may not sum due to independent rounding.

**Table 4 – 2010 Stationary Fuel Combustion GHG Emissions by Fuel ($MTCO_2e$)**

| Fuel | Residential | Commercial | Industrial | Total | Percent of Total |
|---|---|---|---|---|---|
| Electricity | 1,826,175 | 1,838,920 | 444,244 | **4,109,338** | 34% |
| Natural Gas | 1,886,714 | 1,613,889 | 751,311 | **4,251,915** | 35% |
| Fuel Oil | 1,727,143 | 1,351,430 | 186,680 | **3,265,253** | 27% |
| Propane | 158,986 | 46,411 | 6,247 | **211,645** | 2% |
| Coal or Coke | 9,419 | 714 | 178,240 | **188,373** | 2% |
| Other Petroleum | 0 | 0 | 124,394 | **124,394** | 1% |
| Wood | 7,747 | 1,996 | 1,714 | **11,457** | 0% |
| **Total** | **5,616,185** | **4,853,360** | **1,692,830** | **12,162,375** | **100%** |

Note: Totals may not sum due to independent rounding.

## 3.4 Energy Supply

Emissions that result from energy supply processes are included here. These include electricity transmission and distribution (T&D) losses, natural gas T&D losses, and the use of sulfur hexafluoride ($SF_6$) in the utility industry. The following methods are used to calculate emissions from each.

### Data and Methods

To estimate losses due to electricity T&D, total electricity consumption (in MWh) is multiplied by a T&D loss factor to determine the quantity of electricity lost during T&D. This analysis used the Eastern regional loss factor from eGRID, 5.28%. The total electricity lost is then multiplied by the electricity emission factors to estimate emissions from electricity T&D.

Natural gas transmission and distribution losses from pipelines are sources of $CH_4$ emission. Utilities often report their average annual lost and unaccounted for (LAUF) natural gas to the New York Public Service Commission. Natural gas consumption data were gathered from Central Hudson Gas & Electric and Orange & Rockland Utilities, and was estimated for the remaining utilities. Central Hudson Gas & Electric reports a three year (2005-2008) average LAUF of 1.07%.[15] For utilities that do not report LAUF, the statewide average of 1.8% as documented by National Grid in Public Service Commission reporting will be used. The estimated natural gas consumption for each utility was multiplied by the LAUF and then converted from thousand cubic feet (Mcf) to $MTCO_2e$.

Sulfur hexafluoride ($SF_6$) is a greenhouse gas that is used as an electrical insulator in electricity T&D equipment.[16] The $SF_6$ may escape from this equipment and emit into the atmosphere. To estimate these emissions, a national average implied emission factor is used. The emission factor is estimated by dividing 2010 total $SF_6$ emissions from electricity T&D from the U.S. Greenhouse Gas Inventory[17] by total nationwide retail electricity sales from the EIA.[18] The resultant factor of 0.0031 $MTCO_2e$/MWh was applied to total electricity consumption in the Mid-Hudson Region.

### Results

Emissions from energy supply activities in the Mid-Hudson Region were estimated to be 836,500 $MTCO_2e$. The emissions from this sector are summarized in Table 5 below.

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[15] Central Hudson Gas & Electric Corporation, Case Nos. 09-E-0588 & 09-G-0589, Response to Staff Information Request No. 17. Natural Gas Losses table. http://www.centralhudson.com/proposal09/directth/Staff%20Gas%20Rates%20Panel%20Exhibits%20(GRP%201-15).pdf

[16] U.S. EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*. Section 4.23, Electrical Transmission and Distribution.

[17] U.S. EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*. Table 4-1.

[18] EIA. Summary Electricity Statistics, Table ES-1, "Total Retail Sales." http://www.eia.gov/electricity/annual/xls/tablees1.xls

**Table 5 – 2010 Emissions from Energy Supply Activities ($MTCO_2e$)**

| County | Electricity T&D Emissions ($MTCO_2e$) | Natural Gas T&D Emissions ($MTCO_2e$) | Utility $SF_6$ Emissions ($MTCO_2e$) | Total | Percent of Total |
|---|---|---|---|---|---|
| **Dutchess** | 33,877 | 60,996 | 8,885 | **103,757** | **12%** |
| **Orange** | 31,879 | 98,779 | 8,361 | **139,020** | **17%** |
| **Putnam** | 9,731 | 15,337 | 2,552 | **27,619** | **3%** |
| **Rockland** | 25,973 | 135,283 | 6,812 | **168,068** | **20%** |
| **Sullivan** | 8,694 | 1431 | 2,280 | **12,405** | **1%** |
| **Ulster** | 15,232 | 20,518 | 3,995 | **39,744** | **5%** |
| **Westchester** | 92,929 | 233,031 | 19,925 | **345,886** | **41%** |
| **Mid-Hudson Region Total** | **218,315** | **565,374** | **52,811** | **836,500** | **100%** |

Note: Totals may not sum due to independent rounding.

# 4. Mobile Energy Consumption

## 4.1 On-road

On-road mobile transportation includes travel by motor vehicles on roads in the Mid-Hudson Region. The combustion of fuel in vehicles results in emissions of $CO_2$, $CH_4$ and $N_2O$. The amount of $CO_2$ emitted by vehicles depends on the amount of fuel consumed, whereas $CH_4$ and $N_2O$ emissions vary based on control technologies used by vehicles. On-road vehicles include passenger cars, other 2-axle and 4-axle vehicles, single-unit trucks, buses, combination trucks, and motorcycles.

### Data & Methods

There are 3 data components needed to estimate mobile energy emissions:

- Types of vehicles on the road ("Vehicle Mix")
- Distance traveled by on-road vehicles ("VMT," vehicle miles traveled)
- Fuel consumption per vehicle type ("Fuel Economy")

*Vehicle Mix.* Data on the on-road vehicle mix for each functional class of road (e.g., rural interstate, urban freeways and expressways) were obtained for each New York State Department of Transportation (NYSDOT) region from NYSDOT's Environmental Science Bureau dataset.[19] The breakdown of vehicle types for each functional class of road was translated to Highway Performance Monitoring System (HPMS) vehicle categories by the NYGHG Working Group.

*Distance.* Data on vehicle miles traveled (VMT) were obtained from NYSDOT modeled data for all counties. County-level VMT data were available by functional class of roadway.

[19] NYSDOT Environmental Science Bureau, 2009. Mobile 6.2 CO Emission Factors for project-Level Microscale Analysis, Appendix A. https://www.dot.ny.gov/divisions/engineering/environmental-analysis/manuals-and-guidance/epm/repository/coeftab0.pdf

*Fuel Economy.* State- or regional-level data on the fuel economy of the Mid-Hudson Region's vehicle fleet were not available. As a proxy, national average fuel economy values by vehicle class were used based on the Federal Highway Administration's *Highway Statistics 2010* series.

*Data quality.* Table 6 presents salient characteristics of the data used to estimate emissions from on-road mobile energy consumption. As shown, 2009 is the latest year currently available for all sources.

**Table 6 – On-road Energy Consumption Data Summary**

| | Granularity | Data by functional class | Vintage of Data | Notes |
|---|---|---|---|---|
| **VMT** | Counties | Yes | 2009 | |
| **Vehicle Mix** | NYSDOT Regions | Yes | 2009 | |
| **Fuel Economy** | National data | No | 2009 | Do not have separate fuel economy values for gasoline and diesel vehicles. |

The general methodology for estimating $CO_2$ emissions from mobile combustion is:

$$CO_2\ emissions = Fuel\ Consumption\ \times Emission\ Factor$$

Fuel consumption in the Mid-Hudson Region was estimated by determining the distance traveled by different vehicle types and the amount of fuel consumed by each type of vehicle (fuel economy). First, data on total annual distance (VMT) traveled by vehicles within each county was allocated to vehicle types using the NSYDOT dataset on the breakdown of vehicles on NY roads (vehicle mix) by functional class of road. For each vehicle type and functional class, VMT data were multiplied by the average fuel economy of each vehicle type to determine total annual fuel consumption for each vehicle type. Total gasoline and diesel fuel consumption was then multiplied by the $CO_2$ emission factor for each fuel, which resulted in an estimate of $CO_2$ emissions for the region. In equation form:

$$CO_2\ emissions\ (MT) = \sum VMT_{ab} \times FC_{ab} \times EF_{ab}$$

Where:

VMT = annual vehicle miles traveled (miles/year)
FC = fuel consumption per mile traveled (gallons per mile; 1/ fuel economy)
EF = Emission factor ($MTCO_2$/gallon of fuel)
a = fuel type (diesel or gasoline)
b = vehicle type (passenger car, bus, combination truck, motorcycle, single-unit truck, and other 2/4 axle trucks)

Based on guidance from the NYGHG Protocol, it was assumed that 10 percent of gasoline sold in New York is comprised of ethanol, so 10% of gasoline consumption was assumed to be ethanol. $CO_2$ emissions from ethanol were assumed to be zero, as biogenic $CO_2$ is not included in this inventory.

Methane and nitrous oxide make up for less than 2 percent of on-road transportation emissions, and require data on the types of vehicle control technologies in use in the region's on-road vehicle fleet. For the Mid-Hudson Region GHG inventory, per the guidelines of the NYGHG Protocol, non-$CO_2$ emissions from vehicles were estimated by multiplying $CO_2$ emissions by the ratio of $CH_4$ and $N_2O$ emissions from transportation per million tons (MT) of $CO_2$ emissions ($MTCO_2e/MTCO_2$). This ratio, obtained from the EPA's *Inventory of U.S.*

*Greenhouse Gas Emissions and Sinks: 1990-2010*, is 0.000994 $MTCO_2e$ of $CH_4$ per $MTCO_2$ and 0.01367 $MTCO_2e$ of $N_2O$ per $MTCO_2$ of on-road transportation emissions.

## Results

Total emissions from on-road mobile combustion in 2009 (proxy for 2010) were approximately 10.3 million $MTCO_2e$. On-road emissions by county are presented in Table 7, and consumption by fuel is presented in Table 8. Motor gasoline and diesel accounted for 87 percent and 13 percent of on-road emissions, respectively, while motor gasoline, diesel, and ethanol (primarily included through blending with motor gasoline) account for 82 percent, 12 percent, and 6 percent of energy consumption on the basis of BTU. GHG emissions from ethanol are considered to be zero for the purposes of this inventory because they are made of biogenic and not fossil carbon.

**Table 7 - 2009 On-road GHG Emissions by County ($MTCO_2e$)**

| County | $CO_2$ | $CH_4$ | $N_2O$ | Total | Percent of Total |
|---|---|---|---|---|---|
| **Dutchess** | 1,235,366 | 1,228 | 16,882 | 1,253,476 | 12% |
| **Orange** | 1,959,334 | 1,947 | 26,776 | 1,988,057 | 19% |
| **Putnam** | 893,251 | 888 | 12,207 | 906,346 | 9% |
| **Rockland** | 1,197,627 | 1,190 | 16,366 | 1,215,184 | 12% |
| **Sullivan** | 386,678 | 384 | 5,284 | 392,347 | 4% |
| **Ulster** | 954,426 | 949 | 13,043 | 968,418 | 9% |
| **Westchester** | 3,478,105 | 3,457 | 47,531 | 3,529,093 | 34% |
| **Mid-Hudson Region Total** | **10,104,788** | **10,043** | **138,089** | **10,252,920** | **100%** |

Note: Totals may not sum due to independent rounding.

**Table 8 - 2010 On-Road Energy Use by County (MMBTU)**

| | Energy Consumption (MMBTU) | | | | |
|---|---|---|---|---|---|
| **County** | **Gasoline** | **Diesel** | **Ethanol (included in standard gasoline blends)** | **Total** | **Percent of Total** |
| **Dutchess** | 15,756,710 | 1,744,447 | 1,177,168 | 18,678,325 | 12% |
| **Orange** | 24,213,307 | 3,505,332 | 1,808,952 | 29,527,591 | 19% |
| **Putnam** | 11,243,220 | 1,403,787 | 839,970 | 13,486,976 | 9% |
| **Rockland** | 14,723,229 | 2,215,724 | 1,099,958 | 18,038,911 | 12% |
| **Sullivan** | 4,720,625 | 746,810 | 352,673 | 5,820,108 | 4% |
| **Ulster** | 12,017,599 | 1,495,762 | 897,823 | 14,411,183 | 9% |
| **Westchester** | 42,133,255 | 7,029,022 | 3,147,733 | 52,310,011 | 34% |
| **Mid-Hudson Region Total** | **124,807,946** | **18,140,883** | **9,324,276** | **152,273,104** | **100%** |
| **Percent of Total** | *82%* | *12%* | *6%* | *100%* | |

Note: Totals may not sum due to independent rounding.

