

GHG Inventory Report

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Prepared for:

Prepared by:

ECOLOGY AND ENVIRONMENT, INC.

368 Pleasant View Drive
Lancaster, New York 14086

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Introduction

As part of the NYSERDA Cleaner, Greener Communities (CGC) Program, each region in New York State was required, under the terms of its NYSERDA grant, to complete a GHG inventory to provide a baseline indication of emissions sources for the region. Each region would then be able to use the GHG inventory results to identify priorities for developing sustainability goals and actions.

NYSERDA established the GHG Inventory Protocol Working Group (NYGHG Protocol Group) to develop a New York Tier II Regional GHG Inventory Protocol (NYGHG Protocol). While a formal GHG Protocol document has not yet been established, the NYGHG Protocol Group created a reporting template in Microsoft Excel to provide a summary of the agreed-upon GHG inventory calculation methods and to report the resulting GHG inventory for each region. The completed Western New York (WNY) reporting template was submitted to NYSERDA in October and is provided as Attachment A.

This document provides additional specific details and summaries of the GHG inventory data and calculation methodologies required by NYSERDA. In addition, this report includes data and calculations that were provided to working groups to support and inform the sustainability planning process.

The results of the Tier II GHG inventory for WNY are summarized below in Figure 1. The total GHG emissions for 2010 in WNY were estimated at 17.5 million metric tons (MT) of carbon dioxide equivalents (CO₂e).

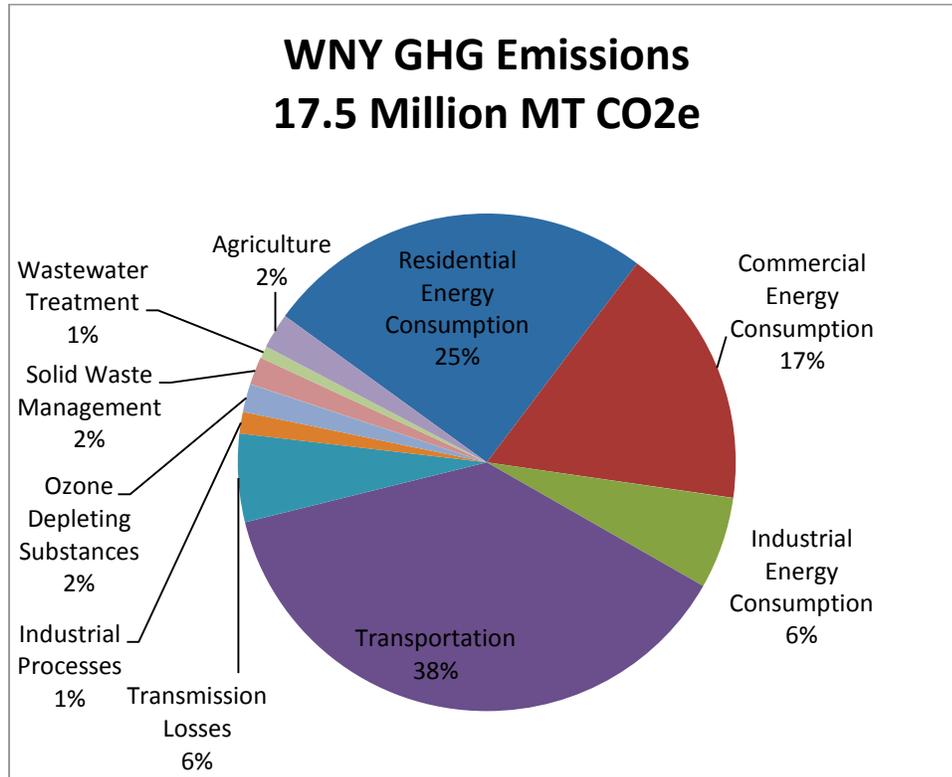


Figure 1 Western New York CO₂e Emissions Baseline Year 2010

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GH Inventory Development Process

2.1 Development of a NYGHG Protocol

NYSERDA established the GHG Inventory Protocol Working Group (New York GHG [NYGHG] Protocol Group) to establish a uniform method for the development of the regional GHG inventories. This group was assigned to develop a New York Tier II Regional GHG Inventory Protocol (NYGHG Protocol) for the NYSERDA CGC and NYSDEC Climate Smart Community (CGC) programs, led and facilitated by Mr. Jim Yienger of Climate Action Associates and Ms. Peggy Foran of The Climate Registry. The NYGHG Working Group is made up of members from other regional teams in the state and representatives of New York State agencies such as the Department of Transportation (NYSDOT), the Department of Environmental Conservation (NYSDEC), and NYSERDA.

The NYGHG Protocol Group began meeting in March 2012 to review existing data, procedures, and methods used by federal, state, and non-governmental organizations (NGOs) such as The Climate Registry and the International Council for Local Environmental Initiatives (ICLEI). Other specific methods reviewed and used as references include the EPA's Draft Regional GHG Inventory Guidelines (EPA 2010), ICLEI's C40 Global Protocol for Community-Scale GHG Emissions (ICLEI 2010), and the EPA's GHG Mandatory Reporting Rule (MRR) regulations (74 *Federal Register (FR)* 209).

The purpose of the NYGHG Protocol Group was to establish a Tier II regional GHG inventory protocol that would ensure consistency across the state while also preserving the priority of GHG emission source assessment of sectors critical and important to the various regions. This NYGHG Protocol Group collaborated for seven months on the NYGHG Protocol. While a formal GHG Protocol document has not yet been established, The NYGHG Protocol Group created a reporting template in Microsoft Excel that provides a summary of the agreed upon GHG Inventory calculation methods and GHG Inventory results for the region. This template was finalized and distributed to the regions on September 17, 2012.

NYSERDA provided the regions with a state-wide, preliminary Tier I GHG inventory in April 2012, estimating regional emissions based on allocation of state-level emissions (TRC 2012). This inventory was limited in that it provided only energy estimates, used a variety of years for source data, and used only population

or employment numbers to allocate energy use. This inventory did provide an approximate estimate of the allocation of energy use, and key reference sources.

To meet the project schedule and to provide useful information to the working groups, the WNY GHG Inventory was developed at the same time as the NYS Regional GHG Inventory Protocol. Therefore, the WNY regional planning team relied upon the discussions and references of the Protocol Group to collect data and assemble a Tier II GHG inventory, which uses specific regional data to the extent possible.