## 4.2 Air

Airplanes that fly in and out of airports in the Mid-Hudson Region are sources of emissions. This inventory uses the Scope 3 approach to estimate emissions from flight, which apportions national emissions based on the share of national commercial air mileage starting or ending at an airport in the region.

The six regional airports with recorded commercial flight data are Kline Kill Airport (airport code NY1) in Ulster County, Sky Acres Airport (NY5) in Dutchess County, Sullivan County International Airport (MSV) in Sullivan County, Stewart International Airport (SWF) in Orange County, Dutchess County Airport (POU) in Dutchess County, and Westchester County Airport (HPN) in Westchester County.

### Data & Methods

The flight dataset is from the U.S. Department of Transportation's Bureau of Transportation Statistics. Data of interest includes the number of performed flights and the distance traveled in 2010. National flight emissions data (114,000,000 $MTCO_2e$) is from the U.S. Inventory for 2010.[20]

The data was filtered to include only domestic flights from and to the six airports in the Mid-Hudson Region. Total miles traveled in 2010 were calculated for each route by multiplying the number of performed flights with the distance per trip. The total miles of flights from and to each of the six airports were calculated. Flight miles are halved in the emissions calculations because emissions from half the trip are attributed to the origin airport and half are attributed to the destination airport. This ensures that two regions following the same methodology would not double-count emissions. Regional flight emissions were calculated using the following:

$$Regional\ flight\ emissions = \frac{Regional\ Departing\ flight\ miles + Regional\ Arriving\ flight\ miles}{National\ flight\ miles} \times National\ Flight\ Emissions\ \times 0.5$$

### Results

Emissions were estimated to be approximately 281,235 $MTCO_2e$ in 2010 (see Table 9).

**Table 9 – 2010 Air Emissions ($MTCO_2e$)**

| County | Total $MTCO_2e$ | Percent of Total |
|---|---|---|
| Dutchess | 2 | 0% |
| Orange | 40,044 | 14% |
| Putnam | - | 0% |
| Rockland | - | 0% |
| Sullivan | 4 | 0% |
| Ulster | 1 | 0% |
| Westchester | 241,184 | 86% |
| **Mid-Hudson Region Total** | **281,235** | **100%** |

Note: Totals may not sum due to independent rounding.

[20] U.S. EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*. Table 3-12. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Chapter-3-Energy.pdf

## 4.3 Marine

The marine transportation sector includes engines used for pleasure craft purposes and commercial marine vehicles on the Hudson River.

### Data & Methods

Non-commercial marine off-road vehicle use and emissions data for each of the seven counties in the Mid-Hudson Region in 2007 was obtained using EPA's NONROAD Emissions Model. The model input values were adjusted by New York State Department of Environmental Conservation (NYS DEC). Among other emissions types, the NONROAD model estimates carbon dioxide emissions. The emissions from all off-road vehicles within the pleasure craft classification in each county were summed, and converted to $MTCO_2e$ from short tons.

Commercial marine emissions for each county were calculated based on carbon monoxide (CO) emissions for the sector reported in the 2008 National Emissions Inventory.[21] The National Emissions Inventory contains CO emissions, by county, for the "Mobile – Commercial Marine Vessels" sector. A ratio of $CO_2$ to CO emissions was used to estimate $CO_2$ emissions from commercial marine vessels. The ratio was based on $CO_2$ and CO emission factors for low-sulfur fuel oil no. 6. The $CO_2$/CO emission factor ratio (25,000 lb $CO_2/10^3$ gal over 5 lb $CO/10^3$ gal)[22] was then multiplied by total CO emissions for each county to get $CO_2$ emissions for commercial marine vessels.

### Results

Emissions were estimated to be approximately 680,978 $MTCO_2e$ in 2010 (using 2007 recreational marine emissions and 2008 commercial marine emissions as proxies).

**Table 10 – 2010 Marine Equipment Emissions ($MTCO_2e$)**

| County | Total $MTCO_2e$ | Percent of Total |
|---|---|---|
| Dutchess | 68,543 | 10% |
| Orange | 31,074 | 5% |
| Putnam | 26,650 | 4% |
| Rockland | 54,978 | 8% |
| Sullivan | 9,189 | 1% |
| Ulster | 105,874 | 16% |
| Westchester | 384,669 | 56% |
| **Mid-Hudson Region Total** | **680,978** | **100%** |

Note: Totals may not sum due to independent rounding.

[21] U.S. EPA, 2009, The National Emissions Inventory. http://www.epa.gov/ttnchie1/net/2008inventory.html

[22] $CO_2$ and CO emission factors came from EPA's AP 42 emissions factor report, fifth edition, Volume I, Chapter 1, Section 1.3. http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s03.pdf

## 4.4 Rail

Emissions from railroad locomotives result from the use of diesel fuel.

### Data & Methods

Due to the limited amount of data available in this sector, the NYGHG Working Group elected to use data from the 2002 New York State Locomotive Survey[23] as a proxy for 2010 emissions. The survey collected information on 2002 locomotive fuel use for four categories of locomotives: Class I, Class II/III, commuter/passenger, and switchyard. Class I railroads are large, long-distance line haul railroads and Class II and III railroads consist primarily of regional and local line haul and switching railroads. Yard locomotives move railcars within a particular railway yard.

The survey reported county-level fuel consumption for Class I and system-wide fuel consumption estimates for Class II/III locomotives. The survey also reported county-level fuel consumption estimates from passenger/commuter lines that operate diesel locomotive cars. The Class I rail companies in New York State operate switchyards and the fuel consumption from switchyards in the Mid-Hudson Region could not be separated out from line haul fuel consumption.

The county-level Class I and commuter/passenger fuel consumption estimates were multiplied by the diesel fuel $CO_2$ emission factor to calculate $CO_2$ emissions. The fuel consumption estimates were converted by the diesel density factor and multiplied by the emission factors and global warming potentials to calculate $CH_4$ and $N_2O$ emissions.[24] The inventory does not report emission from the Class II/III rail type because the fuel consumption estimates are not reported by county.

### Results

Emissions were estimated to be approximately 127,829 $MTCO_2e$.

**Table 11 – 2002 Rail Emissions ($MTCO_2e$)**

| County | $CO_2$ | $CH_4$ | $N_2O$ | Total $MTCO_2e$ | Percent of Total |
|---|---|---|---|---|---|
| Dutchess | 46,930 | 77 | 364 | 47,371 | 37% |
| Orange | 27,181 | 45 | 211 | 27,437 | 21% |
| Putnam | 20,524 | 34 | 159 | 20,717 | 16% |
| Rockland | 10,703 | 18 | 83 | 10,804 | 8% |
| Sullivan | 513 | 1 | 4 | 518 | 0% |
| Ulster | 13,672 | 22 | 106 | 13,800 | 11% |
| Westchester | 7,117 | 12 | 55 | 7,184 | 6% |
| **Mid-Hudson Region Total** | **126,640** | **208** | **982** | **127,829** | **100%** |

Note: Totals may not sum due to independent rounding.

[23] *NYSERDA Clean Diesel Technology: Non-Road Field Demonstration Program. Development of the 2002 Locomotive Survey for New York State*. http://www.nyserda.ny.gov/Publications/Research-and-Development/~/media/Files/Publications/Research/Environmental/locomotive%20survey%20report%20wit%20appendices.ashx

[24] Default factors from EPA's 2012 State Inventory Tool (SIT), Mobile Combustion Module. The SIT's default diesel density factors are from EIA Annual Energy Review 2007. The SIT's default diesel emission factors are from IPCC 1996 Guidelines for National Greenhouse Gas Inventories.

## 4.5 Off-Road

Emissions from off-road vehicles include engines used for agricultural, construction, lawn and garden, and off-road recreation purposes.

### Data & Methods

Off-road vehicle use and emissions data for each of the seven counties in the Mid-Hudson Region in 2007 was obtained using EPA's NONROAD Emissions Model. The model input values were adjusted by NYS DEC. Among other emissions types, the NONROAD model estimates carbon dioxide emissions. The emissions from all off road vehicles, excluding those in the pleasure craft classification, in each county were summed, and converted to $MTCO_2e$ from short tons. To avoid double counting, the emission of vehicles in the pleasure craft classification is accounted in the marine emission source and is not included in the off-road emission source.

### Results

The 2007 (proxy for 2010) off-road emissions in the Mid-Hudson Region were approximately 843,313 $MTCO_2e$. The results of the off-road emissions estimates are shown in Table 12 and Table 13.

**Table 13 – 2007 Off-road Emissions by County ($MTCO_2e$)**

| County | Total $MTCO_2e$ | Percent of Total |
|---|---|---|
| Dutchess | 113,231 | 14% |
| Orange | 117,542 | 14% |
| Putnam | 36,752 | 4% |
| Rockland | 102,364 | 12% |
| Sullivan | 48,117 | 6% |
| Ulster | 63,346 | 8% |
| Westchester | 352,960 | 42% |
| **Total** | **834,313** | **100%** |

Note: Totals may not sum due to independent rounding.

**Table 12 – 2007 Off-road Emissions by Equipment type (MTCO2e)**

| Equipment Type | Total $MTCO_2e$ |
|---|---|
| Recreational Equipment | 54,919 |
| Construction and Mining Equipment | 298,738 |
| Industrial Equipment | 133,235 |
| Lawn and Garden Equipment (Res) | 64,307 |
| Lawn and Garden Equipment (Com) | 123,886 |
| Agricultural Equipment | 20,784 |
| Commercial Equipment | 135,464 |
| Logging Equipment | 1,420 |
| Airport Equipment | 1,344 |
| Railroad Equipment | 216 |
| **Total** | **834,313** |

Note: Totals may not sum due to independent rounding.

# 5. Waste Management

The waste management sector encompasses solid waste and wastewater. The organic material in solid waste and wastewater degrade during the decomposition and treatment processes and emit greenhouse gases.

## 5.1 Solid Waste

The decomposition of organic matter in solid waste produces methane. For this inventory, both Scope 1 and Scope 3 emissions for solid waste were calculated. Scope 1 represents emissions from landfills located within the region, regardless of where the waste originated. Scope 3 represents emissions from waste generated by the region, regardless of where the wasted is ultimately transported. To avoid double-counting, only Scope 3 emissions are included in the total and Scope 1 emissions from solid waste are reported here for informational purposes.

### Scope 1

Scope 1 solid waste accounts for emissions from landfills located within Mid-Hudson Region counties. According to the NYS DEC, there are no active municipal solid waste landfills in the Mid-Hudson Region as of December 30, 2011.[25] However, closed municipal solid waste landfills may still be sources of emissions because waste emits methane for several decades as it decays. Closed municipal solid waste landfill facilities in the region include Al Turi Landfill & Landfill Gas to Energy (LFGTE) Facility and Sullivan County Landfill.

Scope 1 does not include emissions from waste combustion facilities to avoid double-counting. Those facilities, which are also used to generate electricity, are included under electricity generation.

***Data & Methods***

Data on emissions from landfills came from EPA's Greenhouse Gas Reporting Program data for calendar year 2010.[26] This dataset includes emission information from large facilities (defined as those that emit >25,000 $MTCO_2e$ per year) in nine industry groups, including landfills. This data is available through a web tool for download. This project used the most comprehensive dataset available, the full 2010 GHG Dataset.

Methane emissions from landfill processes were reported as solid waste Scope 1 emissions.

***Results***

Landfills in the region emitted 39,648 $MTCO_2e$ in 2010.

### Scope 3

Solid waste Scope 3 accounts for emissions from waste generated within the Mid-Hudson Region counties, regardless of where the waste is sent.

***Data & Methods***

The NYGHG Working Group provided solid waste data from landfill facilities for the inventory year, which were compiled from NYS DEC 2010 Annual Landfill Facility Reports.[27] The solid waste data was filtered to include

[25] NYS DEC Active Municipal Solid Waste Landfills. 12/30/2011. http://www.dec.ny.gov/docs/materials_minerals_pdf/mswlist.pdf

[26] Dataset is available at: http://epa.gov/climatechange/emissions/ghgdata/index.html.