2.2 Regional GHG Inventory Purpose and Boundaries

The Tier II Regional GHG Inventory for WNY provides specific information for state, county and local decision makers to use in prioritizing state-wide as well as local efforts to reduce GHG emissions. While a Tier I, or “top down” inventory uses only allocation and averages to estimate regional emissions, a Tier II analysis uses a “bottom up” approach, using local utility usage or other specific regional data to create the inventory. Specific Tier II data was used when data were available, prioritizing efforts to collect information on large GHG emission sources or sources where specific data provided important information to the WNY Sustainability Plan Working Groups. Data sources for each sector are defined in the discussion of each sector in this document.

A regional GHG inventory is a collection of data summarizing the sources of GHG within and specific to a region, quantifying the GHG emissions that result from these sources. While state and national level GHG emissions have been estimated, quantification of GHG emissions on a regional level in New York State has not yet been accomplished. Valuable lessons were learned by the NYGHG Protocol Group through the NYGHG Protocol development process. Most importantly, energy use, transportation priorities, and data availability vary significantly across the state, and this effort provides key information to manage this variety. To be useful, this data needs to be collected and analyzed in a consistent, transparent, and replicable fashion.

2.2.1 Regional GHG Inventory Boundaries and Parameters

GHG inventory boundaries refer to geographic boundaries, time boundaries, and functional boundaries. The boundaries established for the WNY GHG inventory include the following:

- **Geographic Boundary:** Activities analyzed occur within the WNY region, in the counties of Allegany, Cattaraugus, Chautauqua, Erie, and Niagara.
- **Time Boundary:** Activities analyzed occur within the time frame of one year, providing an annual total comparable to other standard GHG inventories. The NYGHG Protocol established 2010 as the baseline year for this effort, to coincide with the U.S. Census. This also provides the most recent year where most data is available. For some sectors, 2010 data are not available, and in these cases the most recent data are used.

- **Functional Boundary:** The extent of GHG emission impacts is global, and therefore quantification of impacts from objects and activities can extend back to the extraction of raw materials and forward to the final disposal, resulting in a full life-cycle analysis. Establishing the functional boundary of this project is more difficult than establishing the other boundaries. In most cases, the geographic boundaries of the region were used to delineate the functional boundaries. For example, in the transportation analysis, vehicle miles traveled (VMT) on regional roads are considered, rather than trip number and length. Functional boundaries for each sector are defined in the discussion of each sector in this document.

In addition to boundaries, other GHG inventory parameters include source sector divisions and emission types to be included.

2.2.2 GHG Emission Source Sectors

The inventory includes an evaluation of the following source sectors:

- Energy
- Electricity generation
- Electricity consumption
- Direct consumption of fuel (natural gas, stationary fuel oil, bottled gas, and wood and biomass.
- Transmission losses
- Industrial uses and processes
- Transportation
- On-road transportation
- Rail, aviation, and commercial marine vessels
- Off-road, (or non-road) equipment and vehicles (for construction, landscaping, recreation, etc.)
- Waste and wastewater
- Agriculture
- Animal management (manure management, enteric fermentation)
- Agricultural management (fertilizer use, nitrogen-fixing crops)

- Forest carbon and urban trees

2.2.3 GHG Emission Types and Quantification

This inventory evaluates the impact carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), as well as hydrochlorofluorocarbon (HCFC) and chlorofluorocarbon (CFC), and sulfur hexafluoride (SF₆) that are primarily released as fugitive emissions. These six GHGs are internationally recognized as the predominant man-made greenhouse gases contributors and are also specified as such by EPA's MRR program (74 *FR* 209).

Different GHGs also have different capacities to trap heat in the atmosphere, i.e., global warming potential (GWP). For example, CH₄ has 21 times the impact on global warming compared with CO₂, and N₂O has 310 times the impact (74 *FR* 209). In order to compare and sum the impacts of different gases, all six defined emissions are quantified in terms of CO₂ impacts or CO₂e, calculated by multiplying emissions by their respective GWP.

As is customary for GHG inventory reporting, all emissions are reported in metric tons (MT) of carbon dioxide equivalent (MTCO₂e). To account for the difference in magnitude, total regional emissions are reported as million MTCO₂e, while per-capita emissions are reported as MTCO₂e.

3

WNY GHG Inventory Data Collection, Calculation Methods, and Results

3.1 Electricity Generation and Consumption

Electricity is categorized and tabulated in two separate ways in the GHG inventory: *generation* and *consumption*. *Generation* refers to the electricity created at power plants in the region, and the direct GHG emissions are calculated based on the specific type of fuel used. *Consumption* refers to electricity used in the region. These emissions are considered indirect and are calculated from sales data provided by utility companies and upstate NY average emission factors provided by the EPA's Emissions and Generation Resource Integrated Database (eGRID) (EPA 2012). The difference between generation and consumption, allowing for the transmission and distribution losses from regional consumption, represents electricity that is exported and therefore consumed outside the region.

Electricity generation was analyzed by fuel type. The 2010 data on the fuel type and volume and electricity generated and provided to the grid for all electricity-generating facilities in the region were collected from Department of Energy (DOE) Energy Information Administration (EIA) reporting programs (Form 923)(USEIA2011). GHG emission factors for each fuel type from the 2009 EPA GHG Mandatory Reporting Rule (MRR) Calculation Methodology Requirements were used to calculate GHG emissions (74 *FR* 209), using emission factors prescribed by this regulation (40 CFR 98). The assumptions related to the impacts of biogenic sources, e.g., wood and biomass, landfill gas, and waste-to-energy sources, were consistent with the requirements of the MRR methodology.

The boundaries established for this GHG inventory include the consumption of energy by the population, not generation, and therefore these data are not included in the region's total for energy or GHG emissions. However, the NYGHG Protocol Group acknowledged that the accuracy of the generation data, as well as its annual compilation, provided an excellent opportunity to assess the specific GHG emission impacts from generation with the regions and ultimately throughout the state. Figure 2 indicates regional electricity generation in megawatt-hours (MWh) by fuel type.