[27] Spreadsheet received via email from Shelby C. Egan, NYSERDA on 8/9/2012, 4:32 PM.

landfill facilities that service, or receive waste from, the counties in the Mid-Hudson Region. Landfill gas (LFG) collection acreage, total landfill acreage, and percent alternative daily cover (ADC) data were gathered from NYS DEC 2010 Annual Landfill Facility Reports.[28] Solid waste data from waste combustion facilities that service the counties in the Mid-Hudson Region were gathered from NYS DEC 2010 Annual Municipal Waste Combustion Facility Reports.[29]

The weighted percentage of landfill area with LFG capture and weighted ADC were calculated for each county based on the landfills that accept municipal solid waste (MSW) from each county. For each unique landfill facility that services the Mid-Hudson Region, the percent of land in which gas is collected was calculated by dividing the gas collection acreage with the total landfill acreage. The amount of MSW and construction and demolition waste (C&D) generated by each county that was sent to landfills was calculated by summing the amount of waste from the "service area(s)" of interest, which are the counties in the Mid-Hudson Region. Then, the percentage of land with LFG capture for landfill facilities that collect MSW from each county were weighted by the amount of MSW received from that county. The portion of land with LFG capture for all counties ranged from 97% to 100%. The ADC percent for landfill facilities that collect MSW from each county were also weighted by the amount of MSW received from that county. The inventory assumes no LFG capture and ADC for C&D waste.

Because the data from the Landfill Facility Reports does not include waste handled at transfer stations or waste sent out of state, the inventory estimated total MSW generated by using MSW daily disposal per capita for each county. This also ensured that the assumptions used here are consistent with data used by the Mid-Hudson Regional Sustainability Plan. The Mid-Hudson Region Consortium provided data on MSW disposal per capita, compiled from various sources summarized in Table 14. The daily disposal per capita was multiplied by the counties' population, converted from pounds to tons, and converted from daily waste generation to annual. Using the data from the Working Group and NYS DEC Annual Reports, the percentages of MSW and C&D generated that were landfilled versus combusted in each county were calculated. The amount of waste generated was multiplied by the counties' fraction of waste that is sent to landfills to determine the amount of MSW landfilled. The amount of ADC was also calculated by multiplying the MSW landfilled with the weighted ADC percent for each county. The inventory sums up the amount of C&D generated using the data from the Working Group and DEC Annual Reports because those are the only sources with C&D data.

[28] NYS DEC 2010. Annual Landfill Facility Reports. ftp://ftp.dec.state.ny.us/dshm/SWMF/Landfill/Landfill%20Annual%20Reports/Landfill%20Annual%20Reports%20-%202010/

[29] NYS DEC 2010. Annual Municipal Waste Combustion Facility Reports. ftp://ftp.dec.state.ny.us/dshm/SWMF/MWC/MWC%20Annual%20Reports/MWC%20Annual%20Reports%20-%202010/

**Table 14 – Waste data from NYSERDA Cleaner, Greener Communities Program**

| County | Population[1] | Per Capita MSW Disposal Rate[2] (lb/person/day) | Recycling Rate[3] (%) |
|---|---|---|---|
| **Dutchess[4]** | 297,488 | 4.1 | 8% |
| **Orange[5]** | 372,813 | 3.9 | 38% |
| **Putnam[6]** | 99,710 | 4.9 | 11% |
| **Rockland[7]** | 311,687 | 4.0 | 34% |
| **Sullivan[8]** | 77,547 | 4.9 | 3% |
| **Ulster[9]** | 182,493 | 2.8 | 41% |
| **Westchester[10]** | 949,113 | 3.8 | 52% |
| **Mid-Hudson Region** | **2,290,851** | **3.9[11]** | **37%[11]** |
| **New York State** | **19,378,102** | **4.1[12]** | **35%[12]** |

1. Source: NYS Data Center
2. Note: Per Capita MSW Disposal Rate excluded recycled and C&D materials
3. Note: Recycling Rate includes MSW recycled/composted and C&D materials, but does not include combusted materials.
4. Source: Dutchess County Draft Local Solid Waste Management Plan (LSWMP) 2010
   Note: Generation Rate calculated by planning unit using other community and national averages.
5. Source: Orange County LSWMP 2010, Table 4-3, Pg. 4-3
6. Source: Putnam County Materials Generation and Recovery 2010 Data provided by Planning Unit
7. Source: Rockland County 2011 LSWMP, Table 4-3, Pg. 4-3
8. Source: Sullivan County 1992 LSWMP, Table 1, Pg. 32 and 175 of 868
9. Source: Ulster County 2009 report data (http://www.ucrra.org/recycling/graphstats.htm 2009 Data)
10. Source: Westchester County 2011 Annual Report
11. Note: Weighted average based on county populations.
12. Source: NYS DEC 2010, *Beyond Waste Plan.* Pg. 93

The California Air Resources Board's Landfill Emissions Tool Version 1.3 was used to calculate Scope 3 emissions. The tool implements the mathematically exact first-order decay (FOD) model of the 2006 IPCC guidelines. The methodology of the FOD model is available in the Local Government Operations Protocol.[30]

The tool is used to calculate emissions the waste generated in 2010 will emit over its lifetime in a landfill. First, the number of years for which waste generated during the inventory year will be releasing methane was calculated. The half-life of landfilled waste was calculated through the following equation: k = ln(2)/half-life in years. K is determined based on the amount of annual rainfall in the county, and an average rainfall of greater than 40 inches per year was assumed for all counties in the Mid-Hudson Region. Given the rainfall assumption, k= 0.057. The half-life was multiplied by four half-lives to determine T, the number of years for which waste deposited during the inventory year will be releasing methane.

NYS DEC completed a revised solid waste plan, *Beyond Waste: A Sustainable Material Management Strategy*, which includes data on composition of waste discarded in 2008, and is categorized by rural, suburban, and urban settings.[31] NY State-specific solid waste discard composition data was used to find the fractions of waste types which contain anaerobically degradable carbon (ANDOC). For the municipal solid waste (MSW) component, the inventory assumes the waste composition from suburban settings for Dutchess, Orange, Putnam, Rockland, and Westchester Counties and from rural communities for Sullivan and Ulster Counties. For

[30] Local Government Operations Protocol. Version 1.1. 2010. http://www.arb.ca.gov/cc/protocols/localgov/pubs/lgo_protocol_v1_1_2010-05-03.pdf

[31] NYS DEC 2010. *Beyond Waste: A Sustainable Material Management Strategy*. Table H-4: New York State MSW Composition. http://www.dec.ny.gov/docs/materials_minerals_pdf/fbeyondwastegi.pdf

the purposes of the solid waste analysis, NYS DEC defines rural as communities in the state with a population density of less than 325 people per square mile and suburban areas as communities with a population density between 325 and 5,000 people per square mile. The inventory assumes the waste composition for the construction and demolition (C&D) waste emission analysis is 100 percent C&D.

The county and NY State-specific information was used to replace the California-specific default data in the tool. In the "Landfill Model Inputs tab," the state/country input was set to "US-Other" and the k value was set to 0.057. The amount of solid waste generated in the inventory year was entered into the tool's "Landfill Model Inputs tab" T years prior to the inventory year. The NY State-specific waste in place fractions were entered into the "Landfill Specific ANDOC Values" tab of the tool. The new % ANDOC value was entered into the "Landfill Model Inputs" tab to replace the default numbers. The amount of ADC was entered into the tool for MSW estimates and assumes the daily cover is composed of greenwaste and compost. The default % ANDOC value for daily cover that was calculated by the tool was used. The inventory assumes no ADC for C&D waste.

The sum of methane emission results over T years represents the total amount of methane expected to be released by inventory year waste generated and deposited in a landfill without a LFG collection system. The methane emissions for MSW waste then were adjusted for a LFG collection system. The EPA default LFG collection efficiency of 75 percent was assumed because the weighted percent of land with LFG collection per county, ranging from 97 to 100 percent, indicates comprehensive LFG systems.[32] The sum of methane emissions was multiplied by 100 percent minus the default LFG collection efficiency to determine methane emissions from MSW generated and deposited in a landfill without a LFG collection system. The inventory assumes no LFG collection for C&D waste. Carbon dioxide emission outputs from the solid waste tool are considered biogenic and are not included in the inventory emissions.

***Results***

Results indicate that total emissions from municipal solid waste generation in the Mid-Hudson Region were estimated to be 324,372 $MTCO_2e$ in 2010. Emissions from construction and demolition generation in the region were 25,832 $MTCO_2e$ in 2010. Total solid waste Scope 3 emissions were 350,204 $MTCO_2e$ in 2010, as detailed in Table 15.

**Table 15 – 2010 Municipal Solid Waste Generation Emissions ($MTCO_2e$)**

| County | MSW $CH_4$ emissions ($MTCO_2e$) | C&D $CH_4$ emissions ($MTCO_2e$) | Total $CH_4$ emissions ($MTCO_2e$) | Percent of Total |
|---|---|---|---|---|
| **Dutchess** | 22,657 | 227 | 22,883 | 7% |
| **Orange** | 104,404 | 1,728 | 106,133 | 30% |
| **Putnam** | 7,609 | - | 7,609 | 2% |
| **Rockland** | 88,824 | 8,066 | 96,890 | 28% |
| **Sullivan** | 24,497 | 932 | 25,430 | 7% |
| **Ulster** | 32,368 | 3,835 | 36,203 | 10% |
| **Westchester** | 44,014 | 11,044 | 55,057 | 16% |
| **Mid-Hudson Region Total** | **324,372** | **25,832** | **350,204** | **100%** |

Note: Totals may not sum due to independent rounding.

[32] EPA, 2008. AP 42, Fifth Edition, Volume I, Chapter 2: Solid Waste Disposal. http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf

## 5.2 Wastewater

When organic waste material in wastewater degrades during the wastewater treatment processes, it emits both methane and nitrous oxide. Methane is emitted during anaerobic digestion of wastewater, and nitrous oxide is emitted when nitrogen components in wastewater degrade. The amount of methane and nitrous oxide emitted from wastewater depends on the type of wastewater treatment processes used, such as septic systems, centralized wastewater treatment plants (WWTPs), and anaerobic digesters.

### Data & Methods

Wastewater emissions are calculated based on the population served by wastewater treatment processes. Population data in the Mid-Hudson Region were obtained from the NYS Data Center.[33]

Wastewater emissions were calculated using EPA's State Inventory Tool (SIT). Methane emissions from municipal wastewater treatment were calculated by multiplying the population served by municipal WWTPs, from the Census 2010 population data for the region, by the annual per-capita 5-day biological oxygen demand ($BOD_5$) rate times the emission factor of $CH_4$ emitted per quantity of $BOD_5$. Default values for New York State in the SIT were used.

$$CH_4\ Emissions\ (MT) = Population\ x\ Per\ capita\ BOD_5 \left(\frac{kg}{day}\right) x \frac{Days}{year} x \frac{MT}{kg} x\ EF \left(\frac{GgCH_4}{GgBOD_5}\right) x\ \%\ of\ WW\ anaerobically\ digested$$

Where:

| | | |
|---|---|---|
| Population | = | Population served by municipal WWTPs. |
| Per capita $BOD_5$ | = | 5-day biochemical oxygen demand per capita. Default value is 0.09 kg BOD5/day. |
| EF | = | Emission factor of $CH_4$ emitted per quantity of $BOD_5$. Default value is 0.6 Gg $CH_4$/Gg $BOD_5$. |
| % of WW anaerobically digested | = | Fraction of wastewater $BOD_5$ that is anaerobically digested. Default value is 16.25%. |

Nitrous oxide emissions form municipal wastewater treatment were calculated by multiplying the population served by the percent of the population using centralized wastewater treatment (not septic systems), times the amount of direct $N_2O$ emissions from wastewater treatment per person per year.

[33] New York State Data Center, Census 2010. Revised2000to2009SubcountyTotals_Population.xls, http://www.empire.state.ny.us/NYSDataCenter/Census2010.html

$$N_2O\ Emissions\ (MT) = Population\ x\ Fraction\ of\ population\ not\ on\ septic\ x\ Direct\ N_2O\ emissions\ from\ WWT \left(\frac{\frac{gN_2O}{person}}{year}\right) x \frac{MT}{g}$$

Where:

| | | |
|---|---|---|
| Population | = | Population served by municipal WWTPs. |
| Fraction of population not on septic | = | Percent of population that is served by centralized WWTPs as opposed to septic systems. The default value for New York State is 79%. |
| Direct $N_2O$ emissions from WWT | = | The amount of $N_2O$ emitted from WWTPs. Default value is 4.0 grams $N_2O$ per person per year. |

Nitrous oxide emissions from wastewater biosolids were calculated using the following equation:

$$N\ in\ Domestic\ Wastewater = Population\ x\ Protein \left(\frac{\frac{kg}{person}}{year}\right) x\ Frac(npr) \left(\frac{kg\ N}{kg\ protein}\right)\ x\ Fraction\ nonconsumption\ N\ x\ \left(\frac{MT}{kg}\right)$$

$$N_2O\ Emissions\ (MT) = N\ in\ Domestic\ WW\ (MT) - Direct\ N\ Emissions\ from\ Domestic\ WW\ (MT)\ x\ (1 - \%\ of\ Biosolids\ used\ as\ fertilizer)\ x\ EF \left(\frac{kgN_2O - N}{kgsewageN_{produced}}\right) x \left(\frac{N_2O}{N_2}\right)$$

Where:

| | | |
|---|---|---|
| Population | = | Population served by municipal WWTPs. |
| Protein | = | Available protein per person per year (kg/person/year). Default value is 42.6 kg/person/year.[34] |
| Fraction of population not on septic | = | Percent of population that is served by centralized WWTPs as opposed to septic systems. The default value for New York State is 79%. |
| Direct $N_2O$ emissions from WWT | = | The amount of $N_2O$ emitted from WWTPs. Default value is 4.0 grams $N_2O$ per person per year. |

[34] *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2010.* Tables 8 to 14.