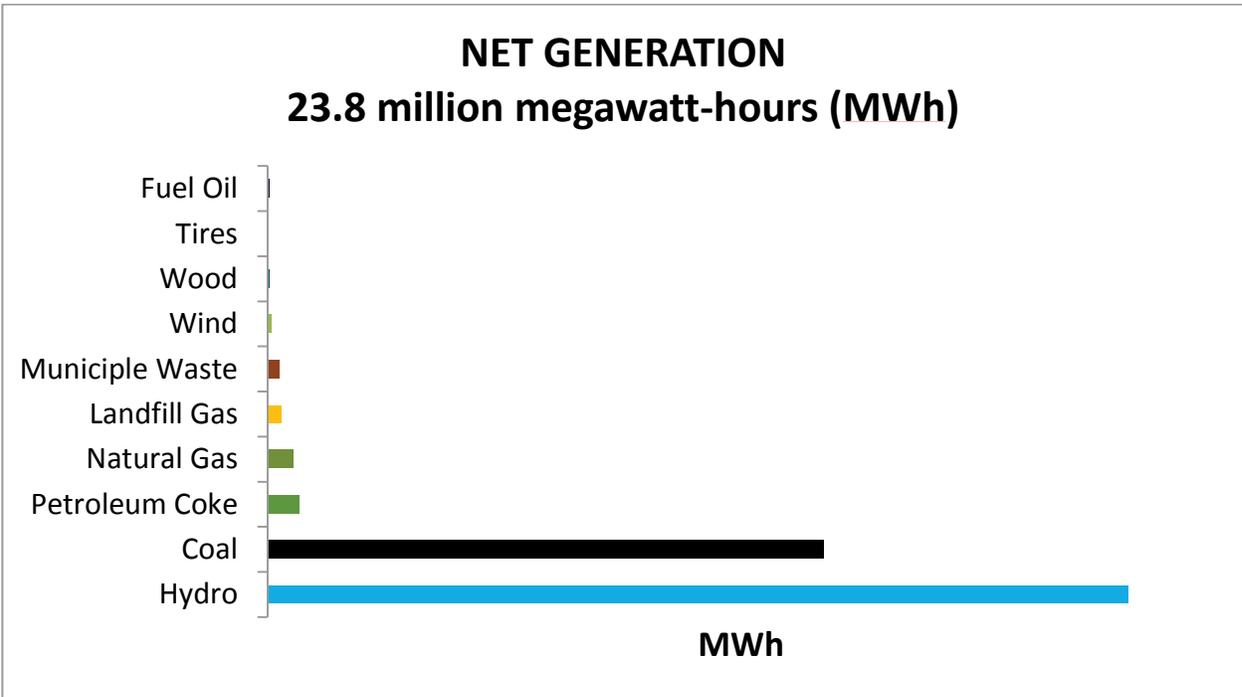


Figure 2 Western New York 2010 Grid-tied Electricity Generation

The WNY region generated 23.8 million MWh in 2010, producing 9.8 MT CO₂e. Most of this energy, more than 13.6 million MWh, was generated without direct GHG emissions at the Robert Moses hydro-electric plant in Niagara County. This renewable source, in addition to energy generation from wind, biomass, landfill gas, and waste-to-energy sources, results in a regional renewable energy percentage of 58% for 2010. This is one of the WNY energy sustainability indicators.

As renewable energy results in almost zero emissions, most GHG emissions from electricity generation in the region is from the use of coal. Figure 3 shows the GHG emissions from WNY grid-tied electricity generation.

3 WNY GHG Inventory Data Collection, Calculation Methods, and Results

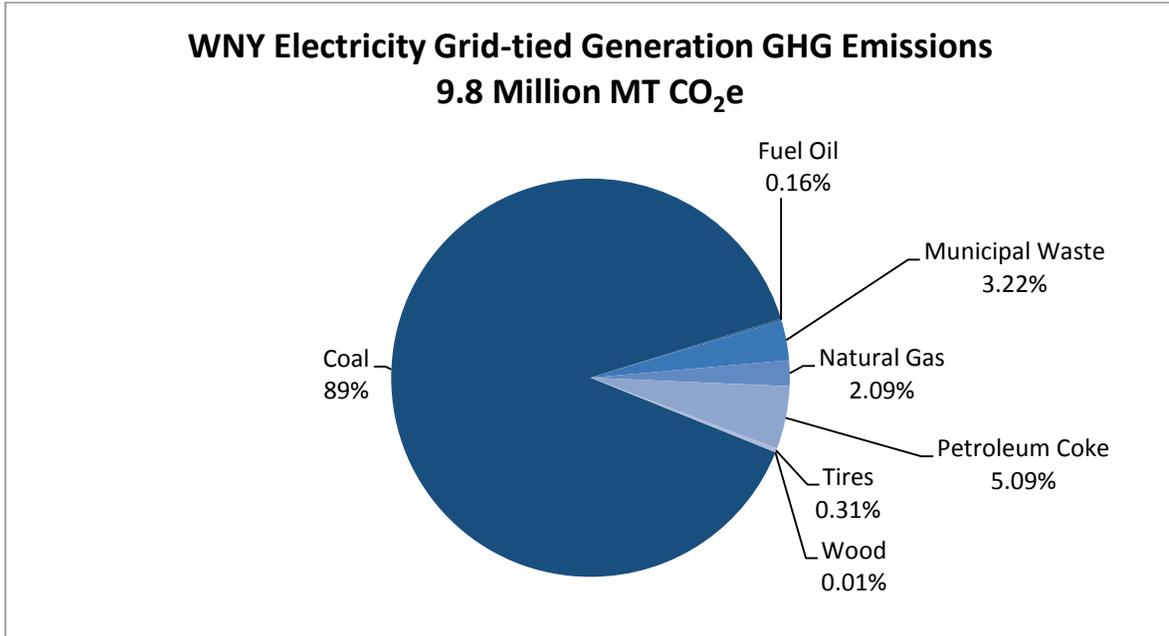


Figure 3 WNY 2010 Grid-tied Electricity Generation GHG Emissions

The WNY CGC Sustainability Plan Energy Working Group also identified an indicator of the average CO₂/MWh, specific to the 2010 energy usage type and volume for the region. This average provides a snapshot of the GHG impacts from electricity generation within the region and can be compared with the consumption based eGRID emission factors established by the EPA. While the EPA factors are calculated for application to end use consumption and do not include efficiency, transmission, or distribution losses, the comparison of the regional generation average with the eGRID average demonstrates how the region’s generating facility emissions compare with the state average. Figure 4 illustrates the average CO₂ emissions based on the different fuel types used for electricity generation in WNY in 2010, resulting in an average of 900 CO₂ lbs/ MWh.