### Results

Wastewater treatment emissions are approximately 222,873 $MTCO_2e$. Table 16 lists wastewater treatment emissions by county.

**Table 16 – 2010 Wastewater Treatment Emissions ($MTCO_2e$)**

| County | $CO_2$ | $CH_4$ | $N_2O$ | Total | Percent of Total |
|---|---|---|---|---|---|
| **Dutchess** | - | 20,009 | 8,933 | 28,942 | 13% |
| **Orange** | - | 25,076 | 11,195 | 36,270 | 16% |
| **Putnam** | - | 6,707 | 2,994 | 9,701 | 4% |
| **Rockland** | - | 20,964 | 9,359 | 30,323 | 14% |
| **Sullivan** | - | 5,216 | 2,329 | 7,544 | 3% |
| **Ulster** | - | 12,275 | 5,480 | 17,754 | 8% |
| **Westchester** | - | 63,838 | 28,500 | 92,338 | 41% |
| **Mid-Hudson Region Total** | **-** | **154,083** | **68,789** | **222,873** | **100%** |

Note: Totals may not sum due to independent rounding.

## 6. Industrial Processes

Industrial process emissions are those produced as by-products of non-energy-related industrial activities. In the Mid-Hudson Region, the primary industrial actor in the region is Revere Smelting and Refining Corporation, a lead manufacturer.

### Data & Methods

Industrial process emissions for the Mid-Hudson Region were estimated for two emission sources to cover the industrial process emissions in the Mid-Hudson Region. These sources are: $CO_2$, $CH_4$, and $N_2O$ from general industrial activity as reported by large facilities and hydrofluorocarbon (HFC) emissions from ozone depleting substances (ODS) substitutes.

Data on industrial activity from large facilities came from EPA's Greenhouse Gas Reporting Program (GHGRP) data for calendar year 2010.[35] This dataset includes emission information from large facilities (defined as those that emit > 25,000 $MTCO_2e$ per year) in nine industry groups, including: power plants, landfills, metals manufacturing, mineral production, petroleum refineries, pulp and paper manufacturing, chemicals manufacturing, government and commercial facilities, and other industrial facilities. These groups cover 29 source categories of emissions. This data is available through a web tool or for download. This project used the most comprehensive dataset available, the full 2010 GHG Dataset. In 2012, this EPA dataset will be expanded to include 12 additional industry groups for calendar year 2011.

To calculate emissions from ODS substitutes, the Mid-Hudson Region developed an implied emission factor based on total national ODS substitute emissions and population. National ODS substitute emissions came

[35] Dataset is available at: http://epa.gov/climatechange/emissions/ghgdata/index.html.

from Table 4-1 of EPA's national GHG inventory. [36] Total 2010 U.S. population was collected from the U.S. Census Bureau.[37].

*Industrial Facility Emissions* - The primary data source is EPA's GHGRP data for calendar year 2010. To identify facilities located in the Mid-Hudson Region, the full dataset of facilities was filtered by state and county. The process also checked, using the facility city, whether any facilities that did not have county designations were actually located in the Mid-Hudson Region. The final result was one facility located in the Mid-Hudson Region. The inventory only includes emissions from lead production under Industrial Processes. Stationary combustion, electricity production, and landfill emissions are included elsewhere in the inventory.

*ODS Substitute Emissions* - To supplement the GHGRP data, emissions were also calculated for ODS substitutes, a key industrial process emissions source category not covered in the EPA dataset. The Mid-Hudson Region used an implied per capita emissions factor based on the national greenhouse gas inventory for 2010.[38] Equipment that use ODS Substitutes are widely distributed throughout all households and businesses. Total 2010 ODS substitution emissions (114.6 Tg $CO_2$e) were divided by total 2010 U.S. population (308,745,538[39]) to derive an implied per capita emission factor. This implied emission factor was multiplied by the population of each of the municipalities in the Mid-Hudson Region to estimate emissions from this industrial process source category.

## Results

Industrial process emissions are approximately 885,115 $MTCO_2e$. The results are shown in Table 17, by county. Other potential sources are excluded from this table based on the difficulty of collecting the data and the relatively low importance of these sources in the U.S. Inventory.

**Table 17 - 2010 Industrial Process GHG Emissions by Industrial Activity ($MTCO_2e$)**

| | Lead Production | ODS Substitution | Total | Percent of Total |
|---|---|---|---|---|
| **Dutchess County** | 0 | 110,421 | 110,421 | 12% |
| **Orange County** | 34,798 | 138,381 | 173,179 | 20% |
| **Putnam County** | 0 | 37,010 | 37,010 | 4% |
| **Rockland County** | 0 | 115,692 | 115,692 | 13% |
| **Sullivan County** | 0 | 28,784 | 28,784 | 3% |
| **Ulster County** | 0 | 67,738 | 67,738 | 8% |
| **Westchester County** | 0 | 352,291 | 352,291 | 40% |
| **Mid-Hudson Region Total** | **34,798** | **850,317** | **885,115** | **100%** |

Note: Totals may not sum due to independent rounding.

[36] U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010. Table 4-1. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Chapter-4-Industrial-Processes.pdf.

[37] U.S. Census Bureau. 2012. State and County QuickFacts – USA. http://quickfacts.census.gov/qfd/states/00000.html.

[38] U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010. Table 4-1. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Chapter-4-Industrial-Processes.pdf.

[39] U.S. Census Bureau. 2012. State and County QuickFacts – USA. http://quickfacts.census.gov/qfd/states/00000.html.

# 7. Agriculture

The agriculture sector of the Mid-Hudson Regional inventory includes non-carbon dioxide emissions from enteric fermentation in domestic livestock, livestock manure management, and agricultural soil management (including fertilizer application). Carbon dioxide emissions are not included as they are assumed to be biogenic and don't represent an anthropogenic emission source.

According to the Mid-Hudson Region's Strategic Economic Development Plan, the percentage of land that is farmed in each county is 20% in Dutchess, 16% in Orange, 4% in Putnam, 3% in Westchester, and 11% in Ulster. The percentage of farmland in Rockland is negligible, and the figures for Sullivan County are not available.[40] The primary agricultural industry in the region is dairy industry, along with other livestock production. The primary crops in the region are corn (for grain and silage), forage, oats, and soybean.

### Data & Methods

Data on 2010 livestock populations and crop productions were available for New York State on the county-level from USDA's National Agricultural Statistics Service (NASS).[41] Livestock populations for 2010 included beef cows, milk cows, and all cattle (including calves). Calf populations were calculated by assuming that calves account for 17.4% of the total non-dairy cattle/cow population. Data for crop production in the Mid-Hudson Region counties covered corn for grain, hay alfalfa, other dry hay, oats, soybeans, and winter wheat.

Data from EPA's Regional GHG Inventory Guidance on livestock population percentage breakdowns in New York State was also used to allocate dairy cattle and beef cattle populations into sub-categories. The subcategories for dairy cattle are dairy cows and dairy replacement heifers.[42] The subcategories for beef cattle are beef cows, beef replacement heifers, heifer stockers, steer stockers, feedlot heifers, feedlot steer, and bulls.[43]

Fertilizer sales data came from the New York State Department of Agriculture and Markets dataset of total fertilizer and nutrients by county for calendar year 2010. For each county, the dataset included total fertilizer sales, broken into single, multi-nutrient, and other; Total N, P205, and K20 in multiple-nutrient fertilizer, and total N, P205, and K20 in all fertilizer.

County-level emissions for agriculture were calculated using EPA's State Inventory Tool (SIT), using default emission factors for New York State. To calculate emissions from enteric fermentation and manure management, the tool requires population information for each livestock subcategory. Total county milk cow population and beef cow population from NASS were multiplied by the percentage breakdowns from EPA's Regional GHG Inventory Guidance to derive subcategory populations. The tool then multiplies the number of animals by a per-head enteric $CH_4$ emission factor to estimate total enteric fermentation emissions for each county. The tool multiplies the subcategory populations by New York defaults for Typical Animal Mass (TAM), volatile solids (VS), and methane conversion factors for different manure management systems to estimate

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[40] *Mid-Hudson Regional Economic Development Council Strategic Plan.* http://regionalcouncils.ny.gov/themes/nyopenrc/rc-files/midhudson/MHREDCSPFINAL11_12_11.pdf.

[41] USDA. 2012. National Agricultural Statistics Service, QuickStats. Data downloaded for All livestock items and All crops; Location: New York / All Counties. http://www.nass.usda.gov/QuickStats/. Calf population in NYS is 17.38% of total cattle population and because calf data are not split out at the county level, assumed 17.38% applies to county level, as well.

[42] From Table A-24 of EPA's Regional GHG Inventory Guidance. Dairy cow population percentages by state, 2006.

[43] From Table A-25 of EPA's Regional GHG Inventory Guidance. Beef cow population percentages by state, 2006.

$CH_4$ emissions from manure management and by TAM, K-Nitrogen factors, and nitrogen emission factors for different manure management systems to estimate $N_2O$ emissions from manure management.

To calculate emissions from management of agricultural soils, the SIT follows three steps. The tool first calculates emissions from plant residues, and allows input of crop production data for 21 crop types. Five of these crop types are grown in the Mid-Hudson Region: Alfalfa (pulled from NASS as "Hay Alfalfa (Dry)"), corn for grain, wheat, oats, and soybeans. The tool multiplies these production amounts by a series of factors, including residue dry matter fraction, fraction residue applied, and nitrogen content of residue to calculate the amount of nitrogen returned to soils and the amount of nitrogen fixed by crops.

The second step of calculating emissions from agricultural soil management estimates emissions from plant fertilizer application. The tool uses the total amounts of fertilizer nitrogen by type (synthetic fertilizers, dried blood, compost, dried manure, activated sewage sludge, other sewage sludge, tankage, or other organic amendments) to estimate direct and indirect $N_2O$ emissions from fertilizer applications. For each county, the total N in all fertilizer types from the New York State dataset was entered into the tool under "Synthetic Fertilizer" to estimate fertilizer emissions.

Finally, the SIT calculates agricultural soil emissions from animals and runoff. This step uses the livestock population data entered under enteric fermentation and manure management and New York state default distributions of livestock management systems (e.g. managed systems, pasture, and daily spread) along with built-in emission factors to estimate $N_2O$ emissions.

## Results

Agriculture emissions are approximately 149,887 $MTCO_2e$. Emissions are shown in Table 18. Orange County, with the highest population of dairy and beef cows, has the largest emissions in the region, accounting for 27 percent of agriculture emissions.

**Table 18 – 2010 Agriculture GHG Emissions by Source ($MTCO_2e$)**

| | Enteric Fermentation | Manure Management | Agricultural Soils | Total | Percent of Total |
|---|---|---|---|---|---|
| **Dutchess County** | 16,432 | 2,690 | 13,192 | 32,315 | 24% |
| **Orange County** | 21,003 | 4,673 | 15,111 | 40,787 | 30% |
| **Putnam County** | 8,176 | 882 | 3,785 | 12,844 | 9% |
| **Rockland County** | 8,176 | 882 | 6,163 | 15,222 | 11% |
| **Sullivan County** | 12,221 | 2,315 | 5,347 | 19,883 | 15% |
| **Ulster County** | 8,389 | 1,052 | 6,205 | 15,645 | 2% |
| **Westchester County** | 372 | 20 | 12,801 | 13,193 | 9% |
| **Mid-Hudson Region Total** | **74,769** | **12,515** | **62,603** | **149,887** | **100%** |

Note: Totals may not sum due to independent rounding.

# 8. Land Use, Land-Use Change and Forestry

Land Use, Land-Use Change and Forestry (LULUCF) measures changes to forest carbon stocks. This measurement reflects the impact of changes in land use on the capacity of forests in the Mid-Hudson Region to store (or "sequester") carbon in their trees, forest litter, and soils. Forest carbon sequestration is the process by which atmospheric carbon dioxide is taken up by trees through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils. This source is considered "optional" under the guidance of the NYGHG Working Group. However, it is included here due to the importance of forest resources to the region.