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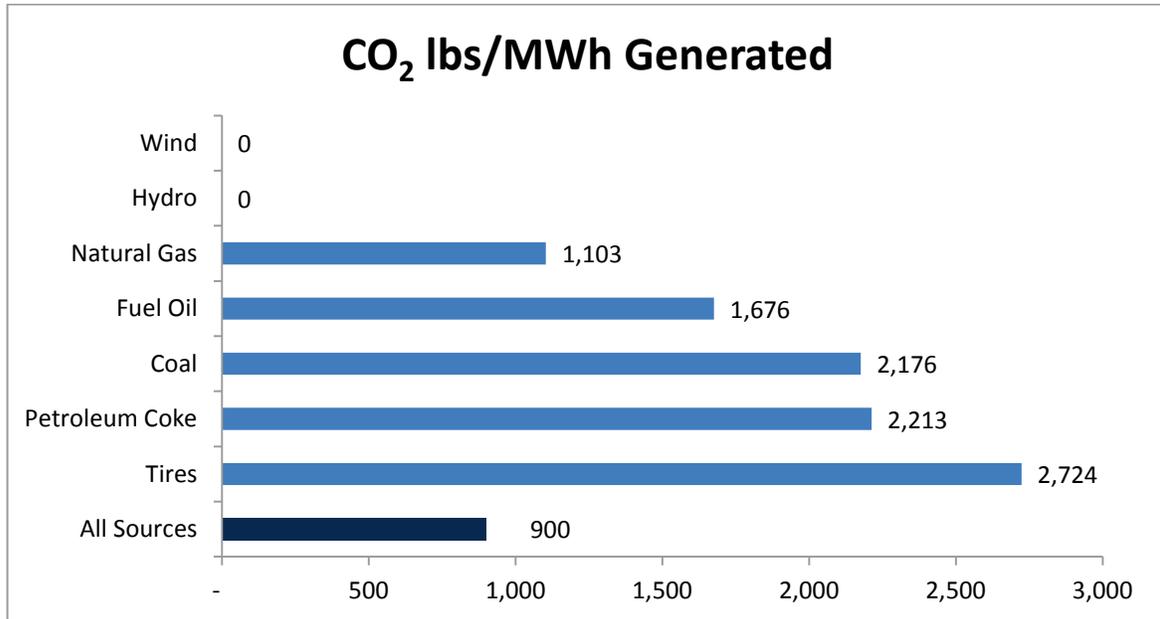


Figure 4 2010 Average Western New York CO₂ Emissions from Electricity Generation by Fuel Type

Electricity consumption in the region is based on utility sales data and categorized by residential, commercial, and industrial usage. Electricity sales data were collected from New York State Electric and Gas (NYSEG), National Grid, and five municipal electricity suppliers, by county. Electricity usage within Rochester Gas and Electric (RGE) territories was not provided but was estimated to make up about 1% of the regional total and quantified based on average usage data provided and the territory’s population (U.S. 2010 Census 2012). GHG emissions are calculated based on eGRID2012 emission factors for consumption in upstate NY (NYUP). Table 1 shows eGRID2012 CO₂ emission factors for New York State (EPA 2012).

Table 1 eGRID2012 CO₂ Emission Factors for New York State

	CO ₂ lbs/MWh
eGRID2012 NYUP (All Upstate NY)	497.92
eGRID2012 NYCW (NYC/Westchester)	610.67
eGRID2012, NYLI (Long Island)	1347.99

In the WNY region, 9.0 million MWh of electricity were consumed. Using eGRID’s emission factors, 2 million MT CO_{2e} is attributed to the region’s use of electricity. This represents 11% of the regional GHG emissions total. Sixty percent of the electricity generated in WNY was exported to other regions of the state. Figure 5 shows the percentage of electricity consumption by sector.

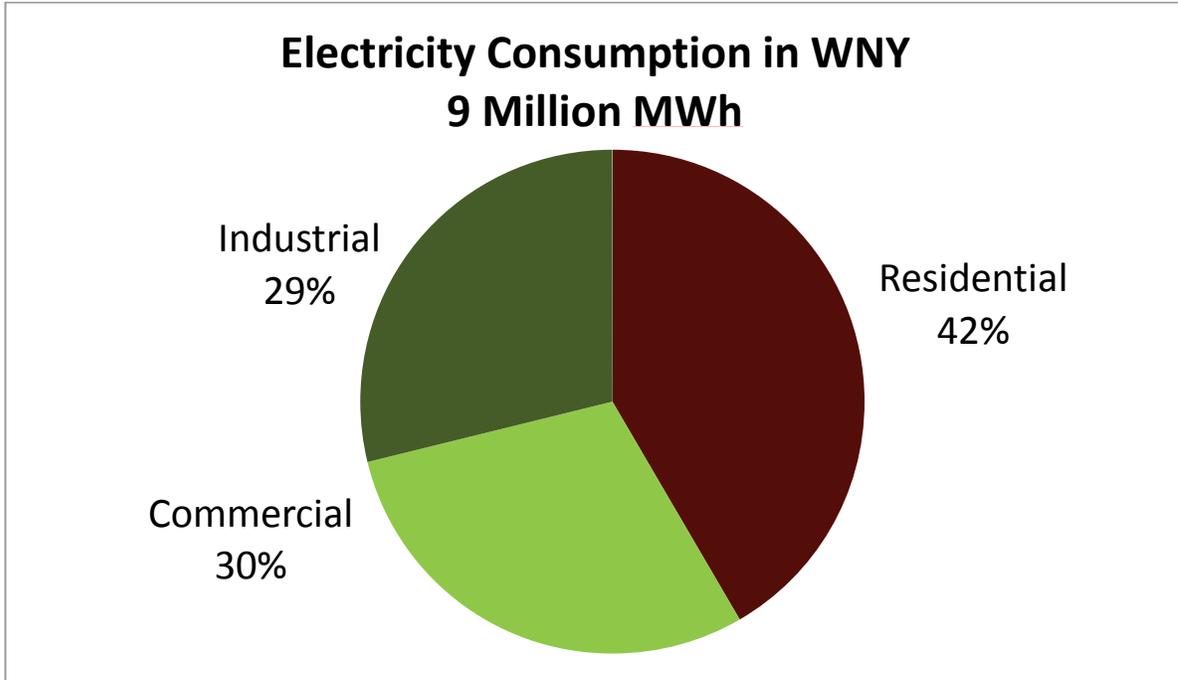


Figure 5 WNY 2010 Electricity Consumption by Sector

3.2 Direct Stationary Energy Consumption

Direct stationary energy consumption includes the use of natural gas, distillate and residual fuel oil (but not gasoline), propane and liquid natural gas (LNG), and wood or bio-mass, primarily for heating buildings and water. This energy use in residential, commercial, and industrial facilities amounted to 6.4 million MT CO_{2e}, or 36% of WNY regional GHG emissions. Figure 6 summarizes GHG emissions from direct stationary energy use in the region by type of energy (excluding direct emissions from electricity generation, which is summarized above).