### Data & Methods

Two datasets were collected to calculate net emissions from LULUCF: (1) the acres of forested land by county in 2005 and 2010 and (2) the carbon sequestration rates for forests in the region.

The acres of forested land were retrieved from the U.S. Forest Service's Forest Inventory and Analysis database via the Forest Inventory Data Online (FIDO) website.[44] Data were originally pulled by county by forest-type group for 1993, 2005 and 2010. The three data samples revealed some inconsistencies in the identification of specific forest-type groups. However, the differences between the total forested area per county demonstrated reasonable changes in acreage. Therefore, to minimize the influence of data sample errors, the calculations were based on the total forested area for each county, and not forest-type groups.

To minimize another source of potential data collection error, the 2005 and 2010 sample years were selected. This decision was based on the fact that the average annual change was more likely to be similar over a shorter time frame and that data collection methodology is more likely to have changed between the 1993 and 2010 data collection than the 2005 and 2010 samples.

The second set of data, the carbon sequestration rates for forested land in the eight counties was retrieved from the Carbon OnLine Estimator (COLE).[45] The composite rate for "All" forest-type groups in the Mid-Hudson Region counties was selected. This is a weighted rate that reflects the distribution of forest-type groups in the region. Only some of the forest-type groups had specific sequestration rates. This composite rate was used for all forest-types in the counties.

Calculations estimated the average annual rate of change for carbon sequestration in the counties. The methodology included a four step calculation:

(1) Subtracted the 2005 acres of forest per county from the 2010 acres of forest per county.

(2) Divided the change by five (years) to get the annual rate of change in acres.

(3) Converted acres of forest to hectares.

(4) Multiplied the annual rate of change in hectares by the composite carbon sequestration rate.

[44] US Forest Service, FIA Program: Forest Inventory Data Online. http://apps.fs.fed.us/fido/ Retrieved August 31, 2012.
[45] Carbon OnLine Estimator (COLE) data are based on USDA Forest Service Forest Inventory & Analysis and Resource Planning Assessment data. http://www.ncasi2.org/COLE/ Retrieved August 31, 2012.

## Results

Land use changes in the Mid-Hudson Region in 2010 resulted in a net emission (decrease in sequestration) of 5,254,734 $MTCO_2e$. Results by county are shown in Table 19. Dutchess, Putnam, Sullivan, and Ulster Counties showed net emissions from LULUCF while Orange, Rockland, and Westchester Counties had net carbon sequestration from LULUCF. This inventory does not include urban tree canopy in the LULUCF calculations. The best available method for calculating urban tree canopy at the county level uses a regional percentage of urban tree canopy that is uniformly applied to all urbanized areas. Without county- or city-specific rates, this calculation reflects the rate of urbanization without incorporating the impact of local tree planting projects. In addition, while urban land appears to have increased in the Mid-Hudson Region between 2005 and 2010, including urban tree sequestration rates would inaccurately reflect an increase in sequestration based on a regional average. As a result, urban tree canopy was excluded from this calculation.

**Table 19 – 2010 Net Change in Forest Carbon Stocks ($MTCO_2e$)**

| | Total Net Change in Forest Carbon Stocks ($MTCO_2e$) |
|---|---|
| **Dutchess County** | 1,825,360 |
| **Orange County** | (1,359,459) |
| **Putnam County** | 653,119 |
| **Rockland County** | (703,539) |
| **Sullivan County** | 4,817,816 |
| **Ulster County** | 833,305 |
| **Westchester County** | (811,868) |
| **Mid-Hudson Region Total** | **5,254,734** |

Note: Totals may not sum due to independent rounding.

# Appendix – Municipal-Level Allocation

## A.1 Introduction

In addition to the regional GHG inventory presented above, this analysis included a municipal-level allocation of regional emissions. The inventory team allocated the region's emissions to individual towns, cities, and villages based on the available data. This effort is intended to provide municipalities with baseline information about their community-level GHG emissions. Because it was not feasible to develop ground-up GHG inventories for each of the region's 198 cities, towns, and villages, the allocation process was driven by readily available demographic and geographic data. A detailed, ground-up inventory would likely provide more reliable results for any one community, but these estimates serve as a useful resource for those communities unable to complete their own GHG inventories. The challenges and limitations of this process are described below, followed by a description of the methods for each sector. The results are presented in county tables at the end of this report, and may also be viewed in the inventory spreadsheet that accompanies this report.

## A.2 Challenges

### Data Limitations and Unallocated Portion

As expected at the outset of this process, it was not practical to fully allocate all emissions from each sector in the region. The team allocated those sources where available local-level activity data could be used to reasonably approximate the spatial distribution of emissions. In cases where no such data were available, regional emissions were not allocated to the local level. Specifically, emissions from rail, marine, aviation, and LULUCF have not been allocated to the municipal level for this inventory. It would be possible to allocate sources such as aviation based on a survey of passenger air travel habits by municipality, but conducting such a survey was beyond the scope of this analysis.

Furthermore, only a subset of industrial emissions and a subset of off-road emission were allocated, as discussed below. The percentage not allocated by sector is shown below in Table 20. Furthermore, Scope 1 emissions from electricity generation—which was calculated for informational purposes but not included in the regional total—were not included in the municipal allocation.

**Table 20 – Percentage of Emissions Not Allocated, by Sector**

| Category | Allocated to Municipalities? | Percentage Not Allocated |
|---|---|---|
| **Stationary Energy Consumption** | | **6%** |
| *Residential* | Yes | N/A |
| *Commercial* | Yes | N/A |
| *Industrial* | Partially | 41% |
| *Energy Supply* | Partially | 11% |
| **Mobile Energy Consumption** | | **10%** |
| *On-Road* | Yes | N/A |
| *Air* | No | 100% |
| *Marine* | No | 100% |
| *Rail* | No | 100% |
| *Off-Road* | Partially | 19% |
| **Waste Management** | | **N/A** |
| *Solid Waste* | Yes | N/A |
| *Wastewater Treatment* | Yes | N/A |
| **Industrial Processes** | **Yes** | **N/A** |
| **Agriculture** | **Yes** | **N/A** |
| **LULUCF** | No | 100% |
| **Across All Sectors** | | **8%** |

### Including Villages

Although village populations are also included within town population estimates, the inventory has allocated to the village level, where possible. Because there is overlap between towns and villages, these allocations should not be viewed additively. For example, three villages could be part of one town; the emissions allocated to each village should not be viewed as mutually exclusive from the town, but are also included in the town's emissions estimates. However, there is value in understanding emissions from each village for facilitating planning activities to target reducing emissions from specific sectors and locales.

## A.3 Methods by Sector

### Stationary Energy Consumption

***Electricity – Scope 1***

Electricity generation emissions are not allocated to the municipal level, as they are not counted in county emission totals.

***Electricity – Scope 2***

Electricity consumption emissions are calculated at the municipal level initially and then added up to the county level. See Section 3.2 for methodology details.

***Fuels – Scope 1***

Residential fuel consumption at the municipal level is calculated using the same methodology described in the main inventory text, based on Census data for housing units, heating fuel use, and statewide residential fuel consumption. Utility data for each municipality, if available, override these estimates. See Section 3 for details.

Commercial fuel consumption at the municipal level is calculated using the same methodology described in the main inventory text, based on Census data for housing units, heating fuel use, and statewide commercial fuel consumption. Utility data for each municipality, if available, override these estimates. See Section 3 for details.

Industrial fuel consumption at the municipal level is based on reported data from three sources: EPA's Greenhouse Gas Reporting Program industrial facilities, the New York State Department of Environmental Conservation (NYS DEC) Title V facilities database, and utility data. Industrial stationary combustion emissions from any facilities within a municipality are assigned to that municipality. For natural gas combustion, utility data overrides GHGRP/Title V facilities data if both are available. The estimated data used to account for consumption not covered by these three sources was not allocated due to the lack of sufficient local level data.

***Energy Supply***

Electricity and natural gas transmission and distribution emissions at the municipal level are calculated using the same methodology as at the county level. Electricity and natural gas consumption for each municipality is multiplied by a transmission and distribution loss factor and converted to emissions. $SF_6$ emissions are also calculated in the same manner for municipalities as for counties, using municipal-level electricity consumption multiplied by the $SF_6$ loss rate in $MTCO_2e$ per MWh. See Section 3.4 for details.

## Transportation

For the transportation sector, on-road motor vehicle activity, as well as off-road terrestrial vehicle activity, has been allocated to the town level. However, due to lack of data and solid methodological options, rail, marine, and air subsectors have not been similarly allocated. See the discussion on data limitations and unallocated portions for more information.

***On-Road Transportation***

On-road emissions in Mid-Hudson Region were allocated to municipalities based on the number of occupied housing units (households) in cities, towns, and villages adjusted based on the journey-to-work mode preference. Household data were obtained from the American Communities Survey 5-year estimates on selected housing characteristics, as were journey-to-work percentages. First, the weighted proportion of commuters driving alone was calculated for each municipality and each county:

$$Weighted\ drive\ alone\ \% = Drive\ alone\ \% + \frac{two - person\ Carpool\ \%}{2} + \frac{three - person\ Carpool\ \%}{3} + \frac{four - or - more\ person\ Carpool\ \%}{4}$$

Next, the weighted proportion of commuters driving alone was normalized by dividing by the county-wide average for each county to provide a "journey-to-work factor" (JTWF, in the equation below). Municipal on-road emissions were estimated by multiplying the county-level emission estimates by a weighting based on the number of households within each municipality and the prevalence of vehicle use for commuting relative to the rest of the county:

$$Emissions_{Municipality} = Emissions_{County} \times \frac{(\#Households \times JTWF)_{Municipality}}{\sum(\#Households \times JTWF)_{All\ Munipalities\ in\ a\ County}}$$

***Off-Road Transportation***

The methodologies for allocating off-road emissions to the municipal level varied by equipment type. Emissions from recreational and logging equipment were allocated based on the inverse of population density, assuming that these types of equipment are more common in areas with more space available per person. The population density was normalized to the county average by dividing the inverse of the log of the each municipality's population density by the inverse of the log of the county's population density. The normalized population density was multiplied by the municipality's 2010 population. This was divided by the sum of the products of the population and normalized density of towns and cities to find the proportion of population density with respect to the county. The proportion was multiplied with the county's emissions from recreational and logging equipment. The net result of this weighting is that usage was weighted by population, but given a higher weighting in places with low population density, and a lower weighting in places with high population density.

Emissions from construction and mining equipment were allocated based on population. The municipalities' population proportions within their respective county were multiplied by the county's emissions from construction and mining equipment.

Residential and commercial lawn and garden equipment took into account the number of single family housing units. The number of total single family detached and attached housing units within the municipality was divided by the total within their respective county. The housing unit proportion was multiplied with the county's emission from residential and commercial lawn and garden equipment. This calculation was based on the activity factors used in the EPA model used to generate these estimates.

Emissions from commercial equipment were allocated based on allocations from the commercial fuel source. The commercial fuel emission from each municipality was divided by the total emissions from their respective county. The commercial fuel proportion was multiplied with the county's emission from commercial equipment.

Emissions from industrial, airport, agricultural, and railroad equipment, which represent 19% of off-road emissions in the region, were not allocated at the municipal level due to lack of available data or methodology

## Waste Management

***Solid Waste***

Scope 1 solid waste emissions were allocated to municipalities based on location of the landfill facilities. Scope 1 emissions are not included in the allocation *totals* for waste, however, to avoid double-counting while Scope 3 emissions were allocated to municipalities based on Census-derived populations. The towns, cities, and villages' population proportions within each of their respective counties were multiplied by the county's overall Scope 3 per-capita emissions.

***Wastewater***

Wastewater emissions were calculated using EPA's State Inventory Tool. Methane emissions from municipal wastewater treatment were calculated by multiplying the population served by municipal WWTPs, from the Census 2010 population data for each municipality, by the annual per-capita 5-day biological oxygen demand

(BOD5) rate times the emission factor of $CH_4$ emitted per quantity of $BOD_5$. Default values for New York State in the SIT were used. See Section 5.2 for more information.

### Industrial Processes

Industrial process emissions at the municipal level are calculated using the same methodology as calculating emissions at the county level (see Section 6). Industrial process emissions from the single facility in the region, the Revere Smelting and Refining Corp. facility located in Middletown, New York, are assigned to that city. Emissions from ODS substitution are assigned to municipalities based on population and the implied per capita ODS emission factor.

### Agriculture

Emissions from the agricultural sector are apportioned to the municipal level using GIS-based land use data from the USDA's National Agricultural Statistics Service.[46] The dataset provides land area by crop type throughout the United States. Using this dataset, the area of each land use type within the Mid-Hudson Region municipalities was determined.