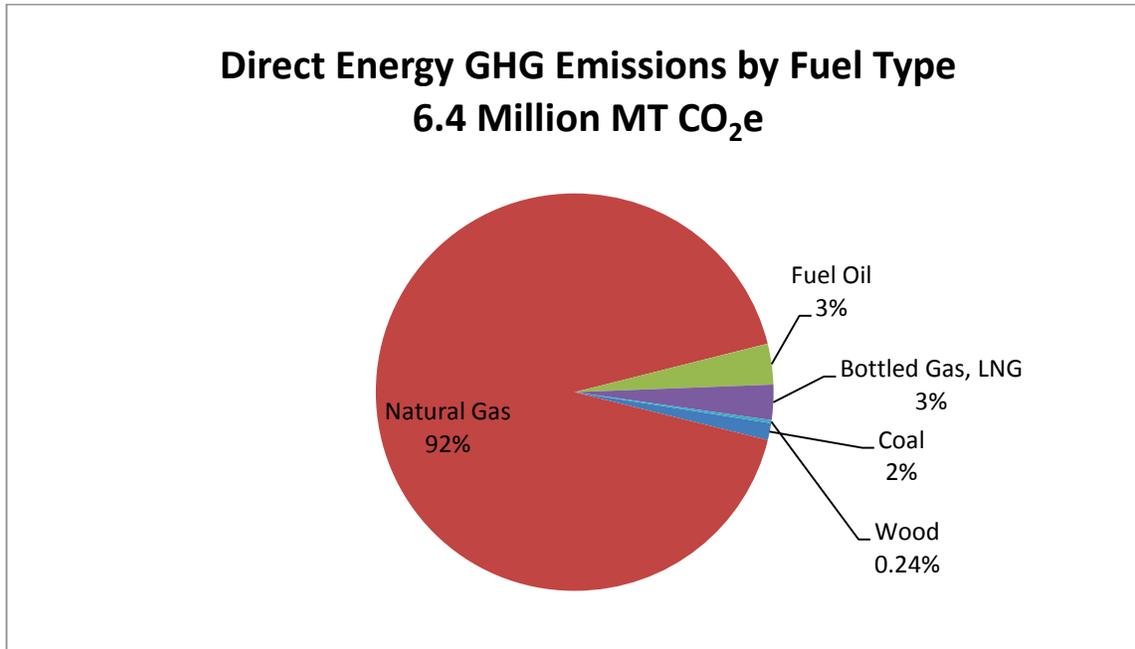


Figure 6 WNY 2010 GHG Emissions from Direct Stationary Energy Usage in WNY by Type*

*excluding electricity generation

Because accurate and complete Tier II Direct energy use data are not available for the region, direct consumption of stationary fuels are calculated using a Tier I, or “top down approach, with energy data collected from 2010 state-wide fuel use data from the EIA State Energy Data System (SEDS)(USEIA 2012) and allocated to each county in the residential, commercial, and industrial sectors using different allocation methods, chosen to best represent energy usage at the regional level throughout the state. While this method provides consistency between the regions and best represents the total regional energy use for 2010, it may not accurately represent actual energy usage from specific or individual residential, commercial, and industrial sources in the region.

Residential energy use is allocated using 2010 heating degree days (HDD), the % of household energy use by type as defined by the three-year average of the American Community Survey (ACS), and the number and size of houses as reported in the 2010 U.S. Census) (U.S. Census 2012). The three-year average was used in WNY, instead of the five- year average recommended by the Protocol group, because it more closely matched 2010 Census data on the number of houses in the region.

Commercial energy use is allocated using 2010 HDD, the % of energy use by type as defined by the residential sector, the number of employees by business type as reported by the New York State Data Center, and the average energy per worker, per square foot space for each type of business reported by the EIA Commercial Building Energy Consumption Survey.

3 WNY GHG Inventory Data Collection, Calculation Methods, and Results

Industrial energy use is not based on an allocation method. Reported energy use is collected from NYS Department of Environmental Conservation (NYSDEC) Title V Air Quality Permitting information.(NYSDEC, 2012b) For all usage sectors, GHG Emission Factors for each fuel type are calculated using 2009 EPA GHG Mandatory Reporting Rule (MRR) emission factors and calculation methodology requirements.

3.3 Transportation

Energy consumption from the operation of vehicles and mobile sources includes a broad range of uses. All mobile sources produced 6.6 million MT CO₂e, or 37% of regional GHG emissions (see Figure 7). On-road vehicle travel represents the majority of transportation emissions, while emissions from aircraft, rail, and marine vessels represent a small percentage of this category. Off road, or non-road mobile sources such as construction equipment, landscaping equipment, and recreational vehicles (including boats and snowmobiles) are considered as well. On-road and rail sources fuel consumption was estimated and then GHG emission factors and GWP were used in accordance with the EPA’s GHG MRR (74 FR 209) to quantify GHG emissions in CO₂e. For aircraft, commercial vessels, and off-road vehicles and equipment, CO₂ emissions are estimated based on reported CO₂ data or calculated using emission modeling. CH₄ and N₂O are estimated based on a ratio to CO₂, and emissions are standardized to a CO₂e basis by multiplying the emissions by the applicable GWP.

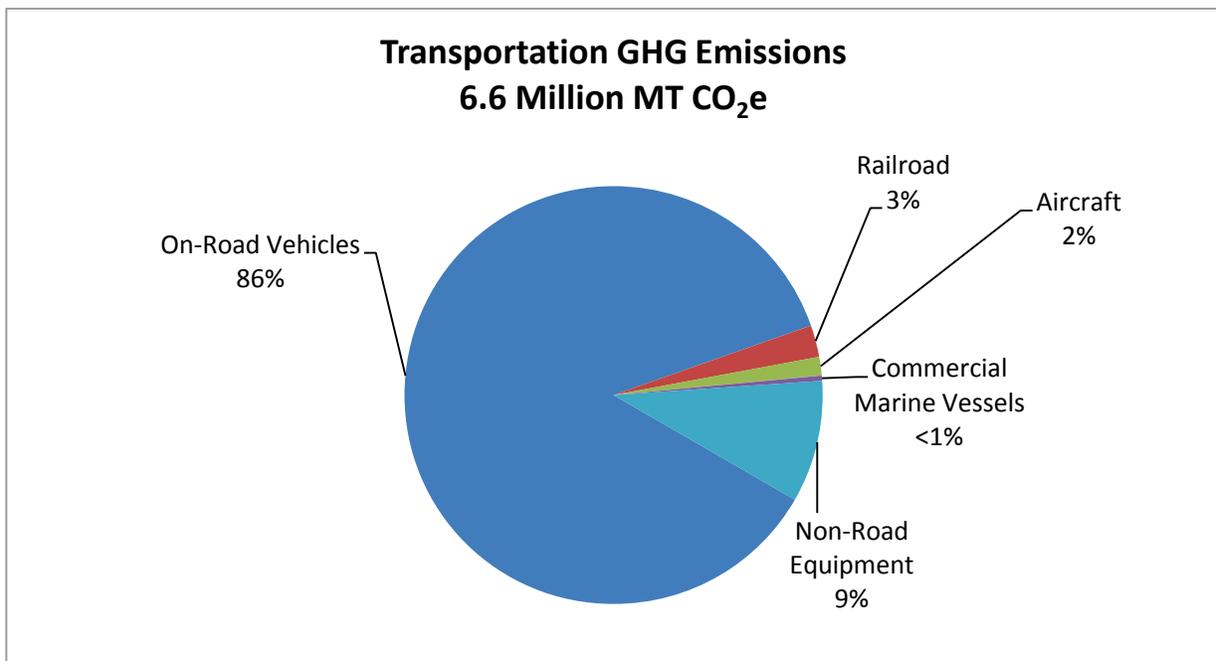


Figure 7 WNY 2010 Transportation GHG Emissions

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3.3.1 On-Road Transportation

On-road transportation includes motor vehicle travel on roads. On-road vehicles include passenger cars, light duty trucks (e.g., mini-vans, pick-up trucks), heavy duty trucks, buses, and motorcycles. The combustion of fuel in motor vehicles generates emissions of CO₂, CH₄ and N₂O. For the purposes of this inventory, it was assumed that all vehicles use either E-10 gasoline or diesel. E-10 gasoline is a blend of gasoline that contains 10% ethanol. GHG emissions from on-road vehicles were calculated based on an estimate of all vehicle miles traveled within the geographic region, regardless of origin or destination. On-road transportation produced 5.6 million MTCO₂e, or 31% of regional GHG emissions.

On-road vehicle travel distance was based on New York State Department of Transportation (NYSDOT)-modeled VMT data that has been prepared for all New York State counties (NYSDOT 2009). The county-level VMT data are estimates of travel by all vehicles in each county. The data are based on model year 2009 and are summarized by functional roadway classes (e.g., interstates, local roads, major arteries) and area types (e.g., urban, rural). This overall VMT was then separated into VMTs by the different vehicle classes (and fuel types) by using vehicle mix data for each NYSDOT region from the NYSDOT's Environmental Science Bureau. The vehicle classes were then consolidated into more general vehicle types. Fuel consumption was calculated by multiplying the VMT of each vehicle type by an applicable fuel consumption rate (fuel economy) for the vehicle type. Fuel economy values were based on national average values reported by the U.S. Department of Transportation (USDOT) Federal Highway Administration for 2010 (USDOT 2010).

In order to estimate annual GHG emissions, annual E-10 gasoline and diesel fuel consumption for each vehicle type was multiplied by emission factors for CO₂, CH₄ and N₂O for each fuel type listed in federal regulations for mandatory reporting for GHGs (74 FR 209). The emissions of each individual GHG were standardized to a CO₂e basis by multiplying the emissions by the applicable GWP as listed in 40 CFR 98.

3.3.2 Air Transportation

Air transportation includes airplanes and helicopters that operate from airports. (Very small airfields were not included in this inventory.) The combustion of fuel in aircraft generates emissions of CO₂, CH₄ and N₂O. For the purposes of this inventory, it was assumed that all aircraft use kerosene-type jet fuel. Air transportation produced 0.1 million MTCO₂e, or less than 1% of regional GHG emissions.

The calculation of fuel consumption and CO₂ emissions from aircraft at each airport in the region was completed using the Emission and Dispersion Modeling System (EDMS) Version 5.1.3. EDMS is a combined emissions and dispersion model used for assessing air quality at civilian airports and military air bases (EDMS 2011). The model was developed by the Federal Aviation Administration (FAA) in cooperation with the United States Air Force (USAF). The model includes a database of fuel use rates and CO₂ emission rates of a wide range of spe-

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cific aircraft types. The emissions and fuel use are calculated for each individual aircraft operation at or near the airport for both takeoff (taxi out, takeoff, climb out) and landing (approach, taxi in). An EDMS run was completed for each airport in the region. The outputs from each run included overall annual fuel consumption and CO₂ emissions for aircraft operations (i.e., takeoffs/ landings) for the airport.

Aircraft emission data is difficult to quantify and allocate, since so much of these emissions take place beyond the geographic regional boundaries. Members of the NYGHG Protocol Group had produced Aircraft emission estimates for their regions using a variety of methods, and there was no consensus how to determine the functional boundaries. As such, it was decided that aircraft emissions would be reported in the GHG inventory, but not included in the “Roll Up” total to be reported to NYSERDA.

For this analysis, the functional boundaries has been defined as recommended by the FAA for aircraft operations. While total emissions have been reported to NYSERDA without these emissions, they have been included in the “Rolled up” totals discussed throughout the WNY GHG Inventory and Sustainability Plan, because the WNY regional planning team determined this was appropriate for the WNY GHG Inventory.

3.3.3 Commercial Marine

Commercial marine transportation includes large commercial vessels with operational activities in waterways in each county in the region. The combustion of fuel in marine vessels generates emissions of CO₂, CH₄ and N₂O. For the purposes of this inventory, it was assumed that commercial marine vessels use residual fuel oil or diesel. The CO₂ emissions were calculated examining the emissions of oxides of nitrogen (NO_x) and sulfur dioxide (SO₂) from commercial vessels as reported for each county in EPA’s 2008 National Emission Inventory (NEI)(EPA 2008). CO₂ emissions were estimated using a ratio of CO₂ emissions to SO₂ emissions for each fuel type. In order to estimate annual CH₄ and N₂O emissions, fuel consumption for commercial marine vessels was multiplied by emission factors for CH₄ and N₂O for the applicable fuel type as listed in federal regulations for mandatory reporting for GHGs (40 CFR 98). Commercial marine transportation produced 0.04 million MTCO₂e, or less than 0.5% of regional GHG emissions.