To apportion emissions, first, the relevant land use types were determined. For Ag Soils, the land uses for the crop types grown in the Mid-Hudson Region and calculated in the State Inventory Tool were used. These crop types are Alfalfa, Corn, Winter Wheat, Oats, Soybeans, and Dry Beans. The sum of the land area for each of these crops for each municipality was considered its "Ag Soils Land Area."

For livestock emissions (Manure Management and Enteric Fermentation in the SIT), land area categorized as "Pasture/Grass" was used to determine the "Livestock Land Area."

Finally, total agricultural emissions (Ag Soils Emissions plus Livestock emissions) for each municipality were determined using the equations below:

$$Ag\ Soils\ Emissions_{Municipal} = Emissions_{County} \times \frac{Ag\ Soils\ Land\ Area_{Municipal}}{Ag\ Soils\ Land\ Area_{County}}$$

$$Livestock\ Emissions_{Municipal} = Emissions_{County} \times \frac{Livestock\ Land\ Area_{Municipal}}{Livestock\ Land\ Area_{County}}$$

## A.4 Results

Emissions for each municipality by sector are presented in Tables 21 through 27, organized by county.

[46] USDA National Agricultural Statistics Service Cropland Data Layer. 2010 Published crop-specific data layer. Available at http://nassgeodata.gmu.edu/CropScape

**Table 21 – Dutchess County; Total Emissions by Municipality and Sector, $MTCO_2e$**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| Amenia | Town | 10,381 | 7,745 | 325 | 21,244 | 341 | 432 | 1,647 | 3,120 | 686 | **45,919** |
| Beacon | City | 29,946 | 45,715 | 94,060 | 69,485 | 1,195 | 1,512 | 5,768 | 87 | 4,590 | **252,359** |
| Beekman | Town | 30,204 | 16,726 | 695 | 53,723 | 1,125 | 1,422 | 5,427 | 1,051 | 1,847 | **112,220** |
| Clinton | Town | 12,421 | 5,935 | 64 | 19,026 | 332 | 420 | 1,601 | 1,669 | 563 | **42,029** |
| Dover | Town | 21,322 | 15,075 | 2,502 | 44,306 | 669 | 846 | 3,229 | 1,257 | 1,550 | **90,756** |
| East Fishkill | Town | 77,942 | 44,038 | 161,970 | 124,358 | 2,233 | 2,824 | 10,775 | 1,179 | 15,677 | **440,996** |
| Fishkill | Town | 46,886 | 66,909 | 330 | 104,720 | 1,701 | 2,151 | 8,206 | 335 | 6,010 | **237,247** |
| Hyde Park | Town | 49,217 | 37,014 | 203 | 98,406 | 1,659 | 2,099 | 8,007 | 530 | 2,667 | **199,803** |
| La Grange | Town | 39,239 | 23,575 | 519 | 68,817 | 1,210 | 1,530 | 5,839 | 1,830 | 1,946 | **144,505** |
| Milan | Town | 6,656 | 3,245 | 1 | 12,008 | 182 | 231 | 880 | 966 | 316 | **24,485** |
| North East | Town | 8,097 | 5,858 | 189 | 13,915 | 233 | 295 | 1,125 | 13 | 531 | **30,256** |
| Pawling | Town | 23,868 | 14,951 | 2,995 | 38,760 | 651 | 823 | 3,141 | 1,064 | 1,683 | **87,937** |
| Pine Plains | Town | 6,918 | 3,913 | 26 | 12,098 | 190 | 241 | 918 | 2,644 | 368 | **27,316** |
| Pleasant Valley | Town | 22,968 | 11,717 | 668 | 46,789 | 744 | 941 | 3,590 | 1,321 | 965 | **89,704** |
| Poughkeepsie | City | 61,270 | 88,475 | 1,728 | 145,067 | 2,518 | 3,185 | 12,151 | 0 | 7,941 | **322,336** |
| Poughkeepsie | Town | 90,650 | 155,145 | 60,265 | 186,459 | 3,334 | 4,217 | 16,087 | 341 | 16,566 | **533,064** |
| Red Hook | Town | 25,088 | 19,802 | 31 | 40,038 | 871 | 1,101 | 4,201 | 1,582 | 1,687 | **94,401** |
| Rhinebeck | Town | 19,851 | 17,277 | 204 | 34,324 | 581 | 734 | 2,802 | 1,071 | 1,487 | **78,331** |
| Stanford | Town | 11,825 | 6,163 | 5 | 19,445 | 294 | 372 | 1,419 | 4,079 | 563 | **44,164** |
| Union Vale | Town | 12,777 | 6,315 | 13 | 23,035 | 375 | 474 | 1,810 | 2,153 | 634 | **47,586** |
| Wappinger | Town | 58,452 | 48,796 | 12,887 | 126,987 | 2,081 | 2,631 | 10,040 | 540 | 5,535 | **267,948** |
| Washington | Town | 13,495 | 9,508 | 71 | 23,344 | 365 | 461 | 1,760 | 5,483 | 873 | **55,360** |
| **Allocated Total** | | **679,471** | **653,897** | **339,750** | **1,326,356** | **22,883** | **28,942** | **110,421** | **32,315** | **74,686** | **3,268,722** |

**Table 22 – Dutchess County; Total Emissions by Municipality and Sector, $MTCO_2e$, Continued**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| *Village emissions, included in town totals* | | | | | | | | | | | |
| *Fishkill* | *Village* | *3,328* | *6,531* | *238* | *12,368* | *167* | *211* | *806* | *0* | *504* | ***24,153*** |
| *Millbrook* | *Village* | *3,940* | *3,907* | *2* | *8,296* | *112* | *141* | *539* | *258* | *312* | ***17,507*** |
| *Millerton* | *Village* | *2,041* | *1,877* | *186* | *3,622* | *74* | *93* | *356* | *13* | *178* | ***8,439*** |
| *Pawling* | *Village* | *5,289* | *4,959* | *2,912* | *11,172* | *181* | *228* | *871* | *0* | *596* | ***26,208*** |
| *Red Hook* | *Village* | *5,098* | *4,203* | *17* | *9,799* | *151* | *191* | *728* | *0* | *324* | ***20,511*** |
| *Rhinebeck* | *Village* | *6,742* | *7,891* | *36* | *14,018* | *204* | *258* | *986* | *0* | *604* | ***30,739*** |
| *Tivoli* | *Village* | *2,542* | *1,596* | *2* | *4,884* | *86* | *109* | *415* | *29* | *171* | ***9,834*** |
| *Wappingers Falls* | *Village* | *9,435* | *11,051* | *102* | *28,821* | *425* | *537* | *2,050* | *4* | *914* | ***53,339*** |

Note: Totals may not sum due to independent rounding.

**Table 23 – Orange County; Total Emissions by Municipality and Sector, $MTCO_2e$**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| Blooming Grove | Town | 50,623 | 22,597 | 1,753 | 113,534 | 5,132 | 1,754 | 6,692 | 2,144 | 4,797 | **209,025** |
| Chester | Town | 28,884 | 29,318 | 4,667 | 73,704 | 3,411 | 1,166 | 4,447 | 1,351 | 4,478 | **151,425** |
| Cornwall | Town | 32,477 | 19,786 | 533 | 84,790 | 3,600 | 1,230 | 4,694 | 802 | 2,506 | **150,419** |
| Crawford | Town | 23,585 | 16,327 | 151 | 57,801 | 2,652 | 906 | 3,458 | 2,431 | 1,845 | **109,155** |
| Deerpark | Town | 20,651 | 16,761 | 2,789 | 54,893 | 2,249 | 769 | 2,933 | 676 | 2,419 | **104,140** |
| Goshen | Town | 33,156 | 45,662 | 6,118 | 68,537 | 3,896 | 1,332 | 5,080 | 5,148 | 7,311 | **176,241** |
| Greenville | Town | 11,066 | 5,866 | 55 | 27,784 | 1,314 | 449 | 1,713 | 909 | 729 | **49,887** |
| Hamptonburgh | Town | 14,000 | 4,789 | 155 | 26,840 | 1,583 | 541 | 2,064 | 2,445 | 603 | **53,021** |
| Highlands | Town | 10,857 | 63,198 | 3,783 | 12,281 | 3,556 | 1,215 | 4,637 | 371 | 5,277 | **105,175** |
| Middletown | City | 59,053 | 77,208 | 14,316 | 147,781 | 7,996 | 2,732 | 45,223 | 47 | 14,765 | **369,121** |
| Minisink | Town | 12,644 | 3,233 | 177 | 26,487 | 1,278 | 437 | 1,667 | 3,255 | 744 | **49,922** |
| Monroe | Town | 77,811 | 42,896 | 5,792 | 144,233 | 11,362 | 3,883 | 14,815 | 339 | 10,715 | **311,847** |
| Montgomery | Town | 51,000 | 43,484 | 5,692 | 143,207 | 6,435 | 2,199 | 8,391 | 4,471 | 4,965 | **269,844** |
| Mount Hope | Town | 14,791 | 6,280 | 509 | 38,275 | 1,998 | 683 | 2,605 | 734 | 520 | **66,395** |
| New Windsor | Town | 56,196 | 47,323 | 29,427 | 168,378 | 7,186 | 2,456 | 9,370 | 1,856 | 7,184 | **329,376** |
| Newburgh | City | 43,256 | 65,379 | 3,812 | 120,512 | 8,218 | 2,808 | 10,714 | 0 | 6,853 | **261,553** |
| Newburgh | Town | 75,772 | 70,661 | 40,562 | 193,481 | 8,484 | 2,899 | 11,062 | 1,771 | 9,780 | **414,472** |
| Port Jervis | City | 22,211 | 24,204 | 4,289 | 57,285 | 2,513 | 859 | 3,277 | 12 | 4,982 | **119,632** |
| Tuxedo | Town | 11,067 | 5,927 | 741 | 23,000 | 1,032 | 353 | 1,345 | 320 | 1,035 | **44,819** |
| Wallkill | Town | 56,079 | 122,792 | 23,624 | 180,536 | 7,808 | 2,668 | 10,180 | 1,950 | 17,487 | **423,124** |
| Warwick | Town | 87,891 | 53,993 | 7,080 | 210,032 | 9,128 | 3,120 | 11,902 | 6,067 | 9,628 | **398,840** |
| Wawayanda | Town | 16,964 | 11,237 | 1,689 | 42,498 | 2,068 | 707 | 2,697 | 3,145 | 1,731 | **82,737** |
| Woodbury | Town | 28,235 | 24,816 | 2,245 | 63,796 | 3,232 | 1,105 | 4,214 | 543 | 3,986 | **132,171** |
| **Allocated Total** | | **838,269** | **823,741** | **159,959** | **2,079,664** | **106,133** | **36,270** | **173,179** | **40,787** | **124,338** | **4,382,339** |

**Table 24 – Orange County; Total Emissions by Municipality and Sector, $MTCO_2e$, Continued**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| *Village emissions, included in town totals* | | | | | | | | | | | |
| *Chester* | *Village* | *7,331* | *13,425* | *2,322* | *28,845* | *1,130* | *386* | *1,473* | *0* | *2,016* | ***56,928*** |
| *Cornwall-on-Hudson* | *Village* | *9,315* | *4,751* | *9* | *19,173* | *859* | *294* | *1,120* | *23* | *788* | ***36,332*** |
| *Florida* | *Village* | *8,007* | *5,387* | *763* | *20,553* | *806* | *276* | *1,052* | *91* | *1,256* | ***38,191*** |
| *Goshen* | *Village* | *14,068* | *22,162* | *1,254* | *32,280* | *1,553* | *531* | *2,024* | *0* | *3,630* | ***77,502*** |
| *Greenwood Lake* | *Village* | *9,812* | *3,860* | *423* | *21,224* | *898* | *307* | *1,171* | *9* | *1,186* | ***38,890*** |
| *Harriman* | *Village* | *5,428* | *8,859* | *1,496* | *18,824* | *690* | *236* | *900* | *42* | *1,339* | ***37,814*** |
| *Highland Falls* | *Village* | *7,378* | *5,068* | *356* | *15,612* | *1,110* | *379* | *1,448* | *6* | *705* | ***32,062*** |
| *Kiryas Joel* | *Village* | *29,260* | *11,407* | *1,284* | *27,238* | *5,743* | *1,963* | *7,489* | *3* | *4,035* | ***88,423*** |
| *Maybrook* | *Village* | *5,392* | *5,460* | *222* | *20,181* | *842* | *288* | *1,098* | *25* | *654* | ***34,162*** |
| *Monroe* | *Village* | *18,737* | *13,287* | *2,001* | *47,614* | *2,381* | *814* | *3,105* | *0* | *3,017* | ***90,955*** |
| *Montgomery* | *Village* | *5,798* | *3,811* | *69* | *24,107* | *1,086* | *371* | *1,416* | *0* | *494* | ***37,152*** |
| *Otisville* | *Village* | *2,928* | *2,042* | *77* | *7,937* | *304* | *104* | *396* | *8* | *215* | ***14,013*** |
| *South Blooming Grove* | *Village* | *9,932* | *5,035* | *80* | *22,677* | *921* | *315* | *1,200* | *85* | *1,379* | ***41,625*** |
| *Tuxedo Park* | *Village* | *2,546* | *694* | *59* | *2,991* | *177* | *61* | *231* | *9* | *121* | ***6,888*** |
| *Unionville* | *Village* | *1,517* | *613* | *85* | *2,782* | *174* | *60* | *227* | *2* | *207* | ***5,667*** |
| *Walden* | *Village* | *15,884* | *9,604* | *1,970* | *49,303* | *1,986* | *679* | *2,590* | *14* | *1,520* | ***83,551*** |
| *Warwick* | *Village* | *14,294* | *13,639* | *2,082* | *50,617* | *1,916* | *655* | *2,498* | *0* | *2,745* | ***88,445*** |
| *Washingtonville* | *Village* | *12,007* | *8,310* | *1,043* | *38,906* | *1,679* | *574* | *2,190* | *322* | *1,306* | ***66,336*** |
| *Woodbury* | *Village* | *26,915* | *22,547* | *1,864* | *58,534* | *3,042* | *1,040* | *3,966* | *0* | *2,710* | ***120,619*** |

Note: Totals may not sum due to independent rounding.