3.3.4 Rail

Similar to the on road analysis, the functional boundaries of Rail transportation data for the region are limited to the geographic boundaries of the region, and therefore the GHG emissions represent the railroads and rail traffic that occurs within each county of the region. The combustion of fuel in railroad locomotive engines generates emissions of CO₂, CH₄ and N₂O. For the purposes of this inventory, it was assumed that railroad engines use primarily diesel, with the exception of the City of Buffalo subway, which uses electricity. The primary source of fuel consumption data for railroad systems was a 2002 New York State Locomo-

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tive Survey conducted by NYSERDA (NYSERDA 2007). The survey includes county-level fuel consumption estimates for large long-distance railroad systems and system-wide fuel consumption estimates for smaller railroad systems. As needed, fuel consumption was separated into individual counties by reviewing NYSDOT railroad system maps (NYSDOT 2011) and assuming equal railroad use over the lines. Rail transportation produced 0.2 million MTCO₂e, or 1% of regional GHG emissions.

3.3.5 Off-Road Equipment and Vehicles

Off-road mobile transportation includes mobile agricultural, commercial, construction, mining, industrial, lawn/garden, logging, marine pleasure craft, and/or recreational equipment. The combustion of fuel in mobile off-road equipment generates emissions of CO₂, CH₄ and N₂O. For the purposes of this inventory, it was assumed that all equipment uses either gasoline, diesel, compressed natural gas (CNG), or liquefied petroleum gas (LPG) (LPG is often in the form of propane). Off-road activities produced 0.7 million MTCO₂e, or 3.7% of regional GHG emissions.

NYSDEC provided estimates of CO₂ emissions for all off-road mobile equipment categories for each county, based on output from NONROAD model runs conducted by NYSDEC using 2007 data and the 2005 version of NONROAD for state-wide air quality inventory (NYSDEC 2012c). NONROAD is an EPA emission model used to calculate past, present, and future emission inventories for all off-road mobile equipment categories except commercial marine, locomotives, and aircraft (EPA 2005). In order to estimate annual CH₄ and N₂O emissions, fuel consumption for commercial marine vessels was multiplied by emission factors for CH₄ and N₂O for the applicable fuel type as listed in federal regulations for mandatory reporting for GHGs (40 CFR 98).

3.4 Industrial Process Sources

Emissions resulting from industrial processes or fugitive system emissions are considered separately from building and facility emissions. These emissions include emissions from industries such as metal processing and pulp and paper production as well as the fugitive refrigerants and lubricants SF₆, HCFC, and CFC. Industrial process emissions are limited to the emissions from large process sources and reported as required by the EPA MMR, which is available from the EPA's Greenhouse Gas Reporting Program (GHGRP) (EPA 2012c). As determined by the Protocol Group, smaller sources are not included. The sources that are reported in WNY are the iron, steel, and ferroalloy industries, which produce 0.25 million MT CO₂e, or 1.4% of regional emissions.

Estimates of fugitive emissions of ozone-depleting substances (or ozone-depleting replacements) such as HCFCs and CFCs were calculated using the EPA 2009 Draft Guidance method (EPA 2010). These emissions are estimated from the national per/capita emissions for all WNY counties, based on county population. This covers fugitive emissions from lubricant uses and heating and cooling

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equipment, including building and mobile refrigeration uses. These emissions total 0.32 million MT CO₂e, or 1.8% of regional emissions.

SF₆ emissions are estimated by apportion the 2010 national SF₆ emission inventory total for the state (EPA 2012c) on a county-based ratio of EIA-reported total state electricity consumption (USEIA 2012) to electricity consumption in each county; 0.03 million MT CO₂e are attributed to SF₆ emissions, which is less than 1% of regional emissions.

3.5 Energy Transmission Losses

GHG emissions are also attributed to losses in energy resulting from transmission, either through the loss of power through the generation of heat by electricity or from direct emission losses of natural gas. To estimate electricity transmission losses, the method recommended by EPA's eGRID is used (USEPA 2012s): the average eastern grid loss rate of 5.82% is applied to regional electricity consumption; 0.12 million MT CO₂e is estimated to result from the electricity transmission losses, which is less than 1% of regional emissions.

Losses from natural gas systems represent a larger percentage of regional emissions than electricity losses. Natural gas is primarily methane, which has a GWP 21 times that of CO₂. In addition, natural gas is the most used fuel in WNY. The Protocol Group determined that emissions will be estimated using the statewide average of 1.8% as documented by National Grid in 2010 PSC Reporting. When considering all natural gas used for residential, commercial, and industrial facilities and for electricity generation, 0.85 million MT of CO₂e result from natural gas transmission losses, or 5% of GHG emissions in the WNY region.

3.6 Solid Waste and Wastewater Management

Unlike energy use emissions, which are mostly CO₂, emissions from waste and wastewater management consist primarily of CH₄ and N₂O, resulting from the breakdown of organic materials. Most waste-related methane emissions are controlled by methane capture for energy production or flaring. GHG emissions are attributed to the region based on the amount of waste generated during 2010. Waste and wastewater produce only a small amount of GHG emissions in our region (1.8% and 0.8%, respectively).

Waste emissions were estimated in two different ways for the GHG Inventory. Direct emissions from Waste facilities, or Scope 1 emissions, have been reported but are not included in the roll up of total regional emissions. Most landfill methane, more than 70%, is captured and used to generate electricity in the region's five landfills or the single waste-to-energy facility in the region, reducing the climate impacts of the methane by preventing its release into the atmosphere and replacing other GHG-emitting fuels used for electricity generation. Because of the high GWP of methane emissions, landfills in WNY are considered large GHG emitters, in accordance with the EPA MRR, and therefore GHG emission reporting is available from the GHGRP (EPA 2012c). Total emissions as reported for all waste facilities in 2010 EPA MRR GHG reporting data, except for the Allegany

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County landfill, which did not report. Emissions are calculated based on average per waste tonnage at the Hyland landfill, also in Allegany. The total emissions from waste facilities in 2010 are 0.77 million MT CO₂e.

The Protocol Group determined that it is necessary to allocate waste-related emissions based on waste generation, instead of waste received data from facilities. Therefore, an indirect, or Scope 3, estimation of methane emissions is calculated, using annual regional waste generation and a First-Order Decay (FOD) Model to estimate all emissions that would result from the waste generated. Waste generation data were obtained for 2010 from the NYSDEC and compiled by NYSERDA for the Protocol Group to provide this allocation (NYSERDA 2012), and emissions were estimated using the California Air Resource Board (CARB) FOD Model (CARB 2011) and assuming an average methane capture of 75% (from flaring or energy recovery).

Wastewater emissions are calculated using the EPA State Inventory Tool, Wastewater module, using NYS defaults (EPA 2012d) and the 2010 population from the 2010 U.S. Census (U.S. Census 2012). The total emissions estimated from wastewater processing in 2010 are 0.14 million MT CO₂e.

3.7 Agriculture

The three major agricultural sources of GHGs are emissions of N₂O from soils, which are the result of applying nitrogen fertilizers; emissions of CH₄ and N₂O from manure management; and CH₄ emissions from livestock digesting their feed, known as *enteric fermentation*. The CH₄ used to estimate agricultural GHGs are described in the EPA's Draft Regional Greenhouse Gas Inventory Guidance (EPA 2010). The CO₂e of these CH₄ emissions are calculated by multiplying the amount of CH₄ times its global warming factor of 21 (40 CFR 98). Similarly, CO₂ equivalents of N₂O emissions are calculated by multiplying the amount of N₂O times its global warming factor of 310 (40 CFR 98). Two percent of total regional GHG emissions are from agricultural Sources.

3.7.1 N₂O Emissions from Agricultural Soils

The EPA method multiplies the estimated total amount of inorganic and organic fertilizer applied to farmland in the region by a factor of 1%, which is the amount of N₂O that is given off per unit of nitrogen in the fertilizers. The amount of nitrogen applied in inorganic fertilizer was estimated by the EPA's estimate of fertilizer purchased in New York State (EPA 2010) and assumes that virtually all fertilizer purchased in the state is applied to cropland. An average amount of fertilizer per acre of cropland was calculated by dividing the total fertilizer purchased by the total cropland in the state (USDA 2009). That average was multiplied by the acres of cropland in each county of the region, according to the 2007 Census of Agriculture (USDA 2009). The organic fertilizer applied was assumed to be limited to bio-solids from New York State facilities approved for land application (NYSDEC 2012) and was assumed to have a nitrogen content of 5% (NCSU n.d.; Kelley et.al. 1984). Although manures are used as organic fertilizers, EPA guidance accounts for GHG emissions from manure in separate calculations. The total

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emissions estimated from the application of fertilizer in the region in were 0.025 million MT CO₂e.

3.7.2 Manure Management

The manure of cattle, swine, poultry, sheep, goats, and horses generates emissions of both CH₄ and N₂O. Estimated CH₄ emissions are based on the number of each type of farm animal and a manure management factor for each animal type. The manure management factor varies with the typical weight (or mass) of the animal, the amount of volatile solids typically contained in that animal's manure, and the quantity of CH₄ that can be produced from the volatile solids of that animal's manure. Estimated N₂O emissions are based on the number and typical mass of each type of animal, the amount of N excreted by each animal type, and an emission factor based on how the manure is stored before applying to fields. Data from 2007 from the USDA is the most recent data available for animal populations in the region (USDA 2009). The total emissions estimated from manure management in the region are 0.06 million MT CO₂e.

3.7.3 Enteric Fermentation

Agricultural animals, especially ruminants (i.e., cattle), generate CH₄ through the digestion of feed through a process of fermentation in their digestive tracts. The CH₄ produced by enteric fermentation is estimated based on the population of agricultural animals—provided by the USDA (USDA 2009)—multiplied by an emission factor for each animal type. The total emissions estimated from enteric fermentation in the region are 0.32 million MT CO₂e.

3.8 Forestry

Forests in rural areas and even in some urban areas can represent a major carbon sink, as the vegetation absorbs CO₂ and stores the carbon within its fibers. The release of this stored carbon through removal resulting from harvest or development results in the generation of emissions, from the burning or decay of the materials, and also from the loss of the regular intake of CO₂ from that vegetation. While this source of emissions and sinks is a complex and difficult sector to estimate accurately, the GHG inventory provides an assessment of current carbon sink values of existing rural and urban forests within the region. Research into the amount of carbon stored in trees and forests has been used to estimate the total CO₂e stored in the region's forests and also the annual amount of GHG emissions absorbed by urban trees. In addition, urban trees can provide an important carbon sink in the region.

3.8.1 Carbon Sequestration by Forests

Forests uptake CO₂ through photosynthesis and store the carbon in the branches, stems and roots. The amount of CO₂ stored by forests is calculated by multiplying the acres of each type of forest in the region (defined by the dominant species or group of species) (USFS 2010) times a factor representing the quantity of carbon stored per acre of each type of forest (called the carbon stock factor) (NCASI 2012). The carbon stock factor depends on the species of trees and the typical quantities of woody material of those forest types and can vary over time and

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from one area to another. The carbon stock factor is determined for each county and is updated frequently (every few years) as conditions vary. While forests are responsible for large annual sinks, this is not a data point that is easily estimated, or even logically applicable to the discussion of man-made carbon covered by this inventory, although, removing a forest for development can have the impact of releasing the stored carbon in the existing forest. Since this change is difficult to track, and more difficult to assess accurately, the region's total carbon storage has been estimated to provide information for discussion about the value of this resource rather than to provide a questionable annual impact. It is estimated that 306 million MT CO₂e is sequestered in WNY regional forests.

3.8.2 Urban Trees

Urban trees uptake CO₂ as they mature and can be a significant sink of CO₂ at the regional level. Since urban trees are not widely diverse or complex, compared with forest ecosystems, they provide an easier point of quantification than forest eco-systems, based on an average age, type, and density of tree cover. The amount of CO₂ sequestered by urban trees can be estimated as a function of the size of urban areas and the percentage of that area with tree cover (data provided by Greenfield 2012). The EPA's national average net sequestration rate for urban trees of 222.80 metric tons of CO₂ per square kilometer was used for this inventory (EPA 2010). While this method provides an annual number, it is also included in this inventory not to provide part of the total impact quantification but for discussion, information, and comparison. Urban trees sequester 0.3 million MT CO₂e of GHG emissions annually in WNY.

4

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