**Table 25 – Putnam County; Total Emissions by Municipality and Sector, $MTCO_2e$**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| Carmel | Town | 90,289 | 59,094 | 8,632 | 329,339 | 2,618 | 3,337 | 12,733 | 1,873 | 6,044 | **513,960** |
| Kent | Town | 38,158 | 12,204 | 24 | 136,234 | 1,031 | 1,314 | 5,014 | 1,205 | 1,474 | **196,656** |
| Patterson | Town | 24,962 | 19,201 | 1,147 | 92,850 | 917 | 1,170 | 4,463 | 2,764 | 2,213 | **149,686** |
| Philipstown | Town | 27,845 | 10,954 | 20 | 75,784 | 737 | 940 | 3,586 | 1,956 | 1,106 | **122,930** |
| Putnam Valley | Town | 33,481 | 10,496 | 2 | 116,212 | 901 | 1,149 | 4,383 | 1,080 | 1,356 | **169,060** |
| Southeast | Town | 46,148 | 40,605 | 6,863 | 187,625 | 1,404 | 1,790 | 6,831 | 3,965 | 5,179 | **300,411** |
| **Allocated Total** | | **418,899** | **262,932** | **29,376** | **1,325,368** | **29,662** | **17,237** | **65,764** | **13,359** | **37,818** | **2,200,415** |
| *Village emissions, included in town totals* | | | | | | | | | | | |
| *Brewster* | *Village* | *4,715* | *6,091* | *7* | *17,940* | *182* | *233* | *887* | *0* | *640* | ***30,695*** |
| *Cold Spring* | *Village* | *5,097* | *2,895* | *1* | *13,505* | *154* | *196* | *747* | *6* | *214* | ***22,814*** |
| *Nelsonville* | *Village* | *1,576* | *549* | *2* | *4,738* | *48* | *61* | *233* | *34* | *48* | ***7,287*** |

Note: Totals may not sum due to independent rounding.

**Table 26 – Rockland County; Total Emissions by Municipality and Sector, $MTCO_2e$**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| Clarkstown | Town | 236,290 | 140,907 | 29,317 | 410,181 | 26,170 | 8,190 | 31,248 | 2,855 | 42,718 | **927,877** |
| Haverstraw | Town | 73,405 | 55,433 | 12,084 | 168,994 | 11,388 | 3,564 | 13,598 | 1,178 | 14,923 | **354,567** |
| Orangetown | Town | 128,717 | 155,935 | 38,034 | 214,800 | 15,298 | 4,788 | 18,266 | 1,654 | 32,823 | **610,314** |
| Ramapo | Town | 277,478 | 164,732 | 36,368 | 422,741 | 39,353 | 12,316 | 46,989 | 6,016 | 51,696 | **1,057,690** |
| Stony Point | Town | 44,519 | 18,775 | 4,256 | 80,081 | 4,681 | 1,465 | 5,590 | 3,519 | 7,265 | **170,150** |
| **Allocated Total** | | **1,451,579** | **960,802** | **166,132** | **3,596,392** | **134,544** | **57,751** | **220,334** | **41,463** | **205,515** | **6,834,513** |

**Table 27 – Rockland County; Total Emissions by Municipality and Sector, $MTCO_2e$, Continued**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| | | | | | | | | | | | |
| *Village emissions, included in town totals* | | | | | | | | | | | |
| *Airmont* | *Village* | *23,720* | *12,306* | *2,552* | *36,704* | *2,682* | *839* | *3,203* | *317* | *4,062* | ***86,387*** |
| *Chestnut Ridge* | *Village* | *23,598* | *11,153* | *2,400* | *34,330* | *2,461* | *770* | *2,938* | *826* | *4,095* | ***82,571*** |
| *Grand View-on-Hudson* | *Village* | *2,185* | *135* | *24* | *1,281* | *89* | *28* | *106* | *0* | *267* | ***4,115*** |
| *Haverstraw* | *Village* | *18,017* | *14,798* | *3,370* | *40,730* | *3,702* | *1,159* | *4,421* | *0* | *4,066* | ***90,263*** |
| *Hillburn* | *Village* | *2,368* | *4,355* | *848* | *4,353* | *296* | *93* | *353* | *173* | *710* | ***13,548*** |
| *Kaser* | *Village* | *5,728* | *292* | *36* | *4,485* | *1,468* | *460* | *1,753* | *4* | *656* | ***14,883*** |
| *Montebello* | *Village* | *17,047* | *9,863* | *2,112* | *18,386* | *1,407* | *440* | *1,680* | *714* | *3,093* | ***54,743*** |
| *New Hempstead* | *Village* | *13,925* | *3,491* | *746* | *17,320* | *1,595* | *499* | *1,905* | *606* | *1,976* | ***42,065*** |
| *New Square* | *Village* | *9,996* | *2,190* | *448* | *6,151* | *2,159* | *676* | *2,577* | *61* | *1,370* | ***25,628*** |
| *Nyack* | *Village* | *14,610* | *20,230* | *4,583* | *40,729* | *2,103* | *658* | *2,511* | *40* | *4,318* | ***89,782*** |
| *Piermont* | *Village* | *6,680* | *3,567* | *786* | *18,736* | *780* | *244* | *932* | *11* | *1,190* | ***32,927*** |
| *Pomona* | *Village* | *15,247* | *6,504* | *1,342* | *15,979* | *965* | *302* | *1,152* | *63* | *2,417* | ***43,971*** |
| *Sloatsburg* | *Village* | *8,754* | *2,504* | *483* | *15,910* | *945* | *296* | *1,128* | *82* | *1,143* | ***31,245*** |
| *South Nyack* | *Village* | *7,724* | *3,475* | *789* | *9,408* | *1,091* | *341* | *1,303* | *60* | *1,315* | ***25,506*** |
| *Spring Valley* | *Village* | *33,609* | *34,810* | *7,931* | *95,224* | *9,744* | *3,050* | *11,635* | *11* | *8,245* | ***204,259*** |
| *Suffern* | *Village* | *23,879* | *40,853* | *9,329* | *61,917* | *3,333* | *1,043* | *3,980* | *27* | *7,955* | ***152,316*** |
| *Upper Nyack* | *Village* | *7,526* | *1,758* | *368* | *10,479* | *641* | *201* | *766* | *134* | *1,088* | ***22,960*** |
| *Wesley Hills* | *Village* | *16,719* | *1,627* | *310* | *19,697* | *1,750* | *548* | *2,089* | *144* | *2,064* | ***44,947*** |
| *West Haverstraw* | *Village* | *18,499* | *14,236* | *3,184* | *47,865* | *3,160* | *989* | *3,773* | *27* | *3,953* | ***95,688*** |

Note: Totals may not sum due to independent rounding.

**Table 28 – Sullivan County; Total Emissions by Municipality and Sector, $MTCO_2e$**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| Bethel | Town | 15,372 | 7,469 | 12 | 25,412 | 1,395 | 414 | 1,579 | 2,976 | 797 | **55,427** |
| Callicoon | Town | 9,794 | 4,511 | 38 | 23,299 | 1,002 | 297 | 1,135 | 3,360 | 357 | **43,793** |
| Cochecton | Town | 3,842 | 1,879 | 287 | 8,539 | 450 | 133 | 509 | 1,716 | 176 | **17,533** |
| Delaware | Town | 7,409 | 6,245 | 21 | 17,526 | 876 | 260 | 991 | 2,662 | 451 | **36,441** |
| Fallsburg | Town | 28,929 | 22,309 | 4,216 | 45,520 | 4,220 | 1,252 | 4,777 | 806 | 2,442 | **114,471** |
| Forestburgh | Town | 3,020 | 1,029 | 29 | 6,408 | 269 | 80 | 304 | 34 | 88 | **11,260** |
| Fremont | Town | 3,945 | 1,576 | 85 | 9,081 | 453 | 134 | 513 | 2,432 | 242 | **18,459** |
| Highland | Town | 7,621 | 3,573 | 0 | 14,813 | 830 | 246 | 939 | 139 | 330 | **28,490** |
| Liberty | Town | 24,450 | 19,220 | 3,250 | 54,797 | 3,242 | 962 | 3,669 | 2,476 | 1,694 | **113,760** |
| Lumberland | Town | 7,079 | 2,934 | 125 | 15,201 | 809 | 240 | 916 | 69 | 237 | **27,611** |
| Mamakating | Town | 32,664 | 13,640 | 586 | 77,551 | 3,963 | 1,176 | 4,486 | 505 | 936 | **135,507** |
| Neversink | Town | 9,963 | 4,254 | 7 | 21,530 | 1,166 | 346 | 1,320 | 553 | 324 | **39,464** |
| Rockland | Town | 11,045 | 6,309 | 1 | 23,259 | 1,238 | 367 | 1,401 | 1,423 | 529 | **45,572** |
| Thompson | Town | 41,211 | 38,771 | 889 | 83,561 | 5,020 | 1,489 | 5,682 | 461 | 3,223 | **180,306** |
| Tusten | Town | 4,506 | 2,186 | 97 | 8,534 | 497 | 147 | 562 | 271 | 199 | **16,999** |
| **Allocated Total** | | **311,080** | **229,187** | **30,764** | **670,212** | **44,058** | **13,375** | **51,027** | **20,227** | **35,333** | **1,405,263** |
| ***Village emissions, included in town totals*** | | | | | | | | | | | |
| *Bloomingburg* | *Village* | *834* | *526* | *39* | *2,230* | *138* | *41* | *156* | *7* | *42* | ***4,012*** |
| *Jeffersonville* | *Village* | *975* | *874* | *0* | *2,239* | *118* | *35* | *133* | *4* | *60* | ***4,439*** |
| *Liberty* | *Village* | *7,911* | *8,478* | *3,200* | *21,112* | *1,440* | *427* | *1,630* | *0* | *762* | ***44,962*** |
| *Monticello* | *Village* | *12,996* | *15,038* | *22* | *34,114* | *2,206* | *654* | *2,497* | *26* | *1,065* | ***68,617*** |
| *Woodridge* | *Village* | *2,181* | *1,682* | *3,440* | *4,648* | *278* | *82* | *314* | *4* | *380* | ***13,009*** |
| *Wurtsboro* | *Village* | *2,733* | *1,670* | *132* | *6,558* | *409* | *121* | *462* | *6* | *127* | ***12,219*** |

Note: Totals may not sum due to independent rounding.

**Table 29 – Ulster County; Total Emissions by Municipality and Sector, $MTCO_2e$**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| Denning | Town | 1,591 | 1,082 | 0 | 3,774 | 109 | 54 | 205 | 158 | 114 | **7,088** |
| Esopus | Town | 22,124 | 14,795 | 689 | 54,415 | 1,794 | 880 | 3,356 | 402 | 1,436 | **99,889** |
| Gardiner | Town | 15,538 | 7,406 | 41 | 34,546 | 1,133 | 556 | 2,121 | 1,778 | 669 | **63,788** |
| Hardenburgh | Town | 588 | 252 | 0 | 959 | 47 | 23 | 88 | 743 | 31 | **2,733** |
| Hurley | Town | 19,457 | 6,995 | 21 | 40,341 | 1,253 | 614 | 2,344 | 97 | 505 | **71,627** |
| Kingston | City | 53,832 | 71,126 | 2,252 | 140,380 | 4,740 | 2,325 | 8,869 | 0 | 6,723 | **290,246** |
| Kingston | Town | 2,978 | 1,799 | 67 | 5,922 | 176 | 86 | 330 | 78 | 124 | **11,560** |
| Lloyd | Town | 23,325 | 19,839 | 1,950 | 60,924 | 2,155 | 1,057 | 4,032 | 634 | 1,903 | **115,819** |
| Marbletown | Town | 17,471 | 7,988 | 1,189 | 33,648 | 1,112 | 545 | 2,081 | 984 | 650 | **65,669** |
| Marlborough | Town | 23,688 | 12,953 | 3,530 | 51,223 | 1,747 | 857 | 3,269 | 1,271 | 1,225 | **99,764** |
| New Paltz | Town | 23,657 | 29,821 | 198 | 50,284 | 2,778 | 1,362 | 5,198 | 1,198 | 2,133 | **116,628** |
| Olive | Town | 13,736 | 7,071 | 232 | 26,804 | 877 | 430 | 1,640 | 143 | 645 | **51,577** |
| Plattekill | Town | 24,638 | 12,227 | 6 | 57,644 | 2,083 | 1,021 | 3,897 | 875 | 1,295 | **103,686** |
| Rochester | Town | 21,973 | 10,836 | 21 | 45,439 | 1,451 | 711 | 2,714 | 1,178 | 945 | **85,269** |
| Rosendale | Town | 17,726 | 10,067 | 3 | 40,744 | 1,205 | 591 | 2,255 | 243 | 761 | **73,596** |
| Saugerties | Town | 51,913 | 30,236 | 47,847 | 120,027 | 3,865 | 1,895 | 7,231 | 799 | 3,473 | **267,287** |
| Shandaken | Town | 10,622 | 7,025 | 0 | 21,237 | 612 | 300 | 1,145 | 159 | 603 | **41,703** |
| Shawangunk | Town | 27,997 | 12,852 | 4,544 | 59,440 | 2,843 | 1,394 | 5,320 | 3,494 | 1,433 | **119,317** |
| Ulster | Town | 30,184 | 53,564 | 1,819 | 80,940 | 2,445 | 1,199 | 4,576 | 464 | 4,075 | **179,266** |
| Wawarsing | Town | 27,295 | 22,757 | 686 | 60,208 | 2,610 | 1,280 | 4,884 | 777 | 1,928 | **122,425** |
| Woodstock | Town | 20,922 | 9,229 | 1,079 | 27,619 | 1,167 | 572 | 2,184 | 172 | 1,015 | **63,958** |
| **Allocated Total** | | **451,256** | **349,919** | **66,172** | **1,016,519** | **36,203** | **17,754** | **67,738** | **15,645** | **31,688** | **2,052,894** |

**Table 30 – Ulster County; Total Emissions by Municipality and Sector, $MTCO_2e$, Continued**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| *Village emissions, included in town totals* | | | | | | | | | | | |
| *Ellenville* | *Village* | *8,688* | *6,842* | *468* | *20,413* | *820* | *402* | *1,535* | *11* | *581* | ***39,760*** |
| *New Paltz* | *Village* | *6,572* | *17,642* | *14* | *14,916* | *1,353* | *663* | *2,531* | *0* | *1,222* | ***44,912*** |
| *Saugerties* | *Village* | *10,787* | *10,290* | *29* | *27,164* | *788* | *386* | *1,474* | *0* | *980* | ***51,898*** |

Note: Totals may not sum due to independent rounding.

**Table 31 – Westchester County; Total Emissions by Municipality and Sector, $MTCO_2e$**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| Bedford | Town | 54,782 | 43,096 | 1,166 | 63,690 | 1,006 | 1,686 | 6,434 | 2,325 | 5,394 | **179,580** |
| Cortlandt | Town | 111,556 | 85,325 | 56,589 | 182,826 | 2,413 | 4,046 | 15,438 | 913 | 18,623 | **477,729** |
| Eastchester | Town | 89,835 | 74,569 | 4,058 | 137,667 | 1,877 | 3,149 | 12,012 | 15 | 13,041 | **336,224** |
| Greenburgh | Town | 246,273 | 252,032 | 20,933 | 378,628 | 5,128 | 8,600 | 32,812 | 191 | 37,532 | **982,130** |
| Harrison | Town | 73,897 | 82,952 | 7,909 | 99,389 | 1,594 | 2,673 | 10,197 | 283 | 12,161 | **291,055** |
| Lewisboro | Town | 41,544 | 25,352 | 27 | 54,436 | 720 | 1,207 | 4,607 | 847 | 3,116 | **131,856** |
| Mamaroneck | Town | 84,533 | 62,320 | 3,284 | 101,730 | 1,691 | 2,837 | 10,822 | 12 | 10,826 | **278,054** |
| Mount Kisco | Town | 25,174 | 36,158 | 3,324 | 47,809 | 631 | 1,058 | 4,037 | 29 | 4,545 | **122,765** |
| Mount Pleasant | Town | 115,776 | 115,420 | 10,078 | 168,665 | 2,536 | 4,254 | 16,229 | 1,278 | 16,061 | **450,298** |
| Mount Vernon | City | 146,601 | 143,773 | 7,409 | 282,854 | 3,904 | 6,547 | 24,977 | 6 | 16,882 | **632,953** |
| New Castle | Town | 60,028 | 31,945 | 1,481 | 64,474 | 1,019 | 1,709 | 6,521 | 500 | 5,535 | **173,212** |
| New Rochelle | City | 180,752 | 160,383 | 8,476 | 289,423 | 4,470 | 7,497 | 28,604 | 6 | 25,079 | **704,692** |
| North Castle | Town | 36,651 | 36,055 | 3,774 | 42,141 | 687 | 1,152 | 4,395 | 656 | 4,535 | **130,046** |
| North Salem | Town | 16,262 | 10,312 | 21 | 21,876 | 296 | 497 | 1,894 | 2,088 | 1,244 | **54,490** |
| Ossining | Town | 88,606 | 78,930 | 4,890 | 150,037 | 2,185 | 3,665 | 13,984 | 256 | 12,203 | **354,756** |
| Peekskill | City | 52,469 | 51,159 | 2,834 | 99,822 | 1,368 | 2,294 | 8,754 | 58 | 7,133 | **225,891** |
| Pelham | Town | 34,881 | 24,364 | 1,378 | 44,288 | 719 | 1,206 | 4,601 | 0 | 4,260 | **115,698** |
| Pound Ridge | Town | 22,152 | 9,184 | 0 | 20,245 | 296 | 497 | 1,894 | 624 | 1,399 | **56,291** |
| Rye | City | 49,489 | 35,090 | 2,267 | 56,077 | 912 | 1,529 | 5,835 | 0 | 6,597 | **157,797** |
| Rye | Town | 109,458 | 105,270 | 7,189 | 174,799 | 2,664 | 4,468 | 17,048 | 108 | 16,077 | **437,080** |
| Scarsdale | Town | 61,847 | 24,501 | 580 | 49,337 | 996 | 1,670 | 6,372 | 14 | 7,231 | **152,548** |
| Somers | Town | 64,255 | 42,647 | 7,176 | 104,797 | 1,185 | 1,988 | 7,585 | 2,060 | 6,287 | **237,980** |
| White Plains | City | 136,157 | 180,138 | 15,175 | 230,334 | 3,298 | 5,531 | 21,103 | 23 | 23,180 | **614,939** |
| Yonkers | City | 409,705 | 414,387 | 107,740 | 784,721 | 11,368 | 19,066 | 72,742 | 55 | 68,249 | **1,888,033** |
| Yorktown | Town | 102,371 | 76,197 | 12,959 | 189,179 | 2,093 | 3,510 | 13,393 | 847 | 10,136 | **410,685** |
| **Allocated Total** | | **2,360,271** | **2,158,462** | **289,552** | **3,775,553** | **54,052** | **90,651** | **345,857** | **10,868** | **331,932** | **9,417,199** |

**Table 32 – Westchester County; Total Emissions by Municipality and Sector, $MTCO_2e$, Continued**

| Municipality | Type | Stationary Energy | | | Mobile Energy | Solid Waste | Wastewater Treatment | Industrial Processes | Agriculture | Energy Supply | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | Commercial | Industrial | | | | | | | |
| *Village emissions, included in town totals* | | | | | | | | | | | |
| *Ardsley* | *Village* | *13,505* | *8,753* | *464* | *18,959* | *258* | *433* | *1,652* | *18* | *1,933* | ***45,975*** |
| *Briarcliff Manor* | *Village* | *25,077* | *22,228* | *2,074* | *26,844* | *456* | *765* | *2,920* | *145* | *3,797* | ***84,307*** |
| *Bronxville* | *Village* | *18,359* | *16,273* | *1,262* | *17,290* | *367* | *615* | *2,347* | *2* | *2,623* | ***59,138*** |
| *Buchanan* | *Village* | *6,386* | *9,945* | *1,146* | *12,274* | *129* | *217* | *828* | *14* | *1,198* | ***32,137*** |
| *Croton-on-Hudson* | *Village* | *23,628* | *15,873* | *696* | *33,425* | *468* | *785* | *2,995* | *152* | *2,721* | ***80,744*** |
| *Dobbs Ferry* | *Village* | *26,720* | *24,904* | *1,688* | *38,047* | *631* | *1,058* | *4,037* | *8* | *3,838* | ***100,930*** |
| *Elmsford* | *Village* | *10,946* | *14,414* | *1,301* | *21,900* | *271* | *454* | *1,731* | *2* | *2,080* | ***53,099*** |
| *Harrison* | *Village* | *46,702* | *34,086* | *0* | *99,389* | *1,594* | *2,673* | *10,197* | *0* | *6,777* | ***201,417*** |
| *Hastings-on-Hudson* | *Village* | *21,934* | *15,595* | *721* | *29,787* | *455* | *764* | *2,913* | *4* | *2,925* | ***75,098*** |
| *Irvington* | *Village* | *18,747* | *13,084* | *541* | *24,947* | *372* | *625* | *2,383* | *8* | *2,226* | ***62,932*** |
| *Larchmont* | *Village* | *17,244* | *10,432* | *399* | *15,017* | *340* | *570* | *2,177* | *4* | *2,054* | ***48,238*** |
| *Mamaroneck* | *Village* | *50,293* | *45,668* | *3,156* | *77,748* | *1,098* | *1,842* | *7,026* | *0* | *7,278* | ***194,108*** |
| *Mount Kisco* | *Village* | *25,174* | *36,158* | *3,324* | *47,809* | *631* | *1,058* | *4,037* | *0* | *4,545* | ***122,736*** |
| *Ossining* | *Village* | *50,620* | *46,971* | *2,241* | *101,090* | *1,454* | *2,438* | *9,302* | *0* | *6,780* | ***220,896*** |
| *Pelham Manor* | *Village* | *16,518* | *11,702* | *837* | *20,993* | *318* | *534* | *2,036* | *0* | *2,070* | ***55,010*** |
| *Pelham* | *Village* | *18,366* | *12,662* | *541* | *22,986* | *401* | *672* | *2,565* | *0* | *2,194* | ***60,386*** |
| *Pleasantville* | *Village* | *20,297* | *16,049* | *889* | *31,273* | *407* | *683* | *2,605* | *2* | *2,594* | ***74,799*** |
| *Port Chester* | *Village* | *59,643* | *68,249* | *4,856* | *104,008* | *1,680* | *2,818* | *10,752* | *0* | *9,327* | ***261,334*** |
| *Rye Brook* | *Village* | *28,881* | *19,340* | *1,095* | *41,028* | *542* | *909* | *3,469* | *79* | *3,727* | ***99,071*** |
| *Scarsdale* | *Village* | *61,847* | *24,501* | *580* | *49,337* | *996* | *1,670* | *6,372* | *0* | *7,231* | ***152,534*** |
| *Sleepy Hollow* | *Village* | *18,896* | *14,421* | *0* | *30,838* | *573* | *960* | *3,664* | *273* | *2,460* | ***72,084*** |
| *Tarrytown* | *Village* | *32,167* | *40,014* | *3,968* | *45,908* | *654* | *1,097* | *4,186* | *22* | *5,378* | ***133,394*** |
| *Tuckahoe* | *Village* | *15,332* | *14,622* | *696* | *28,210* | *376* | *631* | *2,407* | *0* | *2,351* | ***64,626*** |

Note: Totals may not sum due to independent rounding.